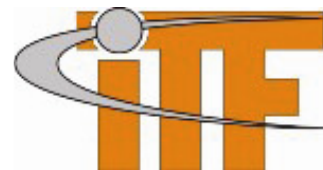




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LATVIA UNIVERSITY OF AGRICULTURE
FACULTY OF INFORMATION TECHNOLOGIES



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FOREWORD

Information and communication technology (ICT) is scientific direction with huge potential of synergistic influence on number of other scientific branches. Computational power of currently available hardware and software opens new possibilities in use of computational methods solving most different tasks.

New opportunities demand also new type of specialists: they have to be interdisciplinary oriented. Additional scientific branch has to be used to widen the potential of the first education.

I am glad that this conference highlights applications of information and communication technologies in different branches thus facilitating interdisciplinary high-tech implementations in industry.

The collection of international scientific conference proceedings contains 52 reports, 8 abstracts by 100 authors from Latvia, Lithuania, Estonia, Netherlands, Sweden, US. The reports and abstracts are divided into the following eight parts:

- Bioinformatics and systems biology
- Modelling and simulation technologies
- ICT in agriculture
- ICT in education
- ICT in education physics
- ICT tools and methods
- Industrial applications of ICT
- Seventh Nordic – Baltic agrometrics conference

We are very thankful to all, who were involved in conference preparing.

Chairman of Organizing Committee

Dr.sc.ing.. Egils Stalidzans

Latvian University of Agriculture

BIOINFORMATICS AND SYSTEMS BIOLOGY (SUPPORTED BY SYSBIO.LV)

APPLICATIONS OF MODELING IN SYNTHETIC BIOLOGY

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Abstract

Synthetic biology is a new scientific field that promotes engineering approach in biology. New organisms can be created using parts and elements from other organisms. New organism can be developed from scratch or based on existing organism using it as a chassis.

The field of synthetic biology holds a great promise for the design, construction and development of artificial biological (sub) systems thus offering potentially viable new routes to genetically modified organisms, smart drugs as well as model systems to examine artificial genomes and proteins. The informed manipulation of such biological (sub) systems could have an enormous positive impact on our societies, with its effects being felt across a range of activities such as the provision of healthcare, environmental protection and remediation, etc.

Mathematical computer modeling becomes integral part of this new interdisciplinary field of biology due to necessity to predict behavior of partly or fully synthetic systems before their execution in vivo. Computer modeling and analysis can be applied also in fields like biosecurity and biosafety to monitor and prevent emergence of dangerous genetic sequences or organisms.

Modelling is necessary in all four main approaches of synthetic biology: 1) bottom up, 2) metabolic engineering, 3) chassis, 4) top down (organisms creating from parts). It is important to predict behavior of systems using modelling in the phase when they are under development and therefore cannot be examined experimentally.

Keywords: *synthetic biology, modeling in synthetic biology*

Introduction

The field of synthetic biology holds a great promise for the design, construction and development of artificial biological (sub)systems thus offering potentially viable new routes to genetically modified organisms, smart drugs as well as model systems to examine artificial genomes and proteins. The informed manipulation of such biological (sub) systems could have an enormous positive impact on our societies, with its effects being felt across a range of activities such as the provision of healthcare, environmental protection and remediation, etc.

Synthetic biology is concerned with applying the engineering paradigm of systems design to biological systems in order to produce predictable and robust systems with novel functionalities that do not exist in nature. Just as all engineering disciplines maintain a fruitful relationship with the fundamental sciences that underlie them, synthetic biology will seek to use and expand the mechanisms that control biological organisms using engineering approaches. These approaches will be applied on all scales of biological complexity: from the basic units (design and synthesis of novel genes and proteins, expansion and modification of the genetic code) to novel interactions between these units (regulation mechanisms, signal sensing, enzymatic reactions) to novel multi-component modules that generate complex logical behavior, and even to completely or partially engineered cells. Bringing the engineering paradigm to biology will allow us to apply existing biological knowledge to biotechnological problems in a much more rational and systematic way than has previously been possible, and at the same time to expand the scope of what can be achieved this way. The introduction of design principles such as modularity of parts, standardization of parts and devices according to internationally recognized criteria, and the (reciprocal) adaptation of available abstract design procedures to biological systems, coupled to novel technological breakthroughs (such as cheap mass synthesis of large DNA segments) that allow the decoupling of design and fabrication, will fundamentally change our current concepts of how to manipulate biological systems. In this sense, synthetic biology is not primarily a “discovery science” (that is, concerned with investigating how nature works), but is ultimately about a new way of making things. By adapting natural biological mechanisms to the requirements of an engineering approach, the possibilities for re-assembling biological systems in a designed way will increase tremendously (European Communities, 2005).

While several of the fundamental scientific issues and current applied objectives of synthetic biology overlap with those in other, more mature fields, especially biotechnology and systems biology, synthetic biology should be properly seen as a completely new discipline, which brings a systematic, application-driven engineering perspective to biology.

It can be anticipated that the major change that the field of synthetic biology will bring is the synergistic integration of existing disciplines: not just biology and engineering, but also computer modeling, information technology, control theory, chemistry and nanotechnology.

Synthetic biology and its approaches definition

One basic feature of all biological systems is to be biosynthetic. The anabolism serves each organisms own characteristic repertoire and dose of naturally occurring substances necessary for survival in its habitat.

In fact, to be described as synthetic, at least two distinguishable components are needed which can be combined artificially in a certain manner in order to form something new with extended functionality (Hutchison et al., 1999).

The assembly of natural and artificial parts results in distinct possible synthesis products, for which the results are all artificial.

The term artificial simply means man-made and differing from naturally occurring structures or processes. Artificial biological components can be designed to have full functional compatibility within their respective biological systems. In technical terms, Synthetic Biology should be defined as distinct from previous technologies of molecular biology - from simple genetic engineering (bottom up) and from theoretical total artificial life in its extremes (top down) (Bernauer, 2005).

The resulting product of a synthesis should be intentionally designed to have improved properties. Exploitation of synergistic effects of biologically active parts in fusion products often plays a role in considering how to plan biological synthetic systems. However the result of Synthetic Biology application consists in a new self-sustaining system of extended functionality. This means that the artificial system is functionally built in, replicating and co-proliferating within the host system, e.g. a new artificial pathway design in a host organism or an artificial “protoliving” particle (Chen et al., 1999) (Rasmussen et al., 2003). The synthesis products of these designed systems are artificial, and are intended for use or application.

There are four main approaches how can create synthetic organisms but in all there is one main condition – need to think about ethical norms and biosafety and biosecurity. Those organisms can be from modified existing organisms to created new unknown organisms by using already known functionality: it means there is theoretically possible in one organism put all nuance you like.

Those four approaches are:

- Bottom up
- Metabolic engineering
- Chassis
- Top down or creating organisms from parts, devices and systems

Bottom up

This approach is known as a classical genetic engineering.

Any DNA sequence which is modified by human influence in any sequence variant that is not naturally occurring is artificial. From the perspective of human intention, the creation of varieties of sequences can only make sense in order to change functionality, to analyses and unravel, or to create new functional features, such as reproducibility and/or robustness of function. For this, it is possible to differentiate three types of functionality – regulators of function, regulated function targeted for specific control by regulators and sensor function.

Changing the properties of regulators, sensors and targets by creating new combinations is a prerequisite for the design of new regulatory circuits with intrinsic new functions, for example on the level of systemic behavior. Many different applications that have already been published are based on the generation of recombinant cells and organisms by genetic engineering and molecular cloning in combination with transformation or transfection experiments (Bernauer, 2005).

There is one unsolved question: there is no clearly defined where begins Synthetic biology in simply recombinant DNA.

Many successful heterologous expression experiments of genes for bioproduction are classical examples of organisms with designed artificial functionality, microorganisms, fungi, cell cultures, transgenic animals and plants (Sorensen et al., 2005). In formal terms, the artificial combination of a homologous regulator controlling the expression of a heterologous gene results in a simple artificial design of at least two natural biological parts. From the perspective of the intention behind the application, these constructs are designed for the production of a single molecule species, mostly proteins.

Systems biology is the analysis of how sensor and regulating functions control natural pathways and how they interact through informational cross talking at the systemic level. Based on the steadily increasing knowledge about systemic behavior, Synthetic biology having the opposite intention aims at designing artificial pathways for optimized regulation or extended catalytically capabilities towards technical solutions (Bernauer, 2005).

Providing technical solutions to systemic regulatory information either needs optimization of single components according to requirement specification in rational technical designs for stringent functional regulatory behavior

or functional processing on the cellular level by optimization cycles for directed evolution on the genomic level, or both.

Technical solutions include deploying mathematical methods and models such as statistics and computational tools as simulation algorithms to create information for optimization. Synthetic biology applies solutions to biological systems in order to influence their function towards a desired technical optimization by generating artificial designs compatible with biological functions at the more complex level of molecular interactions.

Metabolic engineering called also as Pathway Engineering – Bug Sweatshops

While in the past metabolic engineering focused primarily on enhancing strain productivity, expanding substrate utilization range, and forming novel products, the future spectrum of applications for metabolic engineering has expanded hand in hand with the explosive growth in biological research. Driving this expanded role has been the massive efforts towards evaluating system wide biological properties. For example, the full sequence of 42 organisms is currently complete with an additional 250 organisms in process (<http://ncbi.nlm.nih.gov>). Functional genomic technologies are also in place that allows the activity of complete genomes to be observed, proteomic techniques are increasingly being demonstrated, and improved methods of measuring metabolic fluxes are developing rapidly. As a result of these developments, we envision three primary areas of research that an expanded metabolic engineering will impact greatly. First, traditional metabolite overproduction will benefit as global regulatory data accumulate and the effects of directed alterations are resolved at much greater physiological detail. Second, the spectrum of alternative host organisms and relevant gene products will continue to expand as full genomes of plants, fungi, bacteria, and mammals are sequenced. Finally, biocatalytic applications for the production of chiral molecules will progress as we begin to understand the systemic properties that favor the production of stereospecific compounds. Importantly, developments in each of these research areas will be mutually beneficial. That is, the expanded host and gene product range will enhance the production of chiral molecules (Nielsen, 2001).

Although most applications of the past decade and obvious future extensions focus on the improvement of industrial strains for metabolite overproduction, perhaps an even greater impact of metabolic engineering will be in genetic therapy, pharmaceutical diagnostic assays, or programs of drug discovery. Although issues of delivery presently dominate the prospects of gene therapy, the ultimate success of this very promising approach will depend on the correct identification of the target(s) of genetic intervention. As such, the central problem of gene therapy will be no different to that of strain improvement and a systemic analysis of genomic and physiological measurements will play an important role in this area. Moreover, assessing the specific physiological phenotypes observed after overexpression of specific gene therapeutics is an obvious extension of more traditional metabolic engineering systems (Nielsen, 2001).

Another unconventional application of metabolic engineering is the development of targets for the screening of compound libraries in drug discovery. The key concept here is that single enzyme assays are becoming less effective in identifying robust lead molecules with high probability of maintaining activity under in vivo conditions, for the simple reason that it is less likely that a single enzyme is responsible for most systemic diseases (Kelsone et al., 1989). This means that drugs effective against more than one target will have a higher probability of success and fewer side effects. Additionally, identification of lead molecules will have to rely increasingly on the response of multiple markers of cellular function as opposed to a single marker-based selection that is presently the norm. The above characteristics constitute drastic departure from current practice in drug discovery, yet they are entirely within the realm of feasibility given a suitable intellectual framework and sufficient measurements about the cellular state. Such a framework of integration is available from metabolic engineering whose power will be further enhanced with the inclusion of the new methods for probing the cellular phenotype (Nielsen, 2001).

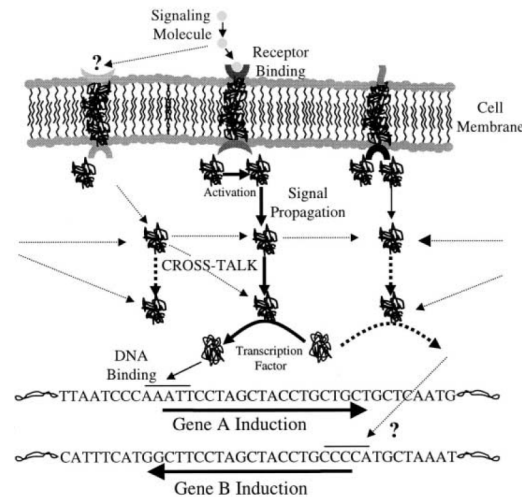


Figure 1. Signal transduction pathways representation (Nielsen, 2001).

Signaling molecules bind to receptor proteins on the outside of the cell membrane. The receptor protein is activated (typically by conformational changes) on the interior side of the cell membrane. The activated protein next transfers an interior signaling molecule to a second signal transduction protein, followed by a third, etc. The end result is the activation of a DNA binding protein, a transcription factor, transcription initiation, and gene induction. Cross-talk occurs when signaling molecules are transferred across signaling pathways leading to the activation of different transcription factors and ultimately inducing different genes. Also, non-specific binding of extracellular signaling molecules can lead to partial activation of alternative signaling pathways (Figure 1) (Nielsen, 2001).

A final nonobvious but very important future role for metabolic engineering will be the analysis of signal transduction pathways. Signal transduction pathways are involved in inter-cellular interactions and communication of extracellular conditions to the interior of the cell. Signaling occurs via consecutive phosphorylation-dephosphorylating steps whereby the phosphorylated (active) form of an intermediate protein acts as a catalyst (kinase) for the phosphorylation of the subsequent step. The final outcome of a signaling pathway is often the activation of a transcription factor that, in turn, initiates gene expression (Lauffenburger et al., 1996). To date, signal transduction pathways have been investigated in isolation from one another. It has become abundantly clear, however, that there is a great degree of interaction (cross-talk) of signal transduction pathways for the simple reason that they share common protein intermediates (Roberts et al., 2000). This introduces the possibility that one ligand may affect the expression of more than one gene or that the expression of a single gene may be effected by more than one ligand (Figure 1). Again, the network features of signaling provide a fertile ground for the application of concepts from metabolic engineering in conjunction with expression and, in particular, proteomics data. Certain modifications influence to a significant extent gene expression and, as such, will have to be made to account for the fact that signaling pathways catalyze the propagation of information compared to interconversion of molecular species characterizing metabolic pathways. The correct formulation and applicable principles that take this difference into consideration are yet to be developed (Nielsen, 2001).

Chassis

Designed and synthesized DNA segments that encode novel functions need to be implemented into a suitable organism, for the time being, by one of the many available genome engineering techniques (see, for example, (Kolisnychenko et al., 2002)), or in the future by novel mega-size cloning strategies (Itaya et al., 2005). As the complexity of existing biological systems is the major problem in implementing synthetic biology's engineering vision, it is desirable to reduce this complexity. One option is to reduce the genome of the host - the chassis - into which the new sequence is implemented, which would eliminate many possibilities for interference. For an intended chemical production with the designed system, this genome reduction will probably be limited to reducing the metabolic capabilities of a strain. A true "minimal genome" - the minimum set of genes that is necessary for a cell to propagate under specific environmental conditions - would be a useful point to start when trying to engage in re-building more complex systems (Forster et al., 2006).

According to theoretical considerations, growth in the presence of a rich but synthetic and defined medium requires as few as 206 genes, basically comprising the DNA replication, transcriptional, and translational machinery, rudimentary DNA repair functions, protein processing and degradation, cell division, and rudimentary metabolic and energy functions (Gil et al., 2004). Towards this goal, one can either substantially reduce the relatively large genomes of established model systems and exploit the abundance of molecular

biology tools for these model organisms, or work on the already very small genome of other organisms in exchange for the requirement to develop novel molecular biology tools (Heinemann et al. 2006).

Regarding the latter, non-pathogenic *Mycoplasma* flora with very attractive cultivation properties and a genome size of 793 kb, is currently being established as such a chassis. Its genomic sequence has recently become available and molecular biology methods are developed. A similar approach is followed with *Mycoplasma genitalium*, for which extensive data on non-essential genes is available (Glass et al., 2006).

Regarding the former, a prominent example is *E. coli* whose genome has been reduced in various projects by 6% (Yu et al., 2002), 8% (Kolisnychenko et al., 2002), or 15% (Kolisnychenko et al., 2002), without any noticeable effect on the investigated physiological properties and by 30% resulting in defects in cell replication (Hashimoto, et al., 2005). *Bacillus subtilis*' genome has been reduced by 8%, again with only minor effects on physiology (Westers et al., 2003), confirming the hypothesis that under controlled laboratory conditions a substantial part of a bacterium's genome is indeed dispensable (Heinemann et al. 2006).

Top down

Based on the theories of evolution derived from observations made in macro and microcosms of nature, experimental designs for creating carbon based artificial life are possible (Grant et al., 1991). Recent projects in nanotechnology are aimed at emulating life processes and may provide the basis for creating real artificial carbon based life in the future. That's mean that during this approach the organisms are unique, developed from different parts of different species and never been before in nature.

Part of creating forms of primitive life artificially and to deploy these very simple forms of artificial life is called the proto-life approach (Rasmussen et al., 2003) (Bedau et al., 2003) (Bedau, 2000). A totally new type of living beings could be established that could not be regarded as a synthetic continuation of the natural historical process initiated by nature. Therefore the key features of being self-creating and historic are key feature for differentiating natural and synthetic biological life of natural origin from totally artificial life.

Artificial components of biological functionality can be theoretically integrated into totally artificial biological systems which show at least all basic features of living systems. Although this has yet to be shown, it would lead to the beginning of new evolutionary processes. If such systems can be designed to enter self-sustaining cycles of evolution they might be termed "Artificial (carbon based) Life" in a scientific discipline which should be termed "Artificial Biology". If this could be achieved, the term Synthetic Biology, which at present synthesizes biological compounds or organisms using artificial ones, could be extended to include the synthesis of artificial biological compounds using artificial ones. This would be the most sophisticated approach for nanotechnology to emulate living systems by applying natural nanostructures from Nano bionic knowledge and creating systems with a level of complexity that would possess features of living systems. (Bernauer, 2005)

It is the goal of some bio-ambitioned nanotechnologists to increase the complexity of their systems towards those of living features, whereas biologists tend to focus on a reduction of the complexity of biological function towards the minimal cell (Hutchison et al., 1999) (Luisi, 2002) (Rasmussen et al., 2004).

A prerequisite is that at least one component of the synthesis precursors must fulfill the minimal criteria of a self-maintaining life cycle under certain circumstances, and that the fusion product behaves in the same way. Depending on the origin of the synthetic components used for (self) assembly, biomimetic chemistry is another overlapping field of activities. If such artificial minimal organisms are employed in complex natural biological systems such as a human being, the synthesis of artificial with natural components would take place on a level higher than the molecular or cellular level. (Bernauer, 2005)

The term "biology" combined with "synthetic" leading to Synthetic Biology in this definition should be used exclusively for creating artificial systems based on DNA as an information store. Other forms of artificial carbon based life should be discussed in the context of "evolutionary nanotechnology" or synthetic artificial biology (Ennenga, 1997).

Parts registry and standardization

One of important aspects of synthetic biology is the standardisation of building elements of synthetic systems. That is precondition of engineering approach used in technics. The first and currently biggest catalogue of biological parts (www.partsregistry.org) is the first and currently the biggest online source of building blocks in synthetic biology.

Building elements are classified in Categories of parts: promoters, ribosome binding sites, protein domains, protein coding sequences, translational units, terminators, DNA, plasmid backbones, plasmids, primers and composite parts. Parts can be put together forming devices. Separate part in the catalogue is the categories of devices: protein generators, reporters, inverters, receivers and senders and measurement devices.

Parts and devices can be found also by functions: biosynthesis, cell-cell signalling and quorum sensing, cell death, coliroid, conjugation, mobility and chemotaxis, odour production and sensing and DNA recombination.

Parts and devices can be browsed also by chasis (organisms used as carriers of needed function): *Escherichia coli*, yeast, bacteriophage and *Bacillus subtilis*.

Methods of engineering

Modeling of the design, to predict system performance prior to fabrication, is an important component of synthetic biology. Synthetic biology is therefore similar to systems biology, in that both rely heavily on computer modeling of biological processes. In systems biology, modeling of whole biological systems is undertaken in order to obtain a better understanding of the complexity of biology for the purposes of analysis. Synthetic biology can therefore be considered at one level to be the application of certain systems biology techniques to the construction of new biological parts, devices and systems. Current and future advances in the modeling of the interactions of molecules and systems will serve to drive progress in the complexity of designs implemented in synthetic biology – for example, how DNA encodes the information needed to sustain and reproduce the cell. Recently, multi-scale models of gene regulatory networks have been developed that model the complete set of bio-molecular interactions in gene regulatory networks, ie transcription, translation, regulation, and induction. This work helps to guide the design of synthetic systems. Commercially available software currently caters for the needs of the systems biologist, but there is a need for an integrated design environment (IDE) for the synthetic biologist, similar to computer aided design (CAD) systems developed for other branches of engineering (The Royal Academy of Engineering, 2009).

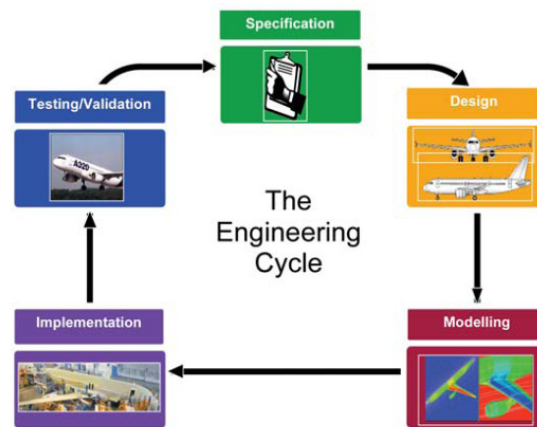


Figure 2. The Engineering Cycle (The Royal Academy of Engineering, 2009).

The quantitative measurement of biological parameters is an essential part of the accurate specification, design, modeling and validation of synthetic biological devices and systems. For example, discrepancies between the behavior predicted by a model and actual measurements may identify shortcomings in current biological control hypotheses and shed light on the malfunction of synthetic systems (The Royal Academy of Engineering, 2009). To close the circle, synthetic biological systems may prove especially useful in substantiating hypotheses regarding natural biological systems; if a functional system can be built in another organism then the hypothesis on which the design is based is likely to be sound. In the future, technologies which allow many parallel, even single cell, and time-dependent measurements, will be especially powerful for synthetic biology (The Royal Academy of Engineering, 2009).

Synthetic biology approaches design of engineered biological systems are made using the engineering cycle (see Figure 2).

Testing by a model

Computer modeling becomes increasingly important in applications of synthetic biology where experimental data of the process of interest usually is completely missing as the organism is not created yet. At the same time costs of in vivo experiments are strongly increasing proportionally to the degree of novelty of synthetically manipulated organism. In this respect novel methods of modeling and optimization should be developed adapting to the specific needs of synthetic biology. Applications of control theory should be developed to manage synthetic biology issues similar way as technical systems.

An ultimate dream is to design synthetic biological systems at a high level of abstraction using engineering-based tools and programming languages, press a button, and have the design translated to DNA sequences that can be synthesized and put to work in living cells. Programming language is proposed to create organism and simulate its behavior (Pedersen et al., 2009). It will allow logical interactions between potentially undetermined proteins and genes to be expressed in a modular manner. Programs can be translated by a compiler into sequences of standard biological parts, a process that relies on logic programming and prototype databases that contain known biological parts and protein interactions. Programs can also be translated to reactions, allowing simulations to be carried out.

Biosecurity and Biosafety

“Biosafety” is a term whose meaning shifts with diplomatic and scientific context, its two major usages relating to laboratory containment and to biotechnology hazards. “Biosecurity” is a closely related term increasingly heard in arms control and in health and agriculture; but which also lacks a consistent usage. In animal health, it sometimes refers to preventative disease management. In Australia and New Zealand, it often refers to invasive alien species, while in the US it is increasingly used in reference to anti-terrorism measures related to agriculture (“farm security”). Still others use biosecurity to refer to access to a safe and appropriate food supply (The Sunshine Project, 2003).

Biosafety, as it arose in microbiology, is shorthand for “safety in biological containment”. In other biosciences and policy related to genetically modified organisms (GMOs), the term appeared as a contraction of “safety in biotechnology”, most often, but not exclusively, in reference to release of GMOs into the open environment. Overlap between the usages has become apparent, and “laboratory biosafety” is now often used to refer to the subset of safety issues specifically related to containment, be it of pathogens, GMOs, or GMO-pathogens (The Sunshine Project, 2003).

Confusion about meanings of biosafety and biosecurity in English deepens in translation. The logical translation of biosecurity into Spanish, French, and other Romance languages is the same word as that used for biosafety (bioseguridad in Spanish, biosécurité in French).

Then again, the term did not exist in English until it was coined in independent instances to refer to different aspects of human and environmental safety from biological threats. We submit that there is little need, conceptually, to differentiate between biosafety and biosecurity and that some meanings of both terms sometimes utilized in arms control (Barletta, 2002) are counterproductive because they are too restrictive. Whether at the BWC, in health, in the laboratory, or in sanitary measures, security and safety are largely synonymous, and in the field or in the laboratory, many of the measures that apply to potentially dangerous pathogens also apply to GMOs (and their products) and, of course, pathogens that are GMOs (The Sunshine Project, 2003).

On a very practical level, there may be differences between means to prevent an unintended release into the environment (sometimes referred to as ‘biosafety’) and means to prevent abuse or theft (sometimes referred to as ‘biosecurity’). But conceptually, legally, and in terms of organization and implementation, there are broad overlapping areas. A wide and shared conceptual framework that integrates sectorial notions of ‘biosafety’ and ‘biosecurity’ is required in order for each sector (agriculture, human and animal health, disarmament, and environment) that addresses them to be efficient and effective (The Sunshine Project, 2003).

Conclusions

Synthetic biology promotes engineering approach in biology. Applications of synthetic biology can be used for the design, construction and development of artificial biological (sub) systems thus offering potentially viable new routes to genetically modified organisms, smart drugs as well as model systems to examine artificial genomes and proteins.

Mathematical computer modeling is integral part of this new interdisciplinary field of biology due to necessity to predict behavior of partly or fully synthetic systems before their execution *in vivo*.

Modeling is necessary in all four main approaches of synthetic biology: 1) bottom up, 2) metabolic engineering, 3) chassis, 4) top down (organisms creating from parts). It is important to predict behavior of systems using modeling in the phase when they are under development and therefore cannot be examined experimentally.

Computer modeling and analysis can be applied also in fields like biosecurity and biosafety to monitor and prevent emergence of dangerous genetic sequences or organisms.

Programming languages for synthetic biology is under development. Programs can be translated by a compiler into sequences of standard biological parts, a process that relies on logic programming and prototype databases that contain known biological parts and protein interactions. Thus models of interconnected parts can be developed to predict features of the synthetic subsystem of interest.

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BIOPROCESS REALTIME FAULT DETECTION AND DIAGNOSIS BASED ON MODEL AND EXPERTISE

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Abstract

The challenges arising from industrialization of biotechnology are generally the same as those encountered in any processing industry and we face, in the field of bioprocessing, almost all of the problems that are being tackled in automatic control. Thus, system requirements for supervision, control and monitoring of the processes in order to optimize operation or detect malfunctions are on the increase. However, in reality, very few installations are provided with such systems. Two principal reasons explain this situation:

- *first of all, biological processes are complex processes involving living organisms whose characteristics are, by nature, very difficult to apprehend.*
- *the second major difficulty is the almost systematic absence of sensors providing access to measurements necessary to know the internal functioning of biological processes.*

Furthermore, these tasks are not easy to carry out, as fault detection has to be accomplished under real conditions - thus online - of the operation of installations:

- *the time-variant characteristics of faults are unknown;*
- *the nominal model of the system is uncertain;*
- *state and measurement noises are present;*
- *the detection signal should be obtained within a finite time, subject to the operating constraints of the process*

With the aid of process models, estimation and decision methods it is possible to also monitor nonmeasurable variables like process states, process parameters and characteristic quantities. The process can be used for recognition algorithms, based on the current process parameters similar to the previous schedule of the same process of dynamic measurement and process assigned in class.

This contribution presents a brief summary of bioprocess fault detection and diagnosis methods.

Keywords: *bioprocess; fault detection; process models; parameter estimation*

Introduction

Industrial systems have also become more and more complex with the automatic control of control loops, introduction of multilevel microprocessors and, more recently, prioritized and distributed information. In fact, this development has complicated the task of diagnosing industrial installations. For the improvement of reliability, safety and efficiency advanced methods of supervision, fault detection and fault diagnosis become increasingly important for many technical processes.

In fact, the modeling of biological processes systems faces two major difficulties:

- On the one hand, the process implements living organisms, which can possibly undergo certain, at least partial, transformations or changes, which are likely to bring the process to a different state from that expected. Lack of reproducibility of experiments and inaccuracy of measurements result not only in one or several difficulties related to selection of model structure but also in difficulties related to the concepts of structural and practical identifiability at the time of identification of a set of given parameters, difficulties also occur at the time of the validation phase of these models whose sets of parameters could have precisely evolved over course of time.
- On the other hand major difficulty is the almost systematic absence of sensors providing access to measurements necessary to know the internal functioning of biological processes. The majority of the key variables associated with these systems (concentration of biomass, substrates and products) can be measured only using analyzers on a laboratory scale - where they exist - which are generally very expensive and often require heavy and expensive maintenance. Thus, the majority of the control strategies used in industries are very often limited to indirect control of fermentation processes by control loops of the environmental variables such as dissolved oxygen concentration, temperature, pH, etc.

The quality of the model and, above all, its structure must correspond to the objective for which the model was built. In fact, a model can be developed for very different purposes, which will have to be clearly identified from the beginning. Thus, the model could be used to:

- reproduce an observed behavior;
- explain an observed behavior;
- predict the evolution of a system;
- help in understanding the mechanisms of the studied system;
- estimate variables which are not measured;
- estimate parameters of the process;
- act on the system to steer and control its variables;
- detect an anomaly in the functioning of the process;

Different approaches for fault detection using mathematical models have been developed in the last 30 years, see (Isermann 2004). The task consists of the detection of faults in the processes, actuators and sensors by using the dependencies between different measurable signals. These dependencies are expressed by mathematical process models.

Materials and Methods

Online detection and diagnosis methods are fundamentally based on the information about the condition of the process to be monitored (i.e., measurements), there are methods employing additional information apart from those brought in only by the physical sensors. This information can in particular be derived from knowledge of the input/output behavior of a process or of internal processes governing the evolution of the same. This knowledge is generally expressed in the form of mathematical models (Venkatasubramanian et. al. 2003).

The use of model-based methods (Dochain 2008) depends on the existence of analytical redundancies. The principle consists of finding mathematical formulations, which help reveal these analytical redundancies by determination of the causal factors, which are inherent to the system to be monitored. Among the different methods for detection and diagnosis using mathematical models, we find mainly parity space, observers and parametric estimation.

1. Model-based methods

1.1. Parity space

The parity space method was one of the early methods employed for fault detection and isolation (FDI) purposes. It derives its name from the field of informatics in which a parity check is made on logic circuits. The principle of the method consists of verifying the consistency that exists between the inputs and outputs of the monitored system (Figure 1.). Two main branches contributed to its development:

- reconciliation of data with the detection of rough errors;
- use of static models and then dynamic models through a representation of systems in the form of transfer and state space function

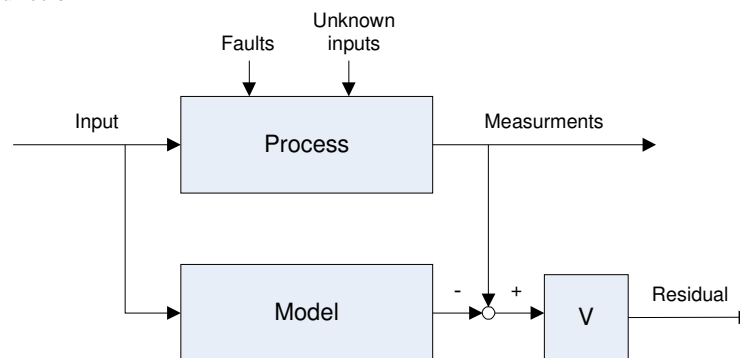


Figure 1. *Parity Space approach in an input- output format* (Dochain 2008)

The detection of rough errors began with the works of Kuehn and Davidson (1961) by the application of linear constraints (i.e., least squares) on the balances produced from noise-added measurements. This method, also called direct redundancy, consists of using the analytical redundancies expressed in the form of algebraic equations among the diverse measurements of the system to be monitored.

Another branch of the parity space method is based on the principle of temporal redundancies. The dynamic relationships between the inputs and outputs are taken into account for generating the residuals with characteristics, which respond to a desired transient behavior and to a noise filtration.

1.2. Observers

Subsequently, we will refer to the strategy called by certain authors observer methods or even closed loop methods as opposed to the open loop methods corresponding to those of parity space methods described earlier. The diagram in Figure 2. represents the use of an observer for the generation of residuals. Error signal $e(t)$ between output $y(t)$ of the process and $y_m(t)$ of the model is the basis for the creation of signals supporting information on the faults. The synthesis of matrix H should thus enable the uncoupling of the outputs from the unknown inputs. This matrix should therefore have the particular characteristics of stability and insensitivity to the perturbations in the output.

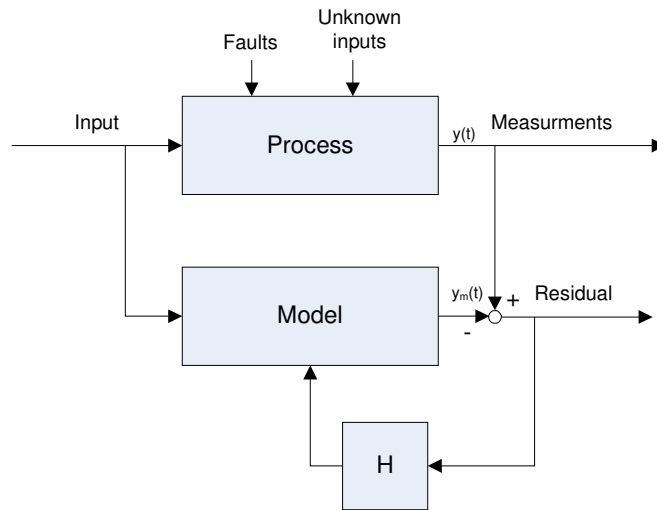


Figure 2. Use of a full-order *observers* (Dochain 2008)

Observer innovations also qualify as fault detection residuals. "Unknown input" design techniques may be used to decouple the residuals from (a limited number of) disturbances. The residual sequence is colored which makes statistical testing somewhat complicated. The freedom in the design of the observer can be utilized to enhance the residuals for isolation. The dynamics of the fault response can be controlled, within certain limits, by placing the poles of the observer.

Different types of observers were also developed depending on the nature of problems to be solved: the observers based on the use of a single output, those using all the system outputs and the output observers.

1.3. Parametric estimation

The parametric estimation approach considers that the influence of faults is reflected on the parameters and not just, as was thought previously, on the variables of the physical system. The principle of this method consists of continuously estimating the process parameters by using the inlet/outlet measurements and evaluating the gap, which separates them from the reference values under the normal condition of the process (Figure 3.).

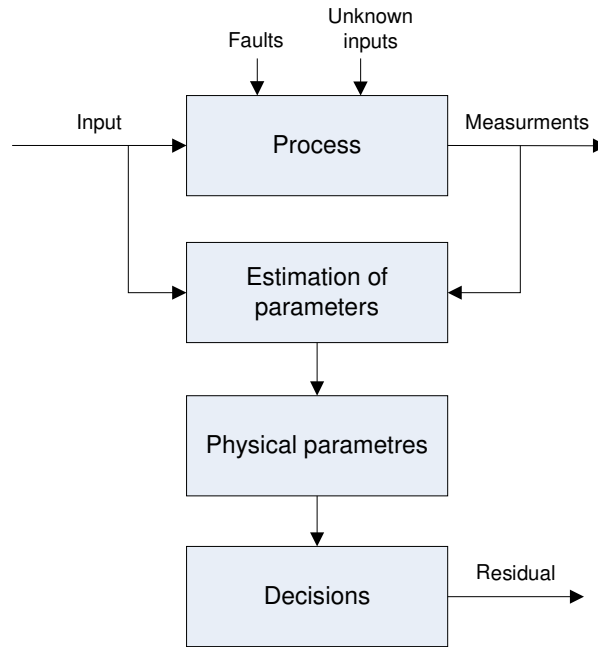


Figure 3. Parametric estimation for fault detection and diagnosis (Dochain 2008)

Parametric estimation has the advantage of furnishing information about the size of deviations (Venkateswarlu 2004). In addition, online identification helps avoid the problem of slow non-stationarities. However, one of the major disadvantages of the method lies in the necessity of having a permanently excited physical system. Thus, this leads to practical problems in the case of processes that are dangerous, costly, or operated in stationary mode. Furthermore, the relationships between mathematical and physical parameters are not always invertible in a unitary manner, thus complicating the task of diagnosis based on residuals.

With extremely rapid developments in computer science (theory and hardware), the idea of creating intelligent machines to automate the reasoning processing has appeared - and at times still appears - to be realizable. In the industry, "intelligent" systems have found many fields of applications: breakdown diagnosis, control, supervision, planning, scheduling, simulation and process design. However, on a finer analysis of these diverse fields of application, it is possible to make out two major trends for the implementation of expert knowledge: "fully automatic", whereby the knowledge is modeled and automated.

2. Methods based on expertise

2.1. Artificial Intelligence models

Diagnosis is a causal process. It consists of determining the defective components that can explain an observed malfunction. If it is based on knowledge about the normal condition of the process, we refer to a coherence-based diagnosis. On the other hand, if information is available only about the breakdowns and their symptoms, we refer to an abductive diagnosis.

Overall, three types of models are employed in AI within the context of monitoring:

- in associative models, situations during which significant malfunctioning occurs are associated with alarm schematics using direct expression of connections between symptoms and characteristic situations.
- as for predictive models, they enable the simulation of the possible behaviors of a system in its different modes: normal behavior, degraded behavior or behavior in case of breakdown. Due to their capacity to calculate the predicted behaviors step-by-step, these models can be directly used to detect faults (i.e., by comparing the predicted behaviors with the observations).
- referring to explicative models, they are based on expertise already formulated in the enterprise in the form of a breakdown catalog or of graphs.

In the influence graphs for example, the interactions among the process variables are described qualitatively. Their nodes thus represent the variables and the arcs represent the connections among them. These arcs can be labeled by a sign, by a gain or by periods. They constitute a qualitative model, which can then be used for detection (e.g., by simulation when the input variables are propagated through the influence graph to obtain qualitative responses).

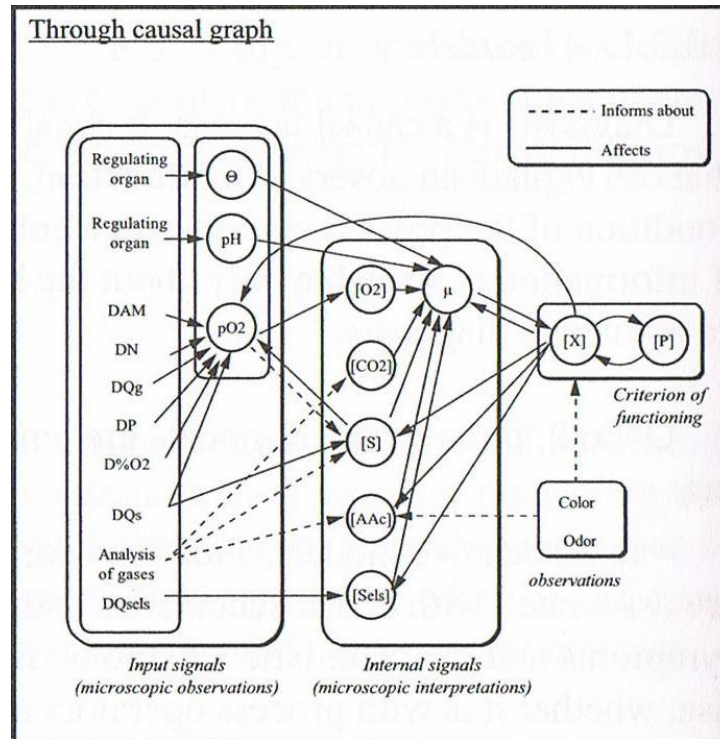


Figure 4. Causal graph for biological process (Dochain 2008)

As for the causal graphs, they describe the chains of causation between the operating conditions and their observed effects (Figure 4.). The causal graphs are by far the most used for modeling real applications of supervision systems. Their advantage consists of expressing the knowledge explicitly and enabling us to manipulate directly the indirect or direct causal antecedents. We can also employ the graphs to produce a hierarchical cut of systems or even jointly with a quantitative model.

2.2. Artificial neural networks

An artificial neural networks (ANN) is in fact a computer system made up of a number of basic processors (or nodes) interconnected among themselves and processes - in a dynamic manner - the information coming to it from external signals.

In general, an ANN is employed in two phases. At first, the network synthesis is carried out, and this comprises many stages: the selection of a network type, neural type, number of layers and learning methods. The learning enables us, on the basis of optimization of a criterion, to reproduce the behavior of the system to be modeled. It consists of searching for a set of parameters (weights) and can be performed in two ways: supervised (network uses the input and output data of the system to be modeled) and unsupervised (only the input data of the system are given and the learning is carried out by comparison between examples). When the learning results obtained by the ANN are satisfactory, we can use it for generalization. Here we are dealing with the second phase, wherein new examples - that have not been used during the learning - are used to judge the capacity of ANN to predict the behaviors of the modeled system.

They can thus be used at three levels:

- as a model for the system to be monitored under normal condition and generating an error residual between the observations and the predictions (Figure 5.);
- as a system of evaluation of residuals for the diagnosis;
- or as a system of detection in one stage (as classifiers) or in two stages (for the generation of residuals and the diagnosis).

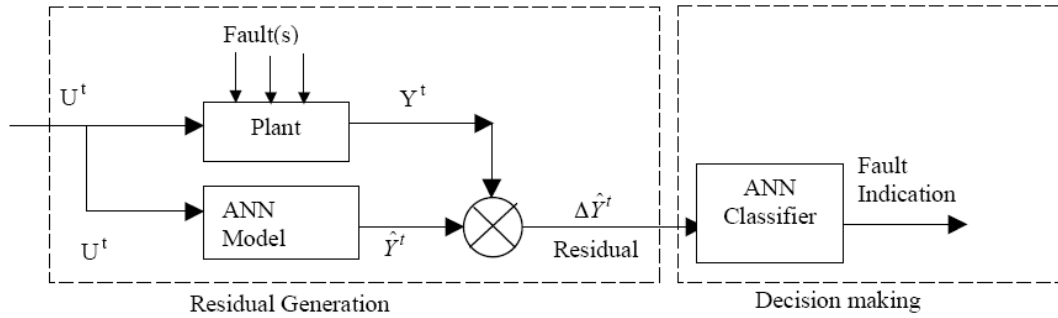


Figure 5. Artificial Neural Network Fault Detection Scheme (Ahmad and Heng 2001)

2.3. Fuzzy inference systems

The basic structure of an FIS is made up of:

- a *universe of discourse* containing the functions for the adherence of input and output variables to classes. These functions can have different forms, the most frequent ones being triangular, trapezoidal and Gaussian;
- a *knowledge base* that contains the rules linking the input and output variables under the form "IF..THEN..";
- a *reasoning mechanism* basing its working on the generalized *modus ponens* logic.

Fuzzy models were proposed by Frank (1996) for detecting faults by using "knowledge-based observers" (KBO) whose structure is represented in Figure 6. A KBO is in fact an expert system made up of the following modules:

- a qualitative model of the process for determination of expected conditions;
 - a disagreement detector which compares the output of the model with that of the process;
- process;
- a generator of prospects for proposing a list of possible faults.

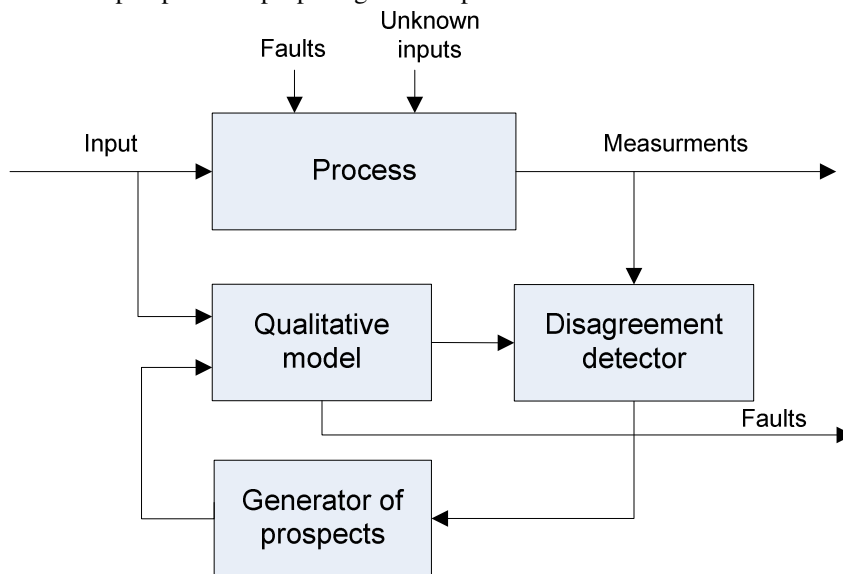


Figure 6. Knowledge based observer (Dochain 2008)

Results and Discussions

Concerning specifically the modeling and control of bioprocesses, we can see numerous applications of methods based on analytical models based on the material balance. On the other hand, it is surprising to note that as for the fault detection and diagnosis, it is especially the use of statistical techniques and artificial intellect techniques which prevail. In fact, this is not particularly amazing as the bioprocesses show highly nonlinear, multivariable and dynamic characteristics, which at times render the mathematical models null and void very rapidly. In addition, the lack of reliable and less expensive sensors has for a long time proved to be a serious disadvantage for the application of analytical methods.

There are a considerable number of methodologies available for the designer of systems intended for detecting and diagnosing industrial processes. Nevertheless, this apparent abundance offers a restricted scope of application because:

- sensors give pertinent information;
- there is rich historical data;
- reliable models of installation under normal conditions or in failure mode are not always available or do not necessitate highly prohibitive investments in terms of money or personnel.

The advantages and disadvantages of different fault detection and diagnosis methods are briefly presented in Table 1.

Table 1.

Advantages and disadvantages of different fault detection and diagnosis methods

Methods	Supporting process knowledge	Advantages	Disadvantages
<i>Parity Space</i>	Mathematical model	Reconciliation of data with the detection of rough errors	Cannot provide reliable estimates in the presence of process uncertainties and measurement noise
<i>Observer</i>	Mathematical model	Provide state estimation in deterministic systems. Nonlinear observers effectively deal with nonlinear processes	Difficult to incorporate stochastic disturbances. Accurate model development is a major task
<i>Parametric estimation</i>	Mathematical model	Provide accurate estimation of states and parameters. Deal with stochastic disturbances and measurement noise	Developing and validating rigorous process models require much time and faults
<i>Artificial intelligence models</i>	Heuristic knowledge in the form chains of causation	Expressing the knowledge explicitly and enabling to manipulate directly the indirect or direct causal antecedents	Disadvantages include its black box nature, greater computational burden, proneness to overfitting, and the empirical nature of model development
<i>Artificial neural networks</i>	Heuristic data in the form empirical nonlinear correlations	Provide better performance with noisy and in-complete data. Neural networks are more adaptive	Poor generalization capability outside the training range. Require more training data
<i>Fuzzy inference systems</i>	Heuristic knowledge in the form of production rules	Useful alternatives for processes which are complex, imprecise and vague	Require good understanding of a process to setup a complete and consistent rule base

Conclusions

Before selecting methods for detection and diagnosis, a good understanding of the anticipated faults is essential. Some faults influence the selection of a diagnostic method more than the detection. Examples of faults that make diagnosis difficult include faults that exhibit different symptoms at different times, faults that are intermittent, and multiple simultaneous faults. Not many methods can diagnose the fault that exhibits different symptoms at different times and depends on the operational dynamics of the system.

In this work had reviewed fault detection and diagnosis methods of bioprocess based on the model and the experience. This comparative study identifies the relative strengths and weaknesses of the different approaches. It also reveals that no single method has all the desirable features we stipulated for a diagnostic system. Some of these methods can complement one another resulting in better diagnostic systems. Integrating these complementary features is one way to develop hybrid systems that could overcome the limitations of individual solution strategies. Hybrid systems are an important future direction for research and development in fault detection and diagnostic systems.

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DETERMINISTIC SIMULATIONS OF DYNAMIC MATHEMATICAL MODEL OF GLYCEROL CYCLE AND GLYCOLYSIS

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Abstract.

The aim of this work was to develop dynamic mathematical model of glycerol cycle in baker's yeast Saccharomyces cerevisiae and by deterministic mathematical simulations explore an interaction between glycerol cycle and glycolysis.

Four genes Gpd1, Gpp1, Gld2 and Dak1 code for enzymes which catalyze reactions of glycerol cycle. Expression of all genes mentioned above take place in a wild type of S. cerevisiae except Gld2. Gene Gld2 was activated in yeast by theoretic genetic modification. Gld2 codes for enzyme Glycerol 2-dehydrogenase which is cofactor NADP dependent. By deterministic dynamic simulations we try to predict dynamic of reduced NADPH which is produced by Gld2 reaction.

Five reactions and twelve species formed model of glycerol cycle. The rate law of Michaelis-Menten was used to describe the velocity of reversible and irreversible reactions. Necessary parameters to describe rate law of reaction like maximal velocity and Michaelis constant were taken from databases BRENDA and SABIO.

An accomplished model of glycerol cycle was introduced into the mathematical model of glycolysis developed by Nielsen et al (1998). To incorporate successfully model of glycerol cycle into the model of glycolysis the reactions related with DHA and GAP formation were modified.

The structural model of glycerol cycle was produced in CellDesigner software although dynamic mathematical model and deterministic simulations were developed and performed in Copasi software.

Simulation results of glycerol cycle and glycolysis suggested that NADP, ATP and NADH could be key parameters which can limit functionality of the model. The concentration of NADH decreased rapidly reaching concentration $0,003 \text{ mmol}\cdot\text{l}^{-1}$ comparing to $4.0 \text{ mmol}\cdot\text{l}^{-1}$ when glycerol cycle is not switched on. Significant decrease of ATP was not observed in a system. When model reached steady state concentration of NADPH reached $51.1 \text{ mmol}\cdot\text{l}^{-1}$ and didn't change by the time anymore.

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STRUCTURAL MODEL OF ACTION MECHANISM OF ANTIISCHMIC DRUG MILDRONATE

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Abstract

The development of new therapeutic drugs is a complex process with a rising cost. Computer modelling is used to reduce this problem. The first step of creation of computer model is development of structural model to explore all the compartments and reactions of examined biochemical network. Structural model of drug action mechanism indicates changes of reactions affected with this drug. Antiischemic drug Mildronate action structural model in the paper is developed.

In Latvia Mildronate is the most outbound drug, but not all mechanisms of action of Mildronate (3-(2,2,2-trimethylhydrazinium) propionate, THP, MET-88) are known. Several researchers investigate the possibility that fast antiischemic action of Mildronate could be mediated, at least in part, by stimulation of Nitric Oxide (NO) production in the vascular endothelium through a modification of the γ -butyrobetaine (GBB) or GBB esters pools. The major target of the modelling of Mildronate action mechanism is to research and verify hypothetical GBB-esterase mechanism.

On the current phase of the modelling main Mildronate action sites are indicated in the article.

Key words: structural model, Mildronate, reaction network, kinetic law, modelling

Abbreviations used: GBB, γ -butyrobetaine; BBD, γ -butyrobetaine hydroxylase; NO, nitric oxide; SBML, Systems Biology Markup Language; SBGN, Systems Biology Graphical Notation.

Introduction

Biological systems typically have an overwhelming amount of detail with thousand of different interactions taking place simultaneously (Burkowski, 2009). Computer modelling of the reaction may represent biochemical reaction process and help to understand the physiology of the process. The modelling and simulation of drug action mechanism is very important in pharmacy. The interest that drug companies and pharmaceutical researchers have in computational systems biology comes from the hope that these emerging simulation tools might make drug discovery and drug testing better, faster and cheaper (Materi W. et al., 2007)

In the paper the mechanism of action of A/S Grindex drug *Mildronate* is examined. *Mildronate* is an antiischemic drug developed in the Latvian Institute of Organic Synthesis and is widely used in some countries (Sjakste et al., 2004). *Mildronate* is efficient in the treatment of heart ischemia and its consequences (Sjakste et al., 2006). According to (Sjakste et al., 2004) it is possible that fast antiischemic action of *Mildronate* could be mediated, at least in part, by stimulation of NO production in the vascular endothelium through a modification of the GBB/GBB esters pools. Research of hypothetical GBB-esterase mechanism was proceeded also in next years (Sjakste et al., 2006, Kalvinsh et al., 2006, Bagdonienė et al., 2009 a,b).

For understanding the mechanism of action of *Mildronate* the structural model of this mechanism was developed. Structural model of drug action mechanism indicates changes of reactions affected with *Mildronate*.

Materials and Methods

Software

For modelling the software CellDesigner 4.0.1 was used. CellDesigner comply with the SBML standard for exchange of biochemical models (Pieper et al., 2009). SBML is an open, XML-based format for representing biochemical reaction networks (Funahashi A. et al., 2003). CellDesigner supports also Systems Biology Graphical Notation (SBGN) standard. CellDesigner is used for development of structural model and graphical illustration of model to show all compartments, reactants and reaction sites.

Databases

Reaction kinetics was obtained from databases which contain structured information about reactions and reactants with indication of the primary source of the information. For enzymatic reactions and information about enzymes (EC number, synonyms, reactions and kinetic parameters) Enzyme Database BRENDA (www.brenda-enzymes.org) was used. Information about synonyms and reactions of substrates and products was obtained from KEGG database (www.genome.jp/kegg). Seeking information about reaction kinetics SABIO-Reaction Kinetics Database (<http://sabio.villa-bosch.de>) was used.

Model structure

Organism could be examined as a system with different interfaced processes and lot of them could not be inspected separately. *Mildronate* action on organism is wide and affects quantity of processes. Model structure and *Mildronate* action mechanism are taken from publications (Sjakste et al., 2004, Sjakste et al., 2006, Kalvinsh

et.al., 2006, Orbidāne et.al., 2004) and adapted by author. *Mildronate* action sites are represented in CellDesigner model (Fig. 1).

Major Reactants

Carnitine is a vitamin-like substance that is synthesized in all vertebrate animals (Janssens et.al., 1999). Carnitine homeostasis in mammals is maintained by a combination of absorption of carnitine from dietary sources, a modest rate of biosynthesis, and highly efficient reabsorption of carnitine (Rebouche et.al., 1998). Carnitine synthesis involves several steps. The last step is the conversion of butyrobetaine to carnitine by GBB hydroxylase (Spaniol et.al., 2001).

Gamma-butyrobetaine is considered a quasi-essential molecule in nutrition (Janssens et.al., 1999). GBB is a precursor of carnitine which is located in all human tissues. Both carnitine and butyrobetaine concentration in human plasma is limited.

Gamma -butyrobetaine hydroxylase (BBD, EC1.14.11.1) is a key enzyme in the biosynthesis of carnitine (Liepinsh et.al., 2006). In mammals, BBD is expressed differentially, and its activity has been found in liver, kidney, brain and possibly in testis and epididymis, but not in other tissues (Vaz et.al., 2002) and distribution of the enzyme GBB hydroxylase in human tissues vary [Table 1].

Table 1

GBB hydroxylase distribution in human tissues

Tissue	GBB hydroxylase concentration (mM)
Liver	369±95
Kidney	1350±230
Brain	140±56
Heart	0
Muscle	0

Source: developed by the author according to Rebouche et.al., 1980.

Mildronate is an inhibitor of Carnitine biosynthesis. The form of inhibition of GBB hydroxylase activity were examined earlier mainly in rats, mice and pigs. In 1988 one group reported that *Mildronate* is a noncompetitive GBB hydroxylase inhibitor (Simkovich et.al., 1988), but later other group found that the drug inhibits GBB hydroxylase competitively, blocks carnitine biosynthesis and interacts competitively with renal carnitine reabsorption (Spaniol et.al., 2001). The network of *Mildronate* action sites is very wide and complex and not all of *Mildronate* action mechanisms are clear yet.

Reactions

To create a mathematical model of *Mildronate* action in human it is necessary to understand the whole process. Hence, mathematical model of action of *Mildronate* include some extra reactions, which may affect *Mildronate* efficiency. It is determined that *Mildronate* inhibits carnitine formation from gamma-butyrobetaine in liver and kidney, inhibits reabsorption of gamma-butyrobetaine and carnitine (not shown), inhibits carnitine transport into plasma and into muscle cells (Sjakste et.al., 2006). Since *Mildronate* acts through lowering of carnitine synthesis from gamma-butyrobetaine and gamma-butyrobetaine undergo esterification, it is necessary to pay attention to gamma-butyrobetaine circulation in organism.

Current model consists of 17 reactions. Part of these reactions are hypothetical, part of them are not described mathematically because of lack of information.

Re1: *Mildronate* inhibits γ -butyrobetaine conversion to carnitine in liver. According to research of Spaniol on rats the rate of this reaction is competitive inhibition (Spaniol et.al., 2001).

Re2: *Mildronate* inhibits γ -butyrobetaine conversion to carnitine in kidney (Sjakste et.al., 2006). The rate of inhibition is unclear. It may be similar to Re1 hence it could be described with competitive inhibition.

Re3 and Re17: Both carnitine and GBB are reabsorbed and excreted efficiently by the kidney. In rats and humans, approximately 54–87% of dietary carnitine is absorbed. Carnitine that is not absorbed is almost totally degraded in the large intestine, by the action of bacterial flora (Rebouche et.al., 1998) or excreted in kidneys. Carnitine and GBB degradation levels in human kidney including *Mildronate* inhibition are not described mathematically in the model.

Re5: GBB transport into the liver could be described by Michaelis-Menten kinetics (Berardi et.al. 1998).

Re4 and Re11: Reactions of GBB transport to the kidney and brain may be similar to Re5 and could be Michaelis-Menten kinetics.

Re6: *Mildronate* excretion of different types and doses of *Mildronate* administration vary. After single intravenously administration of 250, 500 and 1000 mg *Mildronate*, the elimination half-life ($t_{1/2}$) were 5.56±1.55 h, 6.46±1.07 h and 6.55±1.17 h, respectively (Peng et.al., 2010). It means that in approximately 6.55 h the half of 1000 mg administered *Mildronate* degrade in organism. In result of averaging these data the excretion flux of single dose *Mildronate* is purchased.

The half-life of multidoses administration of 500 mg of *Mildronate* intravenously was 15.34±3.14 h (Peng et.al., 2010). In the studies performed at the Latvian Institute of Organic Synthesis after oral administration of the drug

its excretion half-life was nearly 18 h (Sjakste et.al., 2006). Author supposes that excretion half-life of Mildronate administered multidoses orally and intravenously is similar within 15.34 ± 3.14 h. Averaging these data author calculated excretion flux of multidoses administered Mildronate.

Re7 and Re8: Carnitine transport from liver and kidney to plasma is not described in the model.

Re9: Research of Rigault shows that Mildronate doesn't make any significant inhibition of carnitine uptake in heart. Reaction rate is Michaelis-Menten equation (Rigault et.al., 2008).

Re10: The reaction rate of carnitine uptake in muscle is Michaelis-Menten competitive inhibition (Rigault et.al., 2008, Kuwajima et.al., 1999).

Re12: Major sources of carnitine in the human diet are meat, fish and dairy products. Omnivorous humans generally ingest $2-12 \mu\text{mol}$ of carnitine $\text{day}^{-1} \text{kg}$ of body weight⁻¹. This is more than the carnitine produced endogenously, which has been estimated to be $1.2 \mu\text{mol} \text{day}^{-1} \text{kg}^{-1}$ (Vaz et.al., 2002). The flux of carnitine uptake from food may be calculated for particular situation according to diet.

Re13: Inhibition of GBB hydroxylase by mildronate leads to the synthesis of GBB esters (Dambrova et.al., 2004). GBB can undergo esterification in mammalian brain tissue (Bagdonienė, 2009a). In 2006 the GBB-esterase activity was proved (Kalinsh et.al., 2006), but the process of ester formation is unclear yet.

Re14: GBB ester hypothetically binds a specific receptor (Sjakste et.al., 2004) and activate endothelial Nitric oxide synthase (enzyme, EC 1.14.13.39) and synthesis of Nitric Oxide. Both GBB esterase-dependent receptors and acetylcholine receptors are possible candidates for activation of the formation of NO in blood vessels (Kalinsh et.al., 2006).

Re15: GBB esterase hypothetically hydrolyses the ester releasing GBB. GBB ester could trigger Ca²⁺ release and Ca²⁺ ions activate eNOS (Orbidāne et.al., 2004). The research of Bagdonienė shows that enzymatic hydrolysis of GBB naphthyl ester to 1-naphthol in rat blood serum is due to GBB-esterase activity (Bagdonienė, 2009a), but this research didn't give any kinetic constants and rate laws.

Re16: Nitric oxide production is described with Michaelis-Menten rate (Giraldez et.al., 1998).

Results and Discussion

The structural model of *Mildronate* action mechanism is developed in the work (Fig1). This model is not verified with experimental data. Structural model of *Mildronate* action could be improved with time according to new researches.

The main target of modelling of the mechanism of action of *Mildronate* is to check the hypothetical GBB esterification. To achieve this target all the reactions should be verified and compared with experimental data, the model is needed to be enriched with reaction rates and parameters. But model verification also is very difficult because of the lack of experimental data on human. Lot of reactions in human organs are studied on animals defying reaction rates and constants. Not all processes in human organism occur like in animals.

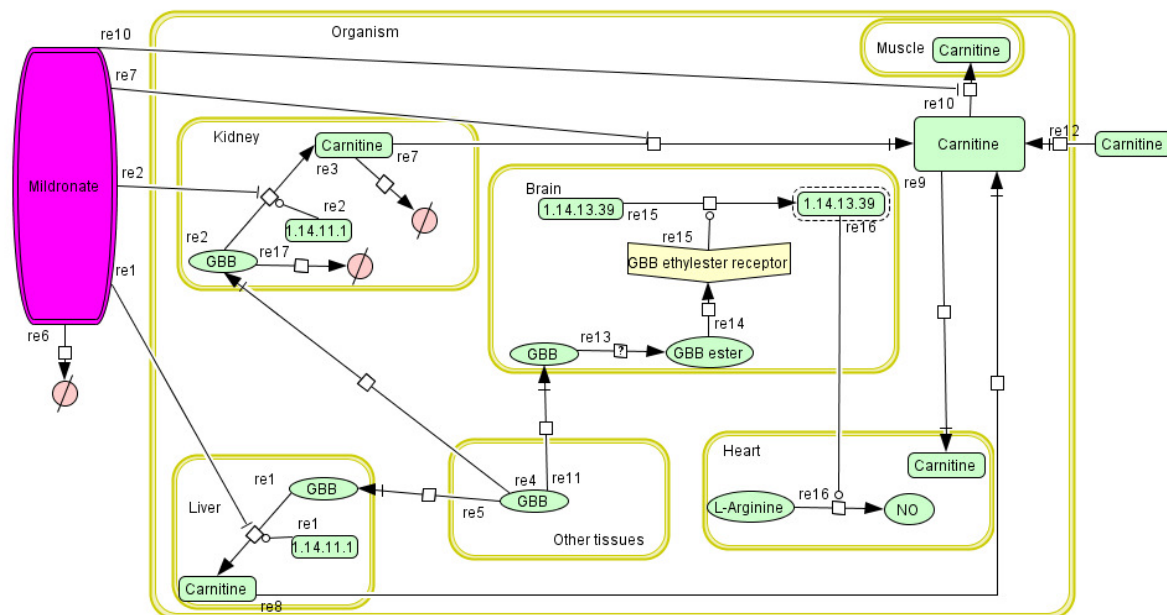
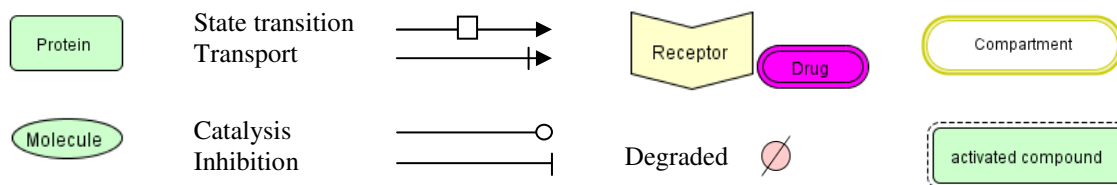


Fig. 1. Structural model of *Mildronate* action sites in SBGN notation

Source: developed by the author according to Sjakste et al., 2006.

Model notation:



Conclusions

Structural model of *Mildronate* therapeutic action is developed. CellDesigner 4.0.1 software is used to represent the structure of the biochemical network in Systems Biology Graphical Notation (SBGN) standard. The model consists of 22 reactants, 17 reactions (including reactions, signalling, transport and other events) and 8 compartments. Structure of developed model can be used for estimation of side effects of therapy. Current model can be used for numerical estimation of kinetic parameters of biochemical network using dynamic experimental data.

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INCREASING FIDELITY OF ROBOT SIMULATION RESULTS USING DISTRIBUTED PROCESSES

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Abstract

Simulations are widely used in robotics field as useful tools that provide reasonable methods for verifying various aspects of developed device, such as control system behaviour testing. However simulated results almost always differ from real world experiments because of combination of various aspects such as sensor perception noises, inaccuracy of actuators or faults of control logics.

This paper proposes possible approach for improving simulated results that follows principle of separation of control logics from simulation core calculations. This approach is opposite to the common simulation methods where all calculations are processed within simulation iteration. Our approach introduces additional timing constraint to control algorithm that is one of the most important aspects in the real-time systems such as robot controllers. Introduction of intellectual methods into the control algorithm of robot increases required computation and prolongs processing time. Simulating this algorithm by means of common methods leads to slowdown of each iteration of simulation and it does not affects precision of results. Having separated control algorithm from the core simulation calculations it is reached better similarity to real world conditions, where control algorithm should perform fast enough to be able to control underlying hardware.

The experiments were performed using open-source Player/Stage software package. This package provides tools for both simulation approaches mentioned before. The mine-like environment and single robot were used in simulation. The algorithm for robot navigation and control were created and tested in various timing conditions. The results of experiments showed that both described simulation processing methods have strengths and weaknesses. Control logics execution as part of simulation iteration ensures stable and predictable results. While simulation separation from control logics is conceptually closer to real hardware control process and theoretically can provide finer results.

SOFTWARE TOOLS FOR STRUCTURE ANALYSIS OF BIOCHEMICAL NETWORKS

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Abstract

In the cell, tissue, organ and organism under different conditions operate metabolic, gene regulation and signaling networks that determine biochemical reactions, biochemical or biophysical process.

Biochemical networks can present the relationships between genes and genes products, between proteins and etc.. Exploring of these networks helps better understand some cellular process or properties of biological system. Therefore, there is a growing need for software tools that allow simulation and modeling.

There are many network visualization, simulation and analysis tools, which play key role in systems biology. Each of these tools is devised for some specific need, for example, representation of cellular state, dynamic of cellular process, time-dependent behavior, etc..

We provide researchers and coterie information on existing tools with goals: 1) to describe briefly existing tools for data visualization, simulation or analysis of different network types; 2) to make easy selection of tool corresponding to research problem and requirements. In this manuscript we focus on tools which include topological analysis of network structure.

Within this manuscript we examine 20 existing tools. 18 tools of them are freely available for academic use and 12 provide source code. During this work we did not found a tool which provides imitation/modeling of evolution. In accordance with main comparison parameter – structure analysis - we prefer VisANT, Cytoscape with BiNoM and NetworkAnalyzer plugins, Biological Networks and CelNetAnalyser.

Types of biochemical networks

From the viewpoint of network architecture, main ingredients are molecules, interactions, pathways and networks. A cellular system can be viewed to be formed conceptually from individual molecules, to pairwise interactions, to local structures (including network motifs, molecules, pathways, subnetworks) and eventually to global biomolecular networks (Zhang, 2009). Biomolecular networks allow visualizing and describing of intracellular molecular interactions of cellular system by using available metabolic and gene regulation experimental data (Zhang, 2009), as well as representation of many biological processes such as metabolism, gene regulation, signal transduction (Zhenjun Hu et al, 2005). In terms of interactions, each type of biomolecular network is assembled by the following different pairwise interactions: *transcription regulatory network*: TF-DNA interactions; *gene regulatory networks*: gene-gene interactions (genetic interactions); *protein interaction network*: protein-protein interactions; *metabolic networks*: enzyme-substrate interactions; *signaling networks*: molecule-molecule interactions (Zhang, 2009).

Component data such as genomic and proteomic data provide a specific molecular content of a cellular system. Also dependent on omic data 4 network types can be defined (Zhang, 2009):

- Transcriptomic data - Transcription regulatory networks
- Proteomic data – Protein Interaction network
- Metabolic data – Metabolic network
- Integrated data - Signaling network

The goals of systems biology are to understand the mechanisms of how biochemical networks generate particular cellular functions in response to environmental stresses or genetic changes. To design biological systems at the molecular interaction level, it is essential to identify a biochemical network map, to build a dynamic model of the system, and to perform system analysis (Nishio et al, 2008).

Modeling and types of models

The main goal of modeling is to supplement researchers understanding of biological system properties (local, global) or behavior corresponding to different perturbations. We briefly characterize here two types of computational models: kinetic (dynamic) and structural models, as well goals of these modeling.

Kinetic models

Cellular systems are commonly modeled by nonlinear dynamical systems such as ordinary differential equations or stochastic processes such as the chemical master equation, based on mass action law and enzyme reaction kinetics.

The term „kinetic model” is used in dual sense. In the biological sense, it is a network of interactions between biological entities. In the mathematical sense, “kinetic” refers to a system of mechanistic ordinary differential equations that determine the temporal state of the corresponding system of biochemical reaction. There are two types of kinetic models that are devised to present system dynamics: a classical chemical kinetic model and stochastic chemical kinetic model. A **classical chemical kinetics (CCK) model** composed of n chemical species and m chemical reaction channels. CCK model utilizes ordinary differential equations to present system dynamics (Myers, 2010).

Dynamic simulations of a cellular system can provide a more thorough quantitative understanding of cellular system principles, mechanism and function (Zhang, 2009). Simulation results allows researchers to test their understanding, to explore „what-if” scenarios (Alberghina and Westerhoff, 2005), make predictions about the system for situations that have not yet been studied and make the design of new synthetic biological systems (Myers, 2010).

Structural (topological) models

An important class of methods in Systems Biology deals with structural or topological (parameter-free) analysis of cellular networks (Klamt et al, 2007). This is a type of model that is used for graphical representation and topological analysis of biological networks.

In structural or topological (parameter-free) models networks are represented in graph form [Klamt et al, 2007, Zhenjun Hu et al, 2005, Zhenjun Hu et al, 2007, Klamt et al, 2006, Zinovyev et al, 2008) (directed, undirected (Klamt et al, 2007) and mixed (Zhenjun Hu et al, 2005)), that consist of nodes and edges. Nodes dependent of number of connections and type of graph can be hubs (highly connected nodes) and metanodes which contains all its descendents and genes annotated directly under it (Zhenjun Hu et al, 2009). Nodes represent genes, gene products, proteins, chemical compounds or small molecules and links (edges) represent various types of interactions or associations between pair of nodes, e.g. metabolic events, protein/protein-nucleotide interactions, regulatory relationships or signaling pathways (Suderman and Hallett, 2007, Zhenjun Hu et al, 2007). Connections can be directed or undirected; they can have physical meaning, denote general associations; they can represent shared characteristics between components (Zhenjun Hu et al, 2005).

Choice of network representation is often dictated by the research problem. Directed networks are suitable when the interactions between two components have a well-defined direction, for example, the direction of metabolic flow from substrates to products, or the information flow from transcription factors to the genes that they regulate. Undirected networks, such as protein interaction networks, represent mutual relationships: if protein A binds to protein B, then protein B binds to protein A. This type of representation also often applies to predictions made by high-throughput proteomic or genomic analysis, or indirect links based on shared genes or protein components between pathways and complexes (Zhenjun Hu et al, 2005).

To represent and analyze networks developers may use different formalisms, for example, CellNetAnalyser use interaction graphs and (logical) interaction hypergraphs (Klamt et al, 2006), but VisAnt use metagraph to (Zhenjun Hu et al, 2009).

Structural analysis of cellular interaction networks contributes to a deeper understanding of network-wide interdependencies, causal relationships, and basic functional capabilities. Structural analysis, towards a functional analysis of the structure is not based on quantitative and dynamic properties and can thus only provide qualitative answers (Klamt et al, 2006). However, some insights into the dynamic properties can nevertheless often be obtained, because fundamental properties of the dynamic behavior are often governed by the network structure (Klamt et al, 2006).

The functions of biomolecular networks are closely related to their topologies and facilitated by characteristic topological patterns. Components of cellular networks including genes, proteins, and other molecules usually act in collaboration to carry out specific biological processes and biochemical activities, by forming relatively isolated functional units called modules. From the topological perspective, a module can be understood as a subnetwork that is densely connected within itself but sparsely connected with the rest of the network. In cellular networks, a module refers to a group of physically or functionally connected biomolecules that work together to achieve some desired cellular function (Luonan Chen et al, 2009).

Structural models characterize and provide information of the connectivity (topology) of the interactions involved in a biological process. Identifying topological features in networks is an important part of understanding the relationship between structure and function of network motifs, e.g. feedback, feed-forward loops (Zhenjun Hu et al, 2005). In biomolecular networks are motifs such as feedback loops and single input motifs, autoregulation loops in transcriptional regulatory networks, and short cycles in protein interaction networks (Luonan Chen et al, 2009). A network motif is a subunit of a complex network that appears much more frequently in the given network than expected by chance alone. Such subnetworks are considered to be basic building blocks of many real complex networks.

Software tools, that represent biochemical network structure

There are many network visualization, simulation and analysis tools, which play key role in systems biology and each meets some specific need. Within this manuscript we consider 20 existing tools (see Table 1). Most available tools are suited to biological network visualization and use definitions, methods and algorithms (Suderman and Hallett, 2007) from graph and control theory. Some of these tools analyze network structure with help of a number of graph structural analysis methods. We discuss here the main differences and similarities of these tools.

Software tools developed for Systems Biology depending on functionality and field of use can be divided in three main groups:

- (1) tools for modeling, simulation and/or analyses metabolic networks (biochemical reaction or process networks) allowing definition of a system like a collection of connected chemical reactions and the boundary of the system where the set of reactions intersects with its environment,
- (2) tools for modeling and analyses genetic regulatory networks,
- (3) tools for visualization and analyses of structure topology.

The list of groups can be extended with other groups, for example, tools for network drawing for presentations, publications, tools for modeling Boolean or logical networks etc.

During software tool estimation, we establish that 8 of examined tools provide modeling of metabolic networks, 4 tools are suitable for modeling gene regulatory networks, 6 tools allow visualization and analysis of network structure (see Figure 1).

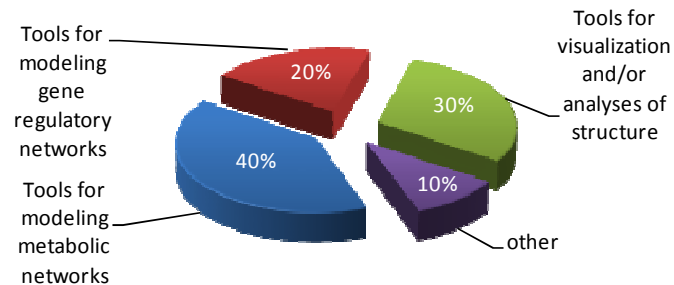


Fig.1. Tools classification and percentage distribution by functionality and field of usage

Tools that contain model simulation are designed for modeling and analysis of dynamic system. Dependent on usage permissions and license type, software tools can divide in several groups:

- 1) License for free academic use in accordance with license terms
- 2) Free software license
- 3) Open source license
- 4) Commercial license

Within this manuscript we establish that 18 of examined 20 tools are freely available for academic use. In all 8 tools are commercial product and 5 of them are freely available for academic use. 12 tools provide source code (see Figure 2).

Depending on built-in function are software tools that support SBML format (allows to import/export models or only export in SBML format) and conversely do not have this function (see Figure 3, 4).

SBML is System Biology Markup Language standard for representing models of biochemical and gene-regulatory networks (Funahashi et al, 2008, Hucka et al, 2008). It is a machine-readable model definition language based upon XML. SBML can encode models consisting of biochemical entities linked by reactions to form biochemical networks (Wanner et al., 2005).

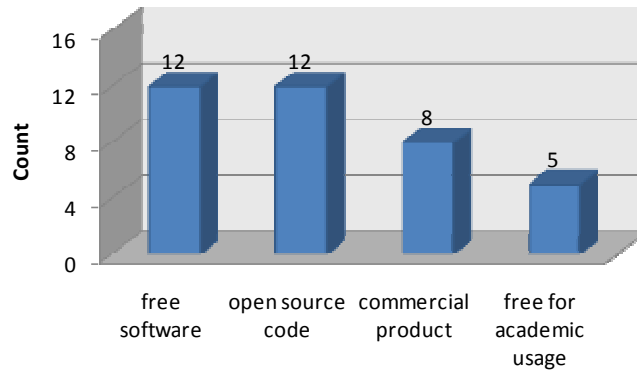


Fig.2. Tools rating by type of license and use permissions

SBML is developed in levels and represent substantial changes to the composition and structure of the language. Level 2 represents an evolution of the language. Minor versions of SBML are termed versions and constitute changes within the Level to correct, adjust and refine language features (Hucka et al, 2008). SBML 1 Level has 2 versions and 2 Level now has 4 versions. One must note that SBML Levels are not linked. If user wants to open the model (saved in SBML Level 1 Version 2 format) on tool that supports SBML Level 2 Version 4, it will not succeed. SBML developers have not provided inheritance between SBML Levels and Versions.

By supporting SBML as a format for reading and writing models, different software tools (including programs for building and editing models, simulation programs, databases, and other systems) can directly communicate and store the same computable representation of those models, removing opportunities for translation errors and assuring a common starting point for analyses and simulations (Hucka et al, 2008). Summary on SBML supporting software can be found at www.sbml.org.

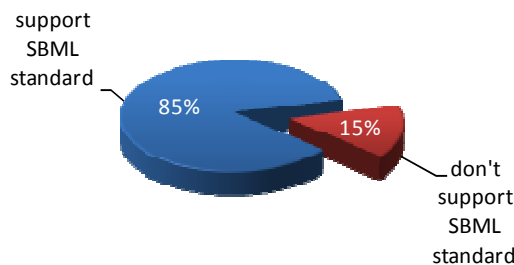


Fig.3. Tools rating by supporting of SBML standard

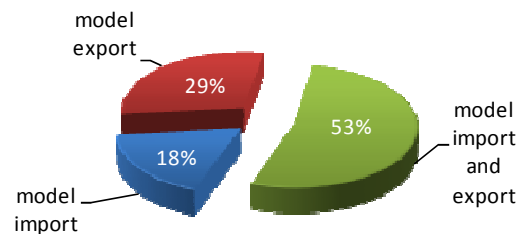


Fig.4. Supported functions of SBML standard

Depending on built-in function are software tools that support SBGN format (allows to import/export or only export models in SBGN format) and conversely do not have this option.

SBGN (Systems Biology Graphical Notation) is a visual language developed by a community of biochemists, modelers and computer scientists that consists of three complementary languages: process diagram, entity relationship diagram and activity flow diagram. Together they enable scientists to represent networks of biochemical interactions in a standard, unambiguous way. A process diagram represents all the molecular processes and interactions taking place between biochemical entities, and their results. The SBGN notation for entity relationships puts the emphasis on the influences that entities have upon each other's transformations rather than the transformations themselves. SBGN activity flow diagram permit modulatory arcs to directly link different activities, rather than entities and processes or relationships as described previously. SBGN can foster efficient and accurate representation, visualization, storage, exchange and reuse of information on all kinds of biological knowledge, from gene regulation, to metabolism, to cellular signaling (Le Novère et al, 2009).

Table 1.

Summary of software tools that was examined, their main goal and functions

Group	Software tool	Main goal	Functions
Tools for modeling metabolic networks or chemical reaction networks	CellDesigner	Tool for kinetic modeling of biochemical networks	CellDesigner includes building, visualizing, and kinetic modeling of biochemical networks (chemical reactions and processes); browse and modify existing SBML models with references to existing databases, simulate and view the dynamics.
	JDesigner	Tool for visual simulation biochemical reaction networks	Tool includes kinetic modeling of biochemical networks, permit users to graphically specify the model, derive the set of differential equations automatically and generate a solution. It allows selecting the appropriate kinetic laws from a wide selection of inbuilt rate laws or defining new user defined rate laws. The graph shows how changes for ex. concentration all nodes in time.
	Pathway analyser		Tool for analysis of metabolic pathways, particularly by flux based analyses and simulations on SBML Models. [http://pathwayanalyser.sourceforge.net]
	PathwayLab	Tool for visualization, documentation and in silico analysis of biochemical pathways	PathwayLab allows to create and store new reaction objects with user specified kinetics, including efficient transient analysis (simulation) and Metabolic Control Analysis (MCA), dynamic biochemical simulation, robust steady-state analysis. This tool allows to create and layout pathways drawings. [http://www.innetics.com/]
	Cobra	COnstraint-Based Reconstruction and Analysis Toolbox for Matlab	Cobra includes implementations of many of the commonly used forms of constraint-based analysis such as FBA, gene deletions, flux variability analysis, sampling, and batch simulations together with tools to read in and manipulate constraint-based models [*].
	Pathway Tools	Development of organism-specific databases (also called model-organism databases) that integrate many bioinformatics datatypes, from genomes to pathways.	Tool includes scientific visualization, web publishing, and dissemination of those organism-specific databases, visual analysis of omics datasets. Computational inferences including prediction of metabolic pathways, prediction of metabolic pathway hole fillers, and prediction of operons, that can be used for genome analysis. Analysis of biological networks: 1) Interactively tracing metabolites through the metabolic network; 2) Finding dead-end metabolites in metabolic networks; 3) identifying choke points (potential drug targets) in metabolic networks. [http://bioinformatics.ai.sri.com/ptools/ptools-overview.html]
	GEPASI	Gepasi is a software package for modeling biochemical systems	It simulates the kinetics of systems of biochemical reactions and provides a number of tools to fit models to data, optimize any function of the model, perform metabolic control analysis and linear stability analysis. Gepasi's <i>scan</i> utility provides a way for advanced exploration of a model's behaviour in multi-dimensional parameter space, is capable of doing data fitting (parameter estimation) with experimental data, of finding maxima or minima of any model variables with any number of adjustable model parameters. The results of simulations can be plotted in 2D and 3D directly from the program
	COPASI (Complex Pathway Simulator)	Software application for simulation and analysis of biochemical networks	Copasi supports chemical reaction network; arbitrary kinetic functions; ODEs for compartments, species, and global quantities, assignments for compartments, species, and global quantities; initial assignments for compartments, species, and global quantities. It includes: stochastic and deterministic time course simulation; steady state analysis (including stability); metabolic control analysis/sensitivity analysis; elementary mode analysis; mass conservation analysis; time scale separation analysis; calculation of Lyapunov exponents; parameter scans; optimization of arbitrary objective functions; parameter estimation using data from time course and/or steady state experiments simultaneously.
	Tools for modeling gene regulatory networks	BioTapestry	Tool for simulating genetic regulatory networks
GenMapp		Tool for visualization gene expression data on maps representing biological pathways and groupings of genes.	GenMap focuses on annotated pathways, using simple graphics and labels to provide biological context to molecular objects Tool allows visualizing an expression data- along pathways (called mapps), creating new mapps, identifying global biological associations within an expression dataset. MAPPFinder Integrated with GenMAPP is to perform a global analysis of gene expression or genomic data in the context of hundreds of pathway MAPPs and thousands of Gene Ontology Terms.
NetBuilder		Tool for modeling and simulation environment of	NetBuilder allows users to create a picture of the (known) components and interactions in the system, and enter quantitative information, such as know or estimated quantities and rates. creating and manipulating the mathematical

Group	Software tool	Main goal	Functions
		genetic regulatory networks	representations they need to predict the behaviour of their systems. NetBuilder' has simulators to carry out stochastic or deterministic numerical integration on the basis of a given initial state and the expressions for the flux that are constructed (by hidden functions in NBMATHModel) on the basis of the model parameters.
	Genetic Network Analyzer	Tool for the modeling and simulation of genetic regulatory networks	GNA consists of a simulator of qualitative models of genetic regulatory networks in the form of piecewise-linear differential equations. Instead of exact numerical values for the parameters, which are often not available for networks of biological interest, the user of GNA specifies inequality constraints. This information is sufficient to generate a state transition graph that describes the qualitative dynamics of the network.
Tools for visualisation and analyses of network structure	Cytoscape	Tool for visually exploring biological networks	Tool for visualizing molecular interaction networks and integrating these interactions with gene expression profiles and other state data which includes complex network analysis and visualization. Cytoscape have a powerful Visual Styles (3D).
	Visant	An integrative software platform for the visualization, mining, analysis and modeling of the biological networks	Tool for creating multi-scale networks, representing many types of biological data, such as biomolecular interactions, cellular pathways and functional modules; provides: a visual interface for combining and annotating network data, supporting function and annotation data for different genomes from the Gene Ontology and KEGG databases and the statistical and analytical tools needed for extracting topological properties of the user-defined networks. Tool introduces extensive functionalities to visualize and integrate the gene ontology with biological networks using metagraph technology.
	Edinburgh Pathway Editor	Tool designed for annotation, visualization and presentation of wide variety of biological networks, including metabolic, genetic and signal transduction pathways.	It allows visual representation to field standards (SBGN), storage and retrieval of annotation such as kinetic and other numerical data in relational databases (local and remote for enterprise development) and links graphical objects to external databases and web resources to show all available information on demand.
	Biological Networks	Application for visualization and analysis of biological pathways	Biological Networks is a graph-based system for creating a combined database of biological pathways, gene regulatory networks and protein interaction maps. After importing expression data, users can apply sorting, normalization and clustering algorithms on the data and then create various tables, heat maps and network views of the data.
	BiNoM (Biological Network Manager)	BiNoM is a Cytoscape plugin, developed to facilitate the manipulation of biological networks	BiNoM include structural analysis of the networks (strongly connected components, path and cycle analysis, network clustering, etc.) and support of generating network modular view.
	NetworkAnalyser	This tools is a Cytoscape plugin, developed to analyze biological and other networks	Networkanalyser computes and displays a large number of simple and complex topological network parameters for directed and undirected networks loaded into Cytoscape using efficient graph algorithms, for example, the number of nodes, edges, and connected components, the network diameter, radius, density, centralization, heterogeneity, and clustering coefficient, the characteristic path length, and the distributions of node degrees, neighborhood connectivities, average clustering coefficients, and shortest path lengths.
	CellNetAnalyzer	CNA is a package for MATLAB and provides a environment for structural and functional analysis of biochemical networks	CNA facilitates the analysis of metabolic (stoichiometric) as well as signaling and regulatory networks solely on their network topology, i.e. independent of kinetic mechanisms and parameters. CNA includes Metabolic flux analysis, Analysis of basic topological / structural properties, Metabolic pathway analysis and for Signal flow (signaling, regulatory) networks: Analysis of interaction graphs, Analysis of logical (Boolean) interaction networks.
	Pathway Builder	Tool for drawing signal transduction pathways for presentation, publications, posters, etc.	Pathway Builder contains pathway templates and illustration items. It allows you to make web pages from the pathways images of the Pathway Builder tool. [http://avaxhome.ws/software/software_type/scientific/Medical/pathway_builder.html]
	SBMLToolBox	SBMLToolbox provides	SBMLToolbox provides functions for reading, writing, and validating SBML models; viewing model structures in a

Group	Software tool	Main goal	Functions
		functions for reading, writing, and validating SBML models.	simple GUI; converting models into a symbolic form suitable for use with MATLAB's Symbolic Math Toolbox; and simulate models using MATLAB's ordinary differential equation solver.

Next Table 2 summarizes properties and facilities of examined software tools.

Table 2.

Summary of examined software tools properties and facilities

Nr.	Software tool	Licence (free software, free open source, free use, commercial)	Base	OS	Model creation	Model simulation	Model creation or simulation using differential	Model analysis	Topological analysis	Support of SBML standart (Import/Eksport)	Support of SBGN standart	Data (Gene data, Pathways) or model import form public available DataBases
1	Cytoscape [37,5, 36]	(LGPL license) open source	Java	L, W, M	Y				Y	I (sif, gml, XDMML, xls) /E		KEGG, Pathway Commons , IntAct , BioMart , NCBI Entrez Gene , PICR
2	Visant [37, 39, 40]	Free and open source code	Java	L, W, M	Y	Y		Y	Y			GenBank, KEGG, SwissProt
3	BioTapestry [25]	Free and open source code	Java	L, W, M	Y	Y	Y			E		
4	CellDesigner [12-15]	free use license, open source code	-	L, W, M	Y	Y	Y			I/E	Y	KEGG, SGD, DBGET, IHOP, Genom Network Platform, PUBMED, Entrez Gene
5	JDesigner [17]	LGPL license Free and open source code	Win32 appl.	W	Y	Y	Y	Y		I/E		
6	Edinburgh Pathway Editor [27]	non-commercial License	Java	L, W, M	Y		Y			E	Y	
7	GenMapp [4,6-8,9,16]	Open source	-		Y	Y						Swiss-Prot, Entrez Gene, PubMed, Unigene, UniProt, Ensembl
8	NetBuilder [31]	free and open source code	C++ 6.0	L, W, M						E	Y	
9	Pathway analyser	free and open source code	C++	L		Y	Y	Y		I		
10	Biological Networks [37]	Free for academic use, commercial	Java		Y			Y	Y	I		Pathway import: KEGG, BIND, GO
11	PathwayLab	commercial		W	Y	Y	Y	Y		E	Y	
12	Pathway Tools	free for academic use, commercial						Y		E		
13	Pathway Builder	free and open source		L, W, M	Y					I		
14	BiNoM [43,44]	free and open source code		L, W, M	Y				Y	I/E (BioPAX, Cell- Designer)	Y	
15	CellNet- Analyser [10]	free for academic use, commercial		L, W, M				Y	Y	I/E		
16	Cobra [11]	Free and open source code		L, W, M				Y		I/E		
17	Network-	free open-source	Java	L,					Y			

Nr.	Software tool	Licence (free software, open source, free use, commercial)	Base	OS	Model creation	Model simulation	Model creation or simulation using differential	Model analysis	Topological analysis	Support of SBML standard (Import/Eksport)	Support of SBGN standard	Data (Gene data, Pathways) or model import form public available Databases
	Analysér [1]			W, M								
18	GEPASI [28]	free		W	Y	Y	Y	Y		I/E (L1)		
19	Genetic Network Analyzer [10]	Free for academic use, commercial	Java	L, W, M	Y	Y	Y	Y		I/E		
20	COPASI [18]	Open source code, free for academic use, commercial	C++ , Java	L, W, M	Y	Y	Y	Y		I (L1V1-2, L2V1-3) /E (L1V2, L2V1-3)		

* OS is Operating System that can be Linux (L), Windows (W) and MacOS (M).

There are many public available databases like KEGG (Kanehisa et al, 2006), GO (Raychaudhuri et al, 2002), GenBank (Benson et al, 2008), etc., that store and share experimental information. There are software tools (see Table 2.) that allow data import from these databases and data connection with set model.

Software tools of structure analysis

Here we describe three software tools that analyze network structure. During survey of these tools we have found 22 structure topological parameters and features which are described here to.

VisAnt

VisANT is a web-based software framework (Java application) for visualizing and analyzing many types of networks of biological interactions and associations, as well as an especially useful tool for integrating information from a wide variety of sources. VisAnt is freely available. VisANT provides (Zhenjun Hu et al, 2005):

- (1) a visual interface for combining and annotating network data.
- (2) supporting annotation data for different genomes from the Gene Ontology. GO terms can be easily dropped into the network to group genes annotated under the term, thereby integrating the hierarchical ontology with the network (Zhenjun Hu et al, 2009). GO is gene ontology, which provides hierarchically organized information about gene products, their activity, biological functions and cellular location (Zhenjun Hu et al, 2009).
- (3) visualization, mining, analysis and modeling of the biological networks, which extend the application of GO (Zhenjun Hu et al, 2009).
- (4) supporting exploratory pathway analysis using metagraphs (type of graph), which includes multi-scale visualization of multiple pathways, editing and annotating pathways using a KEGG compatible visual notation and visualization of expression data in the context of pathways (Zhenjun Hu et al, 2007).
- (5) the statistical and analytical tools needed for extracting topological properties of the user-defined networks.

VisAnt provide functions to annotate genes at any customized level of abstraction (Zhenjun Hu et al, 2009).

VisAnt is capable of easily exploring pathways at different scales: a pathway overview enables user to observe the topology of large sets of pathways, while the detailed internal structure of any particular pathways or set of pathways is easily revealed by mouse-clicking (Zhenjun Hu et al, 2007).

VisANT explicitly allows creation of mixed networks involving different types (Zhenjun Hu et al, 2005), i.e. networks containing both directed and undirected links (Suderman and Hallett, 2007). Networks can also be analyzed for topological characteristics to identify larger global properties, such as degree distribution, path length, shortest path and clustering coefficient calculations (Suderman and Hallett, 2007, Zhenjun Hu et al, 2007), connections finding between a given set of genes/proteins.

CellNetAnalyser

CellNetAnalyser is a package for MATLAB and provides a comprehensive and user-friendly environment for structural and functional analysis of metabolic (stoichiometric) as well as signaling and regulatory networks [CellNetAnalyser Manual]. CAN allows to analyze mass-flow (i.e. stoichiometric or metabolic) networks, signal-flow (signaling and regulatory) networks and stoichiometric networks.

The particular strengths of CellNetAnalyzer are methods for functional network analysis, i.e. for characterising functional states, for detecting functional dependencies, for identifying intervention strategies, or for giving qualitative predictions on the effects of perturbations (Klamt et al, 2007).

CNA provides a powerful battery of methods for metabolic and stoichiometric network analysis:

- (1) Metabolic flux analysis
 - classification of flux scenarios (determinacy and redundancy) and rates (balanceability and calculability)
 - calculation of flux distributions (for all types of flux scenarios)
 - consistency checks in redundant systems
 - flux optimization subject to an arbitrary linear objective function (flux balance analysis, FBA)
 - sensitivity analysis of calculated rates
 - feasibility check of a given scenario
- (2) Analysis of basic topological / structural properties
 - graphical display of the stoichiometric matrix
 - computation of graph-theoretical path lengths in an directed and undirected graph representation of the reaction network; determination of network diameter
 - detection of (elementary) conservation relations, enzyme subsets, isozymes, blocked and parallel reactions

CAN provides a algorithms for a functional analysis of signal-flow networks - Analysis of interaction graphs

- basic topological properties
- large-scale computation of all positive and negative signaling paths connecting inputs with outputs or of all signaling paths between a given pair of nodes; statistical analysis of these paths
- large-scale computation of all positive and negative feedback loops; statistical analysis of these routes
- computation of minimal cut sets (removing reactions or species) for a given set of paths or/and loops
- computation of distance (shortest paths) matrices; separately for positive and negative paths
- large-scale dependency analysis (which species has (positive/negative) influence on which species; identification of activators and inhibitors of a given species enabling predictions on perturbation experiments)connectivity histogram.

CellNetAnalyzer support calculations of global topological properties of the network. It is useful to detect errors in the network structure after the network has been composed (Klamt et al, 2007, Klamt et al, 2006).

CNA is programmed with MATLAB under LINUX as operating system and it is a commercial product.

Cytoscape with BiNoM AND NETWORKANALYSER

Cytoscape is a complex network visualization and analysis tool supporting a core set of features including standards and customizable network display styles, ability to import a large variety of interaction files, and zoomable network views (Suderman and Hallett, 2007). Cytoscape is suitable for analyzing molecular interaction networks and biological pathways and integrating these networks with annotations, gene expression profiles and other state data. Cytoscape specializes in the representation of interaction networks. Automatic layout algorithms help to organize massive amounts of interaction data relating to a set of molecules (in orange). Cytoscape include filter of the network to select subsets of nodes and/or interactions based on the current data, allows to find active subnetworks/pathway modules and find clusters (highly interconnected regions) (Cline et al, 2007).

BiNoM (BIological NetWoRk Manager) is a Cytoscape plugin, developed to facilitate the manipulation of biological networks represented in standard systems biology formats (SBML, SBGN, BioPAX) and to carry out studies on the network structure. Binom allows the analysis of networks created with CellDesigner software and their conversion in BioPAX format. BiNoM proposes to generate three standard interfaces, during BioPAX import operations: reaction network, pathway structure and protein-protein interaction (Zinovyev and Calzone).

BiNoM provides the user with a complete interface for the analysis of biological networks in Cytoscape environment, for example, structural analysis of the networks (strongly connected components, path and cycle

analysis, network clustering, etc.). BiNoM provide simplification and analysis of the network representation are achieved by use of the build-in library of graph analysis tools, including:

- analysis of connected and strongly connected components,
- path analysis (finding shortest, suboptimal, all paths),
- modular decomposition of the network using node semantics, cycle analysis, subnetwork clustering, decomposition of network into modules and clipboard operations (Zinovyev et al, 2008).

Cytoscape is Java application whose source code is released under the Lesser General License (Suderman and Hallett, 2007). This system has plugins (Additional features) that can construct any developers.

NetworkAnalyzer is a software tool for the analysis of biological and other networks. This is the versatile Cytoscape plug-in that computes a comprehensive list of simple and complex topology parameters (single values and distributions) for directed and undirected networks using efficient graph algorithms. Simple parameters are the number of nodes, edges, self-loops, and connected components, the average number of neighbors, the network diameter, radius, density, centralization, heterogeneity, and clustering coefficient, the number of shortest paths, and the characteristic path length. Complex parameters are distributions of node degrees, neighborhood connectivities, average clustering coefficients, topological coefficients, shortest path lengths, and shared neighbors of two nodes. Network-Analyzer displays the distributions as histograms or scatters plots and allow export them as chart images in the formats JPG/PNG/SVG or as tables in plain text files (Assenov et al., 2008).

Biological Networks

BiologicalNetworks is a software platform for biological pathways analysis, querying and visualization of gene regulation and protein interaction networks, metabolic and signaling pathways, and is an information management framework over PathSys. This software integrates over 20 curated and publicly contributed data sources, biological experimental and PubMed data for the 8 representative genomes (*S. cerevisiae*, *D. melanogaster*, etc.). BiologicalNetworks is supported with curated pathways from a number of public databases like KEGG. BiologicalNetworks software is available at <http://biologicalnetworks.net/index.php> and it is a free Integrated Research Environment for biologists.

In BiologicalNetworks is developed a preliminary standard for exchanging files that have visual markup and annotation of network layouts. Users of BiologicalNetworks can input several basic data types, including data in standardized network and interaction data exchange formats, such as PSI-MI, BioPAX and SBML (Baitaluk et al., 2006).

Biological networks include following main functions: Data integration, Data representation, Data analysis, Microarray data analysis (Baitaluk et al., 2006).

Once a network dataset has been imported or loaded into BiologicalNetworks, the genes or proteins within it can be queried for other known and predicted interactions from the PathSys's database. To enable data analysis, the following tools are available (Baitaluk et al., 2006):

- 1) Import and export user data
- 2) Create, save, edit user pathways
- 3) Optimize the view by filtering, pathway expansion, and protein classification.
- 4) Perform graphic drawing and layout optimization
- 5) Search: find and display a list of objects based on a name or a keyword.
- 6) Expand: searches the database and displays objects functionally linked to a selected node or a set of nodes. Thus, by alternating expand and filtering options, users can browse through the database building their favorite pathways.
- 7) Build pathways: finds a set of links between two or more nodes by searching for the shortest path in the total network of all links in the database. This tool assists in finding regulatory paths between all selected objects.
- 8) Find common targets/regulators: searches for common targets or regulators for the group of molecules. This tool as well as Build Pathway can find functional links between proteins in the lists imported from other programs (e.g. gene expression clusters).
- 9) Find intersection with curated pathways: searches a group of nodes for other known and predicted interactions from the PathSys's repository of curated pathways.
- 10) BiologicalNetworks provides an advanced querying facility for retrieving the data of user's interest by querying Nodes and Properties types. User friendly querying interface allows user to make query with any logical combination of conditions both on Node and Property trees.

Networks can also be analyzed for graph topological properties, such as degree distributions, path lengths, shortest paths or clustering coefficients (Baitaluk et al., 2006).

Topological parameters and features

Topological analysis of biomolecular networks can provide quantitative insights into biological networks. Given the network $G=\{V,E\}$, where V is the node set and E is the edge set, the topological indices for characterizing a network include average degree K , clustering coefficient C , average path length L , and network diameter D . The topological distribution include degree distribution $P(k)$, cluster coefficient distribution $C(k)$, shortest path distribution $SP(k)$. The most elementary characteristic of a node is its degree or connectivity k . Topological analysis of cellular networks helps to understand the biological roles and functions of the network. The topological measures (see Table 3) can capture the cellular features of cellular networks and provide broad insight into cellular evolution, molecular function, network stability, and dynamic responses (Luonan Chen et al, 2009).

Table 3:

Summary of computed structure parameters by software tools Visant, Cytoscape with BiNoM, CellNetAnalyser and Biological Networks

Nr	Parameters and features	Visant	Cytoscape with BINOM and NetworkAnalyser	CellNet-Analyser	Biological Networks
1.	Node degree	Y			
1.1.	In-degree	Y			
1.2.	Out-degree	Y			
2.	Degree distribution	Y	Y		Y
2.1.	In-Degree distribution	Y			
2.2.	Out-Degree distribution	Y			
3.	Degree distribution (average value)	Y			
4	Shortest Path	Y	Y (directed or undirected)	Y	Y
4.1.	Shortest path between two given components	Y	Y	Y	Y
4.2.	Shortest path between many given components	Y			
4.3.	Shortest path between all components	Y		Y	Y
4.4.	Optimal and suboptimal shortest paths		Y		
4.5.	All the paths leading from one component		Y		
4.6.	All non-intersecting paths		Y		
5	Shortest Path length		Y	Y	Y
6	Longest path length			Y	
7	Average path length			Y	
8	Network diameter		Y	Y	
9	Path finding		Y	Y	Y
9.1.	Path between two given components	Y			
9.2.	Path find between a given set of nodes	Y		Y	Y
11	Positive (Negative) Feedback loop	Y		Y	
12	Feedforward loop (cycle, circuits)	Y	Y	Y	Y
13	Self-Loop	Y			
14	Randomize Undirected network	Y			
15	Statistical Randomization of undirected network	Y			
16	Randomize Directed networks	Y			
17	Clustering coefficient				Y
18	Average clustering coefficient		Y		
19	Clustering-Coefficient distribution	Y		Y	
20	Average-Clustering- Coefficient distribution	Y			
21	Cluster finding		Y		Y
22	Number of components		Y	Y	
23	Number of edges		Y		
24	Number of self-loops		Y		

Nr	Parameters and features	Visant	Cytoscape with BINOM and NetworkAnalyser	CellNet-Analyser	Biological Networks
25	Number of connected components		Y		
26	Number of shortest paths		Y		
27	The average number of neighbors		Y		
28	Radius		Y		
29	Density		Y		
30	Centralization		Y		
31	Heterogeneity		Y		
32	Neighborhood connectivities		Y		
33	Shared neighbors of two nodes		Y		
34	Topological coefficients		Y		
35	Modular view of the network		Y		
36	Clustering and Decomposition				
36.1.	Cycle clustering and cycle decomposition		Y		
36.2.	Material component clustering and material decomposition		Y		

Almost all of software tools use their own file format (see Table 4.). However, part of them support data exchange formats (see Table 5) that are generally accepted in Systems biology branch, e.g. SBML, SBGN. Implementation of these standards makes easy representation of networks in form that is understandable both for human, and machine, and facilitate communication between different software tools and data exchange, as well as stimulate experience exchange between researchers. Next table represent summary of file formats that supports Cytoscape, VisAnt and CellNetAnalyser.

We should note that BiNoM supports conversion between standards (CellDesigner->BioPAX, BioPAX->SBML) (Zinoviyev et al, 2008). But, CellNetAnalyser supports SBML models with help of SBMLToolBox module. Development of VisAnt is also underway for support of the SBML (Zhenjun Hu et al, 2005).

Table 4:

Summary of existing file format supported by Visant, Cytoscape, CellNetAnalyzer and BiologicalNetworks

File format	Tool	Explanation
BioPAX	VisAnt Cytoscape BiologicalNetworks	Biological Pathway eXchange standard format for pathway information supported by multiple pathway databases.
Edge List	VisAnt	Default text format for non-XML-based data.
Expression	VisAnt	Expression matrix file, the first line must start with #!Expression. Optional parameter addNewNode to determine whether to abandon the nodes that are not in the current network, e.g. addNewNode=false.
GML	VisAnt Cytoscape BiologicalNetworks	Graph Markup Language, a common graph file format supported by several network software.
ID-Mapping	VisAnt	This file format is designed to allow user to add various database IDs in VisAnt, as well as alias and functional descriptions, to the nodes in a network, must start with #!ID Mapping.
KGML	VisAnt	The KEGG Markup Language (KGML) is a data exchange format of the KEGG graph objects, especially the KEGG pathway maps that are manually drawn and updated. The KGML files for KEGG metabolic pathways specify how enzymes (boxes) are linked by a relation and how compounds (circles) are linked by a reaction (Zhenjun Hu et al, 2007).
M	CellNetAnalyzer	MatLab M-file (file-programm, file-function) format.
Macro/Batch	VisAnt	The file format to store a list of commands for VisANT to carry out.
MAT	CellNetAnalyzer	MatLab file format.
PSI-MI	VisAnt BiologicalNetworks	XML standard format for molecular interactions supported by molecular interaction databases. It is a data exchange format for protein-protein interactions.

File format	Tool	Explanation
SBML	Cytoscape CellNetAnalyser BiologicalNetworks	System Biology Markup Language standard for representing models of biochemical and gene-regulatory networks.
SIF	Cytoscape BiologicalNetworks	The simple interaction format is convenient for building a graph from a list of interactions. It also makes it easy to combine different interaction sets into a larger network, or add new interactions to an existing data set.
VisML	VisAnt	Default XML format, containing all the network information. Network stored as VisML format can be safely replayed as it was stored.
XGMML	Cytoscape	XGMML is the XML evolution of GML and is based on the GML definition. In addition to network data, XGMML contains node/edge/network attributes.
XML	BiologicalNetworks	XML is (Extensible Markup Language) a set of rules for encoding documents electronically.
XLS	Cytoscape	The tables in these files can have network data and edge attributes. Users can specify columns containing source nodes, target nodes, interaction types, and edge attributes during file import.

Table 5:

Summary of standardized network and interaction data exchange formats supported by public databases, software tools and directly by Cytoscape, VisAnt, CellNetAnalyser and BiologicalNetworks

File format	KGML	GML	PSI-MI	BioPAX	SBML	SBGN	XGMML
Cytoscape with BiNoM		Y	Y (L1, L2.5)	Y (L1,L2)	Y	Y	Y
VisAnt	Y	Y	Y	Y			
CellNetAnalyser					Y (L2)		
Biological Networks		Y	Y	Y	Y (L1, L2)		

This and other programs that work with graphs use mainly their own file format. Therefore, exchanging graphs between different programs is almost impossible. Simple tasks like exchange of data, externally reproducible results or a common benchmark suite are much harder than necessary (Available at: <http://www.infosun.fim.uni-passau.de/Graphlet/GML/>, 20.12.2009). For that reason we suggest to use the data exchange formats like GML or SBML. In this way (By this means) user can directly communicate between different software tools and store the same computable representation of model.

We don't switch BioPAX data exchange format, while it is a standardized format for exchanging pathway information and integrate knowledge from multiple pathway databases.

Conclusions

Within this manuscript we examine 20 existing tools. 18 tools of them are freely available for academic use, among them 5 are commercial product for non academic use. 12 tools provide source code.

8 tools provide modeling of metabolic networks, 4 tools are suitable for modeling gene regulatory networks, 6 tools allow visualization and analysis of network structure.

Structural model characterize and provide information of the connectivity (topology) of the interactions involved in a biological process. Identifying topological features in networks is an important part of understanding the relationship between network structure and functions of their subunits such as motifs.

Analyzing software tools and scientific literature we found 47 structure topological features, 27 of them are structure parameters that can be used to characterize biomolecular network but there is no software tool that could calculate them all. It is essential to be indicated Cytoscape with BINOM and NetworkAnalyser plugins can calculate large number of above-mentioned topological parameters and features.

Almost all of software tools use their own file format. However, part of them support data exchange formats that are generally accepted in Systems biology branch, e.g. SBML, SBGN. Implementation of these standards makes easy representation of networks in form that is understandable both for human, and machine, and facilitate communication between different software tools and data exchange, as well as stimulate experience exchange between researchers.

Working with graphs we suggest using the data exchange formats like GML or SBML. In this way user can directly communicate between different software tools and store the same computable representation of model. 17 of 20 software tools support SBML standard. 9 tools of them allow both model import and export, 5 tools provide only model export function and 3 tools support model import.

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STRUCTURAL MODEL OF BIOCHEMICAL NETWORK OF *ZYMONONAS MOBILIS* ADAPTATION FOR GLYCEROL CONVERSION INTO BIOETHANOL

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Abstract

One of the biodiesel production problems is a significant quantity (about 10%) of by-product – glycerol occurrence. This problem is offered to solve by adaptation of bacteria *Zymomonas mobilis*, which is notable for ethanol production facilities. To be able to process glycerine into ethanol using *Z.mobilis* bacteria, the bacteria must be modified, because its natural form cannot process glycerine. At the same time computer modelling analysis is required, to assess specific modification affectivity in interconnection with other processes in bacteria.

The computer model, which describes two genes of - bacteria *E.Coli GlpF* and *GlpK* insertions and expressions in bacteria *Zymomonas mobilis*. These gene-coded proteins ensure glycerol transport - in bacteria and conversion to substances, which bacteria can process to ethanol. Biochemical reactions and process regulation network is too complicated, to be able to predict system's respond without extensive computer modelling by changing any of its components. The model describes conversion of glycerol into bioethanol in *Z.mobilis* bacterial cell. First phase of model creation is creation of structure model based on biochemical reactions. On the second phase of model creation were identified kinetic parameters which are available in literature.

Using the databases KEGG, SABIO-RK, BRENDA, where defined reactants, kinetic parameters and reaction equation types. Computer model of *Z. mobilis* biochemical network was created using computer software *CellDesigner* (4.1. beta).

Key words: Computer modelling, *Zymomonas mobilis*, ethanol

Introduction

Z mobilis is undoubtedly one of the unique micro-bacteria in the world. It is known since 1912 as *Termobacterium mobilis*, *Pseudomonas Linder*, and finally as *Z.mobilis*. The first reviewing of their uniqueness was published on 1977th and 1988th years. *Z.mobilis* features manifest not only in biochemistry but also in growth, energy production, and response to the growing conditions. These features caused great interest in science, biotechnology, and industrial areas. *Z.mobilis* is a bacterium which is notable for ethanol production facilities.

In the biodiesel production washing process removes all water-soluble contaminants (methyl alcohol, glycerol, phosphates, etc.). One of the biodiesel production problems is a significant amount (10%) of by-product – glycerol generation. In order to process the glycerine into bioethanol using *Z.mobilis* bacteria, it must be modified. Biological experiments have revealed that by expressing bacterium *E. coli GlpF* and *GlpK* genes bacteria *Z.mobilis* is capable for processing glycerol into ethanol.

Biochemical reactions and process regulation network is too complicated to be able to predict system's respond without extensive computer modelling after changing any of its components.

Computer model characterize the conversion of glycerol into bioethanol inside the cell of bacteria *Z.mobilis*. Computer model was created using *CellDesigner* (4.1. beta) program, which supports SBGN standards.


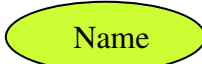


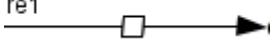
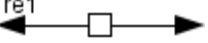

Materials and Methods

The model was created according to Systems Biology Graphical Notation (SBGN) standard. The goal of the SBGN is to standardize the graphical/visual representation of essential biochemical and cellular processes studied in systems biology. SBGN defines a comprehensive set of symbols with precise semantics, together with detailed syntactic rules for their use. It also describes the manner in which such graphical information should be interpreted. Standardizing graphical notations for describing biological interactions is an important step towards the efficient and accurate transmission of biological knowledge between different communities. Traditionally, diagrams representing interactions among genes and molecules have been drawn in an informal manner, using simple unconstrained shapes and edges such as arrows. Until the development of SBGN, no standard agreed-upon convention existed defining exactly how to draw such diagrams in a way that helps readers interpret them consistently, correctly, and unambiguously. (Nicolas Le Nov`ere, et.al. 2008)

The computer model was created using *CellDesigner* (4.1. Beta) program that supports biological SBGN networking standard. *CellDesigner* is a structured diagram editor for drawing gene-regulatory and biochemical

networks. Intuitive user-interface helps you to draw a diagram in rich graphical representation with your own design. (Funahashi et. al., 2007)

The object designations used in model are shown in the following table:

			
Protein – enzyme (catalyat)	substrate or product	inhibitors	catalyze
			
State transition reaction	Reversible reaction	Transport reaction	

Reactions are formed using the program.. There are various reaction types: the reactions that contain single substrate and single product (Fig.1.) and the reactions that contain several substrates and several products (Fig.2.). Additional reactant can be added by using *Add Reactions* button, and products can be added using *Add Product* button. Each reaction has its identification number. The problem while building reactions is that if reaction was deleted then the reaction number is stored and numbering will continue forward through the next reaction, which in turn can break down the total number of actual reaction synthesis.

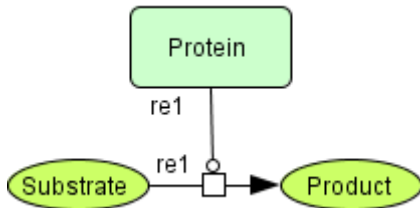


Figure 1. Reaction – one substrate, one product, catalyst

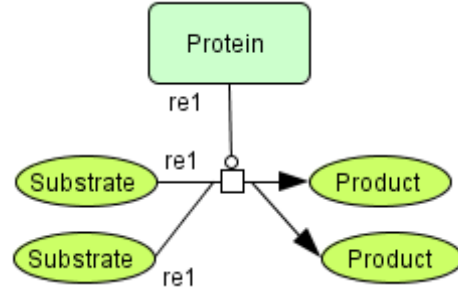


Figure 2. Reaction – two substrates, two products, catalyst

The option *Change properties of the reaction* is used to defined parameters: *Name* – the reaction name, *Type* – the reaction type, *Reversible* – shows does the reaction is reversible (true) or irreversible (false) (Fig.3.). All reaction parameters can be found in the section *Species* where parameter’s name and identification code is written. The reaction name can be seen in the section *Reactions*.

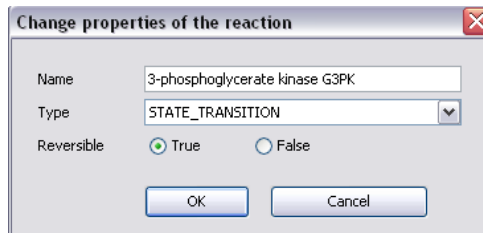


Figure 3. The options where chang reaction parametrs

Created computer model is not transparent. In order to obtain a transparent computer model sort tools used – tab – *Layout*, this menu helps to rearrange computer model in various types. This model was sorted by type – *Orthogonal Layout*, when the layout is not correct, it can be adjusted manually.

Using databases KEGG, BRENDA were inspected publications where bioethanol production process reactions are described. These publications where searched for reagents and enzymes that participate in the reactions. Biochemical reactions and process regulation network of bacteria *Z.mobilis* for glycerol conversion into bioethanol is showed on Figure 4.

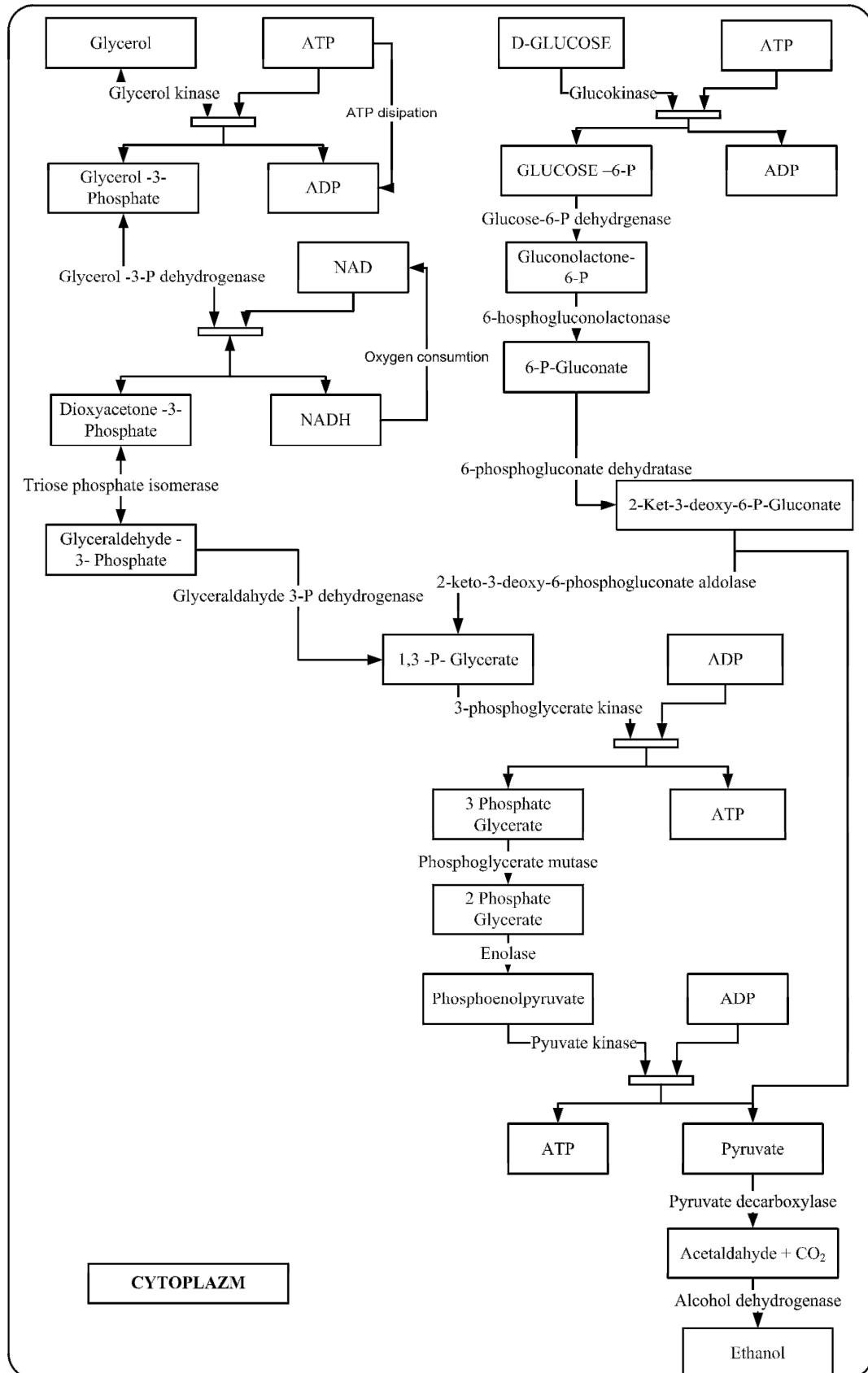


Figure 4. Biochemical reaction network (Alvarez M. et. al., 1998), (Mehmet M. Altintas et. al., 2006), (Pettigrew, D.W. et. al., 1996), (P.L.Rogers et al 2007), (R Fliege et. al., 1992), (Shin-ichi Hayashi et. al. 1967), (Weiner, J.H. et. al., 1972)

Results and Discussion

The computer model of biochemical reactions and process regulation network of bacteria *Z.mobilis* adoption for glycerol conversion into bioethanol is shown on Figure 5. The model have 19 reactions with 22 elements. The elements and reactions are listed in *Species* and *Reactions* sections respectively. Correctness of this model is not evaluated by comparing it with experimental data.

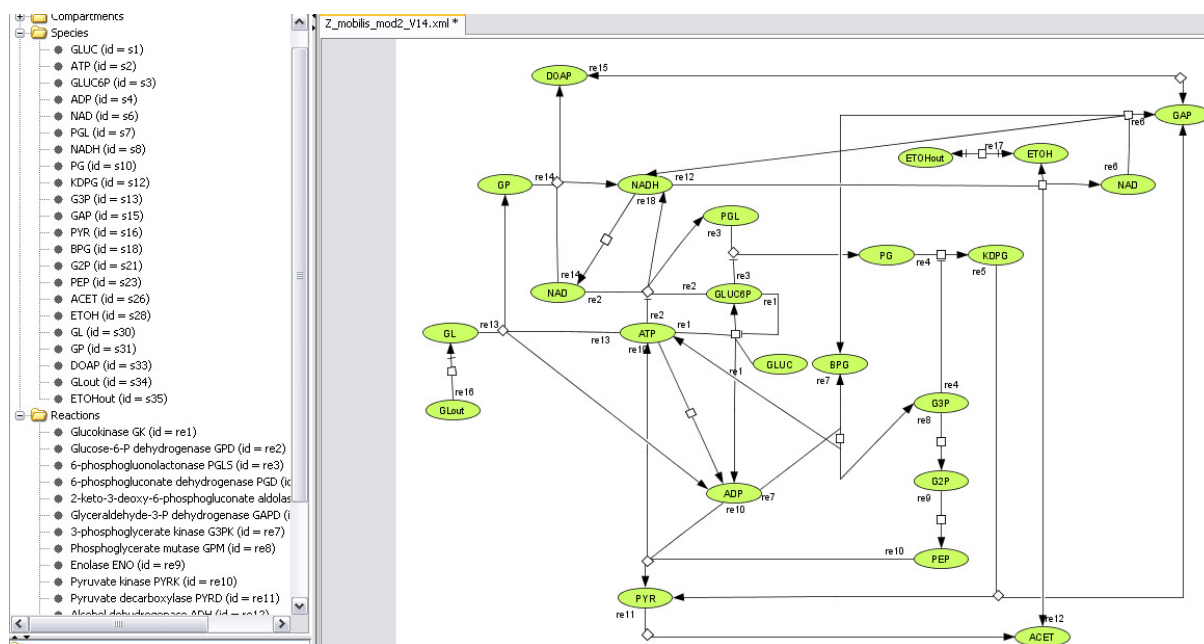


Figure 5. Biochemical reaction network (structural model) in program *CellDesigner*

Conclusions

- The computer model was created using *CellDesigner* (4.1. Beta) program that supports the biological SBGN networking standard.
- The model contains of 19 reactions with 23 elements. Two reactions (*Glycerol fascilitator* and *Glycerol kinase*) was taken from the bacteria *E.Coli*, three reactions (*Glycerol kinase*, *Glycerol 3-P-dehydrogenase*, *Triose phospate isomerase*) was taken from the bacteria *Trypanosoma brucei* model of glycolize as it was published (Bakker et al. 1997; Helfert et al. 2001), tested experimentally (Albert et al. 2005) and was found in the validated models database (*JWS Online Cellular Systems Modelling Model Database*), other reactions - *Entner Doudoroff* pathway has used from the bacteria *Z.Mobilis*. These reactions are described in Mehmet M. Altintas et. al. model (Mehmet M. Altintas et. al. , 2006). Two reactions are added by authors – *Oxygen consumption* and *ATP dissipation*.

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USE OF SENSOR GROUP MEASUREMENTS FOR THE BIOREACTOR CONTROL ADAPTATION

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Abstract

*In this paper are analyzed from bioreactor placed sensors obtained data storing and processing possibilities and its use for the bioreactor control adaptation. To achieve this, were explored bioreactor's control algorithms and yeast (*S. Cerevisiae*) biochemical network models, which helped to determine how the data, received from sensors, can be used to improve management of the bioreactor. This task is studied by many researchers, e.g. Simutis, Banga, Bailey etc. Each of them uses different technologies, to solve main problem - to maximize the yield of ethanol using the feed rate as the control variable.*

Bioreactor is provided with a temperature, pH, pO₂ and foam sensors. Were evaluated different technologies for these sensors measuring data storing and processing, e.g. XML or data base storage technologies and computer program or PLC based bioreactor control. In our case, Firebird 1.5 data base is used. That is easy in use and cost free data base. In this data base from sensors obtained data, constant values, motor rotation speed are stored. This information can be used to improve control of the bioreactor. At this moment, bioreactor use constant values, that can be set only in control panel. The task is to create possibility for dynamic bioprocess controlling, accordingly to dynamic bio-chemical models. Adaptive control involves modifying the control law used by a controller to cope with the fact that the parameters of the system being controlled are slowly time-varying or uncertain. For this project realization, are available bioreactor BIO-3, Siemens S7-200 and S7-300 automatic controllers, as well as computers.

In the result, were examined from bioreactor places sensors obtained data processing for bioreactor control improvement, during yeast fermentation process, which is based on sensors measurement result analysis and biochemical network model predictions. Real-time deviation diagnostics is based on possible problem's reasons clarification, and provided to process the most appropriate model. This project's results can be used to improve yeast fermentation process control, provided most suitable parameters for control algorithm.

Acknowledgements

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WORKFLOW AND TAVERNA MYEXPERIMENT RESEARCH

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Abstract

MyExperiment is an open repository for the born-digital items arising in contemporary research practice, in particular scientific workflows and experiment plans. Launched in November 2007, the public repository (myexperiment.org) has established a significant collection of scientific workflows and multiple workflow systems, which has been accessed by over 16,000 users worldwide. myExperiment provides mechanisms to support the sharing of workflows within and across multiple communities. Built according to Web 2.0 design principles, myExperiment demonstrates the success of blending modern social curation methods with the demands of researchers sharing hard-won intellectual assets and research works within a scholarly communication lifestyle. By making research content more reusable, and providing a social infrastructure which facilitates sharing, the human aspects of the scholarly knowledge cycle may be accelerated and 'time-to-discovery' reduced. Taverna is a free application for designing and executing workflows.

Taverna allows users to integrate many different software tools, including web services, such as those provided by the National Centre for Biotechnology Information, The European Bioinformatics Institute, the DNA Databank of Japan (DDBJ), SoapLab, BioMOBY and EMBOSS. Development of new workflows can be based on predefined services that are available on Taverna or related sites. Methodology of their interconnections is demonstrated. Another way to create a workflow is combining existing workflow with other workflows or services. Several methodologies are described. The Taverna Workbench provides you with a desktop enactment engine and authoring environment for scientific workflows expressed in Scufl (Simple Conceptual Unified Flow language). The Taverna enactment engine is also available separately, and other Scufl enactors are available including Moteur.

Key words *Scientific workflow, Taverna workflow workbench*

Introduction

Scientific workflows are attracting attention in the community. Understanding the whole lifecycle of workflow design, prototyping, production, management, publication and discovery is fundamental to developing systems that support the scientist's work and not just the workflow's execution. Supporting that lifecycle can be the factor that means a workflow approach is adopted or not. Scientific workflows are valuable commodities which require expertise to build. Workflow design is challenging and labour-intensive, and reusing a body of prior designs through registries or catalogues is highly desirable. Reuse is a particular challenge when scientists are outside a predefined Virtual Organisation or enterprise.

Materials and methods

For analyze were used three articles 'Towards Open Science: The myExperiment approach' by (Roure et al., 2009c), 'The design and realisation of the myExperiment Virtual Research Environment for social sharing of workflows' by (Roure et al., 2009a), 'The myExperiment Open Repository for Scientific Workflows' by (Roure et al., 2009b). The paper's target is to analyze Taverna and workflow preferences and faults, using other authors research results and also personnel experience of software acquiring and use in concrete task solving. The workflow enabled a large volume of data to be processed systematically, leading to a new scientific result which arose within part of the data that would have remained unexamined had the work been conducted manually. Then the same workflow was reused successfully by another scientist over a new dataset, to identify the biological pathways implicated in the ability for mice to expel the *Trichuris muris* parasite. Scientific workflows are valuable commodities which require expertise to build(*). The myExperiment repository was motivated by observing a clear need to share workflows – to reduce reinvention, propagate best practice and enable scientists to concentrate on science – amongst decoupled communities of workflow users. It was also motivated by a frustration with existing systems which: (a) missed the social dimension, merely making things available rather than encouraging and controlling sharing; (b) presented complex user interfaces out of line with the popular web sites that people are using on an everyday basis, thereby demanding further skill. These methods are crucial intellectual assets of the research life cycle whose stewardship has been neglected. Repositories often emphasise curation of data, but in digital research the curation of the process around that data is equally important – hence by focusing on workflows, myExperiment also provides a mechanism for expert and community curation of process.

MyExperiment provides an open, extensible environment to permit ease of integration with other software, tools and services, and benefits from participative contribution of software. We show how, by exposing the myExperiment functionality, new interfaces have been built and existing interfaces have incorporated myExperiment functionality.

Workflows are used for bioinformatics and systembiology, and other tasks.

In this paper was used software, as Taverna 2.1 beta 2. It is free software, that may be downloaded from internet of myExperiment site <http://launchpad.net/taverna/t2/2.1-beta-2/+download/taverna-workbench-2.1.b2-installer.exe> for Windows. Scientific workflow systems with significant deployment include the Taverna workflow workbench, Kepler, Triana and Pegasus. Taverna is the exemplar workflow system in this paper. Developed by the myGrid project within the UK e-Science programme, Taverna is used extensively across a range of Life Science problems: gene and protein annotation; proteomics, phylogeny and phenotypical studies; microarray data analysis and medical image analysis; high throughput screening of chemical compounds and clinical statistical analysis (Roure et al., 2009d,e). Importantly, Taverna has been designed to operate in the 'open wild world' of bioinformatics. Taverna is connected with WSDL and SOAP service standards. WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. The operations and messages are described abstractly, and then bound to a concrete network protocol and message format to define an endpoint. Related concrete endpoints are combined into abstract endpoints (services). SOAP is a lightweight protocol for exchange of information in a decentralized, distributed environment (Roure et al., 2009f). It is an XML based protocol that consists of three parts: an envelope that defines a framework for describing what is in a message and how to process it, a set of encoding rules for expressing instances of application-defined datatypes, and a convention for representing remote procedure calls and responses.

Results and discussion

Taverna 2.1 does not, by default, 'know' about a suitable activity to perform the functionality To add the capability click 'Activities' and select 'New Activities' and then 'WSDL...'. Enter the location of the WSDL, in this case 'http://www.webservice.com/globalweather.asmx?WSDL' and click OK. After a while, the services will become available in the Activity Palette. If you choose to order by 'type' and 'url' then you can see the two new services under WSDL and the location. To add the activity into the workflow, click on GetCitiesByCountry and drag it into the Graphical Editor. The workflow needs to have an input, in this case the name of the country to query. You can create a new workflow input by right clicking in a blank area of the Graphical Editor and select Create New Input. This will then ask you for a name for the input, you can change this later but for now use 'country'. Click on 'OK' and you should see your new input appear in the Graphical Editor and Workflow Explorer. Similarly, the workflow will need an output. Follow an equivalent process but this time clicking on 'Create New Output' and using the name 'cities' to create an output. Again, you should see the output appear in the two windows. For many services, you can connect your inputs and outputs directly to the ports of the activity. However, for WSDL services you may need to 'split' the XML used to hold the input and output values. To do this, click on the activity GetCitiesByCountry in the Graphical Editor. A description of the activity will appear in the WSDL Contextual View in the lower-left. Scroll down and click both 'Add input XML splitter' and 'Add output XML splitter', choosing 'parameters' in both cases. To link the input port click on 'country' and drag to the 'GetCitiesByCountry_input'. A connection will appear in the Graphical Editor. If there had been several ports that you could have connected to, then the selection would have been offered. To connect from the 'GetCitiesByCountry_output', right click on it and select 'Link from output GetCitiesByCountryResult' and drag to 'cities'. There are several other ways in which you could make the connections. You can now run the workflow just as for a pre-existing workflow. Select 'Run workflow' from the File Menu. In the Run workflow dialog, as there is only one input port, you can click 'New string'. Double click 'abcd' and replace the string 'abcd' by your chosen country. After you have entered it, you can click 'Launch workflow'. Taverna 2.1 will switch to the Results Perspective. After the workflow has run (indicated by GetCitiesByCountry turning grey), you will see a string similar to 't2:ref/testNamespace?test19' appear in the lower left panel. This is the identifier of the output result. If you click on this, you will see the output appear in the Rendered Result panel. Let a simple task, where we have one input and one output. Using in bioinformatics and systembiology, we were chosen service WSDL @ <http://soap.genome.jp/KEGG.wsdl>, and then - get_compounds_by_enzyme (Figure 1). We must input in new value, for example, 1.1.1.1, that will take results, compounds C00001, C00003, and many others, where 1.1.1.1 is enzyme for *alcohol dehydrogenase; aldehyde reductase; ADH; alcohol dehydrogenase (NAD); aliphatic alcohol dehydrogenase; ethanol dehydrogenase; NAD-dependent alcohol dehydrogenase; NAD-specific aromatic alcohol dehydrogenase; NADH-alcohol dehydrogenase*; and others. Either for *homo sapiens* input enzyme 5.1.3.3 result compounds C00221 and C00267. Positive and negative features of Taverna are summarized in table 1.

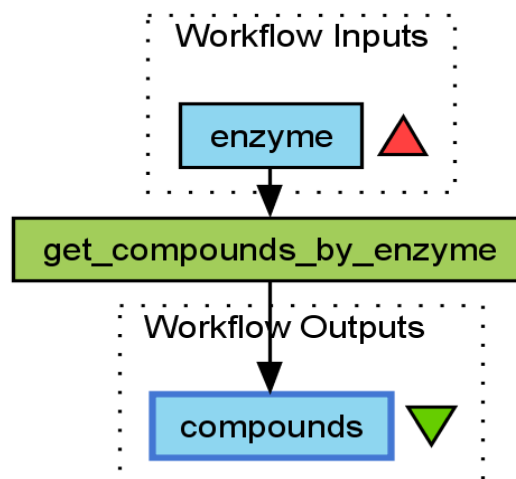


Figure 1. An example of compounds getting by enzyme, using Taverna 2.1 beta 2.

Table 1.

Positive and negative properties of Taverna 2.1 beta 2.

Taverna positive properties	Taverna negative properties
1. Ease understandable interface and learnable software.	1. Slower software running 2. Must to know specific of area, in which are input data, for example, that enzyme is 1.1.1.1 in example of figure 1.

Conclusions

The workflow enabled a large volume of data to be processed systematically, leading to a new scientific result which arose within part of the data that would have remained unexamined had the work been conducted manually. This is preference of workflows. Taverna 2.1 beta 2 is software, that permit to project diagrams, with which we can to connect to online database. If the diagramm is projected rightly, then output results will quickly. Taverna has a simplicity of adoption. Also if Taverna return an error, we can these to consider and so to correct. These are preferences of Taverna. Taverna has also faults: if something not correct in the diagramm structure or with services longly must be waited without results and cycle. Through creating myExperiment we are effectively conducting our own experiment: we are exploring whether communities of scientists will share to the extent that they benefit from the network effects from a social web approach. Through doing this we are gaining insights into the sharing behaviours of research communities across multiple domains. Uptake of the site confirms that, in our initial domains, myExperiment is already bringing benefit to both individuals and communities.

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MODELLING AND SIMULATION TECHNOLOGIES

HYDROGEOLOGICAL MODEL FOR THE PROSPECTIVE UNDERGROUND TRANSPORT TUNNEL AREA IN RIGA, LATVIA

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Abstract

The publication is devoted to numerical modeling of groundwater regime changes that may happen during and after building of the 7 km long and 50 metres deep underground transport tunnel in Riga. Two kinds of changes are expected: the ones caused by the tunnel impermeable body and by harmful effects that may happen during its construction. For example, the impact of open deep construction trenches. To estimate possible after effects caused by the tunnel and the trenches, the hydrogeological model has been created. By comparing results provided by the undisturbed (no tunnel) and disturbed models, the groundwater regime changes were found. They contained the ones for the groundwater heads and flows, for hydraulic gradients, for the meteoric infiltration. These changes were small and the tunnel itself should cause practically no disturbance of groundwater regimes. By modeling possible versions of watertight walls for trenches, it was found out that deep dry wrongly built trenches may cause considerable harm by lowering the groundwater table at their surroundings.

Keywords: hydrogeological models, underground tunnel

Introduction

To develop the Riga city transport system, building of the underground tunnel is planned. The tunnel track location (containing two parallel one way drives) is shown in Fig. 1. and Fig.2. The tunnel length is 7 km, the maximal depth of its installation is 50 m, the diameter of the one-way drive is 15.4 metres. The distance between the tunnel drives is 15.0 metres. It was necessary to estimate changes of groundwater regime that may be caused by building of the tunnel. They contain the permanent change due to the tunnel body and the one caused by deep construction trenches that must be used to build the tunnel.

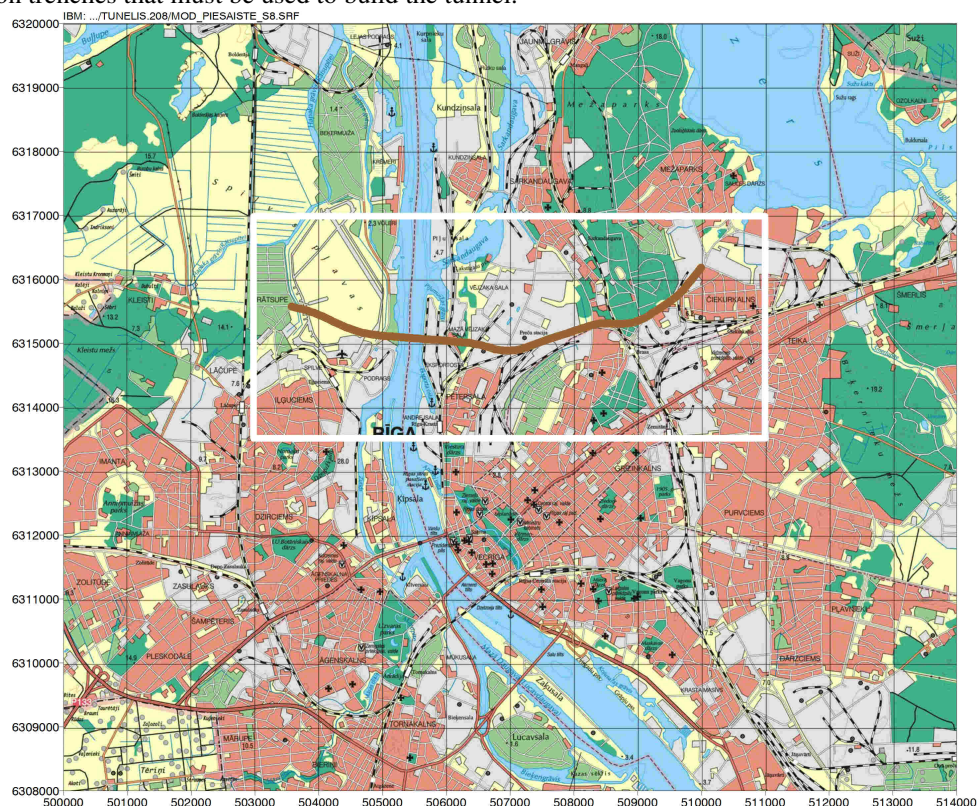


Fig. 1. The model location map

A hydrogeological model (HM) has been built, to estimate the groundwater regime changes (Final report, 2008). Location of HM is shown in Fig.1. The HM size is 3.5km×8.0km. The plane approximation step 10.0 metres enables to account for the tunnel dimensions.

Geology of the HM area is rather complex (Fig.2, Table 1). The area is bedded by the Devonian sandstone aquifer D3gj2. It is covered by the sandstone aquifer D3am which partly ends within the area. The next aquifer D3pl of dolomites exists only in the area southern part. These Devonian aquifers are separated from the Quaternary aquifer by the moraine gQ. In surroundings of the Daugava river, the aquifer Q presents a chaotic mixture of fine sand, sandy loam, clay and stones. Below the Daugava old valley, the area of coarse sand exists. In Fig. 3, the cross section WE of the HM area is presented. On the section, four variants of tunnel road beds are shown (Report, 2008). Only the version 1 (deep tunnel) is considered there, because its influence on the groundwater regime is the largest one (Final report, 2008).

HM was created in the Groundwater Vistas environment (Environment Simulations, 2004).

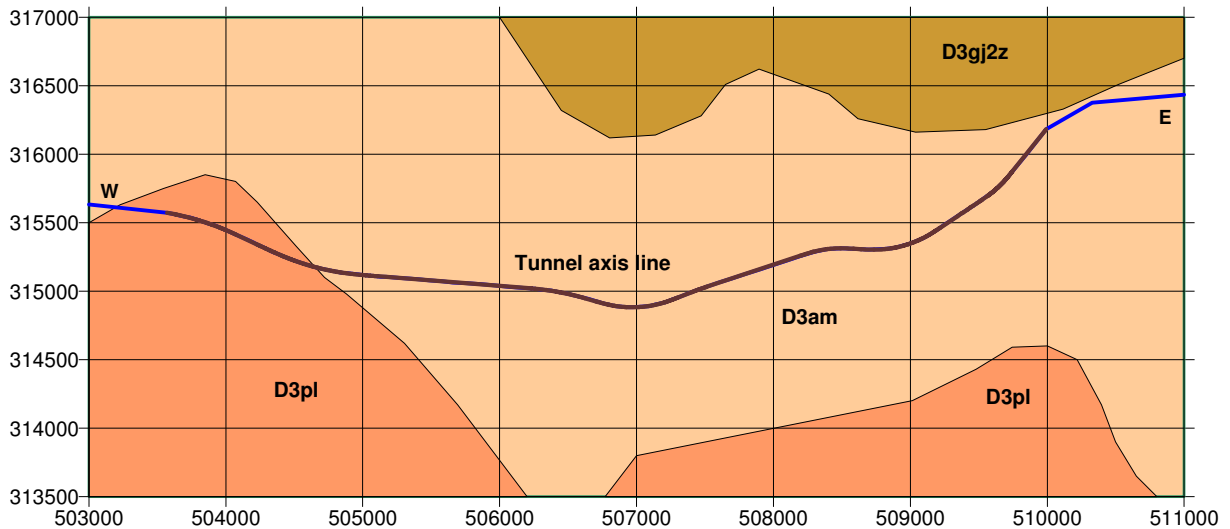


Fig. 2. Geological map of model area

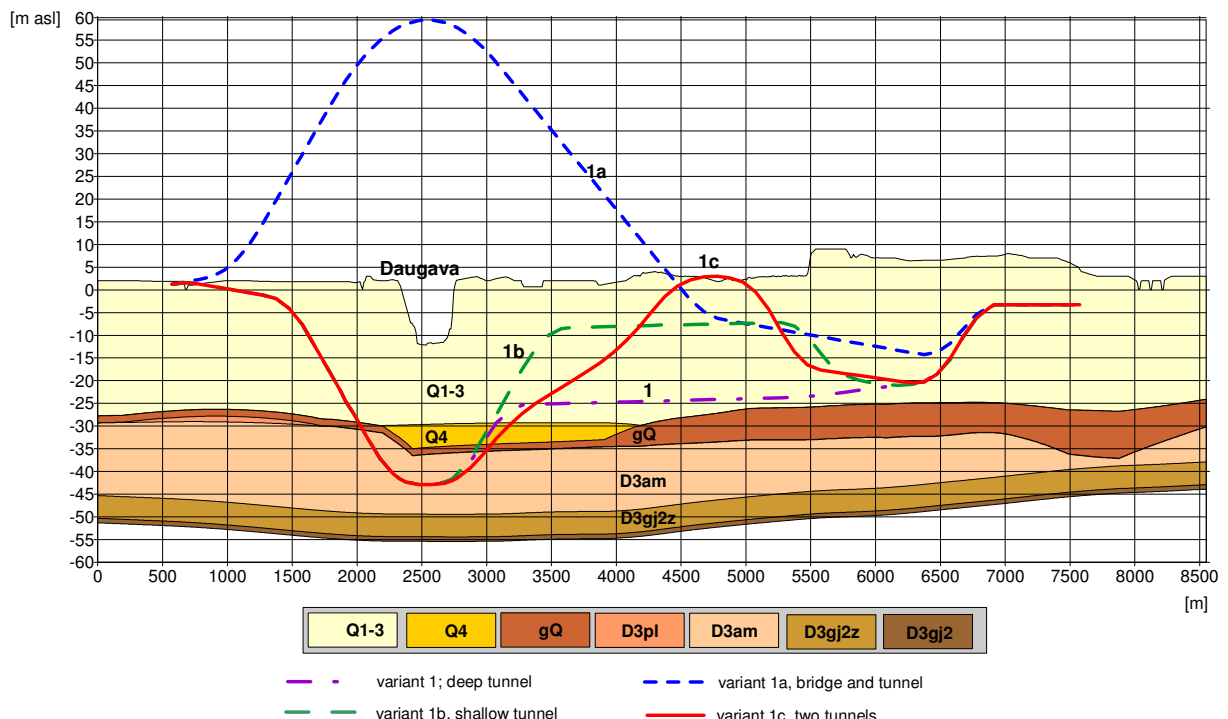


Fig.3. Cross section WE. Variants of the tunnel road base

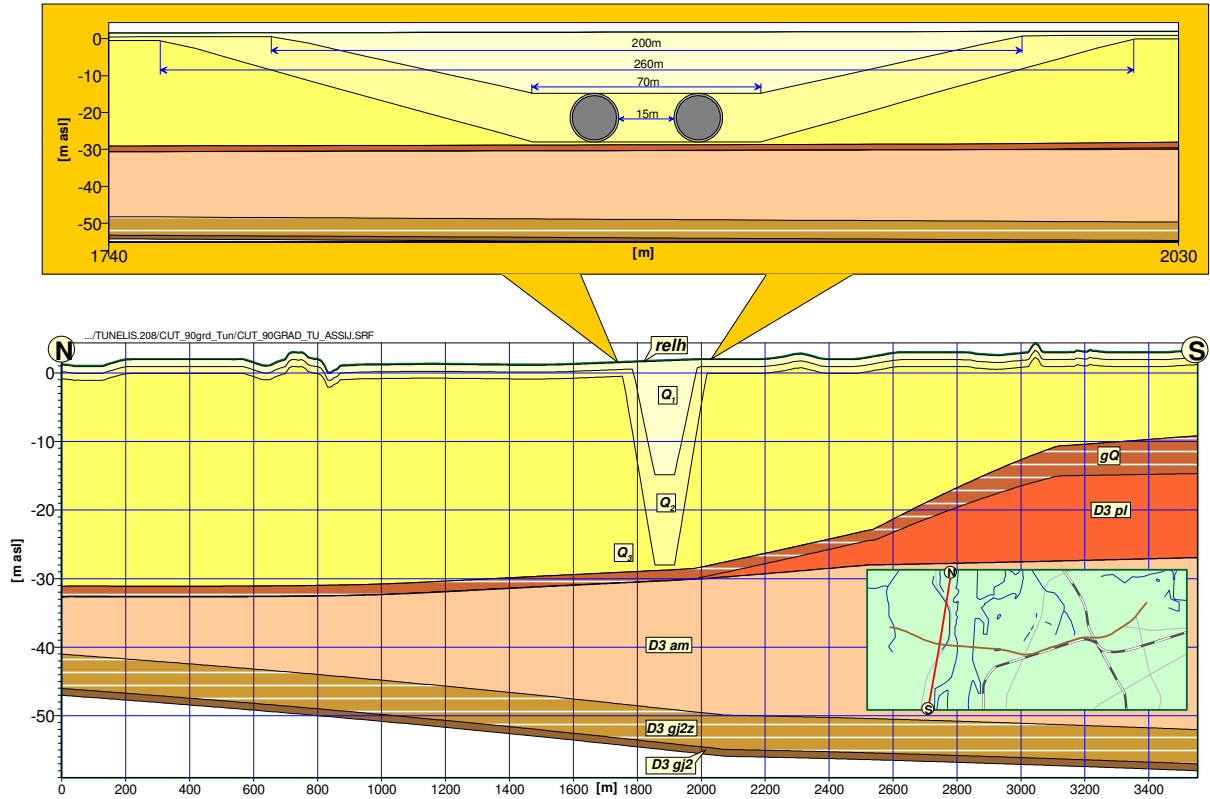


Fig. 4. Cross section NS. Approximation of the tunnel system and its surroundings

Hydrogeological model

As it follows from Fig. 3, in the Daugava river area, the tunnel bottom will nearly reach the D3gj2 aquitard (the tunnel bottom lies 5.8 metres under the road bed) For this reason, the D3gj2 aquifer head distribution φ_{D3gj2} was applied, as the HM boundary condition. Unfortunately, the current φ_{D3gj2} distribution is in process of rising, due to after-effects of the former deep depression cone that will disappear there, approximately, after (5-7) years. In HM, this expected future distribution φ_{D3gj2} is applied, because the tunnel will exist for a long time.

Table 1

Model vertical schematisation

Nr.	Name	Plane code
1.	Relief	relh
2.	Aeration zone	aer
3.	Quaternary (above tunnel)	Q1
4.	Quaternary (tunnel body)	Q2
5.	Quaternary (below tunnel)	Q3
6.	Quaternary (below old Daugava)	Q4
7.	Quaternary moraine	gQ
8.	Plavinu aquifer	D3pl
9.	Amata aquitard	D3amz
10.	Amata aquifer	D3am
11.	Gauja 2 aquitard	D3gj2z
12.	Gauja 2 aquifer	D3gj2

To account for the tunnel geometry, the Q aquifer is divided into four parts (Table 1): above tunnel (Q₁), tunnel (Q₂), below tunnel (Q₃), coarse sand layer (Q₄). It is shown in Fig.4, how the parts Q₁, Q₂, Q₃ are used, to approximate the two tunnel drives.

In Table 2, parameters of permeability for the undisturbed HM (no tunnel) layers are given. For the tunnel body, the constant permeability $k_f=10^{-3} \text{ m day}^{-1}$ is applied.

In HM, the layers relh, D3amz, D3gj2z, D3gj2 have constant thicknesses: 0.05, 0.05, 5.0, 2.0 [metres] , accordingly. To avoid the division by zero, the thicknesses $m=0$, occurring in nonexistent parts of discontinuous layers, is changed to $m=0.05$ metres

The ground surface elevation map φ_{rel} was used as the boundary condition, on the plane 1 of HM. Then the model creates the infiltration flow q_{aer} , through the aeration zone:

$$q_{aer} = (\varphi_{rel} - \varphi_Q) g_{aer} = \Delta_{aer} g_{aer} \tag{1}$$

where Δ_{aer} , g_{aer} are the thickness and hydraulic conductivity of the aeration zone, accordingly. For nodes of hydrographical network (Daugava, ditches, lakes), $g_{aerh} = 100 g_{aer}$ (Table 2). To calibrate the infiltration flow q_{aer} , the condition

$$\Delta_{aer} \geq h_{cr} \tag{2}$$

is checked, and the following correction matrix C is obtained ($h_{cr} = 4.5$ metres is a threshold that prevents further rise of q_{aer}):

$$\begin{aligned} C_i &= 1.0 && \text{if } \Delta_{aer} < 4.5 \\ C_i &= 4.5 \Delta_{aer}^{-1} && \text{if } \Delta_{aer} \geq 4.5 . \end{aligned} \tag{3}$$

The matrix C is used as follows:

$$g_{aer} = C g_{aer} \tag{4}$$

where the value (g_{aer})_{*i*} at the *i*-th node, is multiplied by the correction coefficient $C_i \leq 1.0$.

Table 2

Permeability of model layers

Aquifers (permeability k)

Nr.	Plane code	k [m day ⁻¹]	Notes
1.	relh	10.0	Boundary conditions φ_{rel}
3.-5.	Q ₁ -Q ₃	0.5	Weakly permeable
6.	Q ₄	10.0	Coarse sand
8.	D3pl	20.0	Connected to D3am plane
10.	D3am	4.0	Simulates flow below gQ plane
12.	D3gj2	3000	Boundary conditions φ_{D3gj2}

Aquitards (leakance km^{-1})

Nr.	Plane code	k/m [day ⁻¹]	Notes
2.	aer	$0.84 \cdot 10^{-4}$	$0.84 \cdot 10^{-2}$ for hydrographical network
7.	gQ	$1.5 \cdot 10^{-3} m_{gQ}^{-1}$	Depends on variable thickness m_{gQ}
9.	D3amz	16.7	Joining D3pl un D3am aquifers
11.	D3gj2z	$0.2 \cdot 10^{-4}$	Constant value

In Fig.5, the computed head distribution φ_Q of undisturbed HM is shown. This distribution accounts for influence of the ground surface and of the hydrographical network, because the φ_{rel} map is applied, as the boundary condition (Final report, 2008).

In Fig. 6, the computed graphs of φ_{rel} , φ_Q , φ_{D3am} , φ_{D3gj2} are shown, along the cross section WR. At surroundings of the Daugava river and at the Eastern part of the HM area, the ascending (discharge) and descending (recharge) vertical flows are present, correspondingly.

In Table 3, the summary of the undisturbed HM flows is given. It follows from Table 3 that the total flow through perimeter of the Q aquifer is small ($-17.3 - 7.1 + 21.1$)= -0.3 [m³day⁻¹], and the (D3pl + D3am) aquifer gives the main perimeter inflow (243.8 m³day⁻¹). The total perimeter flow is 240.5 m³day⁻¹ and it is in balance with the flows through the model top and bottom ($243.5+850.8-1091.3=0$), accordingly.

More information about other undisturbed HM features (hydraulic gradient of layers, infiltration, computed head distributions φ_{D3am} , φ_{D3gj2} , HM geometry, etc.) can be found in (Final report, 2008).

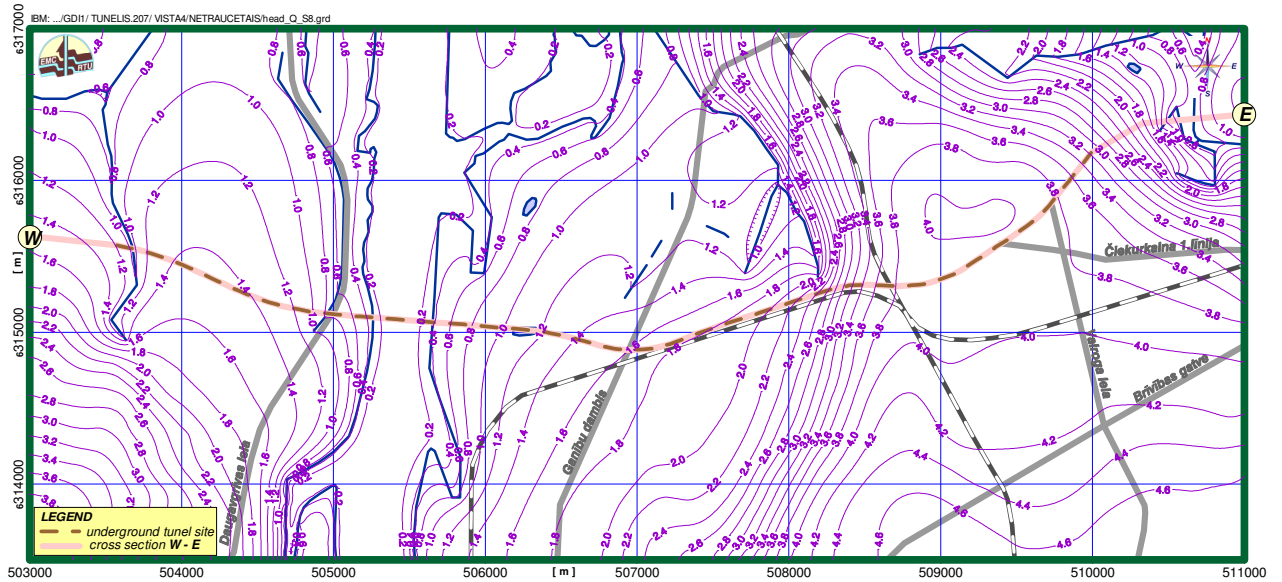


Fig. 5. Head distribution [m asl] of the Q aquifer

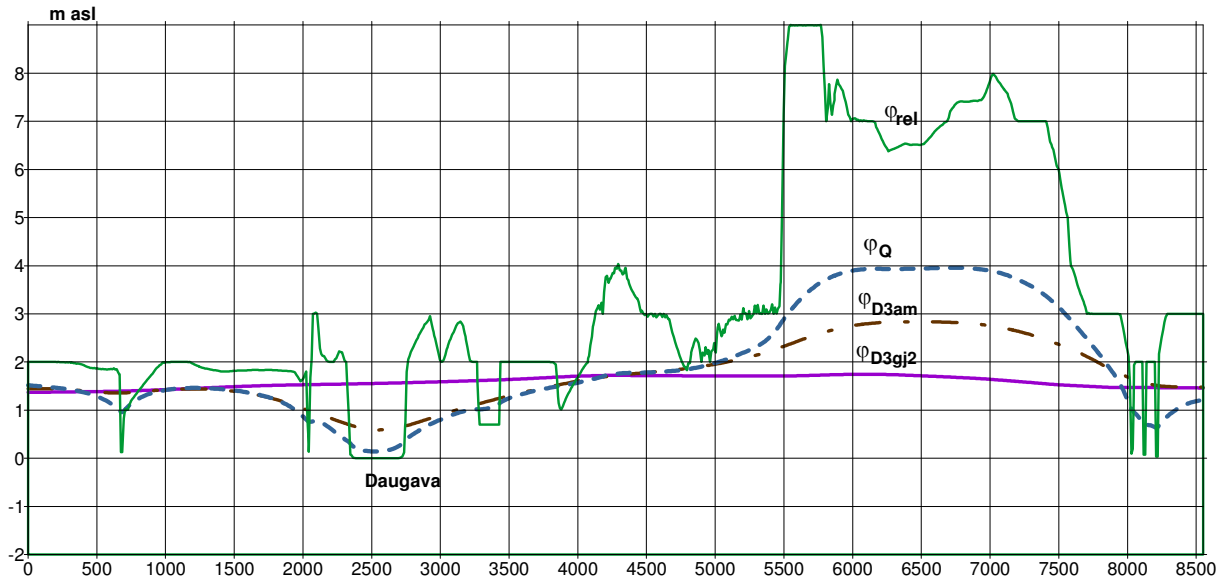


Fig. 6. Cross section WE. Graphs of ground surface φ_{rel} and heads φ_Q , φ_{D3am} , φ_{D3gj2} are shown

Table 3

Summary of undisturbed model flows [$m^3 day^{-1}$]

Plane codes	Plane top	Plane bottom	Perimetre	Total
aer	850.8	-850.8	0.0	0.0
Q1	850.8	-833.5	-17.3	0.0
Q2	833.5	-833.5	0.0	0.0
Q3	833.5	-826.4	-7.1	0.0
Q4	826.4	-847.5	21.1	0.0
gQ	847.5	-847.5	0.0	0.0
D3pl+D3am	847.5	-1091.3	243.8	0.0
D3gj2z	1091.3	-1091.3	0.0	0.0

total 240.5

Model summary: 850.8(top)-1091.3(bottom)+240.5(perimetre)=0.0

Changes of groundwater regime

To evaluate changes caused by the tunnel, results provided by two kinds of HM (undisturbed, disturbed) must be compared. Disturbed HM contains the tunnel. It was found out that both HM must have identical geometries of

surfaces used to approximate the tunnel (Final report, 2008). For disturbed HM, in locations of the two tunnel drives, their permeability $k_t \rightarrow 10^{-3} \text{ m day}^{-1}$. Before the tunnel is introduced, k_t have the values of permeability given by Table 2. Initially, the above rule of the HM geometry identity was ignored. However, it was found that using of the different geometries caused unexpected side-effects. They considerably disturbed main results that were obtained due to the tunnel influence.

It was necessary to evaluate changes of the following features: groundwater heads and flows; hydraulic gradients, meteoric infiltration. It was found out that the head change $\Delta\varphi_Q$ for the Q aquifer was the maximal one. For this reason, it is considered here. The change $\Delta\varphi_Q$ is computed as follows:

$$\Delta\varphi_Q = \varphi_Q - \varphi_{Q_t} \tag{5}$$

where φ_{Q_t} is the head distribution of the Q aquifer when the tunnel is introduced. In Fig. 7, Fig. 8 the graphs of $\Delta\varphi_Q$ are given for the tunnel surroundings. The graphs of Fig. 7 represent the change $\Delta\varphi_Q$, on the axis of the tunnel track and on two lines located at the ± 55 metres distance from the axis. On the axis, $\Delta\varphi_Q$ reaches its maximal values 0.14 metres and 0.08 metres, at locations of a ditch and a small pool, accordingly (see Fig. 5). The two other graphs confirm an expected reaction of a groundwater flow when the tunnel body partially blocks its way: the groundwater head rises and falls down before and after the obstacle, correspondingly. This phenomenon is even more evidently confirmed by the graphs of Fig. 8 where the change $\Delta\varphi_Q$ is shown along orthogonal cross sections. The modelled changes $\Delta\varphi_Q$ are small, therefore, the underground tunnel influence on the groundwater flow is insignificant. The report (Final report, 2008) provides more information about the changes in the D3am aquifer and of the groundwater gradient change in the Q aquifer and of the meteoric infiltration flow change. None of these changes are of practical importance.

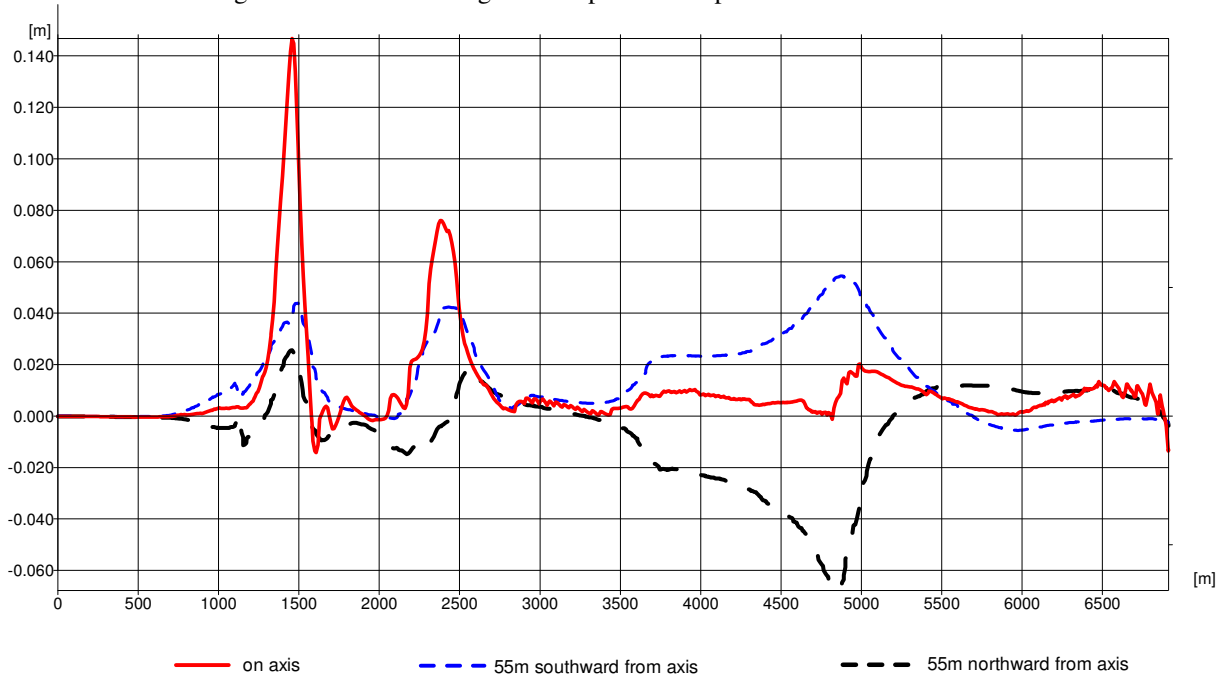


Fig. 7. Groundwater head changes along the tunnel axis

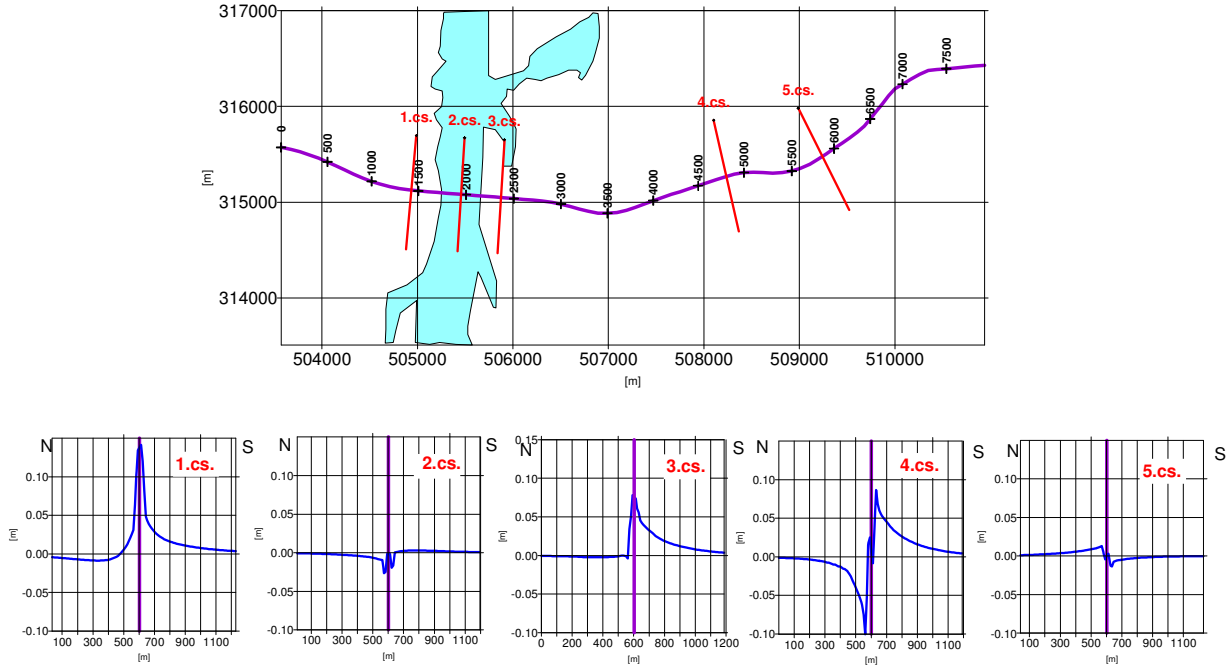


Fig. 8. Groundwater head changes $\Delta\varphi_Q$ in cross sections orthogonal to the tunnel axis

Impact of construction trenches

To build the tunnel, open dry construction trenches are necessary. To keep the trench dry, groundwater should be pumped out from its bottom part. This causes lowering of a groundwater table in the trench surroundings. If this drawdown exceeds an allowable limit then buildings and roads there will be damaged. The most harmful is the trench at the Exporta street (Report, 2008). Its size is 400m×70m and its depth may reach 25 metres.

It is evident that a watertight wall should be used, to prevent damage caused by the trench. If no wall is applied then the trench depression cone (see Fig. 9a) will harm buildings and roads at the distance (500-1000) metres.

Effectiveness of the watertight wall was estimated. Two wall parameters were accounted for:

- the leakance $l_w = k_w h_w^{-1}$ (k_w, h_w – permeability and thickness of a wall, accordingly); the values $\infty, 10^{-3}, 10^{-5}$ were tried;
- the wall bottom location: Q₄, gQ and D3gj2z layers were tried.

Parameters of the tested wall versions are given by Table 4. If the wall bottom is sited on the Q₄ layer (versions 1, 2) then even a perfect wall ($l_w=10^{-5}$) can only slightly decrease the drawdown d_t caused by the trench ($d_t=22\text{m}\rightarrow 17\text{m}$), because no wall can stop the groundwater inflow through the trench bottom sandy area (Table 5).

Table 4

Parameters of construction trench wall

Version Nr.	1.	2.	3.	3a.	4.	4a.
Leakance ^{*)}	∞	10^{-5}	10^{-5}	10^{-3}	10^{-5}	10^{-3}
Wall bottom	Q ₄	Q ₄	gQ	gQ	D3gj2z	D3gj2z

^{*)} leakance – $k_w h_w^{-1}$ [day⁻¹], k_w, h_w wall permeability and thickness

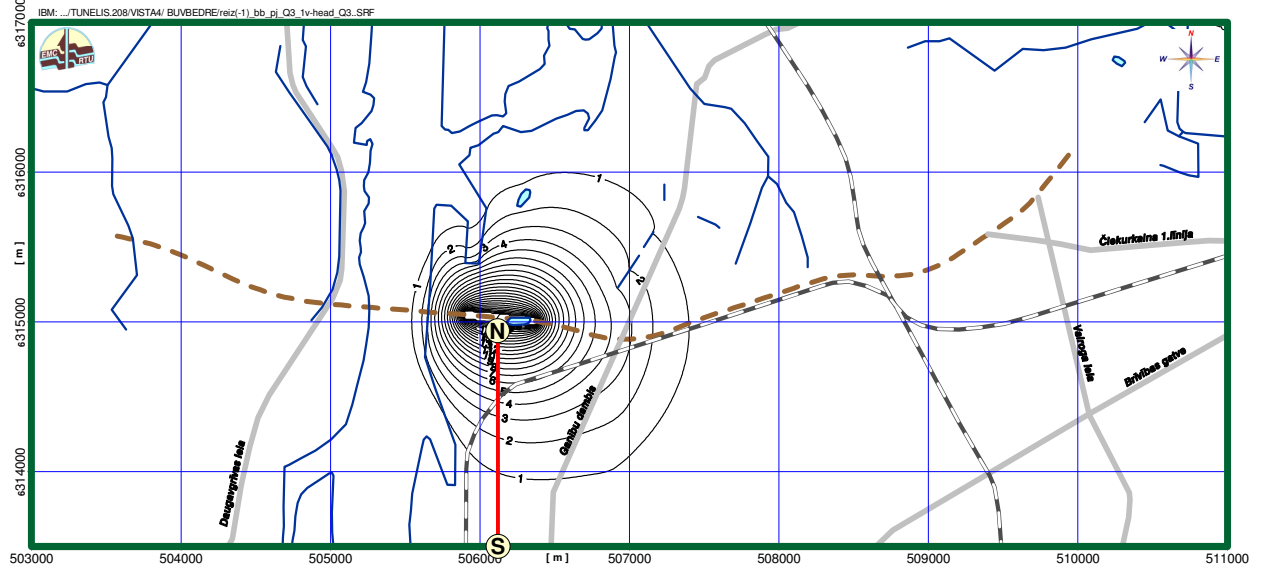
Table 5

Flow summary [m³day⁻¹] of construction trench

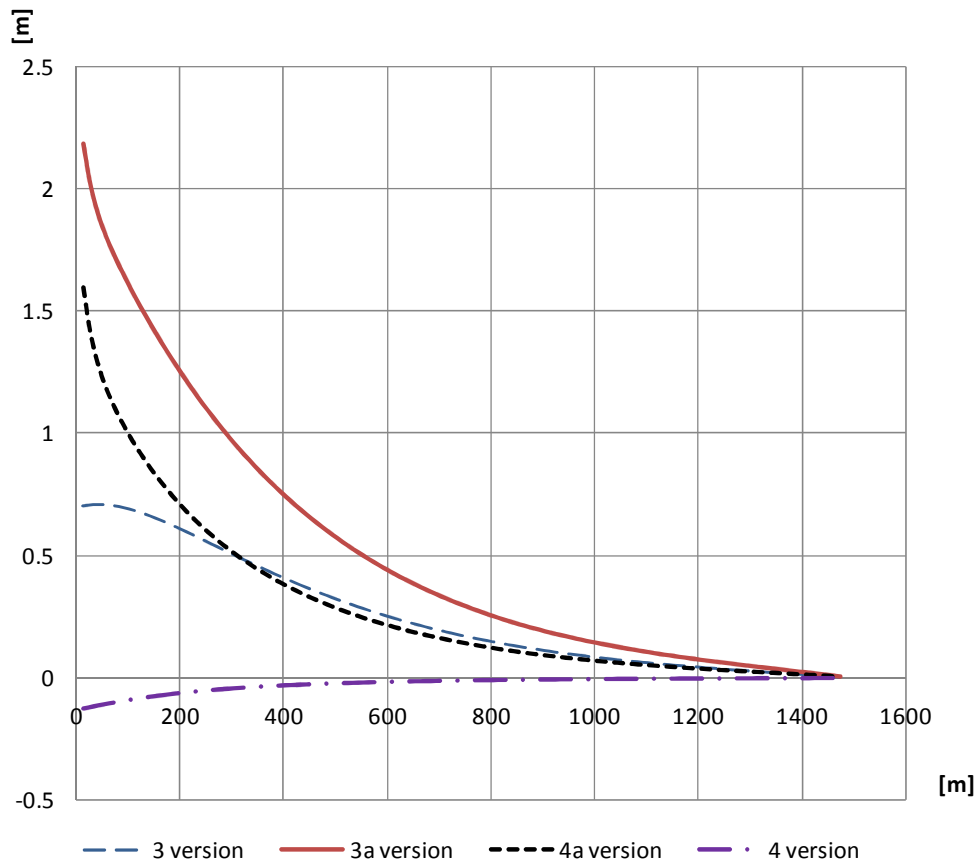
Version Nr.	Bottom inflow	Wall inflow	Pump out	Total
	1	2	3 (1+2)	1+2+3
1.	-3835.5	-3802.5	7638.0	0.0
2.	-5948.2	0.0	5948.2	0.0
3.	-666.6	-4.9	671.5	0.0
3a.	-745.1	-398.6	1143.7	0.0
4.	-134.5	-5.1	139.6	0.0
4a.	-305.1	-397.7	703.8	0.0

If the wall bottom reaches the gQ aquitard (version 3, 3a), then the wall reduces the drawdown tenfold ($d_t=22.0\text{m}\rightarrow 2.2\text{m}$) with respect to the no wall version 1.

In Fig. 9b, the drawdown graphs along the cross section NS are shown. It follows from these graphs that the wall leakance $l_w < 10^{-3}$ provides sufficient isolation of the trench, because further perfection of the wall ($l_w = 10^{-3} \rightarrow 10^{-5}$) gives a small effect ($d_t = 2.2\text{m} \rightarrow 1.6\text{m}$). Unfortunately, the gQ aquitard is thin, at the trench area (see Fig. 3). For this reason, this aquitard is no safe base for the wall bottom.



a) no watertight wall used



b) cross section NS; watertight wall applied

Fig. 9. Depression d_t [m] caused by the construction trench

Only the D3gj2z aquitard may serve, as the reliable base for the wall bottom (versions 4, 4a). Then $d_t < 0.72\text{m}$ ($l_w = 10^{-3}\text{ day}^{-1}$) and if $l_w = 10^{-5}\text{ day}^{-1}$ then the wall behaves as an impermeable obstacle ($d_t = -0.2\text{m}$). However, the wall depth reaches 50 metres (see Fig. 3). Making of such a wall is the very complex engineering task.

In Table 5, the summary of trench flows is presented. To keep the trench dry, the pump-out flow must compensate groundwater inflow through the trench bottom area and its wall. The wall considerably reduces the groundwater discharge when the wall sits on an aquitard. The minimal and maximal discharges $139.6\text{m}^3\text{day}^{-1}$ and $1143.7\text{m}^3\text{day}^{-1}$ are for the versions 4 and 3a, accordingly. For the no wall case (version 1), 7638m^3 should be pumped out each day.

It follows from the above results than making of open deep construction trenches is expected to be rather difficult.

Results

The hydrogeological model has been created to estimate groundwater regime changes that may be caused by building of the underground tunnel in Riga, Latvia. It has been found out that the tunnel itself will cause insignificant changes. During the tunnel construction time, wrongly built deep trenches, at their surroundings, may cause unacceptable lowering of a groundwater table.

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ISTEchnology – META MODEL BASED APPROACH TO IS DEVELOPMENT, EXPERIENCE AND BENEFITS OF ITS USAGE

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Abstract.

The article summarizes the experience during long years developing informative banking systems applying an own developed method based on meta model and the tool „ ISTEchnology” (IST). The mentioned tool offers a new CASE method for the development of an informative system in the conditions of varying requirements without code generation – the project interpreting method. Mentioned method is compared to well known Model Driven Architecture. The article describes meta model of IST and benefits of its usage such as easy system development from high level business model - less system development time, easy to change system - less maintenance time, automatic generation of system documentation, construction of system from pre built components. All benefits analyze are based on experience gathered in developing over then four banking systems what are used in real exploitation in different organizations in Latvia.

Keywords: Metamodel, MDA, Business model

Introduction

In 1995 the Latvian bank security inventory system was introduced. As it turned out, this system was complicated and it was difficult to develop it as the business environment turned out to be not only obscure at the beginning for the programmers, but also very variable - the users themselves had difficulties to define the requirements, also the user business developed fast creating more and more new requirements for the system.

Already at the beginning it was anticipated that in the developed system it would be necessary to make changes due to the above mentioned reasons. Therefore, it was decided to design and develop the system in a way that the process of changing is maximally easy. In the result a tool of system designing and configuration was produced that got a name “ISTehnology” (IST).

The system developed for the Bank of Latvia was successfully implemented and the project finished. Development of similar systems started for other banks where similar problems were faced again - the variable environment. Also in other later developed systems the IST was successfully applied.

The IST solution is based on metamodel. There is a metamodel database containing information about the business model of the system and the IST is able to interpret this business model – to operate the system accordingly. Through this solution it is easy to change the system – cardinal changes in the function of the system can be achieved only by changing the business model data.

Developing systems with IST the general system requirements are described in the business model that is interpreted, but the specific requirements are elaborated in a traditional way – an application is developed that implements the requirement and this application by help of a plug-in mechanism adapts in the total system.

Continuous application of IST allows to make experience based evaluation of the method. The present article summarizes the developed method and the benefits of its application. The first chapter describes the theoretical principles of IST architecture viewed contemporarily - Model Driven Architecture. The second chapter describes the Ist construction – the most essential IST components – metamodel design and its implementation. The third chapter describes the benefits of application of the method:

- Saving of labour- intensity in the development phase of the system
- Saving of labour- intensity in the maintenance phase of the system
- Saving of labour- intensity in the development of documentation of the system
- Reduced system migration to another development platform.

Related Work

When the IST technology was developed the idea of metamodel application was new and undigested. The idea to create a tool that could make exactly the system maintenance easier was original at that time. Also the idea of implementation of this tool was original – to store the functionality description of the system in the data base so that the tool could interpret it ‘Iljins (2004)’. Other automated system development tools, for instance, the specification language GRAPES developed in Latvia and its environment (Development Environment) GRADE ‘(Treimanis, 1992; Bicevskis, 1992)’ offered the design defining, prototyping, but in the implementation of the system code generation was unavoidable. Similarly also the widely applied tools RATIONAL ROSE ‘Quatrani (1999)’ and ORACLE Designer 2000 ‘Oracle (1995)’ etc. that became popular later could not do without code generation.

At present architecture based on models and their transformations has become popular - Model Driven Architecture (MDA). MDA is the software development frame developed by the enterprise Object Management Group (OMG). Its most characteristic feature is the importance of the model software in the development process 'Kleppe (2003)'.

MDA consists of the following main modules:

1. Platform Independent Model (PIM)

This model has a very high abstraction level and it is completely independent on the development technology. PNM is developed from the point of view of business requirements. It describes the system design or business model. In this model it is not important in what programming language the system will be developed or on what platform it will operate. It is not important how the system will operate but what the system will perform.

2. Platform Specific Model (PSM)

The next step is PNM transformation into one or several platform specific models (PSM). PSM describes one definite technology of system implementation. PSM contains specific terms of a specific platform, for instance, in the context of PSM relation data base such terms as "table", "column", "scheme" etc. are included. Only those designers who have knowledge on the corresponding platform understand the PSM construction. Every PNM can be transformed to one or several PSM, that is, for every specific technology platform.

3. Code

The last MDA in the cycle of development is in the code of every PSM transformation. So, as PSM is very close to the corresponding technology, transformation is relatively simple.

So, MDA defines PIM, PSM, the code and how they all will mutually operate. Developing a system PNM should be developed first, then transformed to one or several PSM that, in turn, is transformed in the code. The most complicated step in the process of MDA development is transformation of PNM to PSM. The description of MDA shows that transformation of the system description from one model to other and code generation have become unavoidable steps in the development of automated systems.

Although the IST technology historically has developed independently of MDA, its operating principles can be found in this architecture. ITS is developed PIM (called also IST metamodel) that describes the system operation on the highest business level. The models of lower level (PSM and code) are included in IST tools that are developed for definite environment. The IST tools can interpret PIM in a definite platform ensuring the system operation in actual exploitation. The IST tools include the specific model descriptions of the platform and PIM transformations to them. It can be considered that IST is developed in accordance to MDA, nevertheless there are differences. Provided that MDA code generation is an integral component, IST can do without it. If MDA PIM is transformed to PSM, IST PIM is interpreted and PSM is included in the interpreter.

Description of ISTechnology metamodel and implementation

IST model in the MDA context serves as PIM. It consists of several modules that all together describe the functionality of the system on the business level. Interpreting the functionality described in IST metamodel system operation takes place in actual exploitation. This chapter will describe some of the most important IST metamodel modules and explain how they are interpreted. As IST practical application is mainly in banking systems, banking terms will be used in the examples.

Work place module

The work place module is the central IST module that describes the system core and basic user interface. Figure 1 shows the model design of work place module objects in Object-Oriented Design notation 'Ruabaugh (1991)'.

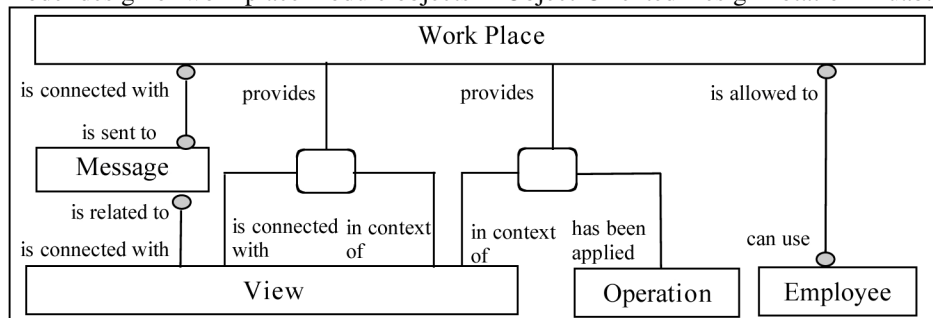


Figure 1 Work place module

In the work place model the Work Place is defined that determines the rights of the employees and the working environment in the system. In relation to Work Place Employees are defined who can login to it.

In relation to Work Place also Views are defined. The ternary link between the work place and views allows for development of a hierarchic view structure within the work place. Every view contains definite objects selected

from the data base. The sub-views subject to the view contain objects for which the objects within the views of higher levels serve as the selection criteria parameters.

Operations that can be done with a definite object within the view can be connected to the view within the work place. Disarranging the operation an application outside IST is created that receives the selected object in the view as a parameter.

Work places are defined according to the descriptions of employee posts that have the rights to work with the system. In the currency operation system the most typical work places are

- Dealer work place – where transactions are necessary
- FX/MM Back Office Work Place – transaction processing views and operations are concentrated.

Work place implementation is shown in Figure 2, it shows the main window of the IST system work place.

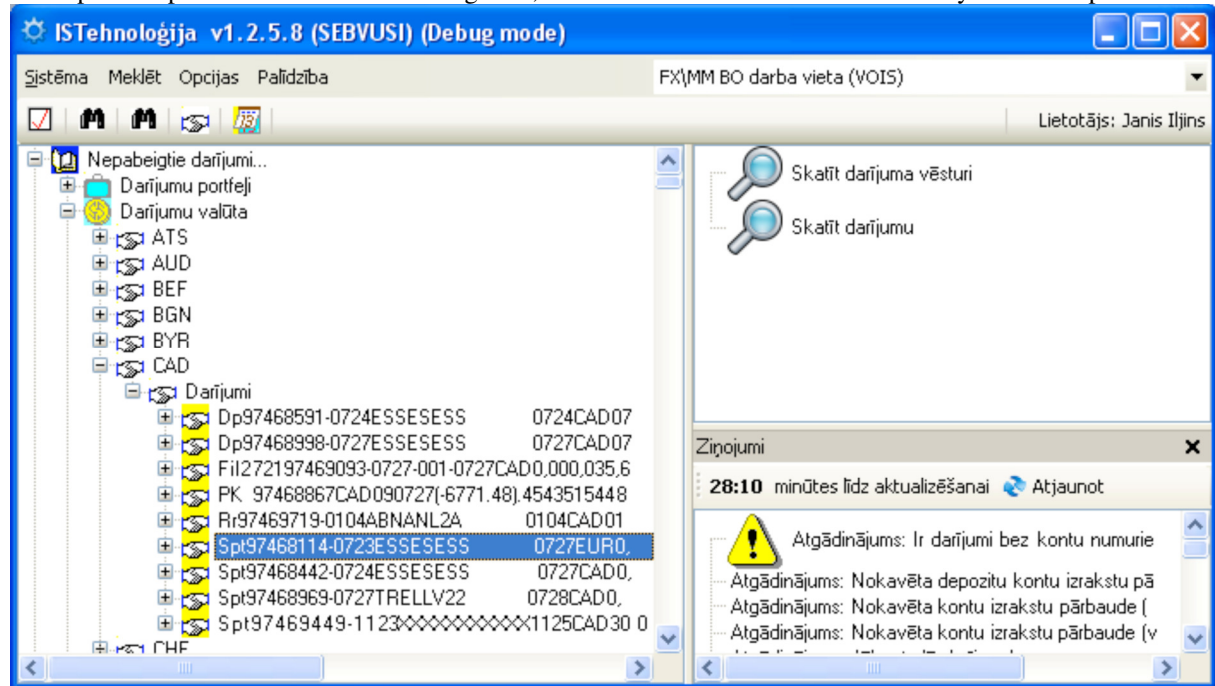


Figure 2 IST work place main window (Back Office work place)(the example is authentic taken from a banking system in the Latvian language)

On the left side of the main window the hierarchic structure of the work place views is depicted (Figure 2). The view shown in the example “Currency of the deals” (org. “Darījumu valūta”) contains the descriptions of currencies. The view definition includes the request to data base (SQL SELECT statement) that returns all currencies defined in the data base. The view “Currency of the deals” has a sub-view “Deals” (org. “Darījumi”) that contains the concluded transactions in the selected currency. The definition of the view “Deals” includes the data base request (SQL SELECT statement) that returns the deals the currency of which is shown in the parameters. The parameter value is determined from the selected object in one level up view (currency).

In the right upper part of the window (Figure 2) operations that can be done with the object selected in the view tree are shown. Selecting the transaction in the view it can be edited or processed as necessary. Double click the operation the “exe module” is called that receives the selected object as a parameter and carries out corresponding operations with it.

In the right lower part of the main window the Messages defined to the work place are depicted. The definition of every message contains the data base request (SQL SELECT statement), if the statement returns an empty data set the statement is rejected, if data set is not empty, it is displayed. The list of the messages regenerates automatically after a definite interval of time. The messages make it possible to follow the changes in the data base that are made by the other user. For instance, if the dealer in the dealer work place has made a deal, in the Back Office work place a message appears that the deal should be processed.

Process Module

The Process Module allows to define the scenarios of state transitions for a class of the data base objects. The object that is processed according to the state transition scenario is in a definite position. During the processing the state can be changed. The Process module saves the history of state changes. In the above mentioned view tree it is possible to define the views that depict the objects in a definite state. Operations are subject to the views. As an object can be in a state only in the defined order there is a possibility to define the order how the object will appear in the views and with this in what order it is possible to carry out operations with the object. This way the Process module defines the sequence of processing for the data base objects.

Figure 3 shows the design of the Process module object model in the Object-Oriented Design notation ‘Ruabaugh (1991)’.

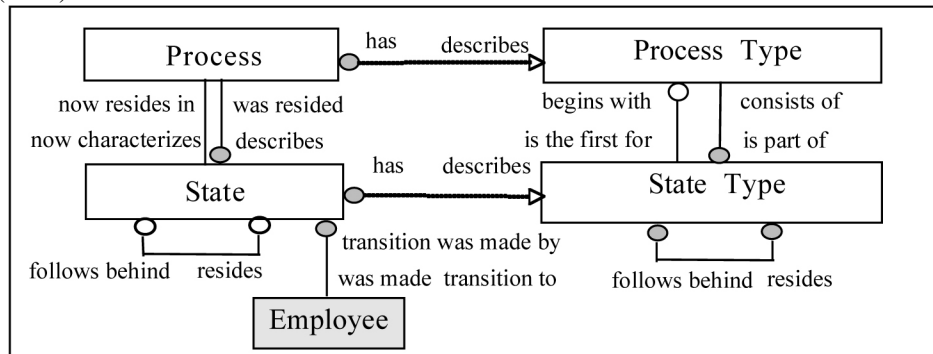


Figure 3 Workflow module

In the implementation in the banking currency operation system several state transition scenarios were defined for deal processing. Some scenarios are applied depending on the risk factor of the deal and the type of deal. Some of the most typical deal processing scenarios:

- Risk currency exchange deal processing
- Non-risk currency exchange deal processing
- Processing of invested deposits
- Processing of loan deposits

Figure 4 shows one of the most typical state transition scenarios – a risk currency exchange deal processing scenario in a diagram.

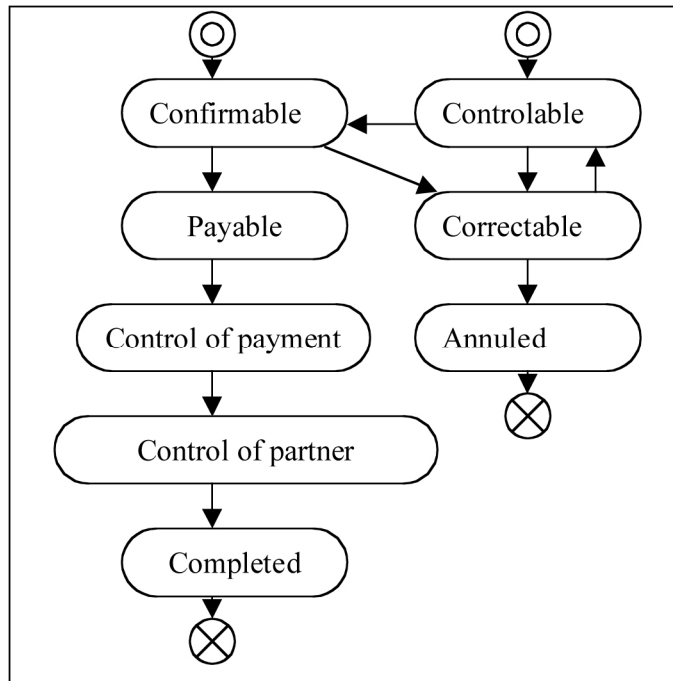


Figure 4. Example of state transition diagram

Reports Module

The Reports module allows to define the most part of the necessary reports that have to be printed by the banking system. The Reports module contains descriptions how the content of the report as well as the design is to be made. It is possible to describe in the Report module that:

- the report is divided in blocks, every block can have its own design and content. The block is described by the Report module class ‘Info set’. The block definition contains the demand to the data base that determines the content of the block
- the report can contain tables for which the number of rows is determined by the amount of the selected data. For every column of the table different number of design style can be defined. It is possible not to select the column value from the data base but to calculate by help of formulae from the values of other columns. Often the total sums of the selected numerical values are calculated. The table column is described by the Report module class ‘Info unit’.

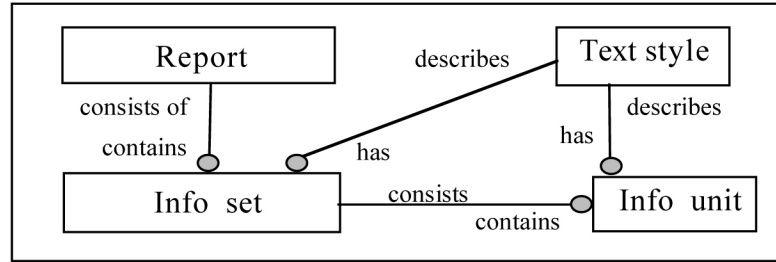


Figure 5 Reports module

Application that according to the report definition given in the Report module can develop a report in Rich Text format that can be opened and printed by the text redactor Microsoft Word is included in IST implementation.

The described ones are not the only ones but the most essential IST metamodel modules. Besides the described ones also the following modules can be mentioned

- Observation module – ensures logging of changes of data in the data base.
- Object module – develops the description of the data base that is used in system prototyping.
- Organization module – forms the descriptions of organizations necessary for business and descriptions of their structural units.

All IST metamodel modules together form the business model of the developed system ‘(Treimanis, 1997; Iijins, 2008)’.

Assessment of the method

Experience of IST application

The existence of IST has proved a typical advantage of MDA – transformations from PIM to PSM can be repeated in several systems. By IST different systems have been developed that are introduced in several banks in Latvia. Introducing every next system only the system business description coded in PIM as well as the specific applications that perform the specific business functions of every system are changed. Some of the newest IST applications that are applied in real exploitation:

Table 1

IST applications		
Bank	System	Year of app
SEB (at that time Latvijas Unibanka)	VOIS – currency operation informative system	1996
The open-ended pension fund ‘SEB atklātais pensiju fonds’ (at that time ‘Unipensija’)	Pension fund registration system	2000
SEB (at that time Latvijas Unibanka)	VUS – security registration system	2002
SEB Wealth Management (at that time “Unifondi”)	Finance governor registration system	2004
AS ‘NORVIK ieguldījumu pārvaldes sabiedrība’	Finance governor registration system	2007
Regionāla investīciju banka, joint stock company	VUS – security registration system	2008
State JSC ‘Mortgage and Land bank of Latvia’	Finance governor registration system	2009
State JSC ‘Mortgage and Land bank of Latvia’	VUS – security registration system	2009

Application of software components in ISTechnology and labour-intensity of system supplementation

A system developed by IST consists of the main module – central component of the system that ensures connection of the user to the system and work at the chosen work place (Figure 2). This component is equal in all developed systems. Besides the main module the system contains also a lot of specific applications that ensure the business functions of a definite system and that are called by the operations chosen by the user in the main module. Among the specific applications there are such that can be configured for a definite application and used in different systems and in different contexts. Such applications are called system components. Components of the system are already ready and there is no need to develop them anew. The most typical operations that are carried out with the components:

- Object position change in accordance with the position transition scenario defined by the IST Process module,
- Registration of the simplest objects in the database and erasing from it,
- Determination of the simplest links between objects,
- Development of reports according to the report description defined in the IST Report module.

Repeated application of the components saves the labour-intensity of the system development. With more than ten years long experience of IST application guidelines evaluating the labour intensity have developed for new system supplementations. The guidelines are based on expert-judgment-based software effort estimation where

the experience of before implemented applications is used 'Jorgensen (2005)'. Demands for development of new functions can be divided:

- the new system function can be implemented only through changes in the IST metamodel data, the work place views should be re-configured and new operations introduced that will call the components that have been developed before
- in order to implement the new function a new specific application has to be developed.

The expert decision determines that for development of the functions of the first kind approximately three times less labour-intensity is needed than for the new functions of the second kind.

The proportion of component application and configuration in the development of the whole system was evaluated. For this purpose the number of the developed specific applications was compared to the number of repeatedly used components in two different systems that are developed with IST – VOIS and in the system of the Pension Fund. All applications that the system consists of are divided in four categories

- IST applications – IST technology functional shell applications ensuring its operation as well as business module input and configuration of the system.
- Configured components – repeatedly used, configured applications that are applied in many IST formed systems and for different business assignments.
- Reports – components for preparation of reports.
- Specific applications – applications developed especially for a definite system for implementation of specific business requirements.

Figure 6 shows the proportion of the applied applications in these categories in the Pension Fund system. Analogically Figure 7 shows the proportion of modules according to their application in the VOIS system.

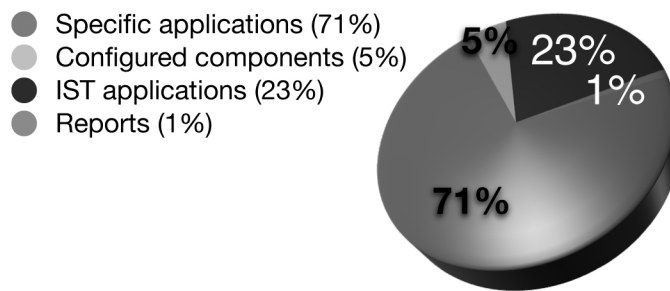


Figure 6 Proportion of applications according to the number in categories in the Pension Fund system

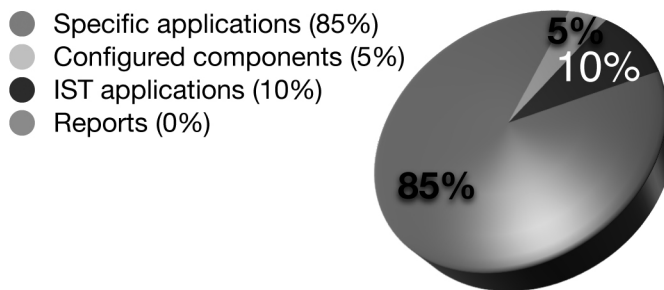


Figure 7 Proportion of applications according to the number in categories in the VOIS system

Considering the IST work place configuration it can be concluded how many times each application is used in the system. The next figures (Figure 8 and Figure 9) show the proportion of operations in the categories of called applications. Figure 8 shows the proportion of the number of operations according to what category application is called in the Pension Fund system. Analogically Figure 9 shows the proportion of the number of operations in the VOIS system.

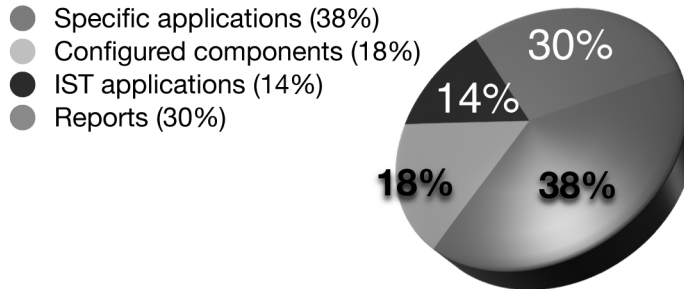


Figure 8 Proportion of application usage in the Pension Fund system

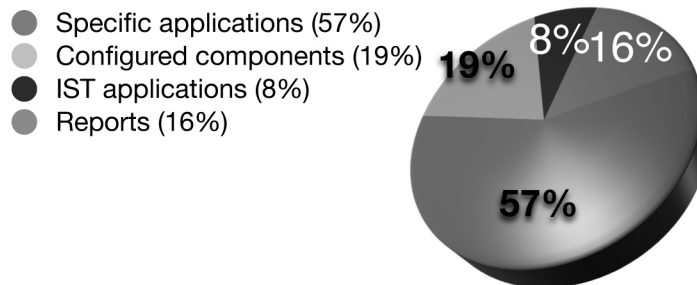


Figure 9 Proportion of application usage in the VOIS system

The Pension Fund system is simpler, the number of applications in it is less and due to this the components have managed to implement even more than a half of the assignments of the system. Nevertheless, also in the large and complicated VOIS system almost a half (in total 43%) of business assignments were implemented by help of configuration so saving the development time.

System migration to another platform

IST applications are used in actual exploitation already for more than ten years. During this period of time IST and system development platforms developed by it have become out-dated, new ones have appeared instead of them. The first IST versions were developed in Centura SQLWindows environment using the version 1.1., later the version 1.5. Today none of these versions is maintained. Therefore, a decision was taken to migrate the IST code from Centura SQLWindows to the up-dated Microsoft .NET. Actually such migration meant to write the IST code once more in another programming language. At the same time IST architecture gave an essential contribution and advantages in system migration:

- IST is common for several systems that need migration. Migrating several systems it was necessary to rewrite the IST code only once.
- Systems developed with IST have modular structure. The system consists of many small applications. Due to this it was possible to do the system migration in parts. In the transition stage both platforms can be applied simultaneously. A part of applications is working in the new environment, a part – in the old.
- As the IST components in systems are used repeatedly in different contexts rewriting one component, several business functions are transferred in the new platform. For instance, in the VOIS system rewriting 15% of the system applications in the new platform already 43% of the system are operated.
- IST metamodel forms platforms independent of the system functionality description. Transferring to another platform the platform specific metamodel interpreter the model itself and the system functionality description saved in it had not to be changed at all.

Analysis of the number of change requests and labour-intensity of maintenance

Let us discuss the history of the VOIS system change request implementation. Since September, 2003 579 change requests were implemented. The listed change requests were analyzed according to what was changed on account of the request:

- IST applications – corrected or supplemented ISTechnology functional shell applications that ensure its operation as well as the input of the business model or system configuration.
- Configuration components – reconfigured frequently applied components or added new operation that uses the already existing component. In other words, the change demand is implemented introducing the changes in the business model.
- Reports – reconfigured existing reports or new ones added.
- Specific applications – corrected specific applications developed for a definite system – changed

- algorithm, the application program code.
- Changes in the data – in the result of the change request changes in the system have not been necessary. Instead the data of the data base have been corrected or even it has been enough with consultation on the system application for the final users.

Figure 10 shows the proportion of the number of change requests in the mentioned categories.

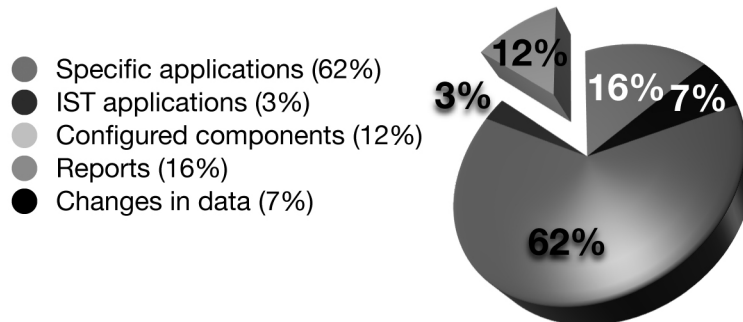


Figure 10 Total number of change requests

In turn, Figure 11 shows the proportion of the consumed time for the implemented change requests in the above mentioned categories.

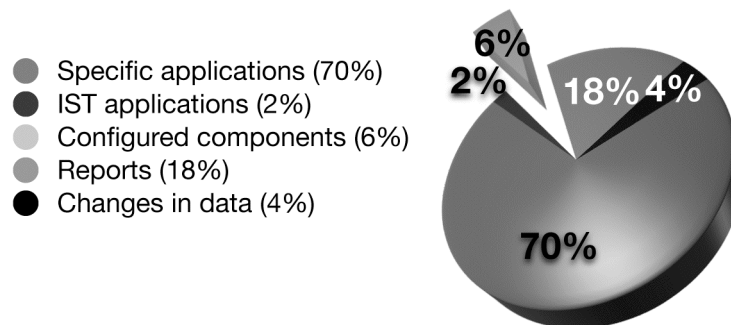


Figure 11 Total time consumed for change requests

The diagrams show that there are less business model changes than specific requirement changes, including correction of errors in implementation of the specific requirements. Nevertheless, for implementation of changes in the business model approximately two times less time is consumed than for implementation of changes in implementation of the specific requirements (12% of change requests consumes 6% of time).

Generation of documentation

Evidently, with the developed system also the system documentation is to be developed. It is usually a time consuming work. IST architecture allowed to automate also this process. The functionality of the system developed with IST is described in the metamodel data base. Using a method characteristic for MDA – transforming the system description from the IST metamodel to the metamodel describing documents a system describing document is obtained. For instance, the system user guide describes the functionality of the system. But the functionality is described in the IST metamodel work place module (Figure 1). The document is described by the IST metamodel Reports module (Figure 5). Defining a report in the Report module on how the document should look like and how its data can be obtained from the Work place module transformations were defined that obtain the system user’s guide.

Generation of documentation is one of the IST development projects being implemented at present. Presently the documentation generator is in the testing phase, soon it will be introduced in actual exploitation. During its development different technical problems were faced, also the ITS report formation component had to be supplemented. An additional tool was developed that could form the system window screen images and insert them in the report.

Several documents were developed by a similar method – the most part of the necessary system documentation:

- User’s guide
- Data base design description
- List of installed units.

Traditionally it is considered that it is ‘uneasy’ to read computerized documentation. Though, resources for development of documentation are essentially saved as well as the developed documentation precisely corresponds to the actual functionality of the system. Working at the comments of the concepts described in the IST metamodel from which the texts included in the documentation are formed more carefully, it will be possible to develop readable system descriptions with small consumption of resources.

It is prognosticated that after introduction of the documentation generator for restoration of the user's guide approximately 87% of the consumed time resources will be saved (Figure 12).

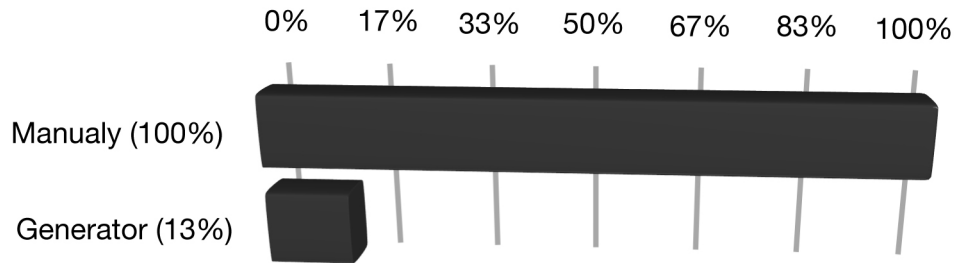


Figure 12 Time consumed for development of the user's guide

Conclusions

The article describes the informative system development method and the tools for its support ISTechnology. The method has proved to be viable as several informative systems that are applied in actual exploitation already for more than ten years have been developed with it. Although IST could be used in the development and application of any informative system it has proved its advantages exactly in the banking sphere where the introduced systems have the following characteristics:

- the systems are small but complicated
- user requirements are often changing
- user requirements are often indistinctly formulated
- applying the existing functions simultaneously new functions are developed.

Development of the IST system is based on metamodel. The business model of the system is developed in accordance with the metamodel. The IST tools interpret the developed model ensuring the operation of the system in actual exploitation.

Analyzing continued experience of IST application the benefits of the system application were evaluated. The main of them:

- The system has a modular structure. New functions can be easily added. The system can be developed and introduced gradually in separate modules.
- The IST tools and several software components can be used repeatedly in several systems. Due to this many requirements in the development of the system can be implemented only with changes in the system business model. In such cases the labour-intensity is saved approximately three times. In total, this way approximately 25-45% of the system functionality can be implemented.
- In the system maintenance phase from the users less reports on errors are received on the potentialities of the system implemented in the business model than on those that are implemented in the specific applications of the system. The processing time of the business model error reports is approximately two times less than for the specific applications.
- Repeatedly applied components facilitate transfer of the system to another development platform.
- The system functionality described in the metamodel allows for automated development of the system documentation. It has been planned to save up to 87% of the time necessary for writing of documentation.

The observed benefits of the application of the method create a stimulus for further development of the method. The documentation generator was developed recently, soon it will be introduced in actual exploitation. At present the IST self-testing component is in the development stage; it will ensure storage of the test examples and performance of regressive tests for the new versions of IST specific applications 'Diebelis (2009)'.

It would be necessary to develop also the repeatedly applied software components for making it possible to implement the largest part of the system only through configuration of the system business model thus saving the above mentioned resources.

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MODEL OF DECISION MAKER AS OPTIMIZATION PROBLEM FOR GENETIC OPTIMIZATION ALGORITHM

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Abstract

Interactive Multiobjective procedure represents interactive process where Decision Maker (DM) gives for interactive multiobjective optimization method a preference information about optimization criteria and search process continue from one solution toward to another until DM will be satisfied with obtained solution(s). Then testing and comparing interactive optimization methods we need to replace real DM with his model to exclude the factor of preconception and obtain more clean results. Exists two ways of comparing optimization methods: in mathematical way and in human way. This work introduce the mathematical type of methods comparison. The model of DM is designed as optimization problem for multiobjective optimization genetic algorithm (MOGA).

Key words: multiobjective optimization, MOGA algorithm, decision making, interactive optimization methods.

Introduction

After designing a new optimization method or for comparing optimization methods we need to use different approaches for testing or comparing optimization methods/algorithms. An approach depends of optimization method(s) which we need to test or to compare. Usually the approaches are divided into two classes: human-oriented and mathematical. First class is used for a posteriori and interactive optimization methods, because human partly or fully influence the optimization process. Second- only for a priori methods, where human only define optimization problem and then method try to solve it. Human in the two classes is Decision Maker (DM), sometimes (in the second class) human is only analyst Miettinen (1999).

This work introduce to testing interactive multiobjective optimization methods using mathematical approach by using multiobjective genetic algorithm (MOGA) introduced in (Fonseca and Fleming, 1995). All figures in the paper are created by author. The form of multiobjective optimization problem is Miettinen (1999):

$$(1) \quad \begin{aligned} & \text{minimize } \{f_1(x), f_2(x), \dots, f_k(x)\} \\ & g_m(x) \leq 0, \\ & h_l(x) = 0, \\ & \text{subject to } x \in S. \end{aligned}$$

where $k (\geq 2)$, objective functions $f_i: \mathbb{R}^n \rightarrow \mathbb{R}$. We denote the objective vector $f(x) = \{f_1(x), f_2(x), \dots, f_k(x)\}$. The variable vectors $x = \{x_1, x_2, \dots, x_n\}$ belongs to the feasible region (set) S formed by inequality and equality constraints $g_m(x)$ and $h_l(x)$.

In the methods of interactive multiobjective optimization, DM plays the main role in the optimization process. Because in every iteration DM define preference representation information or preference information. The optimization process starts from initial solution in Pareto set and continue until DM stops the process (see Fig.1). Decision maker can define weights, marginal rates, ϵ - constraints and etc., or use one of the lexicographical forms.

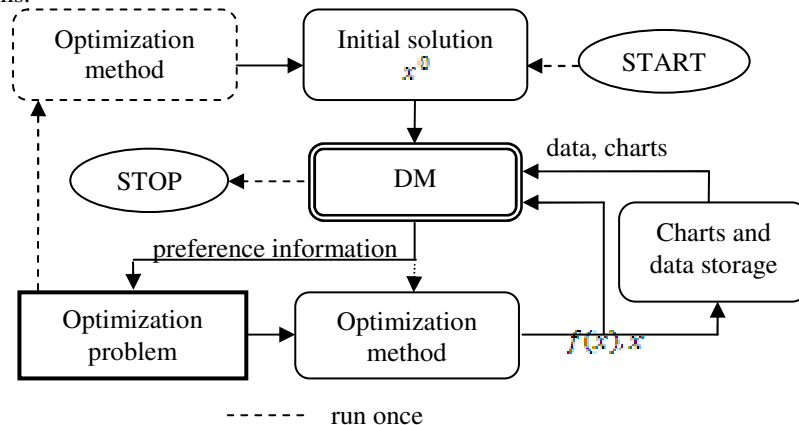


Figure 1. Interactive optimization procedure

In testing or comparing an interactive optimization methods arise one typical situation: the DM adapts to the testing optimization problems and use previously acquired experience (Zujevs and Eiduks, 2008). This impact reduce reliability of experiment's data. This kind of problem can be solved into two ways: 1) every human DM solves optimization problem at once; 2) using a model of DM or value function. In the first way we need invite into experiment large count of decision makers (up to 20), sometimes it is not possible. For example: (Benayoun and etc, 1971) was used 98 decision makers to test CONTEX optimization method; Wallenius (1975) was used 36 students as decision makers to compare GDF, STEM and Trial-And-Error methods; in Buchanan (1994) work was used 24 decision makers to compare SIMOLP, GUESS and Tchebycheff method; in (Corner and Buchanan, 1997) work was used 84 decision makers to compare ZW, GUESS and SMART methods. In the second way/approach instead of human DM bring into use value function. For example: in (Mote and etc., 1988) work was used nonlinear value function for compare GDF, STEM and SWT methods: in (Reeves and Gonzalez, 1989) work was used linear and nonlinear value function to compare Tchebysheff and SIMOLP methods; the work (Aksoy and etc., 1996) authors are used value function together with human DM. Comparison or testing's criteria are depends of way of testing (human DM or value function). In human-oriented experiments usually use the following criteria (adapted from (Ringuest and Downing, 1997)): 1) DM satisfaction of last obtained solution; 2) easy of 'handling'; 3) simple to understanding; 4) support of decision making; 5) iteration count; 6) spent time; 7) preference information impact of obtained solutions. In the experiments with value function usually use criteria/metrics: 1) iteration count; 2) spent time; 3) Euclidian distance to goal solution; 4) general distance; 5) spacing; 6) overall nondominated vector generation metric and etc. The last three metrics usually used in testing of the evolutionary algorithms Veldhuizen (1999). Author of paper suggest to use model of Decision Maker instead of value function. Paper describe the environment (testing ground) for testing interactive multiobjective optimization methods.

Methods and algorithms

For convenient testing of optimization methods it is necessary to use the special environment or testing ground, which consist of the following units: execution unit, decision maker unit, parameters definition unit, database of results, graphic unit, testing problems unit, optimization methods unit, statistics unit and metrics unit (see Fig.2.) Parameter definition unit sets all necessary parameters and constraints for experiment(s). Then execution unit perform method(s) testing on specified problem(s) using model of decision maker. During experiment execution unit saves metric's data into the database (DB). DM unit decide to continue optimization process or to stop it and provide preference information for optimization method(s). Graphic unit helps to understand and visualize experiment data for future analysis. Statistics unit provide statistical analysis of experiment's data.

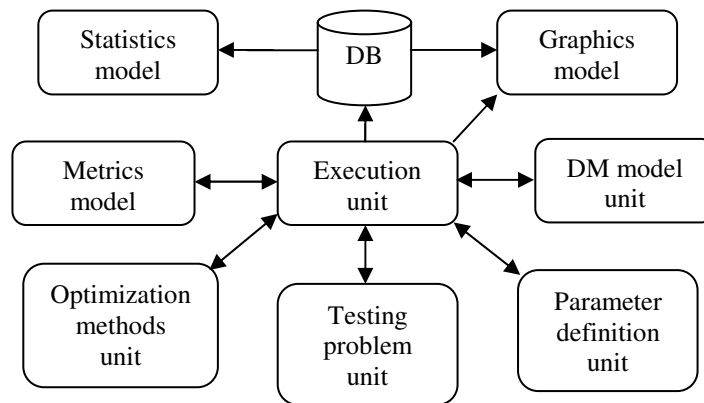


Figure 2. Conceptual scheme of testing ground

Model of Decision Maker is defined as multiobjective optimization problem of two objectives: Euclidean distance to goal solution $f(x)^{**}$, correctness of preference information for conditions of method definition. The problem mathematical definition is:

$$(2) \quad \begin{aligned} & \text{minimize } \{f_1(P, x_i), f_2(P, x_i)\} \\ & \text{subject to } P \in S_{pref} \end{aligned}$$

where f_j are the functions of two arguments: first- DM preference information, second- i -iteration solution of optimization process for initial solution $x_i = x^0$; P - the preference information of interactive optimization method, P belongs to the S_{pref} preference information feasible region (set). In (2) definition x_i is constant and P is problem variable.

Function $f_2(P, x_i)$ is defined as Euclidean distance from solution $F_T(x_i)$ to $F_T(x_{goal})$, where F_T is a testing problem function vector $F_T(x) = \{f_1^T(x), f_2^T(x), \dots, f_m^T(x)\}$ and t - means for clarity the function of testing problem. Function $f_2(P, x_i)$ is defined as penalty function based on difference between correctly defined preference information and P . For example for Weighted-Sum method sum of weights need be equal to 1, but if $sum(P) > 1$, then $f_2(P, x_i) = 1 - sum(P)$. The second function definition is depended from interactive optimization algorithm that we need to test or compare.

Minimizing (2) author imply that optimization processing for one of the optimization algorithms and one of the testing problems.

Optimization problem (2) can be solved by binary-coded multiobjective optimization genetic algorithms (MOGA) which is more preferable instead of classic optimization methods. For more information of MOGA we can find in (Binh, 1999, Deb 2004) works. MOGA algorithm belongs to the class of evolutionary algorithms and partially inherits their characteristics:

1. Evolutionary algorithms are stochastic.
2. Evolutionary algorithms cannot guarantee that obtained solutions belongs to the theoretical Pareto set.
3. Good possibilities of parallel execution.
4. Evolutionary algorithms can obtain Pareto set trade-off.
5. Optimization time can be limited by generation count or by other parameters.
6. After optimization DM can choose more preferred solution from solutions set.
7. Evolutionary algorithms are not depend from criteria derivates.

Modeling decision maker by using evolutionary algorithms we need more critically looking on 1. and 6. previous points. First one is more critical than sixth, because stochastic characteristic negatively impact decision making process. This work introduce why it is possible in decision making, this will be discussed in depth later.

Model of Decision Maker (DMD) is described below. At each iteration the DMD receive from the execution unit a current iteration variable X_c , values of testing problem F_T , the values of F_T for all previous and the current iteration i as list and receive goal's values of $F_T(X^{**})$.

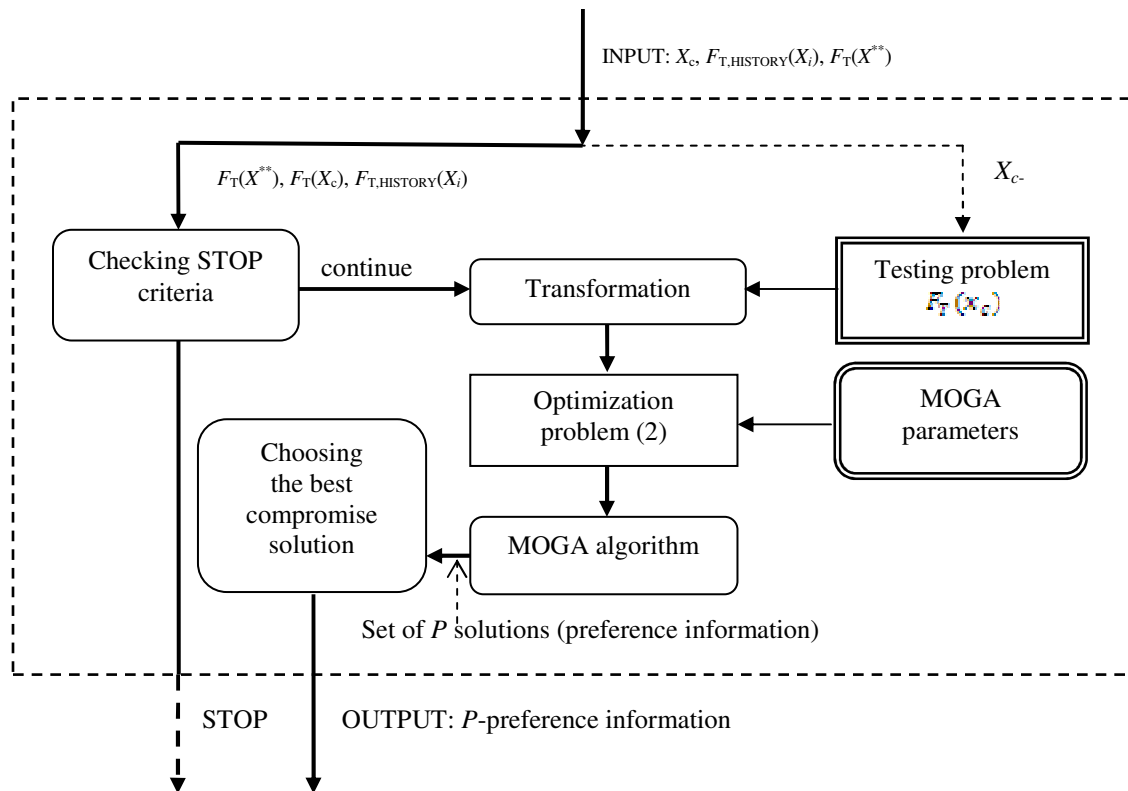


Figure 3. Model of Decision Maker

Before DMD will find a preference information for current iteration- i , DMD perform checking for stop criteria. There are two types of stop criteria: stop if optimization process converge to the goal solution very slowly or stays on same level (Fig.4.), stop if optimization process move away from the goal solution (Fig.5).

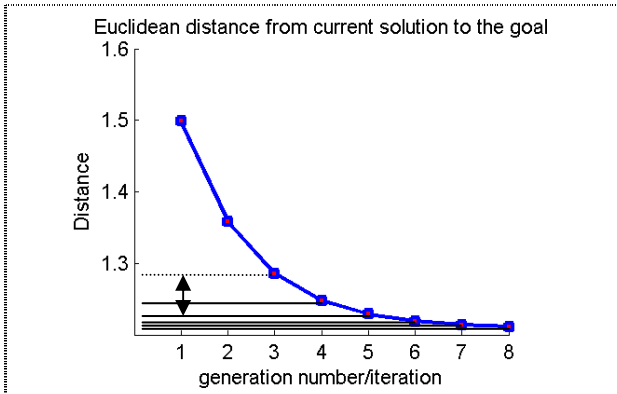


Figure 4. Optimization process converge very slowly to the goal solution

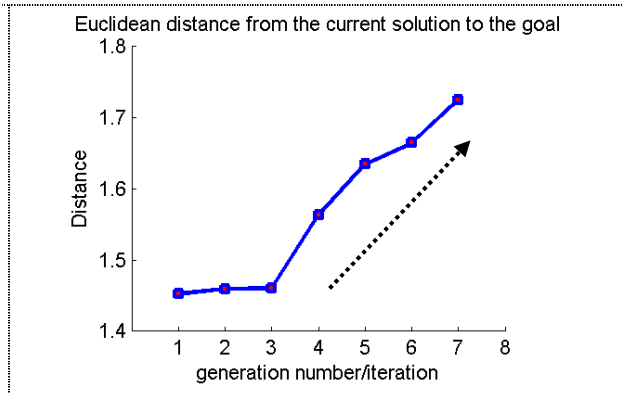


Figure 5. Optimization process move away from the goal solution

Model of Decision Maker (MDM) will choose one solution from the last generation solutions set (Fig.6). It is possible to choose the best compromise solution using minimal ranking and penalty function values or the maximal solution's copy count which evaluates MOGA selection operator. MOGA algorithm for each generation after evaluation of objectives, ranking solutions by using dominance principle Ehrgott (2000). If the rank value of solution is less then solution is better. Rank value shows how many solutions dominate current solution, the minimal value of rank is 1. At first we can find solutions with same minimal rank (L1 list) and then find in them solution for which penalty function value is equal to zero (L2 list). If such solutions not found in L1, then find solutions in L1 with solution's maximal copy count.

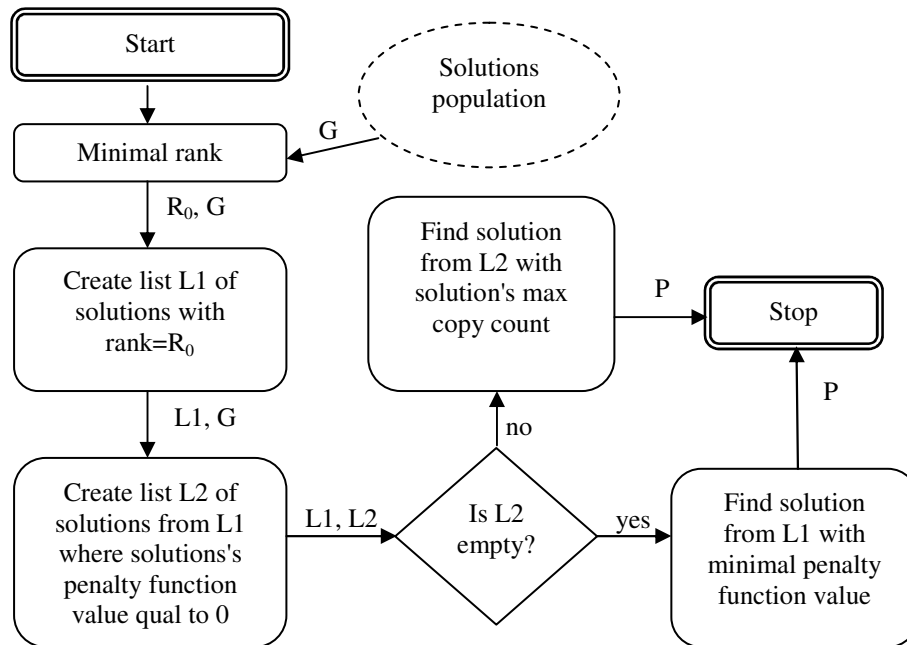


Figure 6. Solution choosing algorithm from population solutions

Experiment design include three testing problems defined and described in Table 1 (red line is the Pareto set). Also experiment design include interactive optimization methods: Interactive Surrogate Worth Trade-Off (ISWT) method described in (Chankong and Haimes, 1983), Geoffrion-Dyer-Freinberg (GDF) method introduced in (Geoffrion and etc.,1972) and author's modified Weighted Sum (WSUM) method for interactive use based on weighted method described in Zadeh (1963).

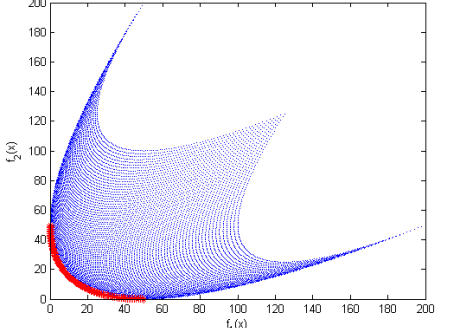
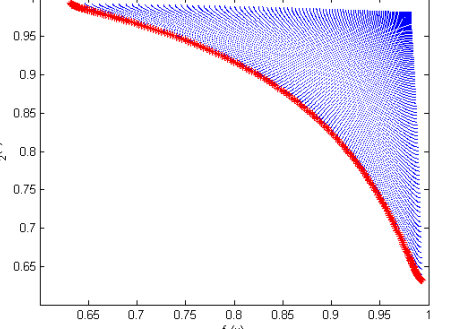
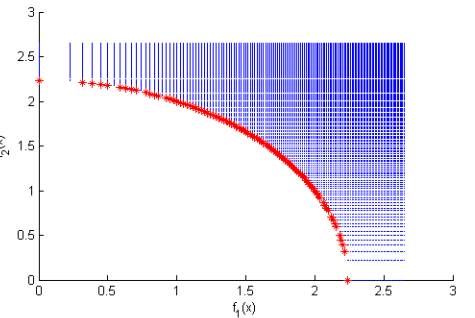
The conditions of experiments are:

- Repeat three times testing of each method with each of testing problem;
- Preference information will be noised with 0% and 25% noise level;
- Maximal iteration count is 12;
- Measure: iteration count, Euclidean distance to the goal solution, correctness of preference information and general distance from theoretical Pareto set.

Parameters for MOGA algorithm are: Share value=0.42 used from Deb (2004), population size=70, generations count=30; probability of mutations=23.80% used from Deb (2004), MOGA type is binary- coded. Methods preference information is binary-coded (weights for WSUM method, ϵ -constraints for ISWT and marginal rates for GDF method). Tolerance for the goal of HANNE problem is 0.1, of BINH1 problem is 0.3 and for FONSECA1 is 0.01.

Testing ground was implemented in MATLAB 2008b with optimization toolbox.

Table 1. Definitions of testing problems

Problem name and type	Objectives	Objectives value space and theoretical Pareto set
<p>BINH1 (concave and continuous) (Binh and Ulrich, 1996)</p>	$f(x) = (f_1(x), f_2(x)),$ <p>where</p> $f_1(x) = x_1^2 + x_2^2,$ $f_2(x) = (x_1 - 5)^2 + (x_2 - 5)^2.$ $x_1 \geq -5,$ $x_2 \leq 10$	
<p>FONSECA1 (convex and continuous) (Fonseca and Fleming, 1995)</p>	$f(x) = (f_1(x), f_2(x)),$ <p>where</p> $f_1(x) = 1 - \exp\left(-\sum_{i=1}^n \left(x_i - \frac{1}{\sqrt{n}}\right)^2\right),$ $f_2(x) = 1 - \exp\left(-\sum_{i=1}^n \left(x_i - \frac{1}{\sqrt{n}}\right)^2\right).$ $-4 \leq x_i \leq 4,$ $i = 1, 2, 3.$	
<p>HANNE (convex and continuous) (Collette and Siarry, 2003)</p>	$f(x) = (f_1(x), f_2(x)),$ <p>where</p> $f_1(x) = \sqrt{x_1},$ $f_2(x) = \sqrt{x_2},$ $x_1 \geq 0,$ $x_2 \geq 0,$ $x_1 + x_2 \geq 5.$	

Results of experiments

After running the experiments for HANNE problem with preference information noise 0% , the goal solution was obtained by ISWT and WSUM method, but GDF method was stopped optimization on the 8-th and 10-th iteration for 2 repeats from 3 (Fig.7). Experiments for HANNE problem with preference information noise 25%, the goal solution was obtained by only WSUM method, but GDF and ISWT methods was not obtained goal solution and finished on 12 iteration (Fig.8).

After running the experiments for BINH1 problem with preference information noise 0% the goal solution was obtained only in experiment repeat 3 by GDF and ISWT algorithms (Fig.9). Experiments for BINH1 problem with preference information noise 25% the goal solution was not obtained by any of optimization methods (Fig.10).

After running the experiments for FONSECA1 problem with preference information noise 0%, the goal solution for all repeats was obtained only by ISWT method (Fig.11). Experiments for FONSECA1 problem with preference information noise 25% the goal solution was not obtained by all methods (Fig. 12).

Figure 13 shows one of the experiment data graphics, where green circles are solutions of preference information, red circle is the choice of P solution by MDM, variables x_1 and x_2 are marginal rates and x_3 is step.

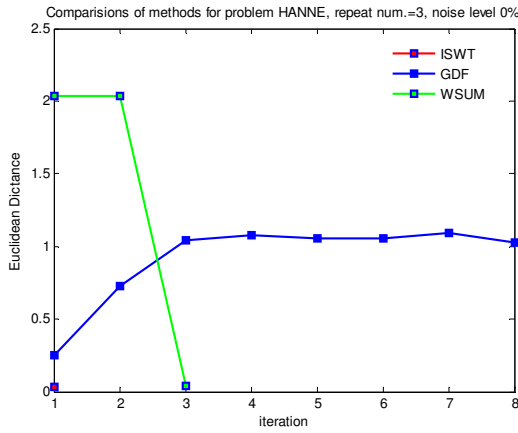


Figure 7. Testing with HANNE problem with 0% level of noise

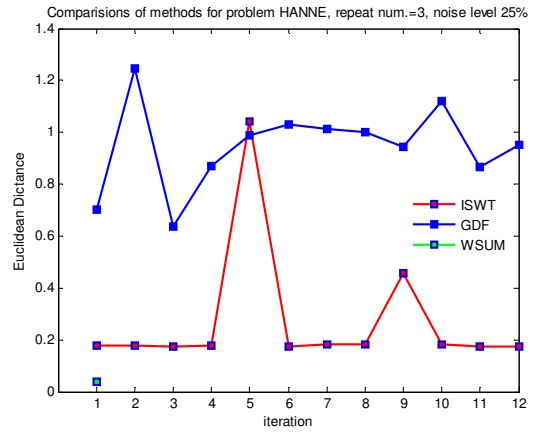


Figure 8. Testing with HANNE problem with 25% level of noise

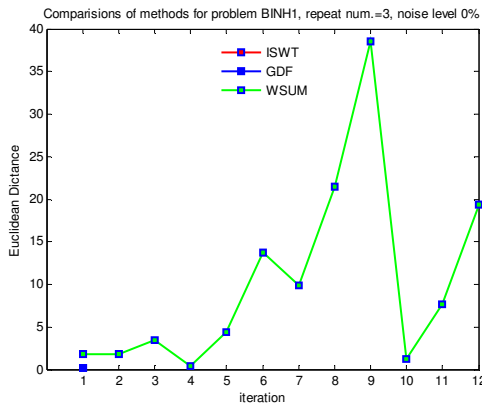


Figure 9. Testing with BINH1 problem with 0% level of noise

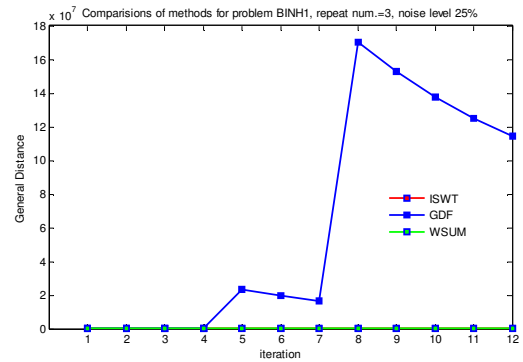


Figure 10. Testing with BINH1 problem with 25% level of noise

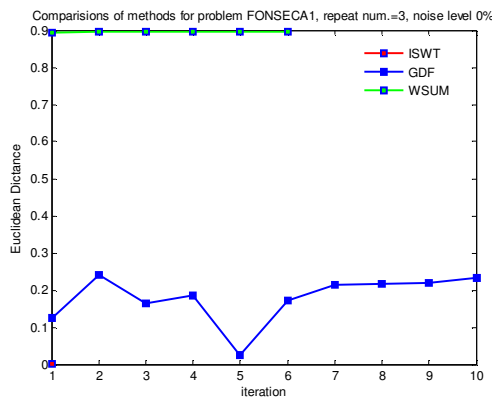


Figure 11. Testing with FONSECA1 problem with 0% level of noise

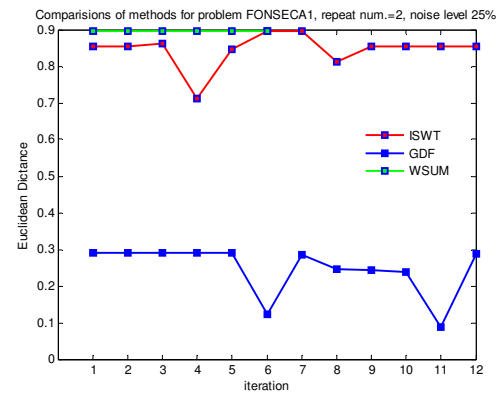


Figure 12. Testing with FONSECA1 problem with 25% level of noise

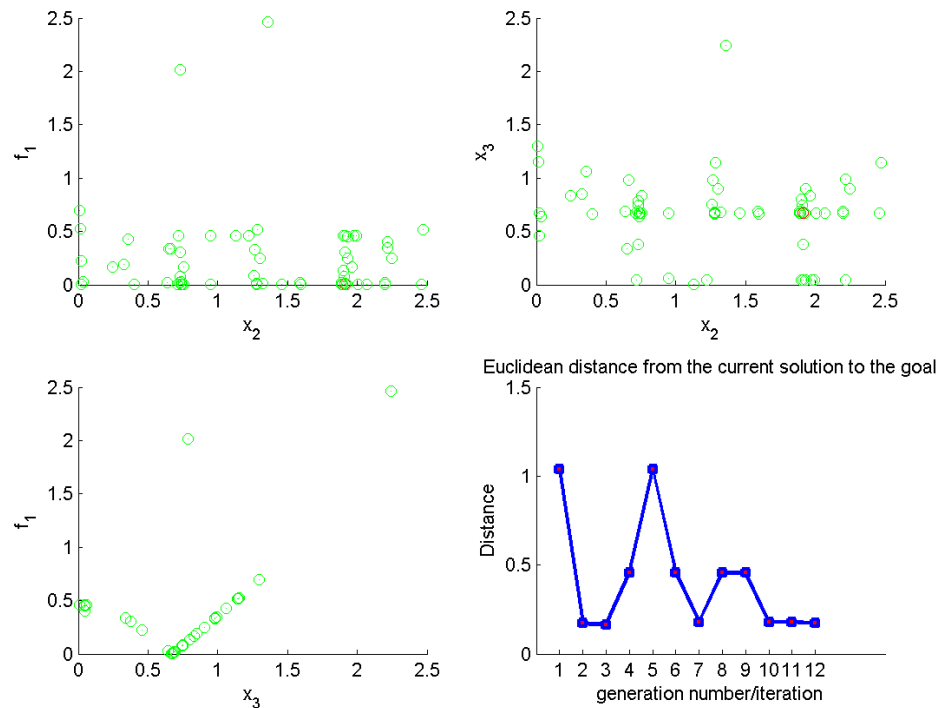


Figure 13. Graphical results of testing the GDF method

Conclusions

Introduced approach of testing or comparing interactive multiobjective optimization methods have stochastic character. When we use evolutionary algorithms, we need to repeat it's running more times and then choose the best result. For decision making it is a problem, because in many cases we need to describe how decision was obtained, that factors was impacted the decision. On the other hand many real problems are stochastic and not fully determined. Evolutionary algorithms gives new possibilities to study and analyses many real problems, one of them- testing an interactive optimization methods using model of decision maker. For this reason we does not need to using large number of decision makers. Evolutionary approach can describe and show how interactive algorithms responds on preference information changes and how they are sensitive for correctness of the preference information. The evolutionary algorithms provide more useful type of coding and representing a structure and values of reference information. This feature of them gives power of search process.

The experiment's results shows that tested algorithms sometimes be held up on one of the solutions and preference information changes cannot impact optimization progress. Sometimes this happens when preference information wrongly defined and interactive optimization algorithm obtain solution which does not belong to Pareto set.

When we use only deterministic model of decision maker, then we need to prepare a complex decision making strategy to give rationality of model. If we using very simple strategy of decision making than comparing process require large number of iterations up to 20.

Aim of this work only to introduce to the comparing and testing interactive optimization methods by using model of decision maker.

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REFINING WI-FI BASED INDOOR POSITIONING

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Abstract

The increasing demand for location-based services inside buildings has made indoor positioning a significant research topic. This study deals with indoor positioning using the Wireless Ethernet IEEE 802.11 (Wi-Fi) standard that has a distinct advantage of low cost over other indoor wireless technologies. Most of the proposed Wi-Fi indoor positioning systems use either proximity detection via radio signal propagation models or location fingerprinting techniques, the latter being usually more accurate. The aim of this study is to examine several aspects of Wi-Fi location fingerprinting based indoor positioning that could enhance the positioning accuracy, without demanding a larger radio map with additional signal strength measurements in more locations, namely making use of weakly-sensed access points, making use of the different available Wi-Fi frequency bands, using device's orientation information provided by a built-in digital compass, and augmenting the radio map using Locally Weighted Regression.

Keywords: *indoor positioning, location fingerprinting, Wi-Fi, IEEE 802.11, WLAN, wireless network*

Introduction

The increasing demand for location-based services inside buildings has made indoor positioning a significant research topic. The applications of indoor positioning are many, for instance, indoor navigation for people or robots, inventory tracking, locating patients in a hospital, guiding blind people, tracking small children or elderly individuals, location-based advertising, ambient intelligence etc.

Although the Global Positioning System is the most popular outdoor positioning system, its signals are easily blocked by most construction materials making it useless for indoor positioning. This study deals with indoor positioning using the Wireless Ethernet IEEE 802.11 (Wi-Fi) standard that has a distinct advantage of low cost over other indoor wireless technologies – it has relatively cheap equipment and in many areas usually a Wi-Fi network already exists as a part of the communication infrastructure avoiding expensive and time-consuming infrastructure deployment.

Although Wi-Fi has not been designed for positioning, its radio signals can be used for location estimation by exploiting the Received Signal Strength (RSS) values measured in any off-the-shelf mobile device equipped with Wi-Fi facilities – and no additional special-purpose hardware is required. Such a positioning system can be relatively easily implemented for notebook computers, Personal Digital Assistants, smartphones, and other Wi-Fi enabled mobile devices.

Most of the proposed Wi-Fi indoor positioning systems use either proximity detection via radio signal propagation models (Thomas and Ros, 2005; Widyawan et al., 2007; Yim et al., 2010) or location fingerprinting techniques (Badawy and Hasan, 2007; Brunato and Battiti, 2005; Ferris et al., 2006; Honkavirta et al., 2009; Hossain et al., 2007; Liao and Kao, 2008; Yim, 2008; Yim et al., 2010). Deriving an accurate propagation model for each Wi-Fi access point (AP) in a real-world indoor environment is extremely complex and therefore usually results in a relatively poor positioning accuracy (Widyawan et al., 2007; Yim et al., 2010). On the other hand, location fingerprinting techniques use empirical data to approximate a location. First, a so-called radio map is constructed by measuring RSS at a number of known locations – calibration points. The location of the user is then determined by comparing the obtained RSS values to a radio map. This provides accurate positioning even in very complex environments while the modelling of the complex signal propagation is avoided. In addition, the fingerprinting techniques usually do not require knowing exact locations of APs.

An early example of a positioning system that uses fingerprinting is RADAR (Bahl and Padmanabhan, 2000). In RADAR, user's location is determined by finding a known fingerprint that is most similar to the actual RSS readings. Since then, many studies have been conducted that perform location estimation from a radio map employing Nearest Neighbours (Honkavirta et al., 2009; Lin and Lin, 2005; Yim et al., 2010), Artificial Neural Networks (Battiti et al., 2002; Derr and Manic, 2008; Lin and Lin, 2005), Support Vector Machines (Brunato and Battiti, 2005), Decision Trees (Badawy and Hasan, 2007; Yim, 2008), Bayesian techniques (Honkavirta et al., 2009; Liao and Kao, 2008; Madigan et al., 2005), or other techniques (Ferris et al., 2006; Honkavirta et al., 2009; Widyawan et al., 2007; Yim et al., 2010). In majority of these studies the Nearest Neighbours technique, in addition to its simplicity, turned out to be among the most accurate ones.

The aim of this study is to examine several aspects of Wi-Fi location fingerprinting based indoor positioning that could enhance the positioning accuracy without demanding a larger radio map with additional RSS measurements in more locations.

Making use of weakly-sensed APs: It is considered to make use of (in many studies frequently ignored) weakly-sensed APs located further away, on other floors, and even in nearby buildings. It is demonstrated that the weak APs can provide additional information for at least a slightly more accurate positioning. Furthermore, also a situation, when in the entire building there would be no APs, is considered – the positioning system may use signal strength information from only those APs of the other buildings nearby.

Making use of the two different Wi-Fi frequency bands: The use of either or both 2.4 GHz and 5 GHz Wi-Fi bands using IEEE 802.11b/g and IEEE 802.11a standards is examined.

Making use of device's orientation information: In studies (Bahl and Padmanabhan, 2000; Honkavirta et al., 2009; Kaemarungsi and Krishnamurthy, 2004; Liao and Kao, 2008), it is argued that the mobile device's orientation information can have a significant effect on the RSS values and therefore on estimated location. This study examines the opportunity to improve positioning accuracy using device's orientation information provided by a digital compass – a piece of hardware that is built-in in many newest handheld devices.

Augmenting the radio map: A method is proposed for augmenting the radio map with additional fingerprints predicted by Locally Weighted Regression (LWR), with locality of interpolation optimized individually for each AP. It is shown that the augmented radio map can provide higher positioning accuracy without additional RSS measurements, especially if the original radio map is sparse.

In many existing studies, to perform the positioning experiments, the (usually) three to six APs are carefully distributed across the area of interest specifically for the purposes of the experiments. Therefore, it should be noted that in the experiments of this study no additional APs were deployed and no existing APs were moved – the experiments are performed using an already existing infrastructure with APs that have been deployed for maximum Wi-Fi internet availability.

The remainder of this paper is organized as follows: The next section outlines location fingerprinting, describes Weighted k-Nearest Neighbours algorithm, sketches the idea of the usage of device's orientation information, and proposes radio map augmentation using LWR. Then the performed experiments are described and experimental results and findings are presented. Finally, the last section concludes the paper.

Methodology

Location fingerprinting

Location fingerprinting based positioning systems usually work in two phases (see Fig. 1): calibration phase (also called offline phase) and working phase (also called online phase or run-time phase). In the calibration phase, a mobile device is used to measure RSS values (in dBm) from several APs at the chosen calibration points in the area of interest. Each of the n measurements becomes a part of the radio map and is a tuple $(\mathbf{q}_i, \mathbf{r}_i)$ $i = 1, 2, \dots, n$ where $\mathbf{q}_i = (x_i, y_i)$ are the geographical coordinates of the i th location and $\mathbf{r}_i = (r_{i1}, r_{i2}, \dots, r_{im})$ are the m RSS values from m APs at that location. Usually, an average of several samples recorded per location is stored.

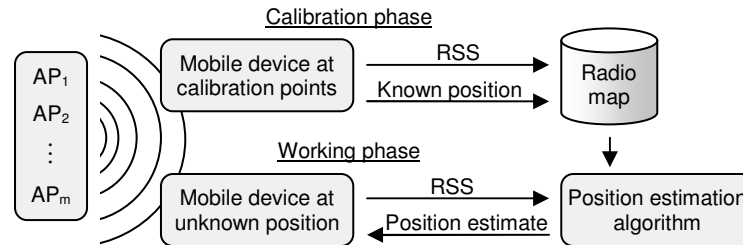


Figure 1. The two phases of location fingerprinting

In the working phase, a mobile device measures the RSS values in an unknown location and applies a location estimation algorithm to estimate its current location using the previously created radio map. As indoor environments have unique signal propagation characteristics, it can be assumed that each location can be associated with a unique combination of RSS values.

Weighted k-Nearest Neighbours

A general Weighted k-Nearest Neighbours (WKNN) algorithm for location fingerprinting can be described as a two step process. First, find within the radio map the k indices i_1, i_2, \dots, i_k whose $\mathbf{r}_{i_1}, \mathbf{r}_{i_2}, \dots, \mathbf{r}_{i_k}$ values are nearest (according to Euclidean distance in the signal space) to the given vector \mathbf{r} measured at the unknown location. In the second step, calculate the estimated location \mathbf{q} (for each coordinate separately) as an average weighted by the inverse of the RSS distances:

$$\mathbf{q} = \sum_{j=1}^k \frac{w_j \mathbf{q}_{i_j}}{\sum_{l=1}^k w_l}, \quad (1)$$

where all weights are nonnegative $w_j = d(\mathbf{r}_{i_j}, \mathbf{r})^{-1}$ and d is the Euclidean distance between the m -vectors. Note that there is a special case when the distance is zero; then as the estimated location just the one with the zero distance is taken without fully computing (1). The reasoning behind this algorithm is that the calibration point with the shortest distance in signal space also has the shortest distance in physical space, and as such acts as a proper location estimate.

WKNN has one tuning parameter, the number of nearest neighbours considered k , which is used to control the locality of the location calculation. When $k = 1$, the algorithm acts as a simple look-up table. For larger values, the location can also be estimated to be somewhere in-between the calibration points. Li et al. (2006) recommends using $k = 1$ only if the density of the radio map is high. However, k should also not be too large as then the location estimates will be too much influenced by calibration points far away. In this study the number is fixed experimentally to $k = 2$.

Making use of device's orientation information

Honkavirta et al. (2009) in their study showed that the positioning accuracy significantly benefit from varying rotation of the measuring device during the calibration phase. This is mostly because of the radio irregularity caused by the direction of a mobile device's antenna, existence of some reflector of the wireless signal, or user's body due to the high proportion of water in human body absorbing wireless signals (Kaemarungsi and Krishnamurthy, 2004; Liao and Kao, 2008). Device's rotation can level out or equalize the impact of its orientation to measure more reliable fingerprint compared to the fingerprint that is measured only to one direction.

In (Liao and Kao, 2008), during the calibration phase RSS values were recorded in four different orientations while in the working phase device's orientation was estimated and employed for a more accurate positioning. It was shown that, when the user movement consists of mostly straight lines, positioning accuracy can be improved. However, if the orientation of the device is estimated incorrectly, the positioning accuracy decreases. Theoretically, the availability of orientation information from a built-in digital compass can improve the positioning accuracy by using radio map data of only the specific orientation. This study examines the potential to improve positioning accuracy using device's orientation information provided by a digital compass.

Augmenting the radio map

Collecting large numbers of fingerprints in the calibration phase is labour-intensive, which makes a large-scale deployment of accurate indoor positioning non-trivial. Therefore, a variety of techniques have been proposed in order to generate synthetic calibration points with predicted RSS values for adding to the radio map, allowing to collect only a limited number of field measurements. Many proposed techniques (Hossain et al., 2007; Pechac and Klepal, 2001; Widyawan et al., 2007) predict the RSS values using a radio signal propagation model requiring knowing exact locations of all used APs or even complete plans of the whole deployment area with precise locations of all walls. And even with this information available, the derived propagation models may be inadequate for the environment and therefore may not bring the desired positioning accuracy. A number of other proposed techniques do not rely on any propagation model, instead the RSS values are predicted via local interpolation of the original calibration points, approximating the behaviour of the radio signal (Ferris et al., 2006; Li et al., 2006).

This study adopts the latter approach and proposes generating synthetic calibration points using LWR with locality of interpolation optimized individually for each AP. The technique does not require knowing locations of neither APs nor walls. The augmentation of the radio map is done using only the original calibration points. This allows performing augmentation also when the available information on the environment is incomplete, e.g. when locations of some APs are unknown, and without additional software for environment layout analysis.

LWR (Cleveland and Devlin, 1988; Atkeson et al., 1997) is designed to address situations in which the models of global behaviour do not perform well or cannot be effectively applied without undue effort. The LWR interpolation is carried out by point-wise fitting of low-degree polynomials to localized subsets of the data. The advantage of this method is that it is not required to specify a global function of the data.

The assumption of the LWR is that near the query point (i.e. the to-be-added synthetic calibration point) the approximated value changes smoothly and can be approximated using a low-degree polynomial. The coefficients of the polynomial are calculated using the weighted least-squares method giving the largest weights to the nearest (according to the Euclidean distance) calibration points and the smallest weights to the farthest calibration points.

Given a regression model

$$F(\mathbf{q}_i) = \beta_0 + \beta_1 x_i + \beta_2 y_i, \quad (2)$$

the coefficients $\boldsymbol{\beta} = (\beta_0, \beta_1, \beta_2)$ are calculated minimizing

$$\boldsymbol{\beta} = \arg \min_{\boldsymbol{\beta}} \sum_{i=1}^n w(q, \mathbf{q}_i) (F(\mathbf{q}_i) - \mathbf{r}_{ij})^2, \quad (3)$$

where j is the index of AP for which the interpolation is done, w is a weight function, and $q = (x, y)$ is the query point (nearest neighbours of which will get the largest weights). The weight function w depends on the distance (in a scaled space) between the point of interest q and a calibration point \mathbf{q}_i . In this study, a Gaussian weight function is used:

$$w(q, \mathbf{q}_i) = \exp(-\alpha \mu), \quad (4)$$

where α is a coefficient that controls the locality of the interpolation and μ is scaled distance from the query point to the i th calibration point:

$$\mu = \frac{d(q - \mathbf{q}_i)}{d(q - q_*)}, \quad (5)$$

where d is Euclidean distance and q_* is the farthest calibration point from the query point q so that $\mu = 1$ when $q_* = \mathbf{q}_i$. Consequently, for each query point, the closer calibration points contribute more heavily in formulating regression equation.

The locality of the interpolation is controlled by varying the value of α . The larger its value, the more local is the interpolation; for $\alpha = 0$, the local model transforms into a global model. To automatically find the ‘best’ value of α for each AP, a simple search algorithm is performed in each step employing Leave-One-Out Cross-Validation (LOOCV) for estimation of LWR’s predictive performance. The algorithm starts with $\alpha = 0$ and gradually increments it by 10, in each step performing LOOCV. The search is stopped after the predictive performance could not be improved for 5 steps in a row.

LOOCV involves n iterations where each time $n-1$ calibration points from the radio map are used as training data, and the remaining one point is used as validation data (acting as the query point in LWR). This is repeated so that each calibration point is used exactly once as the validation data. LOOCV estimates the predictive performance by averaging the individual squared errors of RSS prediction from the n iterations.

Once the ‘best’ α values for each AP are known, the predicted RSS value at a synthetic point is obtained by plugging the two coordinates of a synthetic point and its corresponding three coefficients (computed using (3)) in (2). Note that these computations must be performed for each AP and each synthetic point separately. In other words, for inferring each synthetic point, a different regression equation is obtained for each of the m APs every time.

The Matlab source code of LWR employed in this study is available at <http://www.cs.rtu.lv/jekabsons/>.

Experimental testbed and data collection procedure

The experiments were performed on the fifth floor of a five-storey building of the Faculty of Computer Science and Information Technology, Riga Technical University. The area of the testbed is approximately 860 m², and includes eight classrooms, four offices, and the main hallway.

Fig. 2 displays the layout of the floor where the experiment was performed. The area has five APs installed which have been deployed for maximum Wi-Fi internet availability and can be sensed in at least a third of the area. The largest left-out part of the fifth floor (upwards in the figure) has some additional APs that can be barely sensed from some nearest locations. Furthermore, some APs from the fourth and even third floors can also be sensed in some small areas. This sums up in locally-situated 14 APs. Most of the local APs are Enterasys devices RBT-1002 and RBT-4102 operating in both IEEE 802.11a and IEEE 802.11b/g modes at the same time, allowing getting RSS readings for both 2.4 GHz and 5 GHz Wi-Fi frequency bands. Additionally, there are a total of 43 APs in the nearest other buildings that can be sensed in at least one small location. Note that no additional APs were deployed and no existing APs were moved – the experiments were performed using an already existing infrastructure. The measurements were done mostly in working hours with people walking around and the Wi-Fi internet being used.

The RSS measurements were collected by a human operator using a PC notebook with internal wireless card. The notebook was used for both calibration and working phase. A total of 82 calibration points are defined (see Fig. 2). In the classrooms, the points were placed near the walls and corners, as the walls are responsible for fast drops of signal strength while in the free space the signal strength drops much slower, especially further away from an AP. On average, the distance from one calibration point to the nearest other point is 3.7 m within the same room and 2.6 m when also the points from other rooms are considered. The number of APs that could be sensed from a location ranges from 2 to 13 with average of 7.

To be able to test the usefulness of device's orientation information, for each calibration point the RSS readings were collected in four directions (facing north, east, south, and west), while for each direction a total of 30 RSS samples were collected over a time span of 30 seconds. The readings are then averaged for each direction separately as well as for all the directions combined, resulting in five different average RSS values, each for a separate radio map.

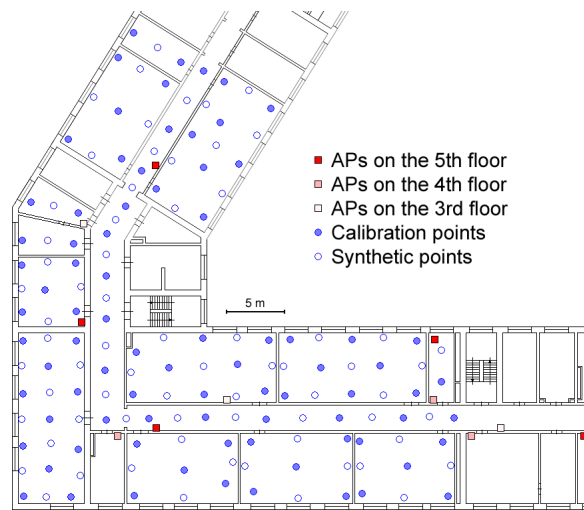


Figure 2. Layout of the testbed environment with calibration points and synthetic points

Finally, a test set of 68 points was created (see Fig. 3). The placement of the testing points mimics a person walking in a route through five classrooms, one office, and the hallway. The route is started at one point and finally ended at the very same point, visiting 34 different locations where each location is visited two times, each time facing a different direction. The measurement process, apart from that it is performed for only two orientations, is the same as for the calibration points.

The averaged RSS values range from -99 dBm (used when the AP is not present) to about -33 dBm in close proximity to an AP. The outcome of the measurement session can be downloaded at <http://www.cs.rtu.lv/jekabsons/>.

Experimental results

Table 1 summarizes the positioning errors for the experiments.

Making use of weakly-sensed APs: The results suggest that indeed the positioning accuracy can be at least slightly improved if the list of the used APs consists of not only the strongest APs (average positioning error of 2.37 m) but also the weakly-sensed APs located further away, on other floors, and even in nearby buildings as well (average positioning error of 2.10 m).

Additionally, an interesting result is that, if in the entire building there would be no APs and the positioning system could use signal strength information from the 'outside' APs only – those of the other buildings nearby, the average positioning error would still be a decent 7.14 m. This suggests that such a positioning system could still be useful, especially if used together with some supplementary positioning or tracking technology while walking through hallways in the middle of the building (where, in this experiment, the positioning error is the largest).

Making use of the two different Wi-Fi frequency bands: Signals from eight of the local APs were strong enough for the measuring device to be able to detect them in both bands, 2.4 GHz (IEEE 802.11b/g) as well as 5 GHz (IEEE 802.11a). It turned out that, in addition to 2.4 GHz RSS, using also the 5 GHz RSS (as if they would come from additional eight APs) always increased the average positioning accuracy by at least 10%. Apparently, despite the sharply dropping 5 GHz signal strength, the RSS values are still useful for extracting additional information for positioning, even if only near the APs.

Test set error (in meters) distribution: mean, median, and percentiles					
	Mean	Median	75 th	90 th	95 th
5 strongest local APs					
2.4 GHz	2.56	2.35	3.60	4.64	5.56
Both freq.	2.28	1.87	3.40	4.24	5.36
Both freq. + orientation info.	2.45	1.88	3.76	4.70	5.50
Both freq. + LWR	2.19	1.95	3.03	4.31	5.60
All local APs (14)					
2.4 GHz	2.33	2.16	3.17	3.99	5.12
Both freq.	2.10	1.67	3.12	4.18	5.41
Both freq. + orientation info.	2.40	1.61	3.26	5.03	7.23
Both freq. + LWR	1.94	1.52	2.55	4.00	5.21
All sensed APs (57)					
2.4 GHz	2.44	2.32	3.58	4.62	5.10
Both freq.	2.02	1.62	3.04	4.22	4.52
Both freq. + orientation info.	2.11	1.71	3.10	4.08	4.96
Both freq. + LWR	1.82	1.56	2.35	3.69	4.58
Only the 'outside' APs (43)					
	7.14	6.51	10.02	13.64	14.55
Reduced radio map, both freq.					
5 strongest local APs	3.48	3.48	4.75	5.99	6.95
5 strongest local APs + LWR	3.22	3.05	4.47	5.33	6.52
All local APs	3.31	3.31	4.61	5.55	6.53
All local APs + LWR	2.83	2.56	3.88	5.03	5.76
All sensed APs	3.43	3.30	4.81	5.87	7.21
All sensed APs + LWR	3.00	2.42	3.99	5.79	7.40

Making use of device's orientation information: For this experiment, four different radio maps were created – one for each orientation. The location estimation for each testing point was done using that radio map corresponding orientation of which is the nearest to the actual orientation of the measuring device at the time of measurement.

While theoretically the availability of orientation information could increase the positioning accuracy, in practice there was no improvement. The reason for this could be the evident signal strength fluctuations, i.e. the noise in the data could be higher than the useful orientation-specific information. Nevertheless, it should be noted that the positioning accuracy significantly benefited from the RSS readings averaged over all four orientations, for example, while using all local APs and both frequency bands, the positioning error decreased from 2.85 m, when RSS information from only the north orientation was used, to 2.10 m, when all four orientations were used.

Augmenting the radio map: For this experiment, the locations of the synthetic points were chosen so that the points in the radio map would retain the uniform distribution. The chosen locations are shown in Fig. 2. Results in Table 1 suggest that there is at least a slight improvement. Fig. 3 shows the location estimation results, where a triangle represents the true location and its corresponding two crosses represent the estimated locations for the two opposite orientations. Note that the estimated locations almost always fall in the correct room providing a near 100% accuracy on the room-level granularity (here, an unaugmented radio map provides similar behaviour). The same experiment was also performed with a reduced radio map formed from the original one by taking only the (one to three) central calibration points for classrooms, one point for each office, and every second point for hallway – a total of 25 calibration points. In the augmentation process, the synthetic calibration points were generated at all the left-out calibration point locations as well. This time the augmented radio map outperforms the unaugmented one more significantly (see Fig. 4a). It can be seen that the gain using an interpolation technique becomes more significant when the radio map is sparse. This also agrees with the results of prior studies (Hossain et al., 2007). The thing to emphasise is that with the significant reduction in the number of measured calibration points, the positioning error increased only to 2.83 m. This means that, if an environment has changed, only a small number of new measurements is needed to quickly generate an updated radio map and get a reasonably accurate positioning.

Finally, Fig. 4b presents the results of an additional experiment where the impact of varying the number of used APs was studied with more detail and without regarding the origin of an AP. The list of all APs was sorted by their overall RSS variance in the full radio map and for each number of used APs only those with the largest variance were used. As expected, the positioning error is not a linear function of the number of APs: the decreasing rate of positioning error gradually slows down and at some threshold it is evident that only little benefit is achieved by further increasing the number of APs. Here, the best results are mostly achieved using about 20 APs. However, the fluctuations of the curves suggest that a better criterion for sorting the APs or a

better algorithm for finding the best subsets of the APs could be used delivering smaller subsets with the same or even slightly better positioning accuracy.

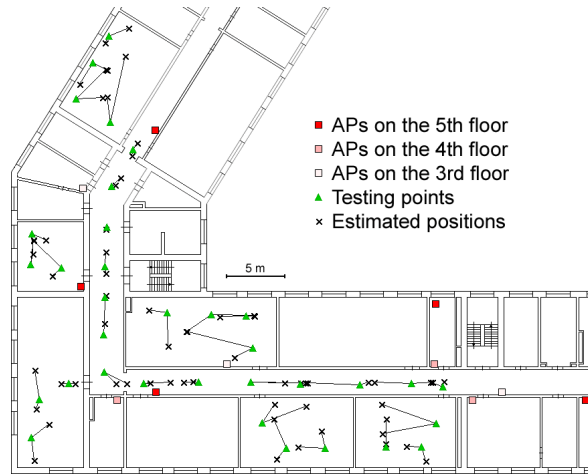


Figure 3. Testing points and their corresponding estimated locations

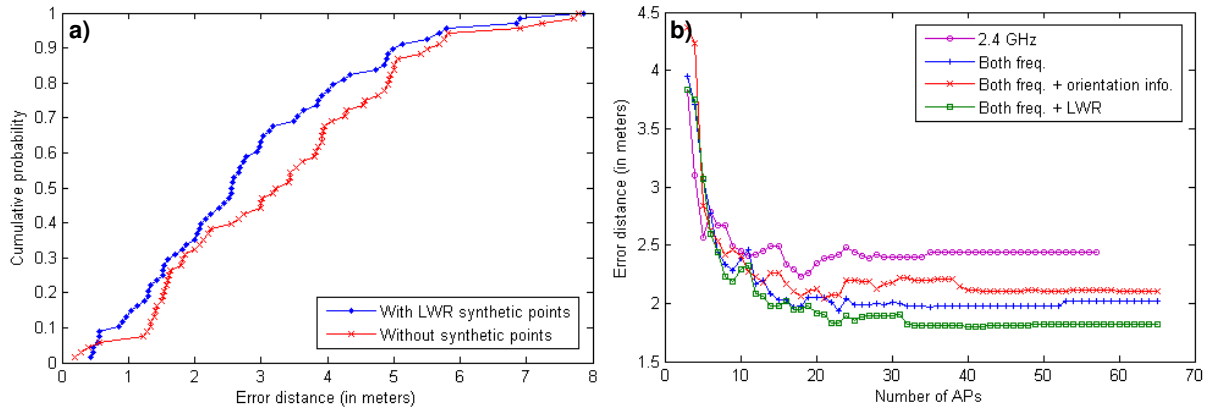


Figure 4. Positioning performance: a) with the reduced radio map; b) with different numbers of APs

Conclusion

This paper examined several aspects of Wi-Fi location fingerprinting based indoor positioning that could enhance the positioning accuracy. Based on the experimental findings, the following conclusions can be drawn. It was observed that a positioning system can benefit from the availability of additional weakly-sensed APs as well as APs working in 5 GHz frequency band (using IEEE 802.11a/n). RSS readings from these APs gave a notable improvement in positioning accuracy – the average positioning error dropped from 2.56 m to 2.02 m. In fact, in this study, using exclusively the APs from the other buildings nearby, the positioning error was still a decent 7.14 m.

Nevertheless, it must be noted that the benefit from adding more and more weakly-sensed APs quickly decreases and after a certain number of APs, the accuracy actually can deteriorate. This is especially true for sparse radio maps. One of the future work directions here could be consideration of some kind of automatic subset selection technique to filter-out the irrelevant APs. While this may not bring much additional accuracy, at least the size of RSS fingerprint database could be significantly reduced.

In this study, the availability of orientation information could not increase the positioning accuracy. The reason for this could be the evident signal strength fluctuations. However, as this result appears to contradict with some other studies, it should be investigated more extensively with different experimental setups.

The results from experiments with LWR show that the largest potential improvement in positioning accuracy is when the radio map is sparse. This makes the technique especially suitable for larger environments in order to shorten the time required for measurements in the calibration phase and still achieve a reasonable positioning accuracy.

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SERVICE ORIENTED MINE HUNTING CLASSROOM SIMULATION SYSTEM

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Abstract

It is well known that mine hunting ship crew training on a real ship is expensive. More cost – effective way is to use a software-based classroom simulator. The purpose of this paper is to describe architecture of Alkmaar class mine hunting ship classroom simulation system built for Latvian ministry of defense. Simulation system is built as a service oriented system and enables high connectivity with other systems – simulators. Computer graphics based user interface ensures high systems flexibility and high quality human-system interactions. Use of object database eliminates the need to predefine or maintain a separate, rigid data model leading to reduction of system development time and database maintenance costs. The simulator is driven by three mathematical models: weather, ship and robot mathematical model. Our work contains analysis of the best practices of designing and implementing service oriented classroom simulator – it's mathematical models, service oriented architecture, database design, ways of user interactions perception, user interface visualization and physical implementation using bleeding edge technologies like .NET 3.5, Windows Communication Foundation, XNA Game Studio and other.

Introduction

It is well known that mine hunting ship crew training on a real ship is expensive. More cost – effective way is to use a software-based classroom simulator. The simulation system is designed for Latvian Ministry of defence to emulate Alkmaar class ship and mine hunting robot Pap104 controlling process during mine hunting operation in operations center (OC) as well as to log all user interactions and analyze accomplishments of the crew.

The simulation system consists of sonar control panel, two sonars (detection and classification sonar), plotting table - computer with integrated geographic information system, ship control panel, mine hunting robot control panel and measurement displays. Team with up to four crew members can participate in mine hunting operation simulations.

The paper sections are organized as follows. First the mathematical models are described. Then analysis of event mechanism design in service oriented systems and demonstration. Third section deals with implementation of sonar ray tracing and visualization is presented and forth is devoted to physical model description of simulation system. Results, discussions and conclusions follow afterwards.

Mathematical models

The simulator is driven by three mathematical models: ship's model that allows to simulate 6 DOF correlated with weather mathematical model i.e. including waving, water laminar resistance and side winds; robot's model in its essence is simplified ship's model that does not need some of the weather components; weather model allows to simulate different weather conditions starting from constant for simpler scenarios and ending with constantly changing with random events such as sudden wind blows for complex scenarios.

Service oriented architecture

The key feature of this classroom simulation system is its service oriented architecture, where the most important feature is event handling and routing in distributed environment. We tried two different technologies: .NET Remoting (Kimmel, 2005) and WCF 3.5 (Chakkaradeepcc, 2008).

Figure 1 shows one way how to implement event handling mechanism using .NET Remoting tehnology. First, the listener subscribes to particular event through remote object proxy. Second, initiator initiates the event and third, event handler on listener side gets the event notification. The problem is that Handler declaration needs to be publicly shared across all simulation system components. Such restriction makes the simulation system very difficult to maintain and adapt to any changes that might occur.

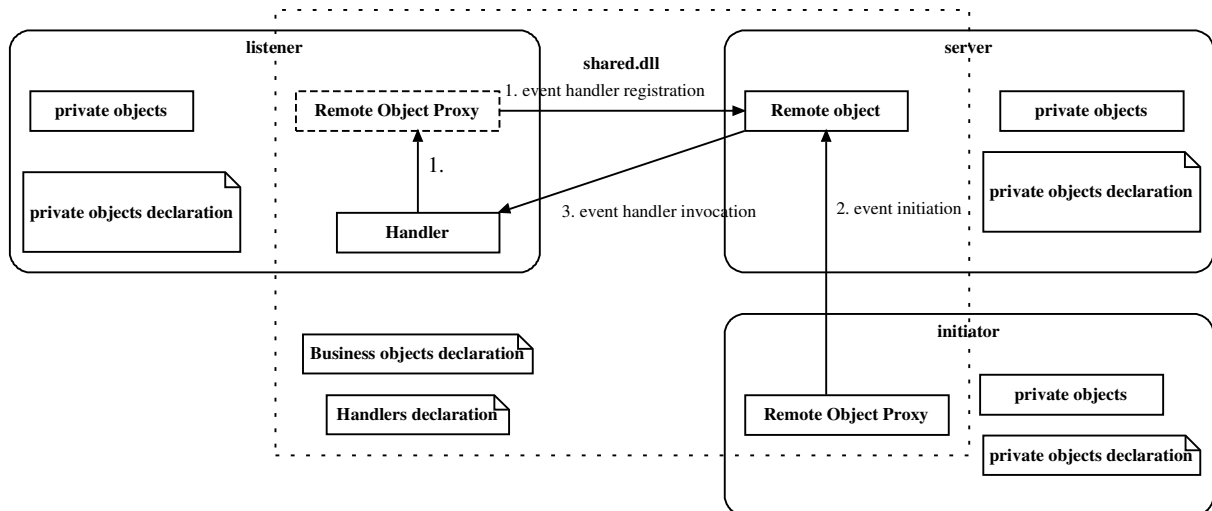


Figure 1. Simple .NET Remoting event handling scheme with public event handling methods

The solution to exclude private event handlers from publicly shared dll (Dynamically linkable library) is the use of event wrapper principle as depicted in figure 2.

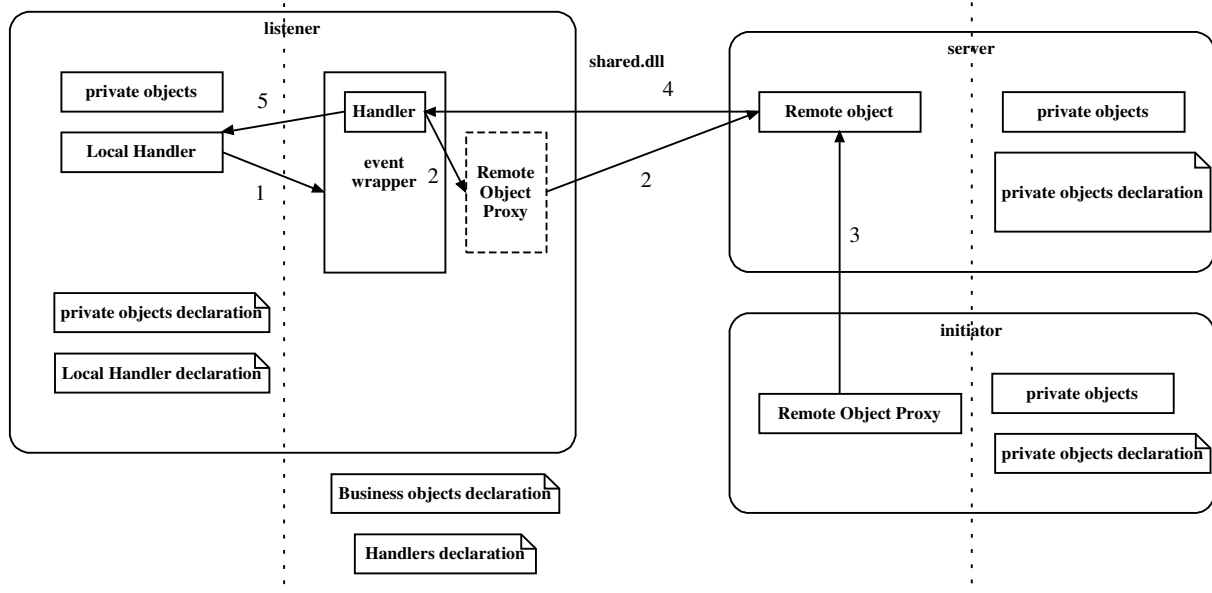


Figure 2. .NET Remoting event handling scheme with private event handling methods

There are two event layers. The first one is event wrapper layer, where local event handling methods are registered and the second one is subscription layer to ‘Remote object’ event, where event wrapper method named ‘Handler’ is registered. In this way event the wrapper objects are created on client side and server side gets reference to client object accordingly. When event occurs on the server, client will execute appropriate event wrapper ‘Handler’, which will call appropriate local event handler.

The event handling mechanism can be described in 5 steps:

1. Creation of the event wrapper object and local method named ‘Local Handler’ registration to receive event wrapper events.
2. Registration of event wrapper method named ‘Handler’ to respond to Remote Object events and raise event wrapper events.
3. Initiation raises Remote Object event.
4. Execution of Remote Object event handler – event wrapper method named ‘Handler’.
5. Method named ‘Handler’ raises event wrapper event to which local event handling methods were registered and these methods are now invoked.

Event wrapper solution had unacceptable performance and as the alternative was decision to implement service architecture using WCF technology which is shown in figure 3 (Chakkaradeepcc, 2008).

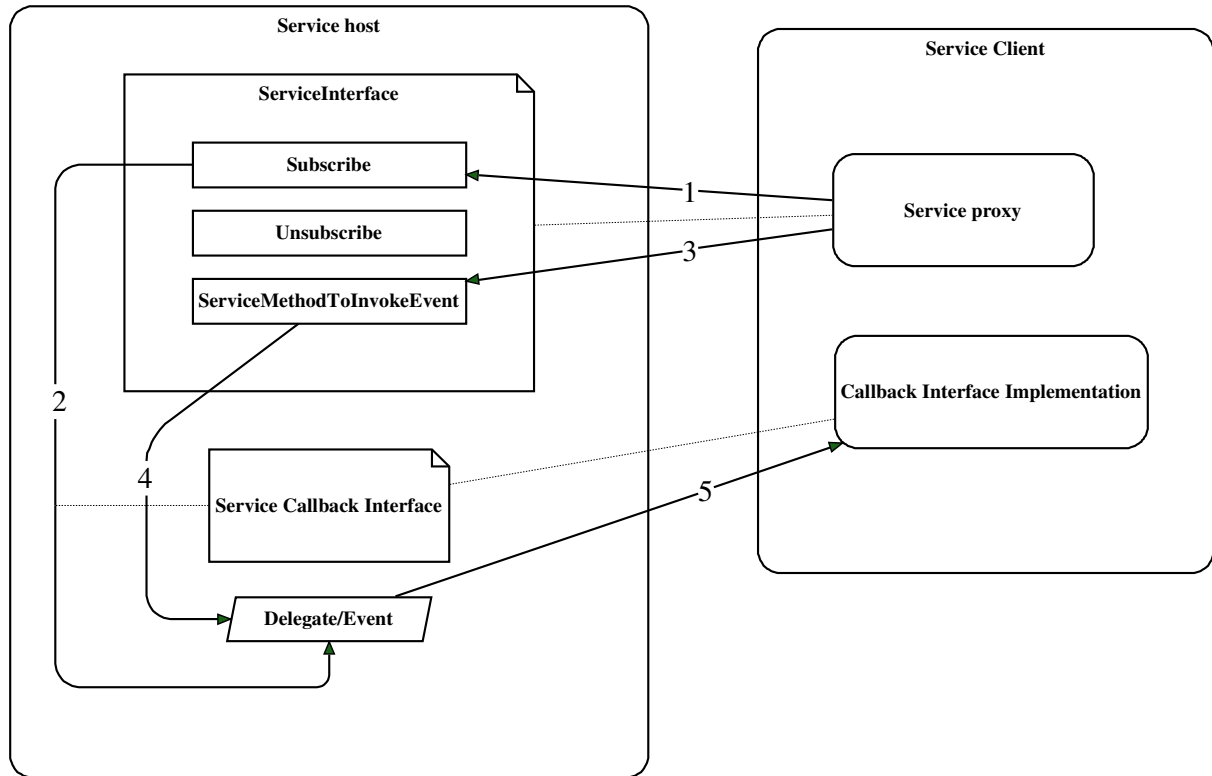


Figure 3. Event handling mechanism using technology WCF

Steps of event handling mechanism depicted in figure 3 are the following.

1. The client calls service method 'Subscribe'.
2. Subscribe method associates callback interface methods that exists on client with appropriate service events.
3. Client calls service method which raises the event.
4. Event underlying delegate is invoked.
5. Delegate invocation executes appropriate callback interface methods on client.

Figure 4 shows the simulation system application layers designed for WCF event handling mechanism. Business logic is implemented in the business layer, while business layer interaction interface is exposed to other simulation system applications through Windows Communication Foundation services.

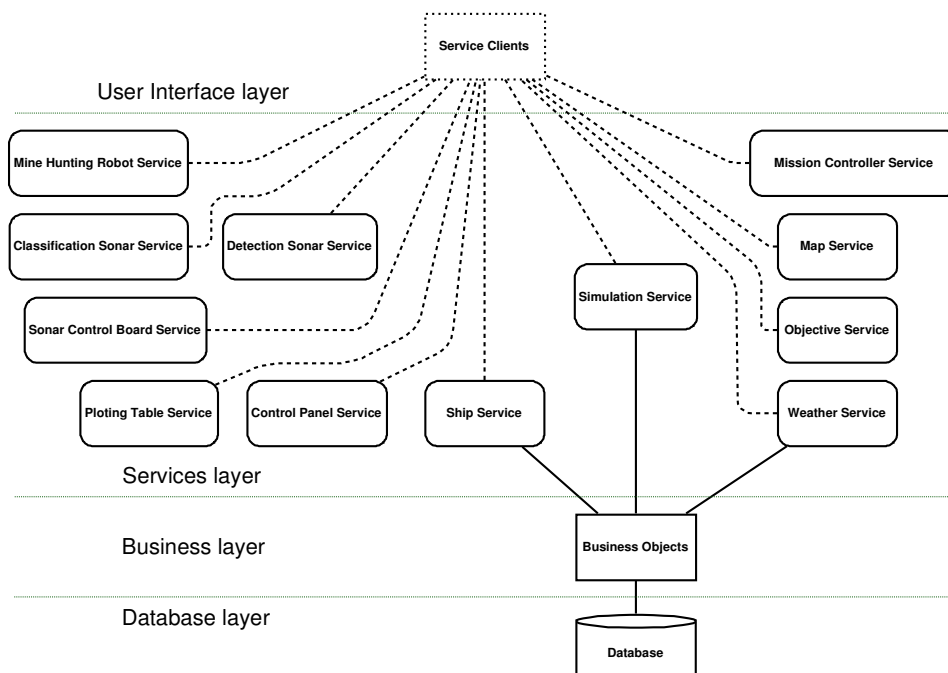


Figure 4. Simulation system application layers

While database, business and services layers are located on simulation server, user interface layer consists of several parts, each of them implemented as a different application. Thereby changes in the business logic don't impact user interface layer simplifying future enhancements and maintenance. Besides, in case of failure in any user interface application the rest of the simulation system applications continue to run. A restart of any user interface application can be done without stopping simulation process or corrupting data, because simulation data and business processes are hosted on the simulation server.

Sonar ray tracing and visualization

The central visible part of the simulation system is detection and classification sonars that are implemented using Microsoft XNA Game Studio 3.0 (this tool is useful in computer game creation).

High Level Shader Language (HLSL) is used as a primary tool for massive parallel computing on graphical processor. For real-time sonar ray tracing it is important to make huge amount of simple and independent calculations in parallel. Sonar visibility range can reach 1km and more, hence at the resolution set to 50cm we should actively render $1.6 \cdot 10^7$ terrain elements each 16ms (60 updates per second). Such amount of calculations is impossible to make even on the latest GPUs.

To solve this problem we have implemented Clipmaps (Asirvatham and Hoppe, 2004). Our clipmap implementations have symmetric layers allowing recursive rendering. Each next level have higher details and changed scale, allowing higher level of details closer to source of sonar signal, and lower details in the distance (see figure 5).

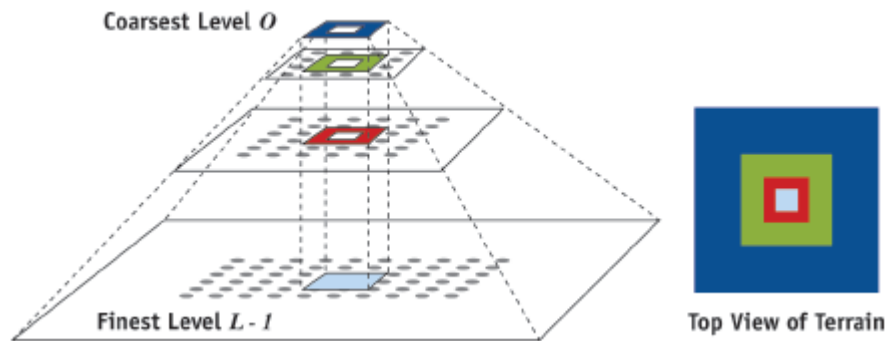


Figure 5. Principle of clipmapping (Asirvatham and Hoppe, 2004)

In clipmap the most important is symmetry in structure and border areas. Examples of clipmaps with different layers are depicted in figure 6 and figure 7.

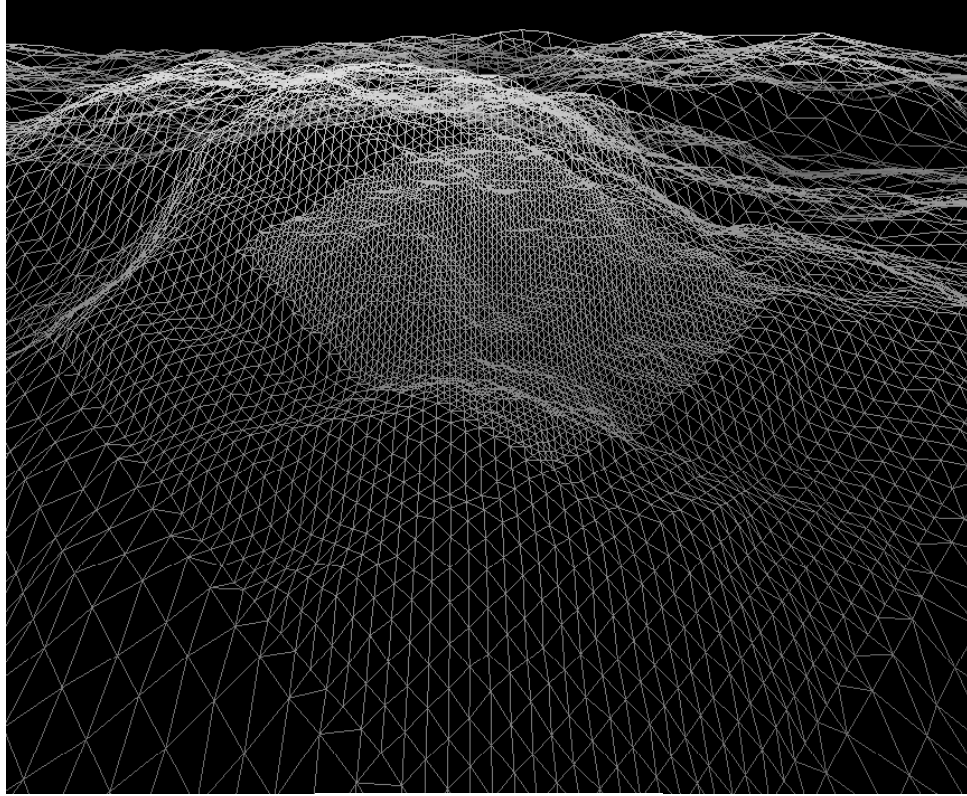


Figure 6. Clipmap 57 x 9 Layers

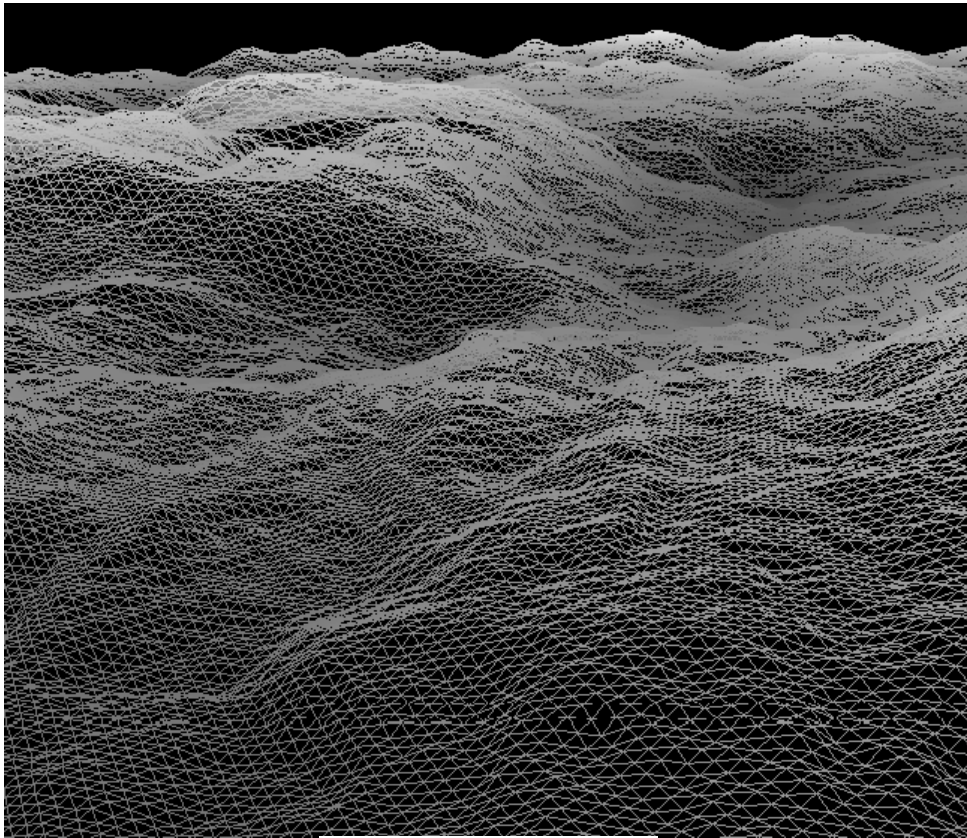


Figure 7. Clipmap 253x5 layers

Clipmap operations like world coordinate, signal source and ship transformations are performed on vertex shaders. Ray tracing and shadow calculations in the same time are calculated on pixel shaders. Actual

complexity of our solution requires only ~ 600 million floating point operations per second, what is reasonable load for average office PC.

Physical model

Classroom simulation system physical model is built as a simple LAN (see figure 8). Sonar displays and other devices are reproduced as standard displays or touch screens. Therefore in case of damage every simulation system component can be easily replaced.

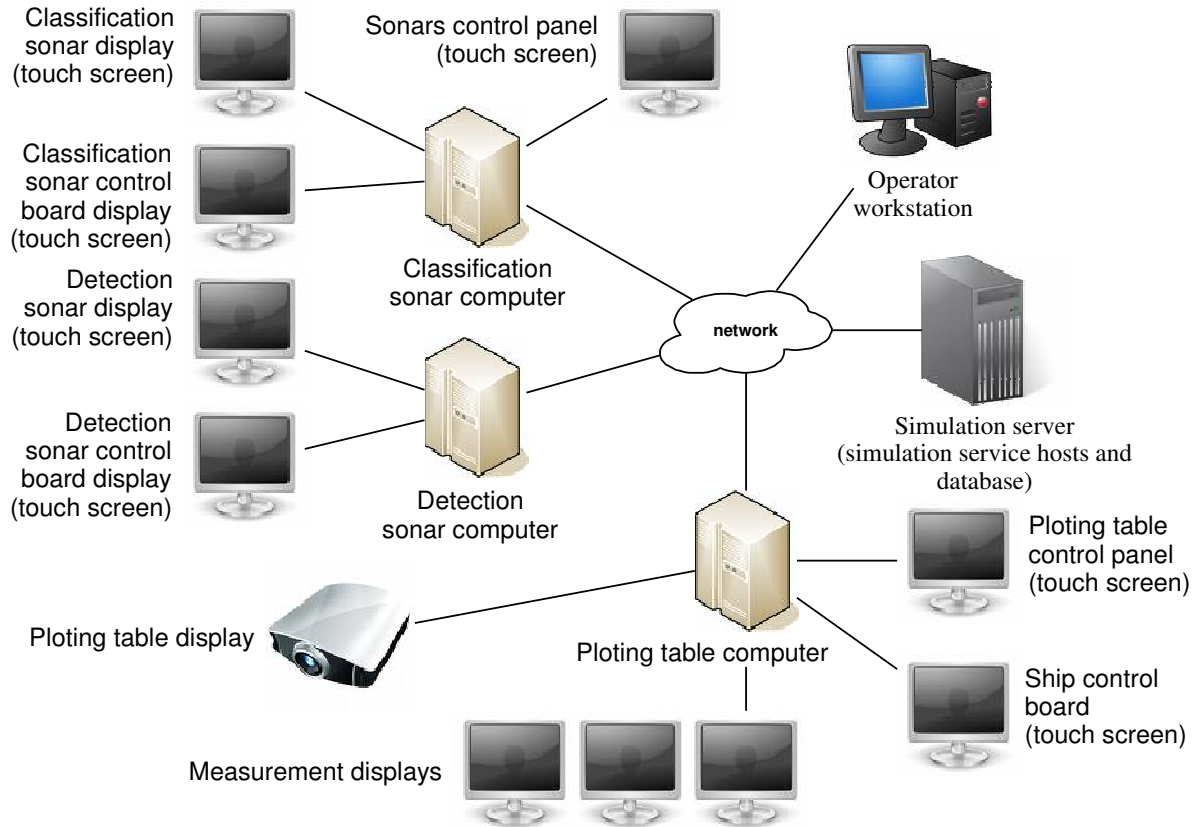


Figure 8. Simulation system physical model

All simulation system displays are designed as touch screens transferring responsibility of user interface design and implementation to software development team. Thereby necessity for other specific user interface engineers is eliminated and system maintenance costs are reduced. Other user interaction objects are industrial joysticks and switches intended for ship and mine hunting robot control.

Maps, missions and all simulation logging data are stored in the open source object database Db4o that enables .NET developers to store and retrieve any application object. Native object database eliminates the need to predefine or maintain a separate, rigid data model leading to reduction of system development time and database maintenance costs. Object database also improves simulation system performance by reducing type conversion operations that would occur in alternative solutions like in case of object relational mapping.

Results

We have developed three mathematical models to drive simulation: weather, ship and robot mathematical model. Simulation system architecture is service oriented and software components is developed using .NET Framework 3.5 and simulation system physical model is built as a usual computer network. Sonar displays and other devices are reproduced as standard displays or touch screens.

Discussion

Classroom simulation system is built as service oriented system and enables high connectivity with other systems – simulators. Computer graphics based user interface ensures high systems flexibility and high quality human-system interactions. Use of object database eliminates the need to predefine or maintain a separate, rigid data model leading to reduction of system development time and database maintenance costs.

Simulation system is implemented using cutting edge technologies like .NET 3.5, Windows Communication Foundation, XNA Game Studio and other. Physically simulation system is developed as usual computer network, therefore development, maintenance and potential enhancements of simulator are cost effective.

Conclusions

The selected technological platform in combination with the developed architecture provides a reliable solution for massive real time calculations as well as high modularity and maintainability.

Service oriented systems with event handling mechanism are not reasonably to implement using technology .NET Remoting because of low event handling performance. Much easier and better from performance perspective is usage of Windows Communication Foundation.

Our clipmap algorithm implementations have symmetric layers allowing recursive rendering which leads to reasonable load for average office PC for ray tracing and sonar visualization.

Acknowledgements

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ICT IN AGRICULTURE

ASSESSMENT OF STATISTICAL DESCRIPTION, LINEAR RELATIONSHIPS AND TECHNOLOGICAL OPTIMIZATION FOR SOWING DEPTH OF WINTER WHEAT AS YIELD AFFECTING FACTOR

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Abstract

Investigations were carried out in 2005-2007 at Research and Study Farm Vecauce of Latvia University of Agriculture in production fields of winter wheat. Sowing of winter wheat was done by driller AMAZONE D8-45 SUPER. The coordinates of observation points were defined by GPS receiver Garmin IQ 3600 using AGROCOM software AgroMAP Professional. The yield was harvested by combine CLAAS LEXION 420. All cereal growing technology met the only difference principle. The aim of the work was to determine differences in depth of sowing and its effect to yield and yield formation parameters. Results shows that sowing depth deeper than 5.5 cm was detected significantly more at winter wheat yield level below 5.00 t ha⁻¹ compare to yield level above 7.00 t ha⁻¹. Using differentiated descriptive statistics by creating six groups of sowing depth showed that the effect of sowing depth in correlation with the winter wheat plant development, describing it with a plant mass and tillering coefficient, characterized polynomial relationship, and negative effect of sowing depth was essential up to depth of 6.0 cm. Further increase of sowing depth effected those parameters of yield formation insignificantly ($P>0.05$). Increased sowing depth to 6.0 cm reduces area of winter wheat flag leaf. In conditions of co-linearity where differences in the depth of sowing are determined by the complex of soil properties, but first of all the thickness of arable horizon and organic matter content, partial linear correlation shows that exclusion of differences in thickness of arable horizon or organic matter content gives no affect to professional interpretation of sowing depth as well as to potential technological optimization models and solutions for their assessment. The existing available technology and possibility to use available information for site-specifically differentiated technologies were marked out as the basic criteria for technological optimization. Sowing technology models must be associated with soil tillage differences on farm level with its existing information and its replenishment capabilities.

Key words: precision agriculture, winter wheat, yield affecting factors, sowing depth, coefficient of tillering

Introduction

Direct sowing of spring barley or minimal soil tillage becomes a very popular method worldwide. Such sowing technology allows economizing resources hereto not decreasing yields of cereals. This fact has also been approved in earlier researches made by the scientists of the Department of Soil management of the Latvia University of Agriculture now Soil and Plant Sciences Institute (Lapins et al., 2001). More and more drillers appear recently in farms in Latvia, which allow reduction of soil tillage in winter or spring cereals but often these drillers are used in traditional soil tillage system – after soil ploughing. Several researches have been made in Lithuania (Maiksteniene, 2000) and Estonia (Lauringson et al., 2001) in this direction.

Formation of yield in crop cultivation is affected by influence of many factors. Simple summation of individual factors is quite rare occasion. Interaction among factors is a dynamic value. The effect of interactions varies depending on the crop development stages as well as by graduation of factors. Rising of value of a single factor resulted in a rise of value of interactions effect (Lapins et al., 2003).

It is well known that winter hardness of winter wheat sowings depends on plants conditions before wintering as well as on properties of particular variety to adapt to meteorologically variable conditions during wintering period. One of the conditions for good winter hardness is winter wheat stand with optimal density, what could be adjusted by choosing proper drilling time and drilling rate (Ruža, et al., 2008). Very important for all cereals is not only the time of sowing but also meteorological conditions right after it, because this determine germination of seeds and further degree of equivalence of number of plants per field area (Lapiņš, 1997).

Precision crop cultivation is a form of modern field management using new technologies, machinery and equipment, including GPS (Global Positioning System). GPS allows detect, analyze and respectively respond to unevenness of cultivable area. It is closely associated with the new information technologies - GIS (Global Information System) and GPS – and includes development and use of structural planning of production

processes and management of modelling of optimal solutions. Precision crop cultivation operational functionality requires computerized management of this process (Lapins et al., 2005; Vilde et al., 2008). The aim of this study was to determine differences in depth of sowing and its effect to yield and yield formation parameters as well as importance of different factors using partial correlation calculations.

Materials and Methods

Investigations were carried out in 2005-2007 in Kurpnieki field at Research and Study Farm Vecauce of Latvia University of Agriculture. Winter wheat *Triticum aestivum* L. variety 'Tarso' was drilled in September 16-18, 2005 and also in the following year on September 25-26, 2006. Drilling was done with combined soil tillage-drilling equipment "AMAZONE D8-45 SUPER" with vertical rotor-tiller "AMAZONE KG 452". Fixed drilling depth at 4 cm resulted in the depth of seed placement in soil on average at depth of 4.5 cm (minimal 2.0 cm, maximal 7.7 cm). The depth of seed placement in soil was determined at winter wheat 1-2 true leaf stage by measuring it for 10 plants in each observation point. For better understanding the depth of drilling will be showed in centimeters in the whole article. Drilling rate was fixed as 450 germinable seeds per m², but it resulted in average 338 seedlings per m² at winter wheat 1-2 leaf stage (minimal 270 plants per m², maximal 634 plants per m²). The number of seedlings was determined in 0.1 m² frame in 3 places in each observation point. Fore crop of wheat in 2005 was winter rape *Brassica napus* ssp. *oleifera*. The agrotechnology used in wheat cultivation was equal in the whole field and in both trial years. 47 points (distributed as grid 50*50 m) for sampling were selected in the winter wheat field. All points were attached to their geographic coordinates. The coordinates of observation points were defined by GPS receiver Garmin IQ 3600 using AGROCOM software AgroMAP Professional that allows to find the coordinates by accuracy of ±3 m, as well as to determine the field boundaries. Information from Garmin IQ 3600 was transferred into a computer and processed by the program AgroMAP Professional. Relative height above the sea level was determine with Trimble GeoXT, and adjusted with GPS Pathfinder Office software version 4.00. Following values of unregulated factors were determined in observation points: altitude, m above the sea level – on average 99.9 m, minimal 94.4 m, maximal 106.8 m; content of organic matter in soil – on average 19 g.kg⁻¹, minimal 14 g kg⁻¹, maximal 91 g kg⁻¹; the thickness of humus horizon, m – on average 0.38 m, minimal 0.23 m, maximal 0.50 m. The thickness of humus horizon was determined by probing. Samples for organic matter content were taken from the depth of 0.20 m using a probe. Sampling was done after harvesting on August 14, 2006, in 3 replicates in each sampling point. Samples were analyzed in certified laboratory VSIA „Agroķīmisko pētījumu centrs”, using local standard methods. Soil granulometric composition determined by field method and described as content of physical clay. Data characterizing growth and development of winter wheat (number of plants, total weight of plant, number of sprouts, coefficient of tillering, and area of flag leaf) were determined from 10 plants in each sampling point at two times – in autumn at winter wheat growth stage BBCH 11-12 and in spring time at growth stage BBCH 25-29. Flag leaf area was determined by using a specialized computer program WinFOLIA. The yield was harvested by combine CLASS LEXION 420.

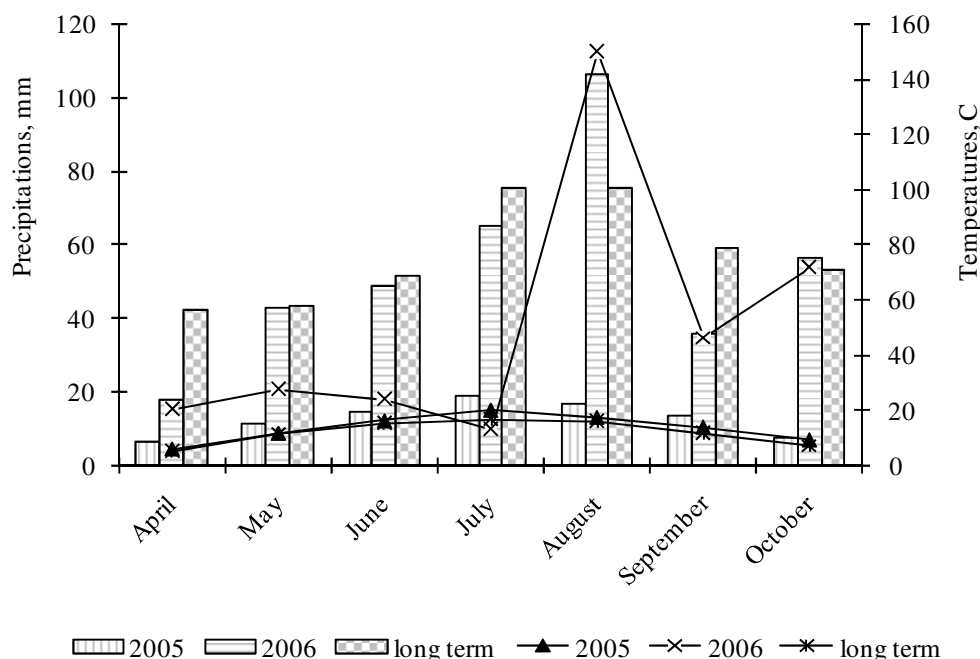


Figure 1. Average day and night air temperatures and precipitations in years 2005 and 2006, °C (according to Vecauce HMS).

Meteorological conditions differ between trial years. Year 2005 characterised by lowered average air temperatures compare to long term observed, but year 2006 – by a pronounced low rainfall and subsequent moisture deficit in the soil, although average air temperature and precipitations in August 2006 were higher than long-term observed (Figure 1).

Data analysis was performed using a mathematical descriptive statistics, correlation and partial correlation analysis.

Results and Discussion

After grouping of observation points by yield of winter wheat grain, we found that yields above 7 t ha^{-1} were harvested in places where the depth of seed placement in soil was on average 3.9 cm. It is significantly shallower compare to other groups of grain yield (Figure 2).

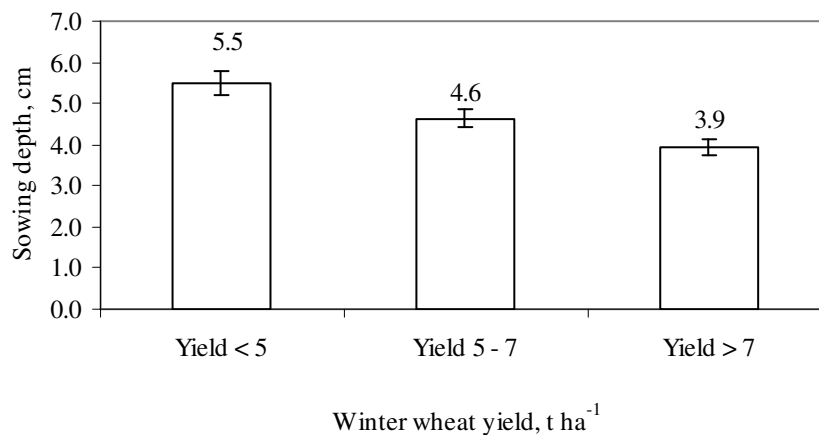


Figure 2. Winter wheat grain yield in dependence of sowing depth.

Overall average grain yield in observation points was 6.09 t ha^{-1} , minimal 3.53 t ha^{-1} , but maximal 9.20 t ha^{-1} . Results shows that formation of high, above 7 t ha^{-1} , grain yield depending on sowing depth as well on plant mass already in autumn (Figure 3). Significant positive effect showed also area of flag leaf what can also be explained by increased weight of plant before wintering.

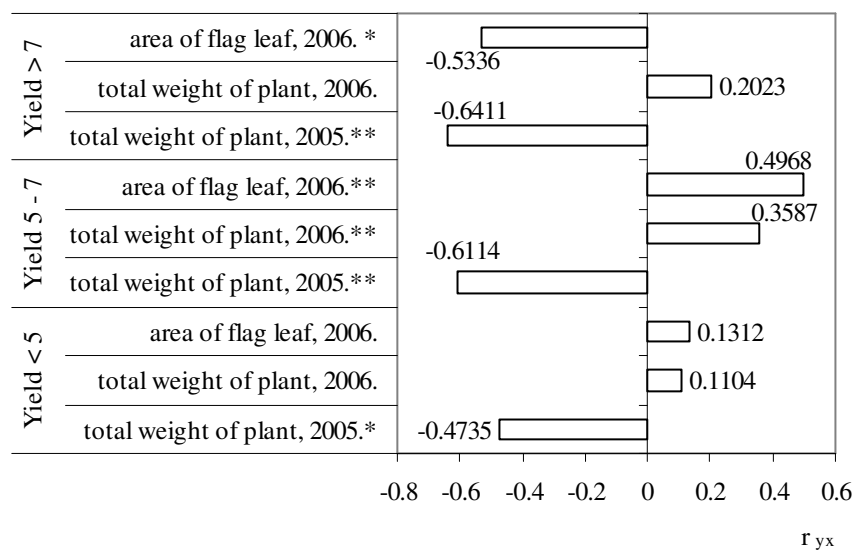


Figure 3. Correlation coefficients between sowing depth and factorial indices ant different winter wheat yield level groups: *P<0.05; **P<0.01.

Importance of sowing depth as a factor determining grain yield at yield levels above 7 t ha⁻¹ sows also correlation coefficients between factorial indices and winter wheat grain yield (Figure 4).

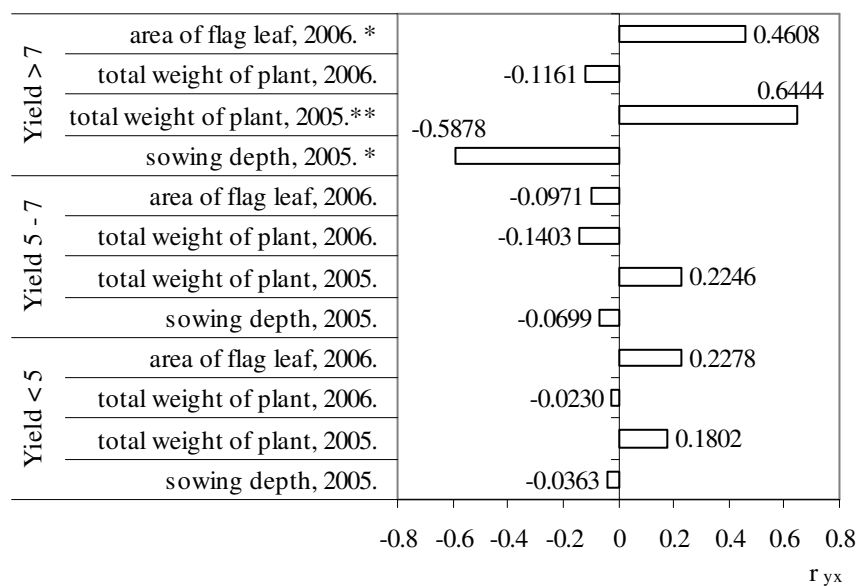


Figure 4. Coefficients correlation among winter wheat grain yield at different yield groups and sowing depth and other factorial indices: *P<0.05; **P<0.01.

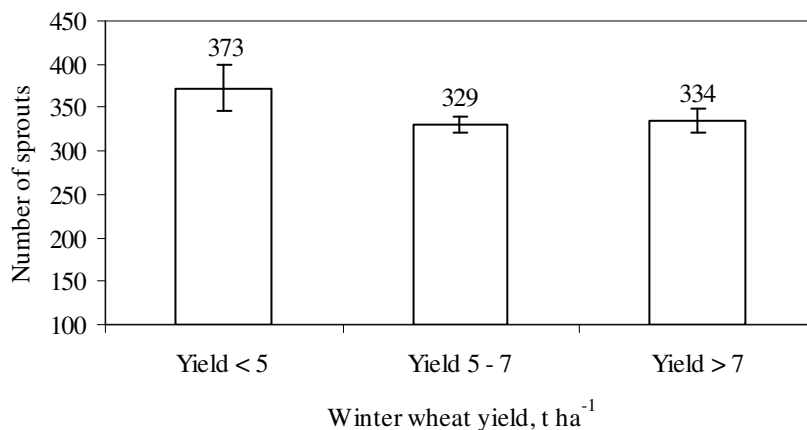


Figure 5. Winter wheat grain yield in dependence of number of sprouts in autumn at BBCH 11-12.

As one of the partly regulated factors for winter wheat yield formation was could be adjusted by drilling rate was number of plants in autumn. Technology of used driller does not allow adjusting drilling rate and sowing depth during working time. Results from observation points shows that in production conditions drilling rate 450 germinable seed per m² gives field germination on average only 75%. It increased up to 82% in observation points with grain yield below 5 t ha⁻¹ and 373 plants per m² in autumn, what shows importance of optimal drilling conditions and winter wheat tillering in autumn (Figure 5).

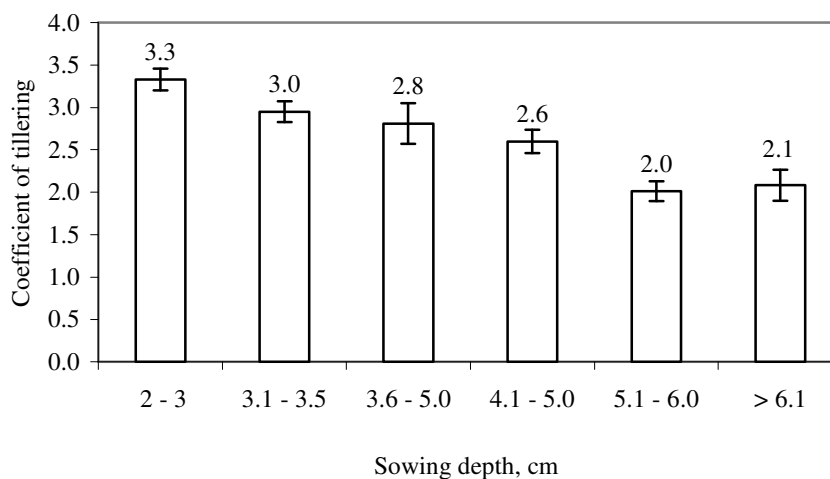


Figure 6. Effect of sowing depth to coefficient of winter wheat tillering at the end of tillering stage.

If we are using drilling rates below 400 germinable seeds per m², it is more important to provide optimal conditions for winter wheat tillering. It was established that sowing depth deeper than 5.1 cm significantly decreased coefficient of tillering (Figure 6).

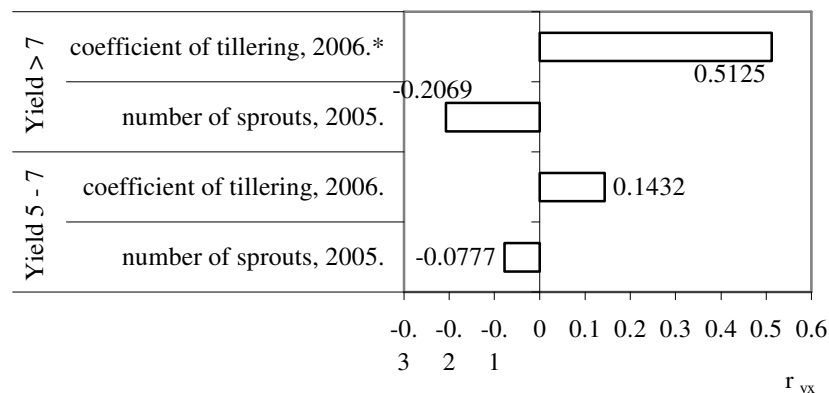


Figure 7. Correlation coefficients between number of sprouts in autumn and coefficient of tillering and winter wheat grain yield at different yield levels: * $P < 0.05$.

In observation points with yield above 7 t ha^{-1} found, that tillering has significant effect to formation of winter wheat grain yield. Data shows that it is possible to harvest high grain yields even in conditions when number of sprouts in autumn is comparable small but only in cases when tillering of winter wheat continues also in spring (Figure 7).

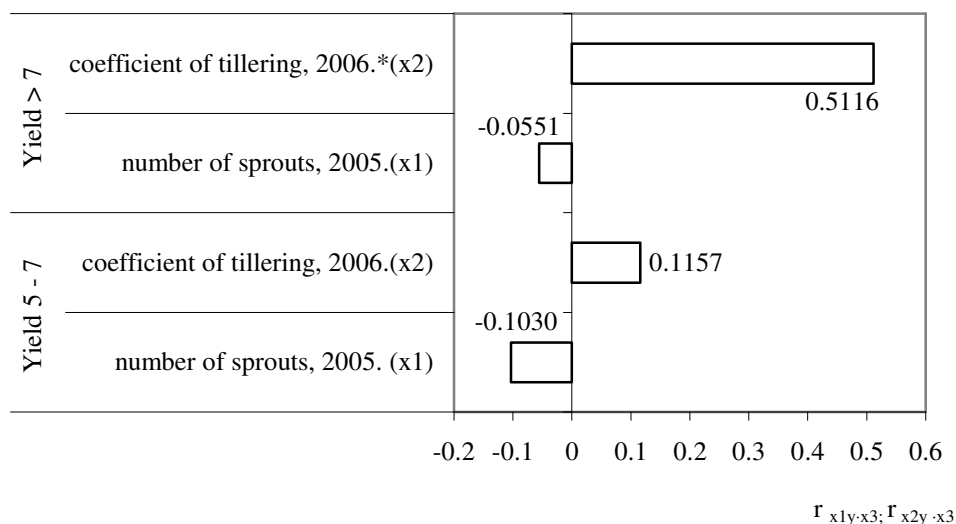


Figure 8. Partial correlation coefficients between winter wheat grain yield at different yield level groups and factorial indices, excluding effect of organic matter content as a factor; * $P < 0.05$.

Hypothesis of trial was that increased sowing depth may be caused by different factors what enable soil looseness: increased organic matter content and thickness of humus horizon. Partial correlation calculations excluding organic matter content as factor showed that it makes no significant effect to coefficient of tillering in places with high grain yield (Figure 8). Similar results were obtained in calculations excluding thickness of humus horizon as factor.

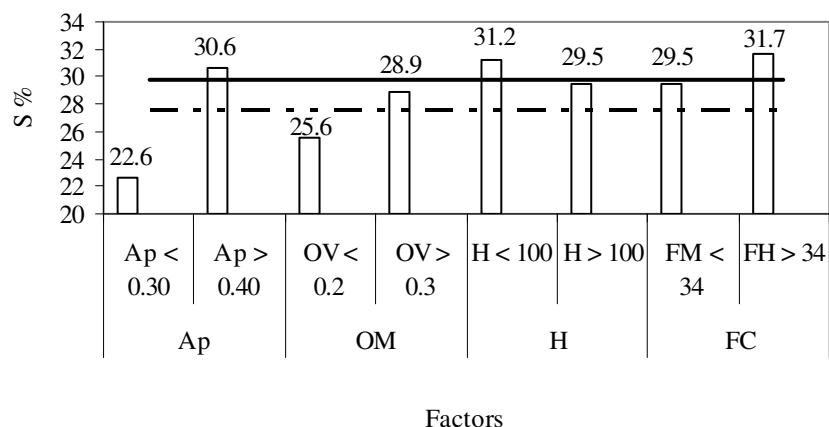


Figure 9. Effect of different factors on dispersion of sowing depth (S%): Ap – thickness of humus horizon, m; OM - organic matter content, g kg⁻¹; H – relative height above the sea level, m; FC – content of physical clay, %.

Increased dispersion of sowing depth was enabled by increased thickness of humus horizon above 0.4 m, field points with low relative altitude above the sea level with increased organic matter content and increase content of physical clay. In circumstances when choice of seeder model and drilling time has already done, the only solution is to harmonize the depth of pre-sowing soil tillage with working specifications of driller. As the possible optimization if using driller Amazone D8-45 Super is to decrease the depth of soil pre-sowing tillage to 12-17 cm so as to ensure plant residues incorporation in soil. For site-specific soil tillage technologies in fields with uneven soil conditions GIS application is essential.

Conclusions

1. Sowing depth was significantly higher at winter wheat grain yield level at 5 t ha⁻¹ if compare with yield above 7 t ha⁻¹.
2. Partial correlation calculations shows that exclusion of both - organic matter content and thickness of humus horizon - shows no significant effect to coefficient of tillering in places with grain yield above 7 t ha⁻¹.
3. It is recommended to decrease pre-sowing soil tillage to 12-17 cm if using driller Amazone D8-45, thus to coordinate the depth of pre-sowing soil tillage and driller working specification.
4. Above 7 t ha⁻¹ grain yield depending on sowing depth as well on plant mass already in autumn. Significant positive effect showed also area of flag leaf what can also be explained by increased weight of plant before wintering.
5. Production conditions drilling rate 450 germinable seed per m² gives field germination on average only 75%. It increased up to 82% in observation points with grain yield below 5 t ha⁻¹ and 373 plants per m² in autumn, what shows importance of optimal drilling conditions and winter wheat tillering in autumn.
6. Partial correlation calculations excluding organic matter content as factor showed that it makes no significant effect to coefficient of tillering in places with high grain yield. Similar results were obtained in calculations excluding thickness of humus horizon as factor.
7. Increased dispersion of sowing depth was enabled by increased thickness of humus horizon above 0.4 m, field points with low relative altitude above the sea level with increased organic matter content and increase content of physical clay. In circumstances when choice of seeder model and drilling time has already done, the only solution is to harmonize the depth of pre-sowing soil tillage with working specifications of driller. As the possible optimization if using driller Amazone D8-45 Super is to decrease the depth of soil pre-sowing tillage to 12-17 cm so as to ensure plant residues incorporation in soil.

Acknowledgements

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EXPERIENCE OF ASSESSMENT OF SOCIAL ECONOMIC SITUATION IN LATVIA

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Abstract

Latvia competitiveness is quite controversial. In a situation with the rapid structural changes, economy develops in balance very rarely - in different fields will always be more rapid changes in another more stagnation.

Researchers from Doctoral study program of Agrarian and Regional Economics in Latvia University of Agriculture have done research about usage of different indices compiled by international organizations and researchers for evaluating social economic situation in Latvia.

Latvia is still at a weak position from a technological perspective, and need to borrow the knowledge and technology from more developed countries. Moreover, technological developments' followers pay relatively less, and it is possible to maintain relatively high growth rates in science and research, investing fewer resources.

Today's intensification of global competition explained by economic openness, which is gradually breaking down economic barriers between regions, and continues to develop various international organizations to agree on mutual terms of trade and investment flows between countries to avoid the recurrence of strong protectionist policy, which led to the global economic crisis.

Exploring the openness of the economy, the author observed certain risks included in the reports describing situation of competitiveness where government policies competing in the tax system, the rates of labour market policies, investment environment, etc. This is a very important factor resulting in competitive advantage.

Key words: regional economic, social economic situation.

Introduction

Each administrative territorial units (parishes, towns, districts, counties) and regions can be described using many different parameters, and each of them can form different spatial clusters. Particular importance of these characteristics is among those that may serve as indicators, both describing the situation as a whole and find a causal relationship, as well as emphasizing the ongoing processes.

Right now such indicators are rarely used, relatively a few studies have been carried out, basic data necessary for analysis are lacking. There is no unanimity concerning value of indicators or value sets in Latvia which would have to be used for regional planning and situation analysis.

Great contribution concerning development of indicators and their usage describing territorial units of Latvia has been made by the following Latvian scientists: J.Eglītis, O. Krastiņš, M. Krūzmētra, A. Melluma, L.Ramute, B. Rivža, P. Rivža, A.Sproģis, I.Stokmane, E. Vanags, I. Vilka.

Macroeconomic and microeconomic situation in the country can be analysed at the global level when assessing general competitiveness of the country, tendencies of economic development, and driving forces of economy in comparison with other countries. However, regional development of the country and assessment of its factors of influence are not less important.

As soon as the country enters in the international circulation policy makers are engaged with state's development planning, opposition, electorate and media worry about loss of competitiveness as a result of a particular decision, and economists *post factum* conclude that monetary or fiscal policy in a particular period enabled increase or loss of competitiveness (Vanags, 2005). This tendency is familiar in every country operating in the international market. However, the most well-known products are indexes of competitiveness - complex indicators calculated according to selected criteria and state's competitiveness success measurements. They allow to rank a country in a particular position in comparison with the entire world and to assess development within a period of time.

Materials and Methods

Statistical data on Latvian rural municipalities published by the Statistics Board of the Republic of Latvia and publicly available statistical data were used as a basis for integrated characterization of the administrative-territorial division research. Together with the above stated concerning preparation of territorial statistics in Latvia, integrated characterization of the administrative-territorial division research has to be perceived as an offer of the methodology with an opportunity to repeat and improve it with possibly published statistical data on newly formed local-municipalities in future.

Monographic and comparison methods, as well as argumentative constructive methods, analysis and synthesis, scientific induction, deductive methods and analysis of factors were used in the research of the socioeconomic situation in Latvia.

Results and Discussion

The first methodology of territorial development index calculation was developed by the Latvian Statistics Institution in 1996 and 1997. It was used to define applicants for obtaining a status of special support territory. The methodology was relatively simple - all the territories were ranged according to their indicators of economic development.

Afterwards the ranks of all the indicators were weighted using special coefficients of indicator weight, and a sum of weighted rank was obtained for the each territorial unit. These sums were ranked again, and the rank of the each unit reflected the position of the particular territory in the whole general process of segregation.

According to the methodology of 1997 the special support territories were defined separately into two groups. The first group consisted of the regions and major cities of the Republic, the second group consisted of the rural municipalities and towns.

The following showings were used within the group of the rural municipalities and towns (weight of their importance is given in brackets):

- Unemployment rate (2);
- Personal income tax per capita (2);
- Demographic burden (1);
- Population density (1);
- Proportion of areas used for industrial needs and of areas with industrial and social infrastructure objects in total area of territory (1);
- Number of persons with the highest and secondary education per 1000 inhabitants who are 18 years old and older (1).

The methodology of 1997 was improved in 2000 improving composition of the group and the scope of the considerable indicators, and substantially changing calculation of the general index. There are no more two indicators in the improved methodology:

- Proportion of areas used for industrial needs and of areas with industrial and social infrastructure objects in total area of territory (1);
- Number of persons with the highest and secondary education per 1000 inhabitants who are 18 years old and older (1).

According to the methodology of 2000 general indexes were calculated by standardizing original basic indicators. Thus, indicators expressed in different units of measurements could be compared, and the average weighted index could be calculated. After 2008 the administrative-territorial division of Latvia consists of self-governments at the local level - districts and major cities of the Republic; rural municipalities and regions are not anymore administrative territories, statistics concerning them are not published, thus, the previously stated methodology to calculate the general index and carry out researches of dynamics can not to be applied anymore.

The U – index as continuation of the factor analysis was used to study urbanization of the Schwerin region (Umland von Schwerin) by the German scientists O. Margraf and H. Usbeck (Margraf, Usbeck, 1984). The U – index was used in Latvia for the first time in the studies of the Latvian frontier area problems carried out by A. Melluma, the Professor of the University of Latvia (Melluma, 2000).

In 2008 the u-index as a complex characterizer of the socioeconomic situation developed by the German scientists O. Margraf and H. Usbeck was adapted for analysis of the administrative-territorial division of Latvia. The particular features were selected for the index synthesis in order the features representing different groups of the statistical indicators could be subjected to the analysis - indicators characterizing territory, inhabitants, economic situation, and infrastructure. The u-index calculated for each administrative-territorial division of Latvia describes a socioeconomic situation of the district, and the administrative territories were ranged and compared according to it. For 70% of the self-governments the total value of the u-index is under the average one of Latvia, and only for 30% it is higher than the average value of Latvia. It has to be pointed out, in its turn, that the average value of the complex indicator unequivocally is influenced by the socioeconomic evaluation of the major cities of the Republic and Riga which sharply differs from the socioeconomic situation of the other administrative territories of Latvia (Table 1).

Table 1.

New Local Municipality Distribution according to U - index

No.	Index value	Number of municipalities	Division of municipalities, %
1.	greater than 0.1	26	25%
2.	from 0 to 0.1	5	5%
3.	from -0.1 to 0	9	9%
4.	from -0.2 to -0.1	15	15%
5.	from -0.3 to -0.2	11	11%
6.	up to -0.3	36	35%

When analysing self-governments according to the values of the complex U-index, a connection between the self-government evaluation and its location - the distance from Riga, the capital city of Latvia, - can be observed. It was stated that there is medium close, negative correlation (the coefficient of correlation $r=-0.6$) between the distance of the districts to be formed anew till Riga, the capital city of Latvia, and the values of the U-index. There is a tendency that if the distance from the district till Riga increases the value of the district U-index decreases.

Traditionally in economy by index we understand changes of the particular indicator within a period of time (Eglītis, 2008). The index within the context of this study is a complex indicator calculated on the basis of mathematical compilation of selected simple or complex indicators. A rating traditionally is a sequence of particular objects depending on value of the particular parameter, indicator or index (a term "rank" is used to describe such a serial number).

The results of international studies can be described in two ways: from the view of foreign (international) and domestic policy. Therefore, certainly the studies have wide international publicity. High indicators create a positive image of the country, institution, field or another object, increase value of the brand, authority of particular institution and person.

High indicators create a positive image of the country, institution, field or another object, increase value of the brand, authority of particular institution and person.

In order the Baltic States and business persons could develop and compete, it is necessary to find new foreign collaboration partners, as well as to further incoming of foreign capital in the Baltic States.

The most important issues presenting data about Baltic States are included in Table 2.

Table 2.

Summary of International Issues

<i>Issue title</i>	<i>Organization</i>
OVERALL	
Human Development Index	United Nations
Worldwide Quality-of-Life Index	The Economist
Quality of Life	International Living
Happy Planet Index	The New Economics Foundation
Index of Globalization	KOF Swiss Economic Institute
Millennium Development Goals Index	United Nations
Sustainable Development Index	United Nations
ECONOMIC	
Knowledge Economy Index	World Bank
(Doing Business	World Bank
Global Competitiveness Index	World Economic Forum
Global Competitiveness Index	International Institute for Management Development
Business Competitiveness Index	World Economic Forum
The Lisbon Review	World Economic Forum
Index of Economical Freedom	Heritage Foundation
The currency evaluation ratings	Standard & Poor's
The currency evaluation ratings	Fitch's
Central Bank assessment ratings	Standard & Poor's
INDUSTRY	
The Logistics Performance Index	World Bank
Travel & Tourism Competitiveness Index	World Economic Forum
Network Readiness Index	World Economic Forum

<i>Issue title</i>	<i>Organization</i>
e-Readiness Rankings	The Economist
KNOWLEDGE	
Knowledge Index	World Bank
Students' research skills	OECD
POLICY	
Index of Freedom	Freedom House
Freedom of the Press	Freedom House
Corruption Perceptions Index	Transparency International
Global Peace Index	Vision of Humanity
Economist Intelligence Unit Democracy Index	The Economist
The Failed States Index	Foreign Policy
SOCIAL	
Migrant Integration Policy Index	British Council
Poverty Index	United Nations
Gender Related Development Index	United Nations
Gender Empowerment Measure	United Nations
ENVIRONMENT	
Environmental Performance Index	Yale University

Source: Eglītis, 2008, Authors' updated information

Several economic indexes mentioned in the Table 2 are discussed and analysed in the study marking potential and competitiveness of the Baltic States in the environment of globalization.

The World Economic Forum is a union made by the leaders of business, politics, economics and other leaders of society with a purpose to improve world economic situation. The Forum was established in Geneva, Switzerland. It is a fund which is not oriented to profit-making, nor is defending particular political or national interests. The Forum has an advisory status in the UNO Economic and Social Council. There are 133 countries included in The Global Competitiveness report prepared by the World Economic Forum in collaboration with Harvard University and collaboration institutions of the Partner States in 2009. It is a significant source of information concerning states economic situation revealing strong and weak points of each country according to the single system. When making policies and for the business sectors it helps assess and pay attention to particular sectors and their dynamics in comparison with other countries. When analysing processes of economic growth at the state level, several factors have to be there to define if a country has reached the corresponding stage of economic development. In 2001 scientists J. Sachs and J. McArthur suggested a new indicator when analysing state's economic growth – Growth Competitiveness Index. It was presented in the publication of the World Economic Forum 'The Global Competitiveness report 2001–2002'. Its aim was to assess potential of the medium-term and long-term economic growth level of the world countries. By 2006 the Report included two different indexes: Growth Competitiveness Index and Business Competitiveness Index (formerly – Microeconomic Competitiveness Index). A new indicator was included in The Global Competitiveness report 2006–2007 – Global Competitiveness Index which replaced the Growth Competitiveness Index. The Baltic States for the first time were included in this Report in 2001. By 2008 the World Economic Forum has improved methodology of index calculation, as a result a single overall index has been developed – Global Competitiveness Index. The new index includes all the ruling aspects of competitiveness and by 2009 completely replaced the separate indicators of the World Economic Forum describing macroeconomic and microeconomic competitiveness.

Within the context of country's competitiveness Index of Economic Freedom also is often mentioned which is calculated since 1995 by the Heritage Foundation and is published in the Wall Street magazine every year (Index of Economic Freedom, 2009). The Heritage Foundation was established in 1973 in the United States of America as a research and educational organization. The aim of the Heritage Foundation is to formulate and promote conservative state policy based on such principles as freedom of business, individual freedom, strict national protection, restriction of governmental regulation, etc.

The index of economic freedom is not based on original statistics, but on derivative materials and information published in the publications of several international organizations (World Bank, World Trade Organization, Economist Intelligence Unit, International Monetary Fund, OECD, etc.), as well as in the official publications of each particular country (Index of Economic Freedom, 2009).

The basic aim for developing this index was to give to policy makers and investors summarized information on business environment and investments and their changes in a particular country in comparison with other countries included in the study. Latvia and Lithuania were included in calculations since 1996, and Estonia - already since 1995.

One of the initiatives of the World Bank in the area of information and research is summarization of information on development of states private sectors. There are two databases: Doing Business and Investment Climate. Within the context of competitiveness there is a database 'Doing Business' – it is a common publication of the World Bank, International Finance Corporation and Oxford University. It was published in 2003 and included indicators on five themes: starting a business, employing workers, enforcing contracts, getting credit and closing a business. There are 10 groups of indicators already included in the publication of 2009, such as starting a business, dealing with construction permits, employing workers, registering property, getting credit, protecting investors, paying taxes, trading across borders, enforcing contracts, closing a business. It is planned to add one more additional group of indicators concerning power supply next year.

The indicators concerning business environment, factors contributing or hindering business in the database of 2009 are summarized on 181 countries, including the Baltic States. It includes all the countries where the number of population is over 1.5 millions (Estonia – 1.4 million, Fiji 0.8, Bhutan 0.9, Maldives 0.3 and other smaller countries), and particular countries also with a smaller amount of inhabitants, except the passive members of the International Development Association (Cuba, Korea, the Korean Democratic Republic, Liberia, Myanmar, Somalia, Sudan), countries where right now is or just was a situation of military conflict, or countries which data are not available (Afghanistan, Eritrea, Iraq, Libya, Tajikistan, Turkmenistan, Gaza-West Bank territory).

The International Institute for Management Development (IMD) World Competitiveness Centre (WCY) is the world's most renowned and comprehensive annual report on the competitiveness of nations, ranking and analyzing how a nation's environment creates and sustains the competitiveness of enterprises. Based on analysis made by leading scholars and by our own research and experience, the methodology of the WCY thus divides the national environment into four main factors – economic performance, government efficiency, business efficiency, and infrastructure. There are 57 countries and regional economies described in the Yearbook in 2009. According to the IMD World Competitiveness Centre those countries and specific regional economies are included in the Yearbook which according to the views of the IMD researchers have influence in world economy and of which comparable international statistical data are available. Estonia has been included in the Yearbook since 2003, Lithuania - since 2007, but Latvia is not included, though, it complies with the criteria. The IMD is interested to include in the Yearbook also Latvia if their administrative and financial resources permit it (World Competitiveness Yearbook, 2009).

By 1996 both institutions – IMD World Competitiveness Centre published a common competitiveness index in the World Competitiveness Yearbook, but in 1996 they split, and now they make separate indexes where the World Economic Forum more emphasizes inquiry data (approximately 3/4 of the data are inquiry data, 1/4 – statistical data), however, the proportions of the IMD are correspondingly 2/3 statistical data and 1/3 – inquiry data.

Conclusions

For long time during the post-war period Europe has been in a comfortable position – the USA had the leading role in development and innovation implementation making investments in development and research, and Europe had followed adapting innovations very successfully which certainly is a cheaper and more comfortable way how to move forward. Naturally, in such a situation expenses for science and research are low, and also collaboration between the research institutions and business sector is not qualitative. Right now the situation is changing – Europe wants to become leading economy, and, therefore, it has to consider remarkable expenses. Besides, Asian players come aggressively into the global market, thus, even more escalating competition and deranging the usual order of issues. There are structural reforms of a broad scale going on in Europe – the EU is enlarging, there are reforms within the financial, goods and services markets, therefore evaluation and comparison of world states competitiveness are carried out by independent international organizations.

Competitiveness often is considered as the main indicator of political success or failure, and its determination at the regional level sometimes can be rather problematic. It is important to remember that an industrial region will never directly compete with an agricultural region or financial centre, thus, determination of competitiveness of such regions is problematic.

Creating the strategy of state's development a discussion on state and regional competitiveness is unavoidable. Instead of making plans how to outdo other countries it would be more helpful to agree on principles and measurements of sustainable development to raise public prosperity using the principle of mutual partnership.

Economists explain current aggravation of competitiveness in the world due to open economy where step by step pulling down economic barriers among the regions various international organizations have to be established with a purpose to agree on mutual rules concerning trade and investment flow direction among the countries in order to prevent recurrence of severe protectionist policy which caused the global economic crisis.

Nowadays competitiveness singles out value of education, knowledge and intangible contribution, as well as technological infrastructure.

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OFFICE AUTOMATION IN RURAL AREA ORIGINS, DEVELOPMENT, AND CURRENT SITUATION

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Abstract

The aim of this paper is to display the current situation and the development of the office automation in rural area of the Latvia. At begin of the article given the three different periods of the in the rural area. Transmission from mechanical office to office automation was passed in these periods. Origins of the typewriter and calculating machine are given in the article. The tabulating machines and the mainframe computers widely used in the Computer Stations. The early era of computing was characterized by batch processing. The crucial difference is that with batch processing the user must put all of the data into the computer before seeing any of the results, while with interactive processing the user can decide how to handle each item on the basis of the results obtained with earlier items. Office automation refers to the varied computer machinery and software used to digitally create, collect, store, manipulate, and relay office information needed for accomplishing basic tasks and goals. 1990s years were characterized by the peasant farms, which were founded in Latvia as result of the Land reform. The farmer as a computer user was becoming more and more directly involved in the processing of information through the PC. The most dramatic shift for business in communications technology has been the Internet. MS Office applications mainly are used in the office of peasant farms. The new technologies of Internet, the mobile and wireless technologies continue to develop in the rural area.

Key words: mechanical office, office automation, farm, software.

Introduction

Today, peasants use computers in the office for four main tasks. There is document preparation: for example, using a word processing program to produce letters and reports. There is information storage: for example, using a database program to store names and addresses, or inventories. And there is financial analysis and accounting: for example, using a spreadsheet program for financial forecasting, or using a computer to organize a payroll. While the 3 streams were centred around the processing of information in the office, the fourth, communications technology, focused on the movement of information from one place to another.

The transmission from office mechanization to office automation passed in rural area in Latvia.

The considerable changes are took place from 1920s to nowadays in rural area also. Social, economic changes concerned the farms in this period. Different kinds of farms are viewed in the separate periods (table 1).

Table 1

Stages of office mechanization and office automation in rural area in Latvia

Stages of development	Years									
	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s	
Office mechanization in private farms										
Office mechanization in collective farms										
Office automation in collective farms										
Office automation in peasant farms										

An office is a single room or separate workplace in the farm. The development of the office work given in connection with technological achievements in the world.

Methods: scientific abstractions, monographic, analysis, expert.

Results and Discussion

The desire to economize time and mental effort in arithmetical computations, and to eliminate human liability to error, is probably as old as the science of arithmetic itself. This desire has led to the design and construction of a variety of aids to calculation beginning with groups of small objects such are pebbles, first used loosely, later as

counters on ruled boards, and later still as beads mounted on wires fixed in a frame, as in the abacus (Randell B., 1975). Appearance of the first writing devices promoted office work. Origins of typewriting and calculating are given in the beginning.

Origins of typewriting

In 1714, Henry Mill obtained a patent in Britain for a machine that, from the patent, appears to have been similar to a typewriter, but nothing further is known. Many of early machines were developed to enable the blind to write. In 1829, William Austin Burt patented a machine called the *Typewriter*, which, in common with many other early machines, is listed as the first typewriter (Campbell-Kelly M., 2004).

By the mid-1800s the increasing pace of business communication had created a need for mechanization of the writing process. Stenographers and telegraphers could take down information at rates up to 130 words per minute, whereas a writer with pen was limited to a maximum of 30 words per minute.

From 1829 to 1870, many printing or typing machines were patented by inventors in Europe and America, but none went into commercial production. The first typewriter to be commercially successful was invented in 1867 by C. Latham Sholes in Milwaukee, Wisconsin. This was the origin of the term *typewriter*. Remington began production of its first typewriter on March 1, 1873, in Ilion, New York. It had a QWERTY keyboard layout. So-called visible typewriters Oliver were introduced in 1895. The first electric typewriter was produced by the Blicken Manufacturing Company, of Stamford, Connecticut, in 1902. The final major development of the typewriter was the electronic typewriter in 1989 (Campbell-Kelly M., 2004).

Initial steps to mechanize office work had been taken in the 1850s. From the 1880s, more and more mechanical machines were to be found in offices. They were used to handle tasks which had previously been done manually or by means of mental arithmetic, and had therefore been time consuming and tiring.

Typewriters symbolized the new office world. From their invention before 1870 through much of the 20th century, typewriters were indispensable tools for many professional writers and in business offices. They made a major mark on the 20th century, shaping the social organization model. They also enabled the large-scale arrival of women in the workplace. Our modern computers still incorporate the fundamental characteristic of typewriters: the keyboard, with QWERTY or AZERTY arrangements of keys. One name is synonymous with typewriters: Remington. In 1878, a second model was released which included a major innovation for its time, one we now take for granted: the possibility of shifting between upper-case and lower-case characters.

The fundamental activity of the office world is to produce documents. The essential complementary functions are the ability to classify, sort, retrieve and archive the said documents. While these secondary activities have never aroused as much passion as typewriters, many inventions have nevertheless greatly helped the rise of office work.

It was in Germany that the typewriter really began to develop, with the 1904 launch of legendary Mignon typewriter. The work carried out by the Italian Camillo Olivetti also deserves recognition.

By the end of World War I, the various players had taken up their positions, and the balance of power was not to shift throughout the 1920s; the US dominating the field of data-processing, gaining a foothold all over the world, and holding a position of leadership that nobody could contest (Goldstine H.H., 1972).

Origins of calculating

The history of calculating machines stretches further back in time than that of the typewriter. It officially began with Blaise Pascal in 1642 (Pascaline), even though, long before then, Leonardo da Vinci had outlined the basic principle, and in 1623 the German Wilhelm Shickard had built Calculating Clock. Gottfried Wilhelm Leibniz devised a competing design, the Stepped Reckoner, in 1672, which could perform addition, subtraction, multiplication and division (Swedin E.G., 2007).

Mechanization of office work began with the Thomas arithmometer, which was produced on a small scale in France from the 1850s. Until the 1870s, it remained the only series-produced calculating machine in the world. Further – and now sweeping – mechanization of office work came from the USA in the 1880s, where first typewriters and cash registers became very popular, followed by calculating machines. The arithmometer, the first mass-produced calculator – manufactured at a rate of one or two per month – appeared in France through the initiative of Thomas Colmar. The second generation of machines can be attributed to the Swede, Willgodt T.Odhner, who perfected a pin-wheel system (O'Regan G., 2008).

Investing in calculating machines could not be justified, given that accountants were well-trained in the art of calculating by hand, without making mistakes and far more quickly than with a manually operated machine, tediously difficult to use. The market would only be convinced if data could be input quickly, and, above all, if the machine could provide written results.

The 1885 invention of the then 22-year-old Felt was a keyboard, which ensured that the dials of the Arithmometer. Although the Arithmometer was relatively inexpensive, demand remained low because its speed of operation was too slow for routine adding in offices. In 1887, Felt joined forces with a local Chicago-based manufacturer, leading to the founding of Felt&Tarrant Manufacturing Co., and the production of 1000 Coptometers in 1900. Patented in the USA by Dorr E. Felt in 1887, the Coptometer was the first commercially successful key-driven mechanical calculator (O'Regan G., 2008).

Around the same time, in 1886, the American Arithmometer Co, was founded, with a view to manufacturing and selling the first-ever calculating machine to feature a printing function, 28-year-old William Seward Burroughs, 1885 invention the Adder-Lister. The company was re-named Burroughs Adding Machine Co, Burroughs Corporation in 1953. By 1920, 800000 Burroughs machines had been sold worldwide, and the one million mark was reached in 1926. Burroughs also made headway abroad, and as early as 1925 were present in 60 countries. Burroughs extended operations by taking over a number of competitors and integrating their techniques (O'Regan G., 2008).

Adding machines were concerned with processing information. The development of mass-produced adding machines followed the development of the typewriter by roughly a decade, and there are many parallels in the two industries. An adding machine is a type of calculator, usually specialized for bookkeeping calculations. In the USA, the earliest adding machines were usually built to read in dollars and cents. Adding machines were ubiquitous office equipment until they were phased out in favour of PC, beginning in about 1985. The machines were rarely seen after the year 2000.

At the beginning of the 1880s the critical challenge in designing an adding machine for office use was to speed up the rate at which numbers could be entered. A second problem came into view: financial organizations, particularly banks, needed a written record of numbers as they were entered into the adding machine so that they would have a permanent record of their financial transactions. The solvers of these two critical problems Felt and Burroughs, were classic inventor-entrepreneurs. The machines they created, dominated the worldwide market well into the 1950s (O'Regan G., 2008).

Filing systems

Typewriters aided the documentation of information, while filing systems facilitated its storage.

Filing systems for record keeping were one of the breakthrough business technologies, occurring roughly in parallel with the development of the typewriter. Without the technology to organize loose sheets of paper, the typewriter revolution itself could never have occurred.

The vertical filing system was a major innovation, but it has become so commonplace that its significance is rarely noted. It is simply the system of filing reports in wood or steel cabinets, each containing three or four deep drawers; in the drawers papers are stored on their edges. Papers on a particular subject or for a particular correspondent are grouped together between cardboard dividers with index tabs. Vertical filing systems used only a tenth of the space of the box-and-drawer filing systems they replaced, and made it much faster to access records.

In the early 1890s, the first vertical filing folders were introduced. However, with the escalating number of files, a means of rapidly identifying the desired documents became indispensable.

Hence, the many inventions that emerged, including handy system of colored labels and strips. James Rand invented a card-based information storage system, going under the name of Kardex.

The first accounting machines appeared on the market in about 1900 – also in the USA. They combined writing in arithmetic. In Germany, mechanization of office work emerged about two decades later than in the USA. From 1900, the makers of office machines, especially in the USA, underwent a tremendous period of growth. American companies were rapidly setting up subsidiaries in Europe, and left little or no room for European innovators (Corniou J.P., 2006).

Sorting

The age of automatic data processing began with Herman Hollerith's punched card systems, which were first used to analyse the USA census in 1890. Now it was possible to collect previously inconceivable amounts of data, and to process these data at an acceptable level of effort and cost. Hollerith's company, Tabulating Machine Co. expanded throughout the continent.

Calculating frames and calculating machines such as Felikss widely have been used in the calculating operation in 1920s-1940s. (Lacis M., 1971) Calculating machines were based to technology of the gear wheels.

Table 2

Calculating machine	Number of arithmetic operations per hour		
	Addition or subtraction	Multiplication	Division
Counting on the paper	600	40	50
Calculating frame	750	50	40
Adding machine SDM-107	1900	x	x
Arithmometer Felikss	500	180	100
VK-1	1000	330	210
VK-2	1300	420	350
KEL	900	410	270

Source: Lacis M. Calculating machines and their exploitation, Riga, Liesma, 1971

Office automation is a general term that includes a wide range of applications of computer, communication and information technologies in office environments. Office automation refers to the varied computer machinery and software used to digitally create, collect, store, manipulate, and relay office information needed for accomplishing basic tasks and goals. Raw data storage, electronic transfer, and the management of electronic business information comprise the basic tasks activities of an office automation system. Office automation helps in optimizing or automating existing office procedures. The backbone of office automation is a LAN, which allows users to transmit data, mail and even voice across the network. All office functions, including dictation, typing, filing, copying, fax, telefax, microfilm and records management, telephone and telephone switchboard operations, fall into this category. Office automation was a popular term in the 1970s and 1980s as the desktop computer exploited onto the scene (Ornstein S.M., 2002).

Table 3

Some machines of the period 1939-1954

Name of machine	Year	Addition time (seconds)
Electromechanical machine, Bell Labs	1939	0.3
Electromechanical, machine Harvard-IBM	1944	0.6
Vacuum-tube computer, ENIAC	1946	0.0002
Vacuum-tube, computer UNIVAC	1951	0.0005
Vacuum-tube, computer IBM 701	1953	0.00006
Vacuum-tube, computer IBM 704	1954	0.000024

Source: Moreau R. The computer comes of age, MIT Press, 1986

Computing in the collective farms

The significant computing started in 1960s in Latvia. The punch tabulating machines processed data of collective farms in the Computing stations. They could sort, merge and summarize data on the punch cards. Germany electromechanical accounting machines such as Ascota, Soemtron, Celletron and other office techniques were supplied to the collective farms.

In the 1960s, 3 clearly identifiable streams of development became evident. The first was computing, where the earliest applications were automated payroll and inventory – control systems. Other applications were also limited to the processing of numerical data. These systems were usually operated only by programmers in the data-processing division of the organization, who jealously guarded their computers and the power their knowledge of the computer gave them. Nevertheless, the applications of computers in organizational settings grew to include more and more kinds of data processing.

The second stream of technological development was in the area of text processing. In the mid-1970s IBM introduced a product called the MCST – Magnetic Card Selectric Typewriter. This device had a box crammed with electronic equipment. The card served as a memory device, on which the text would be written in a code based on magnetized spots. Once it was entered, the text could be edited and played back, causing a new copy to be typed out on the attached typewriter. Compared to current word-processing systems, this one was primitive, but it worked. By the end of the 1980s, word processors and personal computers had largely replaced the tasks previously accomplished with typewriters in the western world.

While the first 2 streams were centred around the processing of information in the office, the third, communications technology, focused on the movement of information from one place to another. A wide range of techniques to achieve this end were introduced, from telex and facsimile services using specially conditioned telephone lines and others using sophisticated satellite links between distant points. The age of rapid communication began with the introduction of electromechanical telegraphs shortly before the middle of the 19th century.

Batch processing was the noninteractive use of computers. In batch processing the user gives the computer a batch of information, referred to as a job – for example, a program and input data – and waits for it to be processed as a whole. Batch processing contrasts with interactive processing, in which the user communicates with the computer by means of a terminal while the program is running. The crucial difference is that with batch processing the user must put all of the data into the computer before seeing any of the results, while with interactive processing the user can decide how to handle each item on the basis of the results obtained with earlier items.

Batch processing was a cumbersome way of computing. For even the smallest programming task, it was necessary to have the relevant code punched onto program cards, which were then combined with control cards to take care of the computer's administrative functions. A computer operator fed the cards into the computer or onto magnetic tape for processing, one batch at a time. Depending on the length of the queue and the complexity of the programs and problems, the wait could be long. It was not unusual to wait a day or longer for results.

Timesharing a technique developed in the 1960s for running more than one program on the same computer at the same time, so that, for example, the computer can serve many users at different terminals simultaneously.

Timesharing is based on the idea that a computer spends most of its time waiting for things to happen. Almost all input-output devices (printers, disks, etc.) operate much more slowly than the CPU itself; the extreme case is a terminal or console where the computer may spend minutes or hours waiting for someone to type something. In a timesharing system, more than one program is loaded into memory at once, and when the computer is unable to proceed with one program, it jumps to another.

Timesharing was, as the term suggests, a new method of giving many users interactive access to computers from individual terminals. The terminals allowed them to interact directly with the mainframe computer. The revolutionary aspect of timesharing was that it eliminated much of the tedious waiting that characterized batch-process computing. Timesharing gave users terminals that allowed them to interact directly with the computer and obtain their results immediately.

The invention of the transistor at Bell Lab in the 40s and the later development of integrated circuits brought PC to the consciousness. These inventions permitted computer to become smaller, faster, cheaper, more powerful, and more reliable.

1980s years were related to using personal computers (PC). The mainframe computers were replaced with PC. On-line approach uses technology when data is input immediately.

Using of PC Robotron-1720 had been expanded.

Personal computer in the peasant farms

1990s years were characterized by the peasant farms, which were founded in Latvia as result of the Land reform (Gailums A., 2004). The peasants purchased PC for different computing works such as book-keeping and planning agricultural production. PC was a power tool for a data processing and a problem-solving tool. The farmer as a computer user was becoming more and more directly involved in the processing of information through the PC.

Peasants use PC for different purposes. Some peasants use computers for entertainment and for education. According to the survey regarding the usage of information technology in rural areas, the biggest user group consists of school – age children. Other peasants use computers for management of the farm. They have one or several software packages. Book-keeping and planning are basic functions of the management in the farms.

Origins of software applications

Word processing, the online preparation, editing, and formatting of documents for later printing, is a term introduced by IBM in 1964 in conjunction with the introduction of a Selectric typewriter augmented with cassette tape memory. Before the time sharing and PC eras, the principal firms making word processing machines were IBM and Wang, a company started by An Wang, the co-inventor of magnetic core memory.

The rudiments of computer - based word processing can be traced to work in the late 1950s for the TX-0/TX-2 at MIT, where Jack Gilmore, Scope Wtiter and Stephen Piner wrote a program called Expensive Typewriter, both supported by an input device called the Likoln Writer. Throughout the 1960s, a number of text editors whose capabilities approached those of a word processing were written for use with time sharing systems, so they required access to large mainframes, or at least minicomputers (Ceruzzi P.E., 2003).

By the mid-1970s, however, things began to change. The Bravo editor developed at Xerox PARC for the Alto brought major innovations in text handling. Larry Tesler and Tim Mott, also of Xerox PARC, developed the Gypsy word processor in 1974, a program that became the basis for MS Word. Bravo and Gypsy displayed the text on a bit-mapped screen in a facsimile of the documents final appearance, the approach called What You see Is What You get ((WYSIWYG), and were thus the first interactive editor/formatters (Ceruzzi P.E., 2003).

In 1978, Seymour Rubinstein formed the Micropro International software company and hired Rob Barnaby to write a new word processor called WordStar, a product that dominated the market for six years. The first word processor for the Apple II was EasyWriter. New computers, exemplified by the Apple Macintosh of 1984, put a priority on easy of use, consistency of user interface editing thought out their operating environment. The earliest full featured word processor for the Macintosh was called FullWrite Professional (Ceruzzi P.E., 2003).

The most widely used word processors in both the Apple and IBM PC environments are now Microsoft Word and Word Perfect.

Spreadsheet is an interactive two-dimensional array of data and formulas originally devised to facilitate financial and business modelling. The spreadsheet is the most significant software product developed for personal computers that had no prior incarnation on mainframes, although a form of noninteractive spreadsheet for scientific applications was incorporated in the language Omnitab in 1966. But the interactive cell-oriented spreadsheet as we now know it was invented by Robert Frankston, Daniel Bricklin, and Daniel Fylstra, who introduced their VisiCalc (Visible Calculator) program to the public on 11 May 1979 at the West Coast Computer Faire. Originally written in assembly language for 32 KB Apple II, VisiCalc had a terse single-line menu. Its virtually instant popularity helped sell so many Apple IIs that other vendors had to react rapidly to license VisiCalc for use with their models as well ().

In 1981, SuperCalc was developed for the Osborne portable and became the primary spreadsheet for 8-bit CP/M computers (Allan R.A., 2001).

In 1983 Jonathan Sachs created Lotus 1-2-3 for 16-bit MS DOS computers. With online help, Macros, sophisticated menus, and facilities for computer graphics and database management, it quickly became the leading spreadsheet product. The leading spreadsheets were MS Excel, Lotus 1-2-3, Quattro Pro (Allan R.A., 2001).

Database

Lyll Morill developed a simple database program for microcomputers called WHATSIT? Database software dBase II for 8-bit computers with a CP/M operating system was introduced in 1981. Oracle was developed on a DEC minicomputer and was introduced in 1978 (Reily E.D., 2003).

When the 3 technologies are incorporated into an office environment, many improvements become possible, but there are mostly improvements in the speed with which work is done rather than in the kind of work that is done. Office automation in the 1980s began a new trend – the integration of previously separate capabilities into single powerful work stations. Even the most basic home office today contains, through the use of single computer, the following capabilities: word-processing and home publishing abilities; access to information previously stored on files at other locations, together with the ability to communicate with other stations on the Net or on other nets; electronic messaging systems, including any combination of text, graphics and voice, connecting users to others on the same net or, through gateways, to people on different nets in other places; activity-management systems, including time management, project planning and scheduling, and electronic calendar capabilities.

Internet

The most dramatic shift for business in communications technology has been the Internet. Increasing use of the Internet in the form of e-mail and websites is transforming the work environment. The Internet has broken down traditional geographic barriers to communication, opened up markets, and created an environment of almost instantaneous feedback. As the government policy of convergence makes high-speed Internet the norm, businesses will rely more and more on the Internet for their communication needs.

The Internet has changed our lives. It has revolutionized research, altered the world of retailing, and caused virtually every institution to redefine itself. Meanwhile, E-mail has become an indispensable means of communication.

The Internet, the most important and most far-reaching communications breakthrough since the telephone, has changed our lives. It has revolutionized research, altered the world of retailing, and caused virtually every institution to redefine itself. Meanwhile, E-mail has become an indispensable means of communication. In the 1960s, when computers were regarded as mere giant calculators, Licklider J. C. R. at MIT saw them as ultimate communications devices (Hafner K., 2006).

Microsoft Office was introduced in 1990. Initially it was a discounted suite of applications that consisted of Word, Excel and PowerPoint. The applications contained in the suit were subsequently changed to incorporate a standard user interface and improved integration features using Object Linking and Embedding technology (Cusumano M.A., 1995).

Version 4.0 of MS Office was released in October 1993. It contained Word 6.0, Excel 5.0 and PowerPoint 4.0, plus Mail and Access in the Professional Office edition. The users mainly employ different MS Office packages: MS Office 2000, MS Office 2003, MS Office 2007. Individuals give preference OpenOffice.org an OPEN-SOURCE office software suite whose functionality rivals the industry – leading Microsoft Office suite. Open Office comprises programs for word processing (Writer), spreadsheets (Calc), presentations (Impress), databases (Base), graphics (Draw).

In nowadays the mechanical office work in peasant farms prevail is substituted with work of office automation. Main four early activities of office work are compared with computer activities in Figure1.

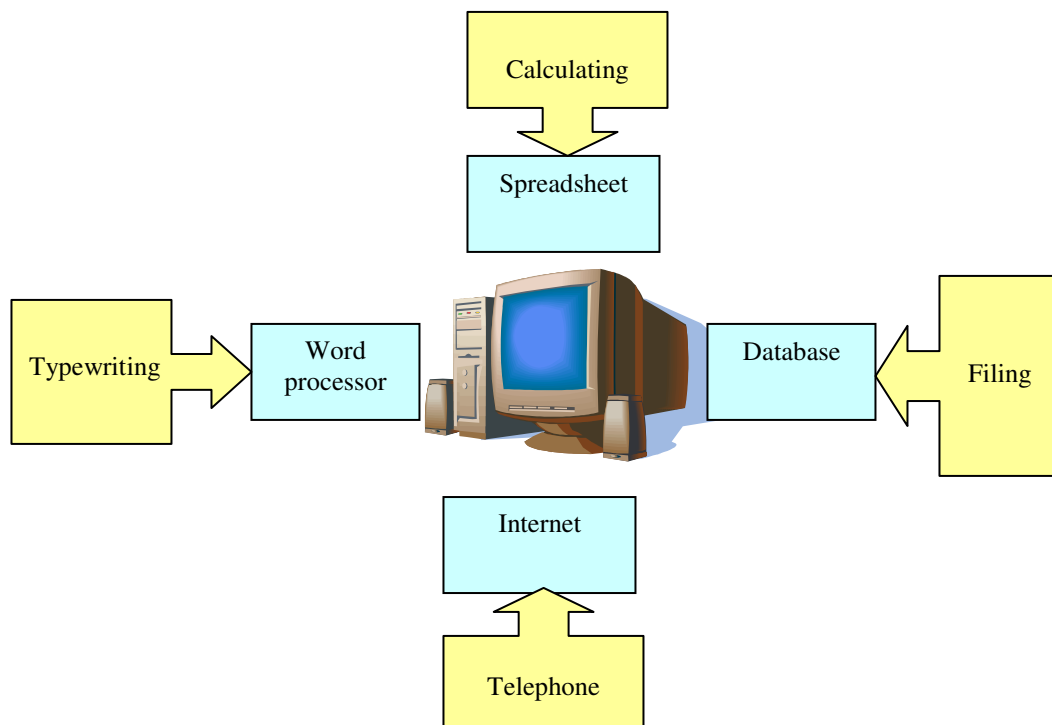


Figure 1. From office mechanization to office automation

Not only can computers process and hold more information, but they also process this information with greater efficiency and speed. The new technologies of Internet, the mobile and wireless technologies continue to develop in the rural area.

Conclusions

The considerable changes that took place from the 1920s to nowadays in the rural area also. Social, economic changes concerned the farms in this period. Different kinds of farms are viewed in the separate periods.

The transition from office mechanization to office automation passed in the rural area in Latvia. The appearance of the first writing and calculating devices promoted office work. Office automation is a general term that includes a wide range of applications of computer, communication and information technologies in office environments. The farmer as a computer user was becoming more and more directly involved in the processing of information through the PC. The most dramatic shift for business in communications technology has been the Internet. MS Office applications mainly are used in the office of peasant farms.

In nowadays the mechanical office work in peasant farms that prevailed is substituted with work of office automation. The new technologies of Internet, the mobile and wireless technologies continue to develop in the rural area.

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SIMULATION OF THE PERFORMANCE OF THE WORKING ELEMENTS AND THEIR DRAFT RESISTANCE IN SOIL USING THE METHOD OF FUNCTIONAL SERIES

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Abstract.

In order to determine the draft resistance of the working parts of soil tillage machines, static, kinetic-static and dynamic methods are usually applied, but their performance and draft resistance can be simulated using the method of functional series (functional lines). Studies were carried out to apply this method to some shapes of the working parts of soil tillage machines: the plane and concave wedges. Their functioning was simulated and the draft resistance of their shapes was determined depending on the weight and inertia forces of the soil moving along their surfaces. The obtained materials demonstrate that the method of functional series can be applied to describe the lifting process of the soil slice on a plane, as well as on a concave surface of the working parts of soil tillage machines and to determine their draft resistance. Unlike the conventional (static, kinetic-static and dynamic) methods, the method of functional series allows to imagine better the physical nature of the processes affecting the draft resistance of the working parts of soil tillage machines. In some cases the use of the method of functional series allows to obtain expressions of the draft resistance regularities in a simpler form than using other methods. The method of functional series may be applied as an independent one for the simulation and determination of the draft resistance of the working parts of soil tillage machines or also as a control method when are used others methods.

Key words: soil tillage, plane wedge, concave wedge, tillage resistance, functional series.

Introduction

In order to determine the draft resistance of the working parts of soil tillage machines, static, kinetic-static and dynamic methods are usually applied (Vilde, 1963, 1967 a, Macepuro, 1959), but their performance and draft resistance can be simulated using the method of functional series (functional lines) (Vilde, 1967 b, 1980). The simulation described in this article was carried out in order to apply this method to some shapes of the working parts of soil tillage machines: the plane and concave wedges, and to assess the usefulness of this method in comparison with others methods.

Materials and Methods

Investigations were carried out by simulating the performance of plane and concave wedges of different shapes and, using the method of functional series, their draft resistance caused by the weight and inertia forces of soil moving along their surfaces, was determined, as well as the usefulness of this method was assessed. There were regularities used which are known from theoretical mechanics and analytical mathematics corresponding to the level acquired in higher technical schools.

Results and Discussion

As an example, there was simulated the draft resistance of the plane and concave surfaces caused by a soil slice gravity and inertia forces.

1. Determination of the draft resistance of a plane two-side wedge, caused by the gravity of a lifted soil slice

The force of gravity (weight) G of a section of the lifted soil slice can be divided into the normal N_l and the tangential T_l' components (Fig. 1):

$$N_l = G \cos\alpha; \quad (1)$$

$$T_l' = G \sin\alpha, \quad (2)$$

where: α – the inclination angle of the lifting surface.

The normal component N causes pressure of the soil upon the surface, and the force of friction F_l

$$F_l = f N_l, \quad (3)$$

where: f – the coefficient of friction of the soil slice along the lifting surface.

Further forces N_l , T_l' , F_l are named as primary forces.

The tangential component T_1' and the force of friction F_1 sum up producing an increased primary tangential force T_1 :

$$T_1 = T_1' + F_1 = G (\sin\alpha + f \cos\alpha). \quad (4)$$

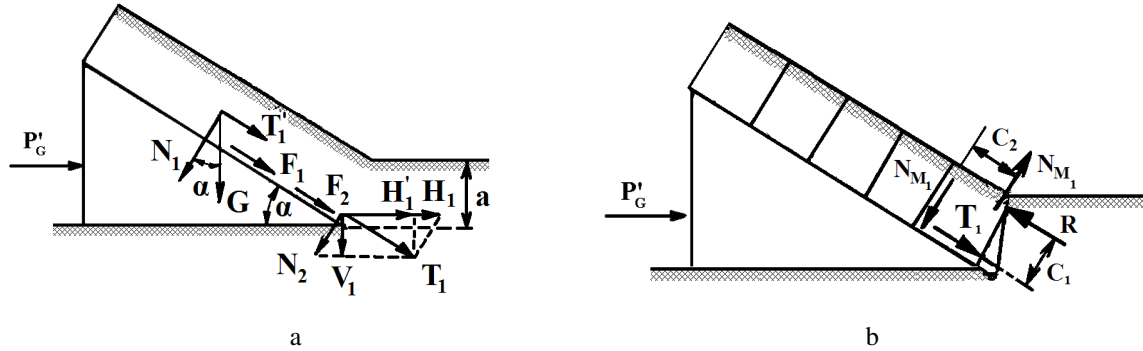


Fig.1. A scheme of the forces acting upon the plane two-side wedge depending on the gravity of the lifted soil slice: a – the tangential force is counterbalanced by the reaction of the frontal layer; b – the tangential force and reaction of the frontal layer create a moment acting upon the soil slice.

The primary tangential force T_1 moves the soil slice towards the subsoil layer, obstructing their separation and causing additional resistance to the penetration of the wedge into soil (Fig.1). Besides, depending on the physico-mechanical properties (variation in the hardness of the layers) of soil, the impact of the primary tangential force T_1 on the draft resistance may be different. Further two versions are reviewed:

- the tangential force T_1 is counterbalanced by the reaction of soil (Fig. 1 a);
- the tangential force T_1 and the reaction of soil create a moment acting upon the soil slice (Fig. 1 b).

The first version is possible for loose soils with the lower layer more compact than the upper layers. The second version is common for dense soils with the upper layer more compact (hard of dry soils) than the lower layers.

In the first version, it is possible to divide the force T_1 into two components: the horizontal H_1' and the vertical V_1 components. The vertical component V_1 causes pressure between the upper and the lower layers of soil and creates additional pressure N_2 upon the lifting surface, further named secondary pressure (Fig. 1 a):

$$N_2 = T_1 \operatorname{tg}\alpha = G (\sin\alpha + f \cos\alpha) \operatorname{tg}\alpha. \quad (5)$$

The secondary pressure creates additional force of friction F_2 , further named secondary force of friction.

$$F_2 = N_2 f = G (\sin\alpha + f \cos\alpha) f \operatorname{tg}\alpha. \quad (6)$$

The secondary force of friction creates the tertiary pressure N_3 and the tertiary force of friction F_3 .

$$N_3 = G (\sin\alpha + f \cos\alpha) f \operatorname{tg}^2\alpha; \quad (7)$$

$$F_3 = G (\sin\alpha + f \cos\alpha) f^2 \operatorname{tg}^2\alpha. \quad (8)$$

Continuing in this way from the tertiary force of friction, one can obtain quaternary forces, quinary forces, and so on.

As a result, we can obtain a series of equations, and, by summing them, the resultant of normal pressure N and the force of friction F .

$$N = N_1 + N_2 + N_3 + \dots + N_n = G [\cos\alpha + (\sin\alpha + f \cos\alpha) (f \operatorname{tg}\alpha + f \operatorname{tg}^2\alpha + f^2 \operatorname{tg}^3\alpha + \dots f^{n-1} \operatorname{tg}^n\alpha)]; \quad (9)$$

$$F = F_1 + F_2 + F_3 + \dots + F_n = G [f \cos\alpha + (\sin\alpha + f \cos\alpha) (f \operatorname{tg}\alpha + f^2 \operatorname{tg}^2\alpha + f^3 \operatorname{tg}^3\alpha + \dots f^n \operatorname{tg}^n\alpha)]; \quad (10)$$

$n \rightarrow \infty$.

The obtained functional series (geometrical progression) converge at $f \operatorname{tg}\alpha < 1$ (Bronshtein and Semendyaev, 1948, p. 183) and give the following equations:

$$N = G [\cos\alpha + (\sin\alpha + f \cos\alpha) \operatorname{tg}\alpha (1 - f \operatorname{tg}\alpha)^{-1}]; \quad (11)$$

$$F = f N = G f [\cos\alpha + (\sin\alpha + f \cos\alpha) \operatorname{tg}\alpha (1 - f \operatorname{tg}\alpha)^{-1}]; \quad (12)$$

$$T = G \sin\alpha + F. \quad (13)$$

By projecting forces N and F upon the direction of the movement of the wedge the required force of traction P'_G is obtained which is caused by the gravity force of the soil slice lifted by the plane surface of the wedge.

$$P_G' = N (\sin\alpha + f \cos\alpha) = G (\sin\alpha + f \cos\alpha) [\cos\alpha + (\sin\alpha + f \cos\alpha) \operatorname{tg}\alpha (1 - f \operatorname{tg}\alpha)^{-1}]. \quad (14)$$

This force of traction P_G' obtained by using the kinetic-static method has the following equation (Vilde, 1967 a; Macepuro, 1959):

$$P_G' = G \operatorname{tg}(\alpha + \varphi), \quad (15)$$

where φ – the angle of friction of the soil slice along the plane lifting surface of the two-side wedge.

By digital computation one can prove that both equations produce equal values of the force of traction:

$$(\sin\alpha + f \cos\alpha) [\cos\alpha + (\sin\alpha + f \cos\alpha) \operatorname{tg}\alpha (1 - f \operatorname{tg}\alpha)^{-1}] \approx \operatorname{tg}(\alpha + \varphi). \quad (16)$$

This means that, despite the fact that the equations of the force of traction obtained using the method of functional series or the kinetic-static method-are different, their numerical values are equal.

In order to find out the normal component N , one can determine the draft resistance of the supporting surface and the required force of traction P_G'' for its overcoming:

$$P_G'' = F'' = N f (\cos\alpha - f \sin\alpha) \quad (17)$$

In the second version, which is common for soils with the upper layer more compact (hard of dry soils) than the lower layers, moment M_1 which acts upon the frontal part of the soil slice lifted by the wedge tries turn the slice, pressing it to the lifting surface, and in such a way increases the resistance of friction (Fig. 1 b).

$$M_1 = T_1 c_1, \quad (18)$$

where c_1 – the distance between the lines of the acting tangential force T_1 and the resulting reaction R of soil.

$$N_{M1} = M_1 c_2^{-1} = T_1 c_1 c_2^{-1}, \quad (19)$$

where: N_{M1} – the additional normal pressure caused by the moment acting upon the lifted soil slice;
 c_2 – the distance between the resulting forces of the additional normal pressure.

The additional (primary) force of friction F_{M1} caused by moment M_1 is:

$$F_{M1} = f N_{M1} = T_1 f c_1 c_2^{-1}. \quad (20)$$

The additional force of friction F_{M1} , in its turn, increases the moment acting upon the frontal part of the soil slice, which increases the pressure of the soil slice upon the lifting surface. Further, in the same way as in the first version, one can regard that the primary force creates secondary forces, the secondary forces – tertiary forces, and so on.

The secondary moment:

$$M_2 = F_{M1} c_1 = T_1 f c_1^2. \quad (21)$$

The secondary additional normal pressure caused by moment M_2 is:

$$N_{M2} = M_2 c_2^{-1} = T_1 f c_1^2 c_2^{-2}. \quad (22)$$

The secondary additional force of friction F_{M2} caused by moment M_2 is:

$$F_{M2} = f N_{M2} = T_1 f^2 c_1^2 c_2^{-2}. \quad (23)$$

Continuing in this way from the secondary force of friction, one can obtain tertiary forces, quaternary forces and the following forces.

As a result, one can obtain a series of equations and, by summing them, the resultant tangential force T and the additional normal pressure N' :

$$T = T_1 (1 + f c_1 c_2^{-1} + f^2 c_1^2 c_2^{-2} + f^3 c_1^3 c_2^{-3} + \dots + f^n c_1^n c_2^{-n}); \quad (24)$$

$$N' = T_1 (c_1 c_2^{-1} + f c_1^2 c_2^{-2} + f^2 c_1^3 c_2^{-3} + \dots + f^{n-1} c_1^n c_2^{-n}). \quad (25)$$

$$n \rightarrow \infty.$$

The obtained functional series (geometrical progression) converge at $f c_1 c_2^{-1} < 1$ and give the following equations:

$$T = T_1 c_2 (c_2 - f c_1)^{-1} = G (\sin\alpha + f \cos\alpha) c_2 (c_2 - f c_1)^{-1}; \quad (26)$$

$$N' = T c_1 c_2^{-1} = G (\sin\alpha + f \cos\alpha) c_1 (c_2 - f c_1)^{-1} \quad (27)$$

Consequently, the summary normal pressure of soil upon the lifting surface is:

$$N = N_1 + N' = G [\cos\alpha + (\sin\alpha + f \cos\alpha) c_1 (c_2 - f c_1)^{-1}]. \quad (28)$$

In the given occasion the value of T and N one can determinate in the other way – by help of equations system:

$$\begin{cases} T = fN + G \sin\alpha \\ N = G \cos\alpha + T c_1 c_2^{-1} \end{cases} \quad (29)$$

By solving this system (29) of equations one can obtain expressions of the forces T and N . These expressions are in full conformity with equations (26) and (28) obtained using the method of functional series.

In this case the required force of traction P_G which is caused by the gravity force of the soil slice lifted by the plane surface of the wedge has the equation:

$$P_G' = N (\sin\alpha + f \cos\alpha) = G (\sin\alpha + f \cos\alpha) [\cos\alpha + (\sin\alpha + f \cos\alpha) c_1 (c_2 - f c_1)^{-1}]. \quad (30)$$

It is evident that in both cases (14) and (30) the equations of the force of traction have only different multipliers:

$$tg\alpha (1 - f tg\alpha)^{-1} \quad \text{and} \quad c_1 (c_2 - f c_1)^{-1} \quad (31)$$

The variation of these multipliers determine in some degree the variations of the draft resistance of the lifting surface and the variations of the required force for traction.

In a similar manner, using the method of functional series, one can find out the draft resistance of the lifting surface caused by the soil inertia force and adhesion, as well as the resistance of the supporting surface.

2. Determination of the draft resistance of a concave lifting surface caused by the soil gravity and inertia forces

In this subchapter we discussed how to determine the draft resistance of a concave lifting surface, caused by the soil gravity and inertia forces, by using the method of functional series. The forces acting upon the concave lifting surface with the radius of curvature r are shown in the scheme (Fig. 2).

The draft resistance caused by the soil gravity.

As an example, there is simulated the draft resistance of a concave surface, caused by the gravity forces G of the soil slice (Fig. 2).

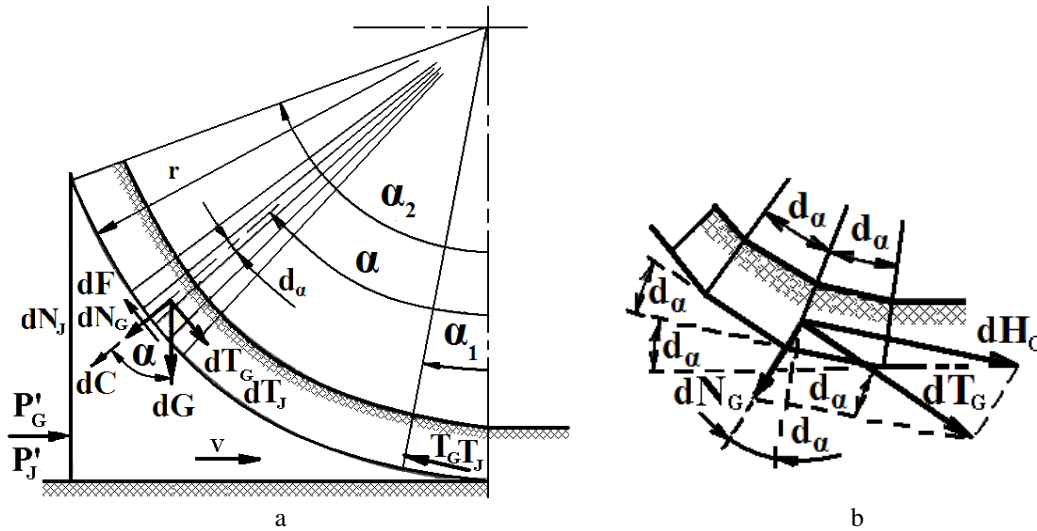


Fig. 2. A scheme of forces acting upon the concave lifting surface, caused by the soil gravity and inertia forces.

On the basis of the scheme equations are constructed in a differential form of the forces acting upon the concave lifting surface:

$$dG = q \delta g ds = q \delta g r da; \quad (32)$$

$$dN_G = q \delta g r \cos\alpha da; \quad (33)$$

$$dT_G = q \delta g r \sin\alpha da; \quad (34)$$

$$dF_G = f dN_G = q \delta g r f \cos\alpha da; \quad (35)$$

$$dT_G = dT_G + dF_G = q \delta g r (\sin\alpha + f \cos\alpha) da, \quad (36)$$

where: q – the cross section area of the soil slice; δ – the density of soil; r – the radius of curvature of the lifting surface; g – acceleration caused by gravity ($g = 9.81$); α – the lifting angle.

The concave surface may be imagined as an inside surface of a regular polyhedron with an unlimited number of sides. In such a way it may be assumed that the concave lifting surface is formed from a series of unlimited small lifting planes with a lifting angle da (the angle between the proximal planes) and the slice of soil – formed from a series of infinitely thin radial laminas (Fig. 2 b).

Similarly as in analyses of the forces acting upon the plane wedge, the tangential force dT_G of the upper lamina acting upon the lower plane can be divided into two components: the tangential force (in relation to the lower plane) and the normal force (in relation to the upper plane). The normal component creates additional pressure of the soil lamina upon the upper lifting surface – secondary pressure d^2N_G .

It follows results from the triangle of forces (Fig. 2 b) that the secondary pressure d^2N_G is:

$$d^2N_G = dT_G \operatorname{tg} da = q \delta g r f (\sin a + f \cos a) da^2, \quad (37)$$

because $\operatorname{tg} da \approx da$.

The secondary pressure d^2N_G causes the additional, secondary force of friction d^2F_G :

$$d^2F_G = f d^2N_G = q \delta g r f (\sin a + f \cos a) da^2; \quad (38)$$

$$d^2T_G = d^2F_G. \quad (39)$$

Continuing in this way, the secondary force of friction creates a tertiary force of pressure and a tertiary force of friction, and so on.

In such a manner one can obtain a series of differential equations.

The tangential force T_G , which acts in the section of the soil slice can be determined from a series of differential equations:

$$dT_G = q \delta g r (\sin a + f \cos a) da; \quad (40)$$

$$d^2T_G = q \delta g r f (\sin a + f \cos a) da^2; \quad (41)$$

$$d^3T_G = q \delta g r f^2 (\sin a + f \cos a) da^3; \quad (43)$$

$$\dots\dots\dots$$

$$d^n T_G = q \delta g r f^{n-1} (\sin a + f \cos a) da^n; \quad (44)$$

$$n \rightarrow \infty.$$

By projecting the forces of normal pressure and of friction upon the direction of the movement of the wedge one can obtain a series of differential equations for the required force of traction P_G of a concave surface of the wedge caused by the gravity force of the lifted soil slice:

$$dP_G = q \delta g r \cos a (\sin a + f \cos a) da; \quad (45)$$

$$d^2P_G = q \delta g r (\sin a + f \cos a)^2 da^2; \quad (46)$$

$$d^3P_G = q \delta g r (\sin a + f \cos a)^2 da^3; \quad (47)$$

$$d^4P_G = q \delta g r (\sin a + f \cos a)^2 da^4; \quad (48)$$

$$\dots\dots\dots$$

$$d^n P_G = q \delta g r (\sin a + f \cos a)^2 da^n; \quad (49)$$

$$n \rightarrow \infty.$$

The obtained series of differential equations are similar to those of the plane lifting surface of the wedge.

By solving these series of differential equations are obtained series of T_G and P_G equations which by summing converge and give equations of total tangential force T_G and required force of traction P_G caused by the gravity of the lifted soil slice.

When the initial lifting angle $\alpha_1 = 0$ and the final angle α_2 :

$$T_G = P_G = q \delta g r (e^{f\alpha_2} - \cos \alpha_2); \quad (50)$$

When the initial lifting angle $\alpha_1 > 0$:

$$T_G = q \delta g r (\cos \alpha_1 e^{f(\alpha_2 - \alpha_1)} - \cos \alpha_2); \quad (51)$$

$$P_G = q \delta g r (\cos \alpha_1 e^{f(\alpha_2 - \alpha_1)} - \cos \alpha_2) \cos \alpha_1 \quad (52)$$

The following forms of equations of these forces T_G and P_G are produced using the conventional methods of integration-(Vilde, 1967 a):

$$T_G = q \delta g r (1 + f^2)^{-1} \{ [2f \sin \alpha_2 - (1 - f^2) \cos \alpha_2] e^{f(\alpha_2 - \alpha_1)} - [2f \sin \alpha_1 - (1 - f^2) \cos \alpha_1] \} \quad (53)$$

$$P_G = q \delta g r (1 + f^2)^{-1} \{ [\cos \alpha_1 e^{f(\alpha_2 - \alpha_1)} - \cos \alpha_2] [2f \sin \alpha_2 - (1 - f^2) \cos \alpha_2] + f (\sin 2\alpha_2 - \sin 2\alpha_1) + (1 - f^2) (\sin^2 \alpha_2 - \sin^2 \alpha_1) \} \quad (54)$$

From the comparison of equations (51) and (52), obtained using the method of functional series, with equations (53) and (54), obtained using the conventional method, it is evident that the first two equations are less complicated and more handy for calculation than the second two equations. By computation one can verify that both pairs of equations give closely equal values of the tangential force T_G and the required force of traction P_G , variations constituting only a few percent (Vilde, 1967 a).

The method of functional series is successfully applied to investigate the performance of the plough bodies and determine their draft resistance caused by the soil gravity, presenting more handy expressions of equations for calculations (Vilde, 1980; 1999).

The Draft resistance caused by the inertia forces

The slice of soil sliding along a concave lifting surface creates a centrifugal force C (Fig. 2 a).

A differential equation of the centrifugal force is:

$$dC = q \delta v^2 d\alpha = C_0 d\alpha \tag{55}$$

The resistance of friction (primary resistance) caused by the centrifugal force:

$$dT_j = dF_j = f dC = f C_0 d\alpha . \tag{56}$$

Similarly as with the force of gravity of soil, the primary tangential force (in this case – primary force of friction) creates additional, secondary pressure and a secondary force of friction, and so on. In that a way one can obtain a series of differential equations for the determination of the tangential force and the required force of traction (draft resistance) caused by the inertia forces of the soil slice:

$$dT_j = f C_0 d\alpha ; \tag{57}$$

$$d^2T_j = f^2 C_0 d\alpha^2 ; \tag{58}$$

$$d^3T_j = f^3 C_0 d\alpha^3 ; \tag{59}$$

$$\dots\dots\dots d^n T_j = f^n C_0 d\alpha^n ; \tag{60}$$

$$dP_j' = C_0 (sina + f cosa) d\alpha ; \tag{61}$$

$$d^2P_j' = C_0 (sina + f cosa) d\alpha^2 ; \tag{62}$$

$$d^3P_j' = C_0 (sina + f cosa) d\alpha^3 ; \tag{63}$$

$$\dots\dots\dots d^n P_j' = C_0 (sina + f cosa) d\alpha^n ; \tag{64}$$

$$n \rightarrow \infty .$$

By solving these series of differential equations are obtained series of T_j and P_j' equations which by summing converge and give equations of total tangential force T_j and required force of traction (draft resistance) P_j caused by the inertia forces of the lifted soil slice.

When the initial lifting angle $\alpha_1 = 0$ and the final angle α_2 is:

$$T_j = q \delta v^2 (e^{f\alpha_2} - 1) ; \tag{65}$$

$$P_j' = q \delta v^2 (e^{f\alpha_2} - \cos\alpha_2) ; \tag{66}$$

When the initial lifting angle $\alpha_1 > 0$:

$$T_j = q \delta v^2 (e^{f(\alpha_2 - \alpha_1)} - 1) ; \tag{67}$$

$$P_j' = q \delta v^2 (\cos\alpha_1 e^{f(\alpha_2 - \alpha_1)} - \cos\alpha_2) ; \tag{68}$$

The equations for T_j and P_j' produced using the method of functional series completely correspond to the equations obtained using the other – the conventional methods (Vilde, 1967 a). This fact confirms again the usability of this method for solving problems connected with the draft resistance of the working parts of soil tillage machines.

Thus, by using the method of functional series one can produce equations for the determination of the resistance of the working surface caused by the soil adhesion force, as well as the resistance of the convex surface. By means of this method the classical Euler formula of friction of a flexible body (belt) is obtained.

Further a case is discussed when the tangential force of a soil slice is not counterbalanced by the reaction of the frontal layer of soil but produces a moment acting upon the soil slice (Fig. 3). Also in this case the sliding resistance can be found out by using the method of functional series.

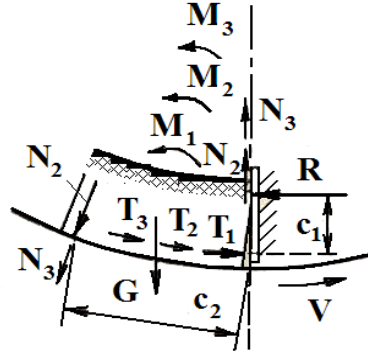


Fig. 3. A scheme for the determination of the moving resistance of the soil slice upon which the moment caused by the tangential force and the reaction of the frontal layer of soil acts.

As an example, the sliding (friction) resistance of a segment of the soil slice caused by the soil gravity (Fig.3) is discussed.

The primary pressure N_1 of a segment of the soil slice is:

$$N_1 = G. \quad (69)$$

The primary tangential force T_1 :

$$T_1 = F_1 = Gf. \quad (70)$$

The primary moment M_1 :

$$M_1 = T_1 c_1. \quad (71)$$

The additional (secondary) pressure N_2 created by the moment M_1 acting upon the surface:

$$N_2 = M_1 c_2^{-1} = T_1 c_1 c_2^{-1}. \quad (72)$$

The additional (secondary) tangential force T_2 :

$$T_2 = N_2 f = T_1 f c_1 c_2^{-1}. \quad (73)$$

The additional (tertiary) pressure N_3 created by the secondary tangential force T_2 :

$$N_3 = T_2 (c_1 c_2^{-1})^2. \quad (74)$$

The following additional (tertiary) tangential force T_3 is:

$$T_3 = N_3 f = T_1 f^2 (c_1 c_2^{-1})^2. \quad (75)$$

Continuing in this way, endless series of the additional tangential forces are obtained. The resulting tangential force T is the sum of the primary tangential force and all following forces:

$$T = T_1 + T_2 + T_3 + \dots + T_n; \quad (76)$$

$$T = T_1 [1 + f c_1 c_2^{-1} + f^2 (c_1 c_2^{-1})^2 + f^3 (c_1 c_2^{-1})^3 + \dots + f^n (c_1 c_2^{-1})^n]; \quad (77)$$

$$n \rightarrow \infty.$$

The expression in square brackets is a geometrical progression. Sliding of the soil slice along the given surface is possible if this progression converges. In that case the total tangential force T has an expression:

$$T = T_1 c_1 (c_2 - f c_1)^{-1} = G f c_2 (c_2 - f c_1)^{-1}. \quad (78)$$

In this case the expression of the total tangential force can be produced from the system of equations:

$$\begin{cases} T = (N + G)f \\ N = T c_1 c_2^{-1} \end{cases} \quad (79)$$

By solving this system of equations the expression of the total tangential force is obtained:

$$T = G f c_2 (c_2 - f c_1)^{-1}. \quad (80)$$

The obtained expressions show that in this case the regularity for the determination of the total tangential force which was discovered using the method of unctional series (78) completely corresponds to the regularity

obtained by using the other – the conventional method (80). This fact confirms again the usability of the method of functional series for solving problems connected with the draft resistance of the working parts of the soil tillage machines.

Conclusions

1. The obtained materials demonstrate that the method of functional series may be applied to describe the lifting process of a soil slice on a plane, as well as on a concave surface of the working part of a soil tillage machine, and to determine their draft resistances.
2. Unlike the conventional (static, kinetic-static and dynamic) methods, the method of functional series allows to imagine better the physical interpretation of the performance of the working parts of soil tillage machines and their draft resistance.
3. In the some cases the equations of the draft resistance obtained using the method of functional series are simpler than the equations obtained by using the conventional methods.
4. The method of functional series should be considered as an independent method for the determination of the draft resistance of the working parts of soil tillage machines, or as a control method if the draft resistance is determined by others methods.

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SIMULATION THE IMPACT OF SOIL HUMIDITY ON THE ENERGY CONSUMPTION FOR PLOUGHING

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Abstract

Ploughing is one of the most power consuming and expensive processes in agricultural production. It is known that the draft resistance of ploughs, the energy requirement for ploughing, the quality of ploughing and expenses depend on the plough body design, which is determined by the share-mouldboard parameters and the parameters of its supporting surfaces, as well as on such soil properties as its hardness, density, friction and adhesion, their values depending on the mechanical composition, structure and humidity of soil.

The correlations obtained allow simulation and assessment of energy consumption for ploughing depending on the soil humidity, mechanical composition and the working speed of the ploughs, determination of the optimal range of soil humidity when the tillage capacity is the lowest. Humidity most of all impacts the soil hardness and cutting resistance which considerably dominates in the summary resistance of the plough body and in energy consumption for ploughing. An increase in the soil humidity leads to a decrease in the ploughing resistance that is more remarkable on the clay soils. Increasing humidity decreases energy consumption for ploughing on the loamy-sand soils to 30 – 40 % but on sticky clay soils – 2 times and more. The working speed influences energy consumption for the ploughing of soil, too. The optimum humidity of the sticky clay soils for ploughing with contemporary ploughs working at speeds 2...2.5 m s⁻¹ is 18 – 24%.

Key words: ploughing resistance, energy consumption, impact of soil humidity, soil properties, plough body parameters.

Introduction

Soil tillage is one of the most power consuming processes in field crop cultivation. It requires 180–320 kWhha⁻¹, which corresponds to 50 – 80 kg of fuel per hectare of the land tilled and makes 20–25% of its total consumption in agriculture. The amount of carbon dioxide CO₂ produced as a result of its combustion is approximately 3.3 times greater. Besides, in case the fuel contains sulphur, its burning yields sulphur dioxide forming further sulphurous acid that, together with the rainfall, comes down into soil increasing its acidity and decreasing its fertility. At the present time it is an international task to avoid overheating of the earth, and therefore lowering harmful emissions by 5.2% is a very urgent matter (the Kyoto Agreement protocols). This explains the great interest in this issue (Vilde, 2003 a, 2005).

Ploughing is the most power-consuming and expensive operation in the soil tillage processes (Vilde, 1999 b; Vilde et al., 2004). It is known that the ploughing resistance and energy consumption depend on the parameters of the plough body (Vilde, 1999 a) and such properties of soil as its hardness, density, friction and adhesion (Vilde, 2001, 2003 b). These properties and the tillage quality depend mainly on the mechanical composition and humidity of soil (Vilde, 2001; Bahtin, 1969; Mogilniy, 1957; Vilde et al., 2007).

Our experience obtained from testing ploughs shows that in Latvian conditions the soil humidity varies on a large scale from 4% to 26% and remarkably influences the draft resistance of ploughs. However, there were no correlations that would enable to determine the draft resistance of ploughs and energy consumption of ploughing depending on the humidity and composition of soil.

The purpose of the investigation is to estimate the energy consumption for ploughing depending on the soil humidity, its mechanical composition, the plough parameters, the mode of aggregation and the working speed.

Materials and Methods

The amount of energy consumed for soil tillage, including ploughing, with machines having passive operating parts depends on their specific draft resistance (Vilde, 1999 b; 2005; Vilde et al., 2004):

$$E_m = K_1 \quad (1)$$

where: E_m is the specific energy capacity of soil tillage, Nm m⁻²;

K_1 is the specific draft resistance of the machine related to a unit of the working width, N m⁻¹.

In terms of the units of measurement used in technical calculations the utilisation of energy obtains the following expression:

$$E_m = 2.778 * 10^{-3} K_1 \quad \text{kW h ha}^{-1} \quad (2)$$

To estimate energetic capacity of the machine using a simplified method, two components of its specific resistance are determined: static resistance that practically is not dependent on speed and dynamic resistance which is functionally related to the working speed according to formula (Vilde, 2005):

$$K_1 = k_1 + \varepsilon_1 v^2 \quad (3)$$

where: k_1' is a generalized (total) specific static resistance related to a unit of the working width, $N m^{-1}$; ε_1 is a coefficient of dynamic resistance related to a unit of the working width, $N s^2 m^{-3}$.

The energy capacity of the soil tillage technologies can be characterised by the amount of the fuel consumed. The specific fuel consumption for soil tillage (ploughing, cultivation, harrowing, etc.) can be determined by the formula (Vilde et al., 2004):

$$Q_0 = 2.778 \cdot 10^{-6} g_e \eta_{v_{max}}^{-1} (k_1 + \varepsilon_1 v^2) e^{c(v_0 - v)^2} \quad (5)$$

where: Q_0 – specific fuel consumption for tillage, $kg ha^{-1}$; g_e – specific fuel consumption of the engine, $g (kWh)^{-1}$; $\eta_{v_{max}}$ – maximum draft coefficient of the tractor; e – basis of the natural logarithm ($e = 2.718$); v – working speed of the aggregate, $m s^{-1}$; v_0 – the speed corresponding to the maximum draft capacity, $m s^{-1}$; c – a coefficient that depends on the physical and mechanical properties of soil and working capacity (gripping with soil, resistance to movement) of the tractor undercarriage (wheels, caterpillar track); $c \approx 0.15 \pm 0.05$ in dense soils, $c \approx 0.30 \pm 0.05$ in loose soils.

The draft coefficient of caterpillar tractors is higher ($\eta_{v_{max}} = 0.72 - 0.82$). It is also higher for tractors with all driving wheels ($\eta_{v_{max}} = 0.60 - 0.72$) than with the rear ones ($\eta_{v_{max}} = 0.52 - 0.60$). It can be increased by 4 – 12% through ballasting the wheeled tractors. The draft coefficient of caterpillar tractors is considerably higher than of the wheeled tractors at low working speeds (3...5 $km h^{-1}$). Increasing speed, this coefficient falls because of the rising energy consumption required to overcome the friction resistance in the caterpillar joints (Vilde, 1999 b).

Formula (5) shows that the fuel consumption required for soil tillage is mainly dependent on the energy capacity of the technological process and the energetic characteristics of the tractor. The static and dynamic resistance of soil tillage machines determine the first, the second are determined by the efficiency of the tractor engine, tractor draft efficiency, and the character of its variations.

The energy and fuel economy and cost reduction of ploughing can be expected from the introduction of more economical ploughs with gently sloping bodies having helicoidal or semihelicoidal mouldboards (the angle between the share and the furrow edge is less than 40°) having a working width 45...50 cm (Vilde, 2003 a). Such a type of ploughs are used for the simulation and assessment of energy consumption for soil ploughing depending on the soil humidity, mechanical composition, the working mode and speed of the ploughs.

The objects of the research are the draft resistance of the ploughs depending on their design parameters, as well as the soil moisture and composition. On the basis of the previous investigations (Vilde, 1999 a) a computer algorithm has been worked out for the simulation of the forces exerted by soil upon the operating (lifting and supporting) surfaces of the ploughs, and the draft resistance caused by these forces. The tillage quality is estimated by testing.

According to our earlier studies (Vilde, 1999 a) the draft resistance R_x of the tillage machines is determined by the share cutting resistance R_{Px} , the resistance caused by weight R_{Gx} of the strip lifted, by the inertia forces R_{Jx} , by soil adhesion R_{Ax} and by weight R_{Qx} of the machine itself. From it follows that the specific draft resistance is:

$$K_1 = (R_x = R_{Px} + R_{Gx} + R_{Jx} + R_{Ax} + R_{Qx}) B^{-1} \quad (6)$$

The vertical reaction R_z and the lateral reaction R_y of the operating part are defined by corresponding partial reactions:

$$R_z = \sum R_{iz}; \quad R_y = \sum R_{iy} \quad (6; 7)$$

The total draft resistance R_x of the operating part – plough body is composed of the resistance of the lifting (share-mouldboard) surface R'_x and the resistance of the supporting (lower and lateral) surfaces R''_x :

$$R_x = R'_x + R''_x = \sum R'_{ix} + f_0 (\sum R_{iz} + \sum R_{iy} + p_{Axy} S_{xy} + p_{Axz} S_{xz}) \quad (8)$$

where f_0 is the coefficient of soil friction along the working and supporting surfaces of the operating part; p_{Axy} and p_{Axz} – specific adhesion forces, respectively, acting upon the lower and the lateral supporting surfaces of the operating part; S_{xy} and S_{xz} – the surface areas, respectively, of the lower and the lateral supporting surfaces of the operating part.

Cutting resistance R_{Px} is proportional to soil hardness ρ_0 and the share edge surface area ω :

$$R'_{Px} = k_p \rho_0 \omega = k_p \rho_0 i b \quad (9)$$

where k_p is a coefficient involving the impact caused by the shape of the share edge frontal surface; i and b – the edge thickness and width.

$$\rho_0 = \delta_0 (b'' + d'' m) e^{-1} W^n \quad (10)$$

where ρ_0 – soil hardness characterising the resistance to the penetration of the flat round steel tip having a cross-section area of 1 cm^2 , H m^{-2} (Vilde, 2001); δ_0 – soil (dried) density, kg m^{-3} ; m – the contents of physical clay (particles of the size $< 0.01 \text{ mm}$, %); W – absolute soil humidity, %; b'' , d'' and l'' – coefficients; n – exponent; $e=2.718\dots$ For the investigation of soil the coefficients and the exponent entered into formula (10) have the following values: $b'' = 1100$; $d'' = 200$; $l'' = 4.10^{-3}$ and $n = 2$ (Vilde, 2001).

At an inclined ploughshare a lateral reaction R_{Py} arises, its value being affected by the friction reaction:

$$R_{Py} = k_p \rho_0 i b \text{ctg} (\gamma_0 + \varphi_0) \quad (11)$$

The summary cutting resistance:

$$R_{Px} = k_p \rho_0 i b [1 + f_0 \text{ctg} (\gamma_0 + \varphi_0)] \quad (12)$$

Forces caused by the gravity of the lifting soil slice:

$$R'_{Gx} \approx q \delta g k_y r \sin^{-1} \gamma \{ [(\sin \gamma \cos \varepsilon_1 + \cos^2 \gamma \sin^{-1} \gamma) e^{f_0 \sin \gamma (\varepsilon_2 - \varepsilon_1)} - (\sin \gamma \cos \varepsilon_2 + \cos^2 \gamma \sin^{-1} \gamma)] \cos \varepsilon_1 + (\cos \varepsilon_1 e^{f_0 \sin \gamma (\varepsilon_2 - \varepsilon_1)} - \cos \varepsilon_2) * (\cos \varepsilon_1 - f_0 \sin \varepsilon_1 \sin \gamma)^{-1} \sin \varepsilon_1 [\sin \varepsilon_1 \sin \gamma + f_0 (\sin^2 \gamma \cos \varepsilon_1 + \cos^2 \gamma)] \} \quad (13)$$

$$R_{Gz} \approx q \delta g r \sin^{-1} \gamma (\varepsilon_2 - \varepsilon_1) \quad (14)$$

$$R_{Gy} \approx q \delta g r \sin^{-1} \gamma (\varepsilon_2 - \varepsilon_1) (\varepsilon_1 + 0.52) \text{ctg} \gamma \quad (15)$$

$$R''_{Gx} = f_0 (R_{Gz} + R_{Gy}) = F''_{Gx} \quad (16)$$

Forces caused by the soil inertia:

$$R'_{Jx} = q \delta v^2 k_y^{-1} \sin \gamma \{ (\sin \gamma \cos \varepsilon_1 + \cos^2 \gamma \sin^{-1} \gamma) e^{f_0 \sin \gamma (\varepsilon_2 - \varepsilon_1)} - (\sin \gamma \cos \varepsilon_2 + \cos^2 \gamma \sin^{-1} \gamma) + (\cos \varepsilon_1 - f_0 \sin \varepsilon_1 \sin \gamma)^{-1} e^{f_0 \sin \gamma (\varepsilon_2 - \varepsilon_1)} * \sin \varepsilon_1 [\sin \varepsilon_1 \sin \gamma + f_0 (\sin^2 \gamma \cos \varepsilon_1 + \cos^2 \gamma)] \} \quad (17)$$

$$R_{Jz} = q \delta v^2 k_y^{-1} \sin \gamma \sin \varepsilon_2 e^{f_0 \sin \gamma (\varepsilon_2 - \varepsilon_1)} \quad (18)$$

$$R_{Jy} \approx q \delta v^2 k_y^{-1} \sin \gamma \cos \gamma (1 - \cos \varepsilon_2) \quad (19)$$

$$R''_{Jx} = f_0 (R_{Jz} + R_{Jy}) = F''_{Jx} \quad (20)$$

Forces caused by the soil adhesion:

$$R'_{Ax} = p_A b r \sin^{-1} \gamma (e^{f_0 \sin \gamma (\varepsilon_2 - \varepsilon_1)} - 1) \{ \sin \gamma \cos \varepsilon_1 + \cos^2 \gamma \sin^{-1} \gamma + (\cos \varepsilon_1 - f_0 \sin \varepsilon_1 \sin \gamma)^{-1} \sin \varepsilon_1 [\sin \varepsilon_1 \sin \gamma + f_0 (\sin^2 \gamma \cos \varepsilon_1 + \cos^2 \gamma)] \} \quad (21)$$

$$R_{Az} = 0 ; \quad R_{Ay} \approx 0 ; \quad R_{Ay} \approx 0 \quad (22; 23; 24)$$

where: q – the cross section area of the soil slice; δ – the density of soil; k_y – the soil compaction coefficient; f_0 – the soil friction coefficient; v – the speed of ploughing; p_A – the specific force of soil adhesion; b – the surface width of the soil slice; ε_1 and ε_2 are correspondingly the initial and the final angles of the lifting (share – mouldboard) surface; γ_0 – the inclination angle of the share edge; γ – the inclination angle of the horizontal shape lines (generatrix); g – acceleration caused by gravity ($g = 9.81$).

The draft resistance caused by the weight Q of the plough is proportional to the friction coefficient:

$$R''_{Qx} = Q f_0 \quad (25)$$

From the formulae (9) – (25) it follows that the generalised (total) specific static resistance related to a unit of the working width k'_1 , N m^{-1} is:

$$k'_1 = (R_{Px} + R_{Gx} + R_{Ax} + R_{Qx}) B^{-1} \quad (26)$$

and the coefficient of dynamic resistance related to a unit of the working width ε_1 , $\text{N s}^2 \text{m}^{-3}$:

$$\varepsilon_1 = R_{jx} B^{-1} v^{-2} \quad (27)$$

Soil density δ is dependent on the strata density (the mass of a volume unit of the dried soil) δ_0 and soil moisture W :

$$\delta = \delta_0(1 + W) \quad (28)$$

Observations indicate that the density of mineral soils may vary in a very wide range: from 700 kg m^{-3} for dry, loose (freshly ploughed) soil to 2200 kg m^{-3} for wet, compact soil, but generally it varies from 1200 to 1800 kg m^{-3} . The resistance of the operating parts of the soil tillage machines varies in proportion to soil density (Vilde, 2001, 2003 b).

As a rule, all the sources provide slipping resistance coefficients of soil. On the basis of these data, by the method of least squares, we determined the coefficients of friction and specific adhesion force, by means of which dependencies were deduced between them, and the mechanical composition and moisture of soil (Vilde et al., 2007):

$$f_0 = (a + e^{-[b_1(b_2 - m)]^2})e^{-b_3 W^2} + (c + dm)e^{-[(k+lm)(t+zm-W)]^2} \quad (29)$$

where $a, b_1, b_2, b_3, c, d, k, l, t, z$ – the indices depending on the type of soil, the material and the condition of the surface of the object along which the soil slides; $e = 2.718\dots$; W – absolute humidity of soil, %; m – the content of physical clay in soil (the particle size $< 0.01 \text{ mm}$), %.

Variations in the specific adhesion force p_A of soil correspond to the relation of the type (Vilde, 2001, 2003 b):

$$p_A = (a' + b'p) + (c' + d'm)e^{-[(k'+l'm)(t'+z'm-W)]^2} \quad (30)$$

where p – the specific pressure of the layer (soil) upon the surface; $a', b', c', d', k', l', t', z'$ – the indices depending on the type of soil, the material and the condition of the surface along which the soil slides.

The soil sliding (slipping) resistance along a steel surface depends on the sliding speed (Vilde et al., 2007), the structure of soil, the humus content and the surface temperature. The effect of these parameters may be considered by respective coefficients. For example, the coefficients of velocity k_v and k'_v :

$$k_v = k_{vmrg} \left[1 + a(1 + bv^n)^{-1} \right] \quad (31)$$

$$k'_v = k'_{vmrg} \left[1 + a'(1 + b'v^{n'})^{-1} \right] \quad (32)$$

where: k_{vmrg} and k'_{vmrg} – the marginal value of the velocity impact coefficient on the coefficient of friction and on the specific force of adhesion; v – the speed of sliding, m s^{-1} ; a, a' and b, b' – indices; n and n' – the exponents of indices.

There is insufficient amount of data for deriving mathematical dependencies characterising the influence of temperature upon the friction coefficient of soil along a steel surface. When temperature rises, the specific adhesion force of soil to steel decreases, forming a parabolic curve (on the basis of the data provided by H.G.Riek) described by the following relation (Vilde, 2003 b; Vilde et al., 2007):

$$p_A = p_{A0} (1 - 10^{-4} t^{-2}) \quad (33)$$

where: p_{A0} – the specific adhesion force to a steel surface at a temperature close to 0°C ; t – the temperature of the adhesive surfaces, $^\circ\text{C}$.

There are no data either to deduce dependencies of the influence between the structure and the humus content upon the sliding resistance of soil along a steel surface. According to the data by H.G.Riek, if for a wet residual (paste-like) soil the coefficient of structurality k'_{st} is accepted as being 1, for a structured soil it will be 0.75-0.80. The optimum humidity of soil at which the draft resistance will be minimal is determined by equating the first derivative of the function (8) to zero:

$$dR_x(dW)^{-1} = 0 \quad (34)$$

Because of the complexity of this equation in its full view, partial decisions can be used, and the optimum humidity of soil can be determined from the variables of the partial resistance depending on the humidity of soil, its mechanical structure, and the speed of work of the plough.

Results and Discussion

The methods and equations given above allow studying the regularities of the ploughing draft resistance depending on the humidity of soil, its mechanical composition, the plough body parameters, and its working speed.

As an example, comparative studies (simulation of the impact of the soil humidity on the ploughing resistance) have been made with ploughs having semi-helicoidal bodies with the following main parameters:

the working width of the plough body b , m	0.45
the depth of ploughing a , m	0.20
the cross section area of the soil slice q , m^2	0.09
the working speed v , $m\ s^{-1}$	1 – 5
the working width of plough share b_s , m	0.45
the thickness (sharpness) of the plough share i , m.....	0.001; 0.002; 0.004
the initial inclination angle of the ploughshare to the furrow botom ε_1 , degrees	30
the final lifting angle of the the share–mouldboard surface ε_2 , degrees.....	100
the angle of the horizontal shape lines (generatrix) γ , degrees	30; 40; 45
the radius of the share-mouldboard surface r , m.....	0.5
the surface areas of the lower and the lateral supporting surfaces S_{xy} , S_{yz} , m^2	0.02; 0.07
the weight of the plough body (with a part of the weight of the plough) Q , N.....	2000

The indices of some soil properties used in the calculations are given in Tables 1, and 2.

Table 1

The indices of some soil properties used in calculations (Vilde, 2001, 2003 b)

Type of soil	Content of physical clay m , %	Humidity w , %	Density δ , $kg\ m^{-3}$	Coefficient of friction f_0	Specific force of adhesion p_A , Pa	Hardness ρ_0 , MPa
Loamy sand	10	5	1260	0.34	600	3.4
		10	1320	0.36	1600	2.5
		15	1380	0.33	2500	1.6
		20	1440	0.27	2300	0.8
		25	1500	0.22	1500	0.6
Loam carbonate	30	5	1470	0.38	300	9.1
		10	1540	0.41	1100	6.7
		15	1600	0.40	2500	4.1
		20	1680	0.33	3600	2.0
		25	1750	0.24	3100	0.8
Clay	40	5	1575	0.40	200	12.0
		10	1650	0.38	800	8.9
		15	1725	0.41	2200	5.2
		20	1800	0.37	4000	2.8
		25	1875	0.27	4000	1.2
Clay dark chestnut (temno – kashtanovaya) (Mogilniy, 1957)	63	5	1520	0.64	0	11.0
		10	1595	0.45	200	9.0
		15	1670	0.30	1100	6.5
		20	1740	0.30	3150	4.3
		25	1810	0.42	5400	2.0
		30	1875	0.62	5100	1.0

Table 2

Impact of speed on the indices of soil properties parameters (Vilde, 2001, 2003 b)

Working speed v , m s ⁻¹	Value of the impact coefficients on:	
	soil friction coefficient along steel	specific force of adhesion
~0	1	1
1	0.9	0.63
2	0.82	0.40
3	0.76	0.28
4	0.71	0.23
5	0.69	0.23

Simulation of the impact of soil humidity on the energy consumption for ploughing is carried out on loamy sand, loam carbonate and clay soils that predominate in Latvia.

As an example, the indices of the draft resistance of the selected plough body and its elements in these types of soil with various humidity at the angle of the horizontal shape lines $\gamma = 40^\circ$ and the working speed $v = 2 \text{ m s}^{-1}$ are given in Tables 3, 4, 5 and shown on the graphs below (Figure 1). These indices are estimated for the share-mouldboard surface with a share-blade thickness (sharpness) $i = 1; 2$ and 4 mm .

In the tables given below (Tables 3-5) the share of the relative indices of the components of the share-mouldboard surface draft resistance are determined according to the following formulae:

$$R'_x(\%) = R_x R_x^{-1}; \quad R'_{ix}(\%) = R_{ix} R_x^{-1}; \quad R_{Qx}(\%) = R_{Qx} R_x^{-1} \quad (35; 36; 37)$$

On the basis of the obtained data the specific draft resistance of the plough body and the energy consumption for ploughing depending on the soil humidity of various soil types and working speeds are given in Table 6 and shown on the following graphs (Figures 2 and 3).

Table 3

The indices of the plough body draft resistance and its components at the angle of the horizontal shape lines $\gamma = 40^\circ$, the thickness of the plough share blade $i=0.001 \text{ m}$ and at the speed $v = 2 \text{ m s}^{-1}$

Indices	Type of soil															
	Loamy sand					Loam carbonate					Clay					
	Content of physical clay m, 10 %					Content of physical clay m, 30%					Content of physical clay m, 40%					
Humidity W, %	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	
R_x	N	4025	3946	3564	2927	2260	7192	6546	5610	4417	3278	8830	7523	6414	5391	3960
	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
R'_{ix}	N	2910	2797	2524	2104	1724	5338	4748	3999	3155	2410	6586	5562	4596	3835	2882
	%	72	71	71	72	76	74	73	71	71	74	75	74	72	71	73
R'_{Px}	N	1224	900	576	288	144	3276	2412	1476	720	288	4320	3204	1872	1008	432
	%	30	23	16	10	6	46	37	26	16	9	49	43	29	19	11
R'_{Gx}	N	1211	1305	1308	1253	1145	1494	1631	1672	1592	1458	1646	1677	1827	1804	1631
	%	30	33	37	43	51	21	25	30	36	44	19	22	28	33	41
R'_{Jx}	N	389	420	420	401	364	481	526	539	511	466	530	540	589	581	522
	%	10	11	12	14	16	7	8	10	12	14	6	7	9	11	13
R'_{Ax}	N	41	121	173	125	47	25	106	240	274	159	19	71	226	370	247
	%	1	3	5	4	2	0	2	4	6	5	0	1	4	7	6
R_{Qx}	N	680	720	660	540	530	760	820	800	660	480	800	820	820	740	540
	%	17	18	19	18	23	11	13	14	15	15	9	11	13	14	14

Table 4

The indices of the plough body draft resistance and its components at the angle of the horizontal shape lines $\gamma = 40^\circ$, the thickness of the plough share blade $i=0.002$ m and at the speed $v = 2$ m s⁻¹

Indices	Type of soil															
	Loamy sand					Loam carbonate					Clay					
	Content of physical clay m, 10 %					Content of physical clay m, 30%					Content of physical clay m, 40%					
Humidity W, %	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	
R _x	N	5472	5014	4244	3262	2422	11092	9430	7372	5266	3610	13987	11337	8652	6589	4462
	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
R' _x	N	4134	3697	3100	2392	1868	8614	7160	5475	3875	2698	10906	8766	6468	4843	3314
	%	76	74	73	73	77	78	76	74	74	75	78	77	75	74	74
R' _{Px}	N	2448	1800	1152	576	288	6552	4824	2952	1440	576	8640	6408	3744	2016	864
	%	45	36	27	18	12	59	51	40	27	16	62	57	43	31	19
R' _{Gx}	N	1211	1305	1308	1253	1145	1494	1631	1672	1592	1458	1646	1677	1827	1804	1631
	%	22	26	31	38	47	13	17	23	30	40	12	15	21	27	37
R' _{Jx}	N	389	420	420	401	364	481	526	539	511	466	530	540	589	581	522
	%	7	8	10	12	15	4	6	7	10	13	4	5	7	9	12
R' _{Ax}	N	41	121	173	125	47	25	106	240	274	159	19	71	226	370	247
	%	1	2	4	4	2	0	1	3	5	4	0	1	3	6	6
R _{Qx}	N	680	720	660	540	530	760	820	800	660	480	800	820	820	740	540
	%	12	14	16	17	22	7	9	11	13	13	6	7	9	11	12

Table 5

The indices of the plough body draft resistance and its components at the angle of the horizontal shape lines $\gamma = 40^\circ$, the thickness of the plough share blade $i=0.004$ m and at the speed $v = 2$ m s⁻¹

Indices	Type of soil															
	Loamy sand					Loam carbonate					Clay					
	Content of physical clay m, 10 %					Content of physical clay m, 30%					Content of physical clay m, 40%					
Humidity W, %	5	10	15	20	25	5	10	15	20	25	5	10	15	20	25	
R _x	N	8366	7149	5603	3931	2746	18892	15196	10896	6965	4273	24302	18965	13127	8985	5466
	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
R' _x	N	6582	5497	4252	2968	2156	15166	11984	8427	5315	3274	19546	15174	10212	6859	4178
	%	79	77	76	76	79	80	79	77	76	77	80	80	78	76	76
R' _{Px}	N	4896	3600	2304	1152	576	13104	9648	5904	2880	1152	17280	12816	7488	4032	1728
	%	59	50	41	29	21	69	63	54	41	27	71	68	57	45	32
R' _{Gx}	N	1211	1305	1308	1253	1145	1494	1631	1672	1592	1458	1646	1677	1827	1804	1631
	%	14	18	23	32	42	8	11	15	23	34	7	9	14	20	30
R' _{Jx}	N	389	420	420	401	364	481	526	539	511	466	530	540	589	581	522
	%	5	6	7	10	13	3	3	5	7	11	2	3	4	6	10
R' _{Ax}	N	41	121	173	125	47	25	106	240	274	159	19	71	226	370	247
	%	0	2	3	3	2	0	1	2	4	4	0	0	2	4	5
R _{Qx}	N	680	720	660	540	530	760	820	800	660	480	800	820	820	740	540
	%	8	10	12	14	19	4	5	7	9	11	3	4	6	8	10

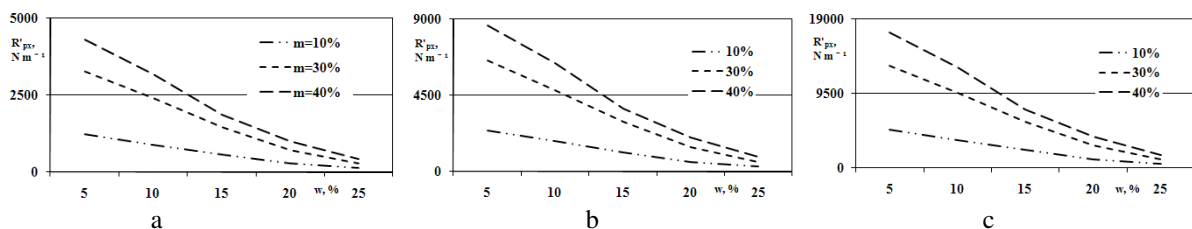


Fig.1. The soil cutting resistance depending on soil humidity of some types of soil at different edge thicknesses of the share. a – $i = 0.001$ m, b – $i = 0.002$ m, c – $i = 0.004$ m.

Table 6

The indices of the specific draft resistance K_I (N m^{-1}) and energy capacity E_m (kWh ha^{-1}) of ploughing depending on soil humidity of some types of soil and the share blade thickness i at the speed $v = 2 \text{ m s}^{-1}$

Indices		Type of soil														
		Loamy sand					Loam carbonate					Clay				
		Content of physical clay m, 10 %					Content of physical clay m, 30%					Content of physical clay m, 40%				
Humidity w, %		5	10	15	20	25	5	10	15	20	25	5	10	15	20	25
i=0.001 m	K_I	8945	8768	7921	6505	5021	15983	14548	12467	9816	7285	19623	16717	14254	11980	8799
	E_m	24,8	24,3	22,0	18,1	13,9	44,4	40,4	34,6	27,3	20,2	54,5	46,4	39,6	33,3	24,4
i=0.002 m	K_I	12161	11141	9431	7249	5382	24649	20955	16383	11703	8022	31083	25193	19227	14643	9915
	E_m	33,8	30,9	26,2	20,1	14,9	68,5	58,2	45,5	32,5	22,3	86,3	70,0	53,4	40,7	27,5
i=0.004 m	K_I	18591	15887	12451	8737	6102	41981	33769	24214	15478	9496	54004	42144	29172	19967	12147
	E_m	51,6	44,1	34,6	24,3	16,9	116,6	93,8	67,2	43,0	26,4	150,0	117,0	81,0	55,4	33,7

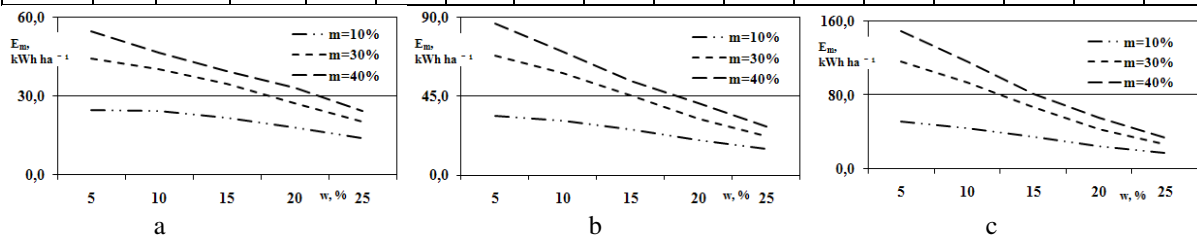


Fig.2. The specific energy consumption of ploughing depending on soil humidity of some types of soil and the edge thicknesses of the share at the speed $v = 2 \text{ m s}^{-1}$. The thickness of the plough share blade: a – $i = 0.001 \text{ m}$, b – $i = 0.002 \text{ m}$, c – $i = 0.004 \text{ m}$.

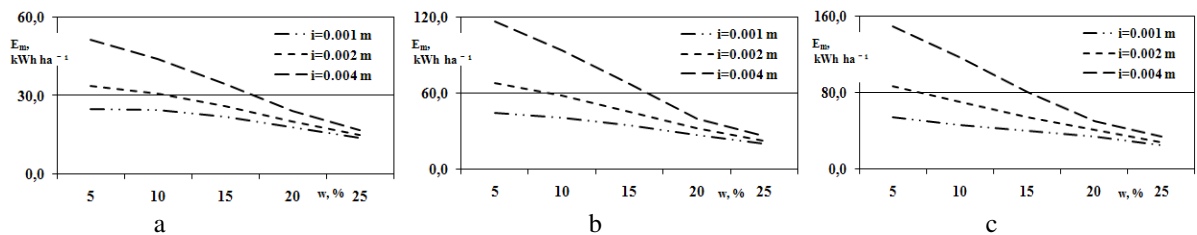


Fig.3. The specific energy consumption of ploughing depending on soil humidity of some types of soil and the edge thicknesses of the share at the speed $v = 2 \text{ m s}^{-1}$. The content of physical clay (particles of the size $< 0.01 \text{ mm}$): a – $m = 10\%$, b – $m = 30\%$, c – $m = 40\%$.

The deduced analytical correlations and the developed computer algorithm allow assessment of the forces acting upon the operating surfaces of the plough body and determination of its draft resistance depending on the value of the soil humidity and composition, as well as its design parameters and working speed.

Presentation of the plough body draft resistance as the sum of components – the cutting resistance of the soil slice, the resistance caused by its weight, the inertia forces, adhesion and the weight of the plough itself – allows analysing the forces acting upon the share-mouldboard surface and supporting surfaces and their impact on the plough body draft resistance. The value of the cutting resistance of the soil slice is dependent on the thickness of the share edge and changes in accordance with the variations of the soil hardness. Variations in the draft resistance caused by the weight and inertia forces of the lifted soil slice and its own weight correspond to the values of the friction resistance, but the resistance caused by the soil adhesion corresponds to the values of the specific force of its adhesion to the working share-mouldboard and supporting surfaces.

The data in the tables (Tables 3-5) and graphs (Fig. 1) show that the part of draft resistance for cutting off a soil slice is remarkable, but exclusive on dry clay soils. In very dry soils it makes a summary draft resistance of the plough body at a sharp share blade 30 – 49 % (Table 3 and Fig. 1 a), but at a blunt blade - 51 – 79 % (Table 5. and Fig. 1 c). Therefore, in order to minimise energy consumption, plough shares with sharp blades are used.

The draft resistance caused by cutting off a strip of soil depends on the working width of the share. By using a share which is narrower than working width of the body one can reduce the relative value of this component because the resistance caused by the break-off of the soil slice is insignificant in comparison with the cutting resistance (Rucins and Vilde, 2005).

Our experience obtained from testing ploughs shows that on dry loam and clay soils the separation of the soil slice proceeds by successive cutting and break-off operations. As the resistance of the break-off operation is insignificant in contrast to the cutting resistance, the average value of resistance to the separation of the soil slice may be less.

The data in the tables (Tables 3-6) and the graphs above (Fig. 2 and 3) show that in case the share blade is sharp, the variations in the soil humidity have little impact on the plough body resistance and the energy consumption in the light loamy sand soils, but the impact is considerable on the clay soils. The clay soils show a minimum of these indices at the humidity of 18...24 %. Such a change of the ploughing resistance depending on the soil humidity is obtained also in the investigations by other researchers, for example, P. U. Bahtin (Bahtin, 1969, pp. 250–259) and I. P. Mogilniy (Mogilniy, 1957, p. 476).

The data in the tables above (Tables 3-5) show, too, that in the dry soils there is predominant resistance to the cutting-off of the soil slice whereas in the wet soils a resistance predominates or has relatively important values which is caused by the weight and inertia forces of the slice of soil, as well as the relative resistance caused by the proper weight of the plough.

It should be noted that the data about the energy consumption for ploughing given in this article characterise only the clear energy consumption of the plough itself. The energy consumption of the plough-tractor units is greater by approximately 30...49 % (when using wheeled tractors) and the optimum soil humidity may be different, most probably less (Cēsniēks et al. 2005), depending on the value of the draft coefficient η_v of the tractor used for ploughing (see formula (5) in this article).

It is evident from these tables, too, that the draft resistance of the share-moulboard surface constitutes 71-80 % of the total plough body draft resistance. This means that the resistance of the supporting surfaces makes 20-29 %. Therefore, in order to increase the efficiency of ploughing, it is important to decrease this part of resistance, which can be done using tractors with mounted ploughs during the operation of which it is possible to transfer extra weight of the plough (in order to perform technological operations) to the tractor by means of the automatic control system of its hydraulic hitch-up device (Cēsniēks et al., 2005).

The energetical indices of ploughing clay dark chestnut (temno – kashtanovaya) soils (Table 1) are similar to those of the clay soils, yet only at very high humidity ($W = 30\%$ and more) because of the hard adhesion the resistance and energy consumption of ploughing increased (Mogilniy, 1957).

Conclusions

1. The deduced analytical correlations and the developed computer algorithm allow simulation and assessment of the ploughing resistance and energy consumption depending on the soil humidity, mechanical composition, the plough parameters, mode of aggregation and the working speed of the plough. They may be applied to determine the range of the optimal soil humidity and determine measures for lowering the energy consumption in ploughing.
2. Humidity affects most of all the hardness and cutting resistance of soil. It is the dominating factor in the summary resistance in dry soils. An increase in the soil humidity leads to a decrease in the ploughing resistance and energy consumption, which is more remarkable in the clay soils. The optimum humidity of clay soils, when ploughing at a speed 2...2.5m s⁻¹, is 18...24 %.

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ICT IN EDUCATION

INFORMATION SECURITY ASPECTS OF E-LEARNING SYSTEMS.

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Abstract.

Already long time e-learning is more than availability of materials online. Nowadays they are very efficient systems to improve knowledge and skills that is necessary for future life. E-learning systems require several media types, sharing, merging, linking, online information changing and other activities. Sometimes these activities need to be done not only within self system, but among other universities e-learning systems. Security play very important role for these system, because e-learning systems is very dynamic and opens systems, but the same time vulnerable to several attacks. Information security is necessary for this system survivability, if information in these systems won't be adequate, organization can lose their reputation and all work will become useless. E-learning systems usually have large amount of users and resources, these characteristics dynamically are growing. These systems are changes all the time – active resource creation and release, functionality creation and destruction, active network connections from several places. Whereas increases e-learning popularity, also increases need of security, it becomes quite challenging, information must be secure and adequate, but the same time system need to stay easy to use, can't lose productivity and availability. That is one of the biggest problems in many systems, because security increases complexity and that is the reason why security perspective is often ignored, but it is important to remember, that people will use system if they trust it. That why is important provide that the true persons have access to the true information in right time and right place. The purpose of this paper is to give clear explanation about most important security needs and challenges that can be relevant for e-learning systems.

Keywords. *Information security, E-learning, privacy, distributed systems, security requirements*

Introduction

One of the key characteristics of our information economy is the requirement for lifelong learning. Industrial and occupational changes, global competition, and the explosion of information technologies have all highlighted the need for skills, knowledge, and training (El-Khatib, 2003). All biggest universities Latvia offers e-learning courses, which offers great potential for continuous learning. While many opportunities have been made in functionality of providing materials online, the needs for security have been left in second plan. E-learning popularity shows that the importance of information security increases. It is clear that security play an increasingly important role for any information system, if system will be compromised of lack of information security it can impact not only system reliability, but also reduce reputation of institution.

Some of the key features have been identified by several publications about e-learning system protection as traditional e-business system protection. Problem is that e-learning system difference is in self process organization and user's needs during systems work. That why is necessary to understand e-learning system specific and their requirements for security. The purpose of this paper is to give clear explanation of information security aspects that is relevant for today's e-learning systems. During research has been explored several standards for information security and e-learning systems to identify the best fit of security requirements for e-learning systems.

Materials and methods

During the research were studied several publications and standards about e-learning security. For research materials selection has been used EBSCO, ScienceDirect and SpringerLink online databases. Some of the articles, which highlight the e-learning security, are also taken into account of the Internet magazines and books. For information security specificity in e-learning systems analyze, was chosen standard information security procedure – in these procedure needs to provide confidentiality, integrity and availability of data in e-business system, for these purposes are used organizational, personal and physical security or in other words information security is composed in three parts hardware, software and communication. Analyzing these parts, where attempting to determine what is e-learning systems specificity and differences in the procedure of information security.

Results and Discussion

Security in general terms is often taken to mean protection from risks and danger. With regard to computer security, this risk relates to malicious or accidental behavior. (Tsiantis L.E, 2007). Information system security depends first of all on the consciousness of personal, but need to remember that this is team work and long time process from planning before system development till maintenance during system monitoring process.

Like any system, one of most important aspect of e-learning systems is standardization and compatibility, especially because e-learning systems time after time different e-learning systems must interact with one another. There is several international standards related to information security in e-learning:

- IEEE P1484 – is a standard for learning Society technology proposed by the Learning Technology Standards Committee (LTSC) of the IEEE Computer. The specification of Public and Private Information. It defines the elements for recording descriptive information related to a learner’s learning process, including personal contact information, learner’s relationships and portfolios. It defines the security and privacy concerns from point of view of different stakeholders, such as developer, institution, regulation and user.
- IMS Global Learning Consortium Learner information Package – it covers ways of organizing learner information so that learning systems can be more responsive to the specific needs of each user. Final version of specification does provide the following structure to support the implementation of “any suitable architecture” for learner privacy protection – 1) The privacy and protection meta-structure: within a learner information tree structure, each tree node and leaf has an associated set of privacy description, which defines the concerns of privacy level, access rights, and date integrity. 2) A “securityKey” data structure: the security keys for the learner include password, public key, and digital signatures. In this structure, the password, the password and security codes are used for communication. (El-Khatib, 2003)
- ISO 2007 series of standards – for information of security. ISO 27002 standard is the rename of the ISO 17799 standard, and is a code of practice for information security. ISO 27003 is guidance in implementing an Information security Management System. ISO 27004 emerging standard covering information security management measurement and metric. ISO 2005 the name of an emerging standard covering information security risk management.
- COBIT – The Control Objectives for Information and related Technology is a set of best practices for IT management. COBIT provides a set of generally accepted measures, indicators, processes and best practices to assist them in maximizing the benefits derived through the use of information technology and developing appropriate IT governance control. The COBIT-based security baseline, providing key controls and mapping to ISO 27002.
- ISO 13335 – IT security management techniques for the management of IT security, for focusing primarily on technical security control measures. ISO 13335 build from five parts where is analized - concepts and models for information and communication technology security management, guidance for selection of safeguards, and how this can be supported by the use of baseline models and controls and guidance for identifications and analysis of the communications related factors that should be taken into account to establish network security.

The roles of security include the following: user authentication, protection of private information from unintended access, and protection of data integrity. El-Khatib K according to Learning Technology Systems Architecture prescribes processes, storage areas, and information flows for E-learning. Figure 1 shows the relationships between these elements. The solid arrows represent data flows (the thick arrows are explained below); the dashed arrows represent control flows. The overall operation is as follows: Learning Preferences, including the learning styles, strategies, methods, etc., are initially passed from the learner entity to the Coach process; the Coach reviews the set of incoming information, such as performance history, future objectives, and searches Learning Resources, via Query, for appropriate learning content; the Coach extracts Locators for the content from the Catalog Info and passes them to Delivery, which uses them to retrieve the content for delivery to the learner as multimedia; multimedia represents learning content, to which the learner exhibits a certain behavior; this behavior is evaluated and results in an Assessment and/or Learner Information such as performance; Learner Information is stored in Learner Records; Interaction Context provides the context used to interpret the learner’s behavior. (El-Khatib K, 2003)

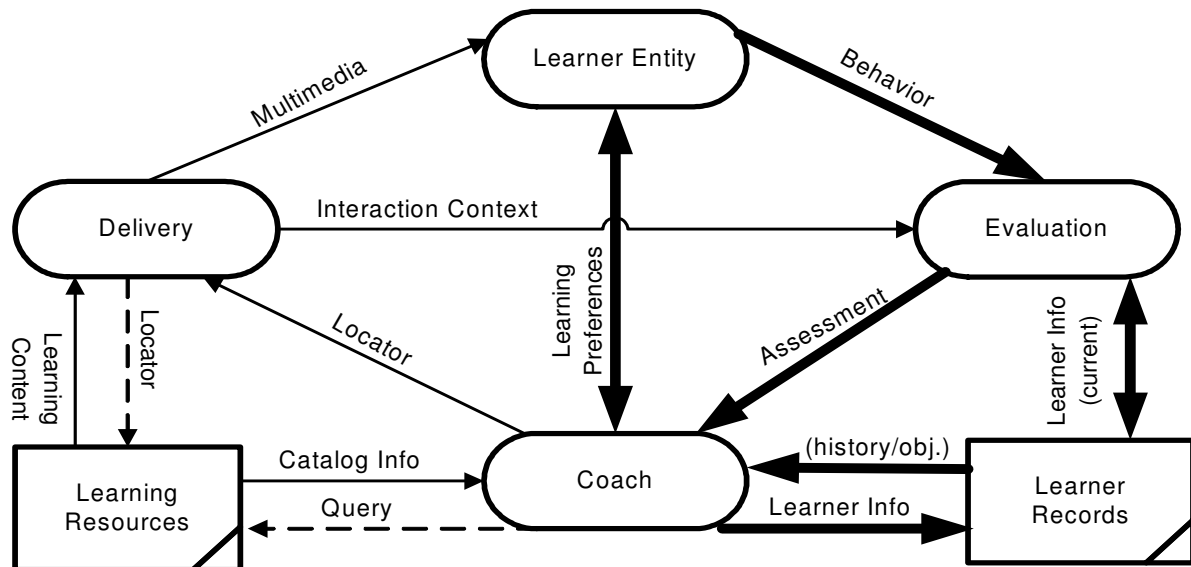


Figure 1: Learning Technology Systems Architecture systems components. (El-Khatib K, 2003)

In 2005 researches proposed the connection of information security and e-learning with different approaches. Weippl discussed a specific security risk analysis with five steps: identification of assets, estimation or calculation of threats and risks, setting priorities, Implementation of controls and counter measures, monitoring of risks and of the effectiveness of counter measures (Weippl E, 2005). That shows that information security need to provide already in software engineering. That is one of e-learning problems that often organizational process of e-learning introduction is taken by academics, but for information technology experts remains only system development or maintenance. E-learning programs require lot of work and resources for development and support and the cooperation of several departments within the organization. Before system development need to understand baseline technologies within institution – used standards, hardware requirements, minimum system requirements. The implementation of system will require corporate IT department and academic top management. In this step is very important determine business requirements, that will help to calculate how much it will cost and integrate the total cost into the business plan. Often e-learning systems are introduced as a project. A project has a clearly defined schedule, goals that need to be met and, in most cases, a limited budget (Weippl E, 2005). Usually limited in the case of the budget, priority is given to functionality rather than security. When it done correctly, information security is pervasive throughout enterprise, but when it is done incorrectly, it can cost all system. Identifications of assets not just for calculation expenses that help also understand what is worth protecting and is that asset valuable enough for protection and what is significant threats and vulnerabilities for the identified assets.

Estimation of threats and risks is related to asset identification, as already mentioned, identification of assets helps find their vulnerabilities and risks. For example, Weippl recommends that integers between 1 and 10 have to be assigned to these assets. For every pair of asset and risk, one integer represents the probability that a security risk gets real and a second integer describes the impact of such a security threat to the asset. Problem is with understanding about asset and risk importance, especially in universities. During risk discovery process, the business management team and information security team need to work together to identify the most critical information. Everyone need to be clear about business targets and their role in this system. That is reason why already in the system design and operation process important to divide the roles and responsibilities. Only so is possible introduce counter measures and keep secrecy and integrity of system. In most cases controls of system have not been adequately resolved. Most enterprises focus excessively on perimeters, and take no effective measures to protect key sensitive data within the boundaries of the enterprise. (Witty R, 2001)

Witty R. have written IT control requirements needed to comprehensively protect an enterprise. Where also defined new IT control requirement is entitled “Non Interference” that address someone trespassing within an enterprise. These requirements may e used also for e-learning systems

Table 2

IT Control requirements (Witty R, 2001)

Requirement	Definition	Security control
Non - Interference	Ensure that control is exercised over the entry and use of an enterprise's electronic assets	<ul style="list-style-type: none"> • User ID/Password • Firewall • Nondisclosure of Passwords • UCC4A Unauthorized use Banner
Authentication	Ensuring that users and applications are appropriately identified before gaining access to information assets	<ul style="list-style-type: none"> • User ID/Password • Token • Biometric Device • PKI Credentials • Location
Authorization	Ensuring that a properly authenticated user/application can access only those IT resources to which the information owner has give approval	<ul style="list-style-type: none"> • Access Control List • Attribute Certificates
Confidentiality	Ensure that only those people who have a need to see information are able to see it	<ul style="list-style-type: none"> • Encryption
Integrity	Ensure that it can be identified if a transaction has changed between the sender and the receiver	<ul style="list-style-type: none"> • Message Authentication Code (MAC)/Hash
Privacy	Ensuring that information provided by employees, customers and others is protected so that the information is used solely for the stated purposes of the enterprise's costumer privacy policies, the person has authorized such use and its use is in compliance with all local privacy regulations	<ul style="list-style-type: none"> • Policies and Procedures • Encryption • Policy Management Tools
Non – Repudiation	Ensure that both the sender and receiver of information can unequivocally prove that the exchange occurred between the two parties	<ul style="list-style-type: none"> • Digital Signature • Time Stamp
Availability	Ensure that an enterprise's IT infrastructure has suitable recoverability and protection from system failures, natural disasters or malicious attacks	<ul style="list-style-type: none"> • Redundancy • Load Balancing • Policies and Procedures • Business Continuity Plan • Alternate Processing Site

Like traditional face- to- face education, “trust” is an important concern in e-learning systems. In the context of networking and distributed applications, one system needs to be trusted to access another underlying systems or service. (El-Khatib, 2003) The essential security requirements in this context are that students must be able to rely on the accuracy of the content and they want to read unobserved. It is therefore relevant to protect the content of an e-learning platform against unauthorized modifications. (Weippl, 204) Trust management is combination of authentication, authorization and no repudiation controls. Example of trust management system includes REFEREE - Rule-controlled Environment for Evaluation of Rules and Everything Else. (Chu Y, 1997) This is trust management system for making access decisions relating to Web documents and can be easily integrated into applications. Trust management systems provide a number of advantages for specifying and controlling authorization, especially where it is advantageous to distribute trust policy. Trust mechanisms in e-learning systems protects not just self system, but also student privacy, these mechanisms clearly states what will be stored for how long can reduce this risk for students. In reality that means that all digital content have to be personalized by someone, for example if students sends his home work it should be signed with digital signature, or exams starts with checking student's identities. E-learning system specific is their great amount of users what means big usability of problems, for example if student realize that he can fail in exam, he might try to crash whole system and get another chance to pass exam. Such situations clearly shows need of monitoring and control of risks during system work. Management of risks presents a number of challenges for information security manager. For successful risk monitoring and management need at first make shore that all resources are being used effectively and efficiently. Need to set measures of effectiveness related to the prior notion of value with regard to cost-effectiveness. Security manager need to understand some issues – what would constitute effective and efficient resource management, what measures would be useful, can existing resources be used to greater effect, what processes might be put in place that ensure effective use of resources, how would those processes be monitored of reassured? (Brotby K, 2009) With better resource management is possible achieve lower costs and

better security. Standardized processes will be more efficient than custom solutions. The information security risk monitoring process can include:

- The time it takes to detect and report security-related incidents. Incident response is typically more effective the sooner it responds before an incident becomes a problem, will be the times it takes to detect, respond to, and resolve incidents.
- The number and frequency of subsequently discovered unreported incidents. Undetected incidents and compromises pose a considerable risk as evidenced by frequent headlines. IT would be similar to the foregoing one in terms of the acceptable time to detect incidents or incidents subsequently uncovered by external auditors or others.
- The ability to determine the effectiveness, efficiency, accuracy, and reliability of metrics. Metrics are only useful to the extent that they are accurate, reliable, and cost-effective. Metrics on management and operational metrics in terms of validating accuracy, reliability, and cost-effectiveness.
- Clear indications that security objectives are being met. All defined objectives need to have predetermined measures of success.
- Threat and vulnerability management. Knowledge and monitoring of impending threats and vulnerabilities is important to successful outcomes. The KGI would be processes to track and monitor emerging threats and vulnerabilities and assess potential exposure and impacts. Consistency or effectiveness of log review practices. Log reviews are a useful monitoring and detection practice frequently not performed. The KGI would be the extent to which logs are systematically reviewed or, perhaps, the number of significant events uncovered by log reviews. (Brotby K, 2009)

Log files are very useful for saving request history of the fact that they can be stored by different applications operating on different computers. Details of the transaction including the time of its occurrence would be “logged” and the resulting record secured using cryptographic techniques, to provide assurance that their modifications, deletion or insertion would be detectable. The existence of secured record of transactions allows verification that conformance to each principle has been maintained. In the case of Challenging Compliance, the existence of a record is very useful for possibly showing where compliance has wavered. (El-Khatib, 2003)

Conclusions

In this paper presented and analyzed the information security mechanisms and investigated standards which are related to e-learning systems. Current e-learning standards treat security superficially, together with information security standards can be identified components of e-learning system which require specific security solutions, some of them are already identified in this research:

- Important security aspect is process organization. With little additional effort possible significantly increase compliance of process, but non-compliance is greatest security risk. E-learning systems require corporate IT department and academics and clearly define roles and responsibilities.
- E-learning systems must be standard based and flexible. These systems are distributed computing systems and they not working just by themselves; need to ensure that it is possible work also with other systems.
- It is necessary to implement trust mechanisms in e-learning system, which provides trusted interactions between a service user and service provider. It can be used set up authorizations for course access and learner privacy safeguards via policies.
- Because of possible network attacks need to be provide security risk monitoring during system work. Need to be made security measures, adaption control and coordination among the different mechanisms whose capabilities are used during system work.
- It is expected to continue research to improve information security technologies for e-learning systems. Current research shows that must be made security measurement mechanism, which can help to check system security. Based on such measurement results developers and information security administrators will be able to check system security and implement the necessary changes.

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QUALITY MODEL OF THE CURRICULA OF INFORMATION TECHNOLOGY STUDIES

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Abstract

The quality of intangible products currently becomes more and more essential in different fields. The software products and the outcome of educational process are typical examples of such products. A concept of their quality can be considered more detailed as consisting from the internal and external quality. The internal and external quality in the sphere of education is usually understood in relation to an education institution. On the one hand, each education institution shall define internal policy for quality assurance of its curricula, standards, and graduation degrees. On the other hand, there should be an accredited external administrative body, which is responsible for external quality assurance. In the scope of software development the internal quality is defined as the totality of attributes of a product, which determines its ability to satisfy stated and implied needs when used on specific conditions (ISO/IEC 9126-3). The definition and quality assurance is connected with such interim products as specification of requirements, design description, and source code. The present paper reposing on the analogy with the quality of software products considers the internal quality of curricula as a set of characteristics, which determines a possibility to acquire the stated or implied knowledge, or to teach or to learn the needed skills and proficiency.

The paper describes the quality characteristics of separate study courses and the whole curricula as well as the evaluation process based on defined metrics, which is obtained during a poll of students. The study focuses on the questionnaire data collected within one term and analysis of problems related to the involvement of students in quality improvement of study courses. The paper tackles upon the description of selection related to the characteristics and sub-characteristics to be evaluated, and definition of metrics. These metrics serve as the basis for the questionnaire.

Key words: *education process, quality model, metrics.*

Introduction

Quality improvement of study courses and curricula has always been a more or less topical issue for education institutions. Especially notable this topicality is today with the development of the European Higher Education Area. In accordance with decisions made in the framework of the Bologna Process, the main responsibility for quality of study process falls upon the education institutions themselves (Thune, 2005). The Department of Computer Systems of Faculty of Information Technologies has expanded for several past years activities connected with the improvement of qualification of information technology specialists. Teaching students can be regarded as the first stage that lays the foundation for the quality of software products. In accordance with the quality in software product life cycle (ISO/IEC 9126-1) it is the process quality, which in the sphere of software development is usually solved by means of a process quality assurance, for example, by the development of quality system according to the requirements of ISO 9001 Standard. It is necessary to select quality characteristics to be evaluated, and to define the metrics and the mode for obtaining metrics to evaluate the quality of curricula using the model of internal and external quality. By analogy with quality evaluation of software products, the internal metrics can be obtained by assessing the content of an interim product (document). Lecturers- experts may review curricula and study courses in details based on the curricula description documents as the source of such metrics. Quality characteristics may also be evaluated by external metrics, which in case of software products are obtained during software testing or operation. The teaching process is the analogous of operation in the sphere of education. In this case students are the persons involved in evaluation, and a targeted questionnaire is applied for obtaining metrics.

The paper contains information on the students' poll initiated in the study year 2009/2010. The poll will be continued at the end of each study year for four years running, i.e. up to the end of bachelor studies.

Materials and Methods

In the development of software products internal quality is usually evaluated by the analysis of software and/or system requirements specification, design description, and source code.

Software requirements specification (SRS) is a document that specifies the requirements for a system or component, and typically includes functional requirements, performance requirements, interface requirements, quality requirements, design requirements, and development standards (IEEE Std 610.12).

Software design description (SDD) is a document that describes the design of a system or component. Typical contents include system or component architecture, control logic, data structures, input/output formats, interface descriptions, and algorithms (IEEE Std 610.12). This description is a model of software system.

Theoretical methods, standards and practical recommendations have been presented for the development and evaluation of such documents, focused mainly on the quality of the content.

The study process comprises the basic documents such as the curricula, the study plan, and the description of study courses, which may be regarded as fundament of quality.

Curricula is a group of related courses, in a special field of study, necessary for obtaining a bachelor's or a master's degree. Curricula shall be described in a special document, which contains information on the content of studies and its implementation, and defines the goal, tasks, and planned outcomes. The amount of compulsory, restricted elective and elective courses shall also be described as well as their arrangement in time, types of control and procedure (Law on Institutions of Higher Education, Republic of Latvia).

Study plan is a part of curricula, which contains the information on courses, their amount, types of control, sequence and division into the terms (Study Regulations, 2008).

Study course is a specially organised presentment of a study item or its part on the defined level, amount and time, and with a defined study outcome (Study Regulations, 2008). The study course is a separate unit of the curricula plan.

Different regulatory enactments of higher education prescribe the development, arrangement and approval of these documents. Internal and external units of higher education institutions carry out the control of implementation. Nevertheless, there are no practical recommendations for the performance of quality assurance and content evaluation of the curricula and courses.

The analogy of software development and study process, analysed before (Cevere, Sproge, Arhipova, 2008), provides a possibility to use methods of software engineering in the development of curricula and their courses. Therefore similar aspects of basic documents were analysed in both fields. Basic interim documents of software development have a strong sequence of development: first it is necessary to answer the question on the main tasks of software. Then the information shall be included in the SRS. The main task of the SDD is to describe the procedure how these requirements are implemented in the software.

Sequence of development of the curricula and course description has not so strong continuity, they can contain both kinds of information simultaneously, i.e. they contain information on the content of a particular course as well as the process of teaching.

Quality attributes of software requirements specification, recommended by the Standard (IEEE Std 830) were analysed, and similar parameters of study courses were described to define characteristics and metrics that should be used in the evaluation of curricula (Table 1).

Table 3

Quality characteristics of software requirements specification and basic documents of study courses

Quality characteristics	Software and/or System Requirements Specification (IEEE Std 830)	Study Programme and/or Course
Correct	A SRS is correct if, and only if, every requirement stated therein is one that the software shall meet. There is no tool or procedure that ensures correctness. The SRS should be compared with any applicable superior specification, such as a system requirements specification, with other project documentation, and with other applicable standards, to ensure that it agrees	A course is correct if, and only if, every topic stated therein is one that corresponds to required scope and level of the particular course.
Unambiguous	A SRS is unambiguous if and only if, every requirement stated therein has only one interpretation and no one of the described requirements mutually conflicts with other ones. As a minimum, it requires that each characteristic of the final product be described using a single unique term.	A course is unambiguous if, and only if, every described topic is not in mutual conflict with any other topic. It requires at least usage of unified terminology
Complete	A SRS is complete if, and only if, it includes all significant requirements; definition of the responses of the software to all implementable classes of input data in all implementable classes of situations; full labels and references to all figures, tables, and diagrams	A course is complete if, and only if, it includes all significant topics; definition of all practical or laboratory works; describes all kinds of control and contains references

Quality characteristics	Software and/or System Requirements Specification (IEEE Std 830)	Study Programme and/or Course
Consistent	Consistency refers to internal consistency. If a SRS does not agree with some higher-level document, such as a system requirements specification, then it is not correct	Consistency refers to internal consistency. If a course does not agree with some higher-level document, such as a study programme or other courses, then it is not correct
Ranked for importance and/or stability	A SRS is ranked for importance and/or stability if each requirement in it has an identifier to indicate either the importance or stability of that particular requirement	A course is ranked for importance and/or stability if each topic in it has been identified to indicate either the importance or stability of that particular topic
Verifiable	A SRS is verifiable if, and only if, every requirement stated therein is verifiable. A requirement is verifiable if, and only if, there exists some finite cost-effective process with which a person or machine can check that the software product meets the requirement. In general any ambiguous requirement is not verifiable	A course is verifiable if, and only if, every topic stated therein is verifiable. A topic is verifiable if, and only if, there exists some finite cost-effective process with which a person can check that the studying of the particular topic facilitates meeting the goal of the course. In general any ambiguous topic is not verifiable
Modifiable	A SRS is modifiable if, and only if, its structure and style are such that any changes to the requirements can be made easily, completely, and consistently while retaining the structure and style. Modifiability generally requires a SRS to a) have a coherent and easy-to-use organisation with a table of contents, an index, and explicit cross- referencing; b) not be redundant (i.e. the same requirement should not appear in more than one place in the SRS); c) express each requirement separately, rather than intermixed with other requirements	A course is modifiable if, and only if, its structure and style are such that any changes to the topics can be made easily, completely, and consistently while retaining the structure and style. Modifiability generally requires an course to a) have a common structure of description, and explicit cross- referencing to literature and other courses; b) not be redundant (i.e. the same topic should not appear in more than one place in the course); c) express each topic separately, rather than intermixed with other topics
Traceable	A SRS is traceable if the origin of each of its requirements is clear and if it facilitates the referencing of each requirement in the future development or enhancement documentation. The following two types of traceability are recommended: a) backward traceability (i.e. to previous stages of development). It depends upon each requirement explicitly referencing its source in earlier documents. b) forward traceability (i.e. to all documents spawned by the SRS). It depends upon each requirement in the SRS having a unique name or reference number	A course is traceable if the origin of each of its topics is clear and if it facilitates the referencing of each topic in the future development of practical or laboratory works. The following two types of traceability are recommended: a) backward traceability (i.e. to previous stages of development). It depends upon each course explicitly referencing its source literature; b) forward traceability (i.e. to all documents spawned by the course)

Further analysis of an analogy looks to the recommendations given in the standard of Software Design Description (LVS 72:1996). The comparison of Software Design Description and Curricula Plan is represented in Figure 1.

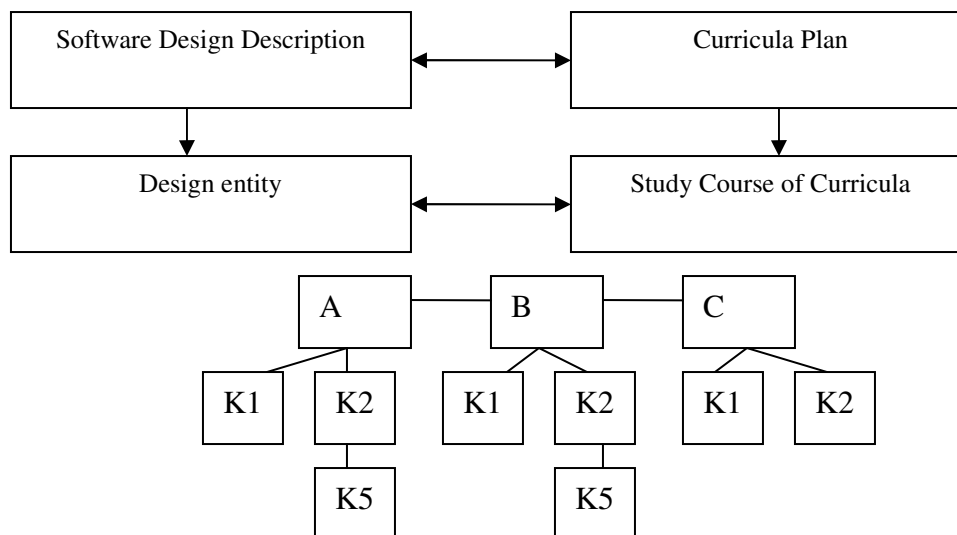


Figure 1. The analogy of Software Design Description and Curricula Plan

A new concept of the next level of distribution, called a design entity, arises in the development of software design description.

Design entity is an element (component) of a design that is structurally and functionally distinct from other elements and that is separately named and referenced (IEEE Std 1016-19). Design entities arise as a result of decomposition of software system requirements. The goal of such decomposition is to divide system into separate components, which can be implemented, changed, and tested separately with minimal impact on other entities. Despite various natures of entities they have some common characteristics. Each design entity should have its name, purpose, and function. Common relationships exist between the entities, such as interfaces or common data. Common characteristics of entities are described by the attributes of design entities. An attribute of a design entity is a characteristic or feature of a design entity that has a name assigned to it. An attribute describes essential design information; it does not describe information relevant to design process.

Study course or topic of curricula discussed before can be considered as an analogue of design entity. Attributes of study course discussed in this paper describe essential features of the content of course, though not the way of its implementation in the study process. The possible analogy of attributes of a design entity and study course is described in Table 2.

Table 4

Attributes of design entity and study course

Attribute of design entity (LVS 72:1996).	Similar attribute of study course (Regulation of Study Course)
Identification – name of entity	Name of a study course and its code in the information system
Type – description of kind of entity	Place of a study course in the study plan – Parts A, B or C, and type of control
Purpose – description of why an entity exists	Aim of a study course
Function – statement of what an entity does	Description of the content of a study course
Subordinates – identification of all those entities that compose the particular entity	Division of a study course into terms and forms of study work
Dependencies – description of relations between the particular entity and other entities	Relations of a course with other courses
Interface – description of interaction of other entities with the particular one	Preliminary knowledge required to acquire the course, necessity of the particular course for other courses
Resources – description of external elements of a design used by the particular entity	Division of lectures and practical work, technical resources necessary for the course
Processing – description of rules used by the particular entity for implementation of its functions	Requirements of a course for obtaining the credit points
Data – description of elements of external data of entity	Bibliography, necessary for a course content, electronic materials of lectures

Defined characteristics of the description of study courses may further be used for determination of their relevance to the model of internal and external quality, and for selection the useful metrics. Four essential stages in the quality assurance can be defined in the sphere of education by analogy with the quality in software product life cycle, described in software engineering (ISO/IEC 9126-1:2001) (Figure 2).

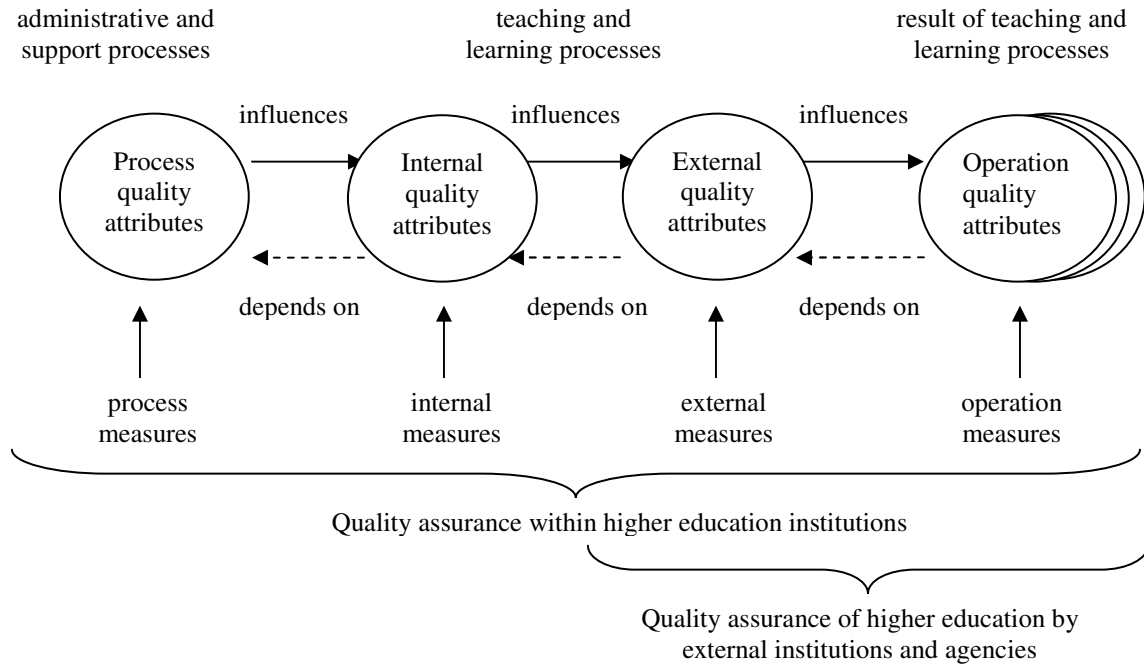


Figure 2. Quality in the life cycle of teaching and learning processes (Cevere, Spröge, Arhipova, 2008)

Any higher education institution shall perform quality evaluation and quality assurance in all four stages, while external supervising institutions shall focus mainly on the control of external quality characteristics without including detailed control of content’s quality (Thune, 2005). This problem should be resolved by an education institution internally.

In accordance with the quality model, the quality of curricula consists of its internal quality (quality of content of curricula and quality of all study materials), and external quality (quality of curricula and all its courses during their implementation, i.e. during teaching and learning processes). A model of internal and external quality of software products, adopted for the sphere of education, is described in Table 3 (Cevere, Spröge, Arhipova, 2008).

Table 5

Hierarchy of quality characteristics and sub-characteristics in the quality model

Characteristics	Sub-characteristics	Description
Functionality	Suitability	Ability to be used for teaching and learning of a particular course
	Accuracy	Ability to teach a particular course correctly
	Interoperability	Ability to cooperate with other courses and curricula
	Functionality compliance	Curricula compliance with the existing study regulations
Usability	Understandability	Student’s time spent to understand the particular course and/or curricula
	Learnability	Student’s time spent to acquire the particular course
	Deliverability	Lecturer’s time spent to prepare a course for delivering
	Attractiveness	Ability of curricula to be attractive to students
Efficiency	Time behaviour	Ability to carry out teaching in time stated in the curricula
	Resource utilisation	Ability to carry out teaching with the resources of education institution (lecturers, study rooms, laboratories, equipment, software, etc.)

Characteristics	Sub-characteristics	Description
	Efficiency compliance	Compliance with the budget of an education institution
Maintainability	Analysability	Convenience to analyse the content of a course as well as its impact on the curricula, and convenience to change an individual course or topic
	Changeability	Labour-intensity necessary for change implementation
	Stability	Ability of curricula to maintain integrity during the change implementation
	Verifiability	Labour-intensity necessary to assure that introduced changes ensure the desired outcome
Tailorability	Adaptability	Ability to adopt curricula to different study environments without additional activities
	Co-existence	Ability of courses to be delivered together (in parallel) with another courses, ability to share resources
	Replaceability	Ability to use the course instead of another course for acquiring the particular knowledge

For the improvement of curricula firstly it was decided to evaluate sub-characteristics of functionality and usability. Polls of students of Faculty of Information Technologies are undertaken starting from the study year 2009/2010. They will be carried out at the end of every term with the purpose to obtain evaluation of all courses of the curricula “Programming” and “Computer Control and Computer Science”, and the whole curricula in general. During polls it is possible to obtain external quality metrics, which characterises the external quality of curricula, and gives an indirect view of the internal quality. The purpose of each metric has been defined as a question to which metric tries to answer in the quality evaluation of software products (IEEE Std 1061-1998). These questions can be used to develop a questionnaire. Questions used in the first poll, and their relation to the quality characteristics and sub-characteristics are given in Table 4.

Table 6

Relevance of the evaluation metrics of study courses to the quality characteristics

Metric purpose (question)	Quality Characteristics and Sub-characteristics
Compliance of the delivered course content with the defined content of course	Functionality (Functional compliance)
Compliance of the information delivered in a course with one's expectations	Usability (Suitability)
Understandability of a study course	Usability (Understandability)
Quality of lectures	Functionality (Suitability)
Quality of practical/laboratory works	Functionality (Suitability)
Relation of the number of lectures and practical works in a course	Functionality (Suitability)
Quality of study materials for practical/laboratory works	Usability (Learnability)
Adequacy/availability of literature to the requirements of a study course	Usability (Learnability)
How do you understand the meaning of a course	Usability (Understandability)
How much effort students have to invest to acquire the particular course	Efficiency (Time behaviour)
Was the knowledge acquired in other courses useful for acquiring the particular course	Tailorability (Co-existence)
Was information in the particular course redundant to other courses	Tailorability (Co-existence)

ISO 9126 Standard offers different metrics for quality evaluation responding to internal and external characteristics of a quality model (ISO/IEC 9126-2). By analogy, a common form of definition and interpretation of metrics is used for the evaluation of internal quality of a study course. An example of one metric is described in Table 5.

Table 7

Form of definition and interpretation of a metric

Purpose of the metric	Does the content of a study course respond to the initially defined one?
Data element computation	Number of given negative estimations (shocking bad, bad or average) related to the total number of estimations
Measurement and formula	$X=1-A/B$ A – number of negative estimations

	B – total number of estimations
Interpretation of measured value	$0 \leq X \leq 1$ The closer to 1, the better
Metric scale type	Absolute
Measure type	A, B – number X – number / number

Results and discussion

It is necessary to use a definite quality model for the quality evaluation of any object. The evaluation of study quality comprises consideration of several aspects, like quality of study process, quality of interim results, and study outcome quality. For example, qualitative development of a study course, which is done in accordance with all regulations and performed by qualified lecturers and experts, is a precondition for preparing a qualitative study course, though it does not guarantee such an outcome. It is necessary also to carry out a content evaluation, which in general is a very complex and multiform task for different courses of different curricula.

Evaluation of internal quality of the existing curricula and study courses of Faculty of Information Technologies has been initiated in the study year 2009/2010. The first poll of users, i.e. students was organised, and external metrics of functionality and usability were collected at the end of winter term. The poll will be continued for the next 4 years running at the end of each term. The first poll included twelve questions on each course delivered during this term (for questions see Table 4). Year 1 and Year 2 students of both bachelor curricula of the Faculty were asked to evaluate each course answering 10 questions by scale of 5 points (1 – shocking bad, 2 – bad, 3 – average, 4 – good, 5 – very well). Two more questions suggested free-text answer. Text field for qualitative estimation was already added to each question.

External measurement is indirect measurement of a product internal quality, obtained during the implementation of study courses, i.e. during the education process. Therefore the obtained estimation reflects internal quality of study courses, and at the same time shows an impact of delivery environment (lecturer, other courses acquired in parallel, equipment of laboratory and practical works, preliminary knowledge of students etc.). For these reasons a qualitative usage of the obtained data is planned during the first years of inquires excluding special theoretical methods of data processing. All lecturers are introduced to the results of their course evaluation, and the mean values of all given answers.

In parallel, internal measurement of the content of courses is being prepared. This evaluation will be performed by lecturers-experts, and, possibly, postgraduate students. The information obtained during external measurement will be used for preparing checklists for this evaluation.

During the poll carried out at the end of winter term of the study year 2009/2010, answers were given by 41 (34%) students of total number of 120 respondents. It shows that students' activity is less than a half, and we think on the way for its improvement. Students evaluated seven study courses of Term 1 and nine courses of Term 3. Table 6 and Figures 3 – 5 illustrate the outcomes from different point of view.

Table 8

Common estimates of study courses

Question (purpose of metric)	Term 1	Term 3
Compliance of the delivered content of course with the defined content of course	4.1	4.1
Compliance of the information delivered in a course with one's expectations	3.8	3.9
Understandability of a study course	3.4	3.7
Quality of lectures	3.9	3.8
Quality of practical/laboratory works	3.9	4.1
Relation of the number of lectures and practical works in a course	3.8	4.0
Quality of study materials for practical/laboratory works	3.9	3.8
Adequacy/availability of literature to the requirements of a study course	3.7	3.5
How do you understand the meaning of a course	3.7	3.8
How much effort students have to invest to acquire the particular course	3.6	3.9

Data in Table 6 show that the average value of metrics assigned by students is “good” or a little bit better (4.0) only for three questions.

Figure 3 shows that 31% of students in both terms have given the rating “average” and less than average, and therefore it requires the necessity for improvement of study courses.

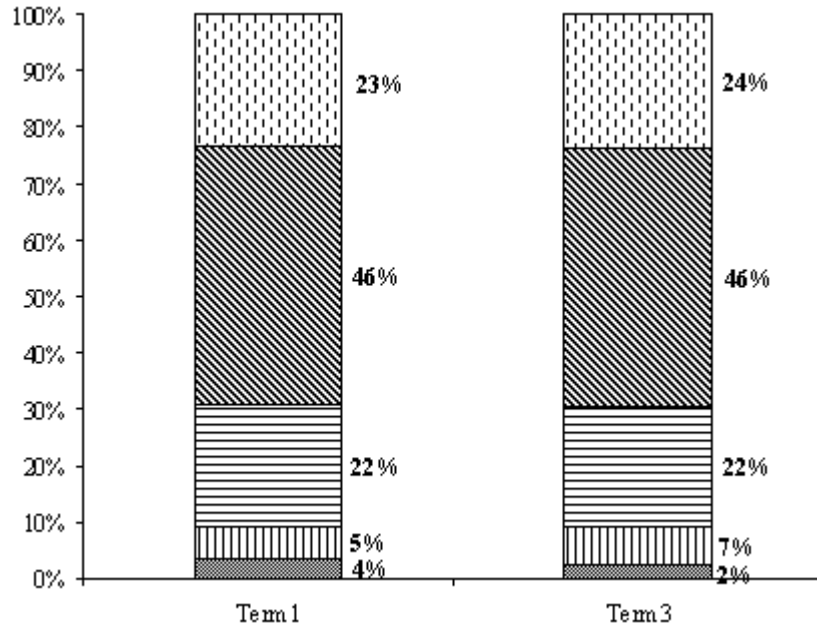


Figure 3. Breakdown of students' responses by terms
 1 – shocking bad, 2 – bad, 3 – average, 4 – good, 5 – very well.

The assessments of each course individually show that the evaluation from “average” and above it ranges between 7% and 56% (Figures 4 and 5). It again requires the necessity for improvement of the situation.

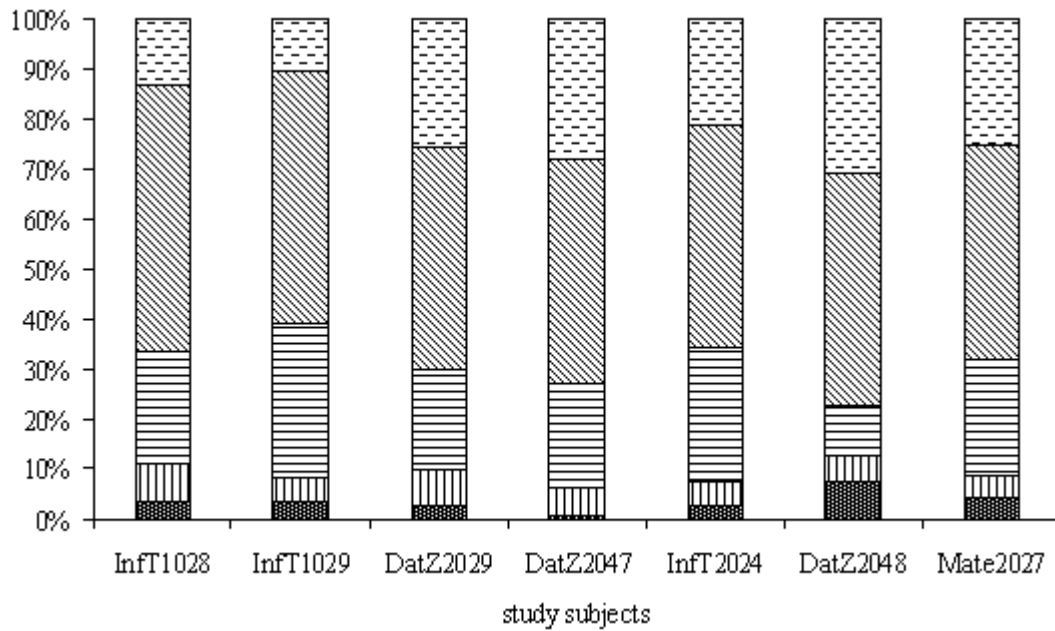


Figure 4. Breakdown of students' responses by courses of Term 1
 1 – shocking bad, 2 – bad, 3 – average, 4 – good, 5 – very well.

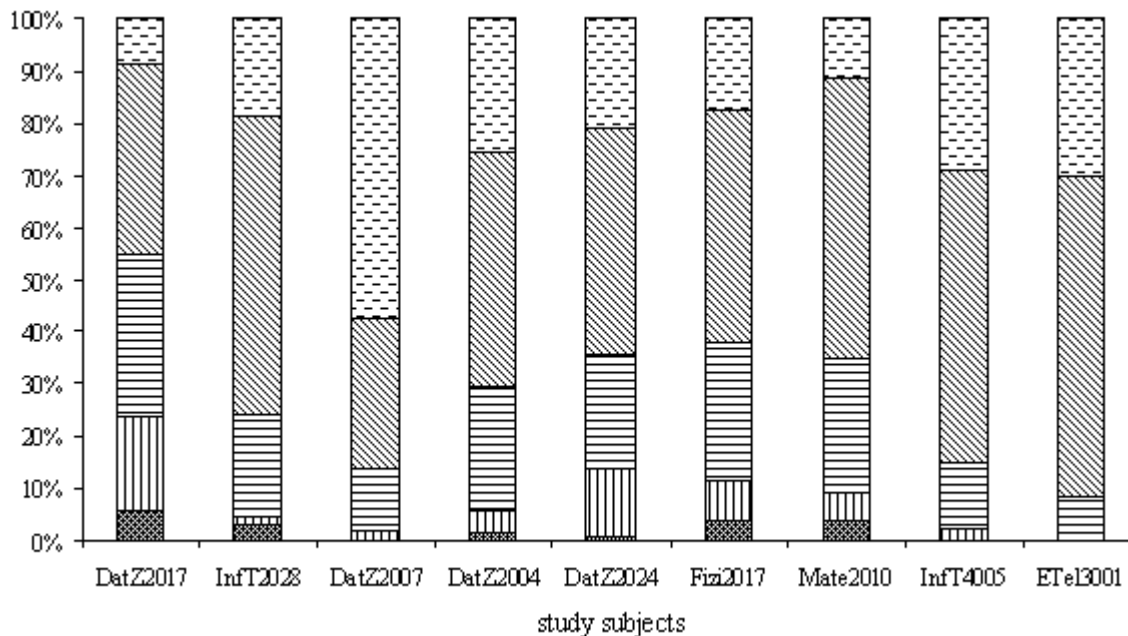


Figure 5. Breakdown of students' responses by courses of Term 3
1 – shocking bad, 2 – bad, 3 – average, 4 – good, 5 – very well.

Students have provided the following arguments for the low evaluation of study courses:

1. Understandability of a study course:
 - a) amount of course does not respond to the amount of included topics;
 - b) amount of practical works is not enough to consolidate theoretical knowledge acquired in lectures;
 - c) materials of offered practical and laboratory works are too large-scaled; it is difficult to understand lectures, more detailed explanation is desired;
 - d) lectures and practical works are not complementary enough, different topics are discussed in one and the other;
2. Adequacy/availability of literature to the requirements of a study course:
 - a) quantity of books in the library is not enough;
 - b) there is no information on additional literature in a course description;
 - c) course contains references to literature, which is not available;
3. How do you understand the meaning of a course:
 - a) large amount of topics has been included in a comparatively small course;
 - b) during a course delivery there is no explanation on the use of the particular course and its importance for future professional career;
4. How much effort students have to invest to acquire the particular course:
 - a) more practical or home tasks are necessary for better mastering the course;
 - b) very large time period should be devoted to perform laboratory works.

Table 7 contains the summary of quality characteristics evaluation results for study courses using the metric described in Table 5.

Table 9

Evaluation of quality characteristics of study courses

Metric purpose (question)	Quality Characteristics and Sub-characteristics	Term 1	Term 3
Compliance of the delivered content of course with the defined content of course	Functionality (Functional compliance)	0.81	0.78
Compliance of the information delivered in a course with one's expectations	Usability (Suitability)	0.68	0.73
Understandability of a study course	Usability (Understandability)	0.51	0.63
Quality of lectures	Functionality (Suitability)	0.73	0.71
Quality of practical/laboratory works	Functionality (Suitability)	0.75	0.77

Metric purpose (question)	Quality Characteristics and Sub-characteristics	Term 1	Term 3
Relation of the number of lectures and practical works in a course	Functionality (Suitability)	0.70	0.77
Quality of study materials for practical/laboratory works	Usability (Learnability)	0.74	0.67
Adequacy/availability of literature to the requirements of a study course	Usability (Learnability)	0.64	0.55
How do you understand the meaning of a course	Usability (Understandability)	0.69	0.70
How much effort students have to invest to acquire the particular course	Efficiency (Time behaviour)	0.67	0.65

Conclusions

The present paper describes an approach, which has been initiated by the Department of Computer Systems of Faculty of Information Technologies during several past years with the aim to improve internal work of education institution for the quality assurance and quality evaluation. The entire academic staff has been involved in this work with a gradual involvement of students of information technologies. This approach of quality improvement is based on the analogy with software development process. Involvement of students, on the one hand, implements the recommendations of the Bologna Process on the involvement of students in the quality improvement of study process, and moving from teaching process to learning. On the other hand, it gives students practical skills of quality assurance work necessary in the field of software development. Therefore it plays a serious role in the improvement of professional qualification.

Acknowledgements

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SINGLE AUTHORIZATION OPPORTUNITIES FOR LLU INFORMATION SYSTEMS

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Abstract

For each authority which maintains more than one information system, a uniform user authorization is an issue. Latvian University of Agriculture (LLU) use at least four information systems, which would need to introduce a uniform user authorization. They are: the website, email system, LLUIS, library. These systems use a large proportion of university staff and students, but they are not the only systems. Some departments use information systems of different size such as accounting, economic authority, hostels. All LLU information systems have a separate user management - hence the authorization. Such a situation has arisen because the information systems were designed for a different range of users and at different times. Historically, the uniform user management was not necessary for those information systems. As time moves on, the information systems was expanded to offer the user experience to a wider range of users. Consequently, a uniform user authorization issue arises. Now it is a situation that one and the same person is a registered user in LLUIS, e-mail system and the university website. The user must remember multiple login names and possibly also different passwords. This is inconvenient for the user, but there are also a number of security problems. If an employee is dismissed from employment, his account needs to be blocked in all systems in which he has ever been registered. Because each information system has its own administrator, often the user's access is blocked in some information systems, if anything is blocked.

Uniform user management would allow for centralized management to add, delete and define user privileges. Unified user management would allow to immediately determine which information systems the person uses. Unified user authorization is obvious, but it wouldn't be easy to implement. Firstly a large proportion of university information systems is a special order, which was build up based on university requirements. Such systems generally have not been provided for external user management. Information systems are developed by different suppliers in different programming languages (php, c++, c#), so that external user management option would have to develop for each system separately. The author shall specify the largest LLU information system authorization mechanisms and analyze how difficult it would be to convert it to work with an external user management. The author gives proposals for a single user management choices, or design, depending on the university's future vision for their own information systems.

Introduction

Latvian University of Agriculture use eight information systems. In the central building only about 1000 MS Windows workstation are depicted. All workstations must be configured for different access rights to server resources and information systems.

Terms such as "unified authorization", "single identity" and "single user and role management" refer to one and the same thing - in all university information systems, the user is authenticated with the same identity, and once.

The introduction of such a major information technology solution as a single identity can not completely avoid the changes in IT governance processes.

Identity repository has to be linked to the university's information system for digital identities. In planning this linkage should be remembered that the repository of identity becomes a significant part of information technology infrastructure. Depending on the information system and the number of users, ensure high availability.

Materials and methods

Often the information system maintain each user and their role in the registry, hence their identity management processes. Such decentralization has a rigid environment for development, namely, creating difficulties for the introduction of new information technology solutions. Users and roles of the registers are filled again, often with the same users and the same roles.

User data is duplicated in several systems, increasing data-maintenance costs. LLU deal with the administration of digital identities and maintain their ties in a number of information systems. Administrators at several different interfaces create new user accounts, delete old ones, restore user profiles, and digital identities in a link to each information system is most recently available data.

LLU information systems should allow the possibility of identity management for the organization single identity repository. The market offers many ready-made information technology solutions with the following options, as well as a number of identity repository and identity management solutions. However, as alleged in

Reed(2004), there is no ready identity management solution that could solve all the organization's identity management challenges in any organization.

Key challenges for the introduction of the single identity of the organization:

- Minimal damage to LLU learning processes and management work
- Information system linking digital identities to identity repositories;
- Identity repository performance;
- The information system of identity management procedures to the identity repository.

Usually the organization benefits from a single identity is mainly associated with the introduction of spending resources on the individual digital identities management and organization of information technology infrastructure flexibility. [**Gordon 2004**] lists a Salford university gains by a single identity, namely, users will reduce support costs, reduce administration costs, speed up the user account creation, improved digital identity management monitoring, so the cost of transparency, easier to carry out audits, better security, easier integrate the new system, flexible environment for business needs change.

Significantly easier could be new system implementation process, since user management can be done in university's single identity repository. Most likely the new system will use the same digital identities, which are already used in other systems.

Single identity implementation methodology can be used to allocate the identity repository types. A relational database management system can perform identity repository functions, but as mentioned in **Anand(2004)** - the source of authentication and authorization functions more suited to the Directory Services. Examples of the use of a directory service to fulfill the role of identity repository can be found **Reed(2004)**, **Andreu(2003)** and **PresenceID(2008)**.

There are two directory service as the identity repository uses - a virtual directory and meta-directory. A virtual directory is a technology that offers a way to create a single view (a virtual directory) to compile a digital identity from different data sources - databases or directories. Advantages of virtual directories is a simple introduction, real-time information and the fact that data is not duplicated. As mentioned in [Yang 2006] virtual directory is relatively simple to implement, because there is no need for data synchronization mechanisms to be established for each information system. Virtual directory scheme shown the of Fig. 1.

Meta-directory is a directory service, in which the synchronization mechanisms combines organization digital identities from the organization's information systems identities storages. Data from the information systems are summarized in the directory service.

Each information system have specially developed synchronization mechanism to synchronize data in the directory service. Meta-directory scheme shown the of Fig. 2. Synchronization mechanisms must be regularly driven to collect meta-directory to-date information, and therefore the credibility of the information appears in the time shift.

Directory service is the software suite that provides structured storage of information on digital identities - computer network users and resources, allowing the network administrator to manage user access rights to resources. There are two directory service standards - X.500 and LDAP (Lightweight Directory Access Protocol). All possible attributes of a directory entry is defined in the directory scheme. The scheme is defined in the object class attribute value of syntax, the attribute comparison rules. Standard [RFC4523 2006] defines a standard LDAP schemes.

Information systems used by Latvian University of Agriculture are: LLUIS, e-mail, LLU website, Aleph, Hotel, Apvārnis E-learning system and ITF practices website.

More details on each of the systems:

LLUIS is one of the main university information systems. In this system the identity of each person who is associated with the university is stored. Data on students' learning programs, performance and loads of staff - everything is in that information system. Each student has a username and password in this system. Using this system each year, students may apply for study subjects. Application to study subjects is considered as student's will to continue studies. This system has been developed for Latvian University and adapted for use in Latvian University of Agriculture.

E-mail system is serving the majority of university staff. Since the e-mail is a paid service, only few students are using it. Staff and students can access their e-mail using mail client or through webmail. Horde is used as webmail system.

University website currently does not offer any public services for registered users. Information on the portal is placed by several editors who are registered users of the portal system. University portal has been developed by full time programmers from university staff. It has been from scratch.

Aleph is the library information system. Information about literature can be searched by both registered and unregistered users.

“Apvārsnis” is an accounting information system.

Currently, only the Faculty of Information Technology use E-learning system. There are plans to extend this system to the university-wide. Teachers and students are registered users of this system.

In ITF practices website the Faculty of Information Technology students regularly report on the practices work. Students have their own user names that are different from the E-learning system.

Since most of workstations are MS Windows desktops, single sign-on is an option for university. There are well documented SSO setup guides for Ubuntu Linux **SingleSignOn(2010)** and Apple computers as well.

General requirements for single sign-on

- The solution needs to be highly available.
- The solution needs to provide interfaces for backup, 24x7 monitoring and operations, etc.
- The solution needs to be able to scale to many thousands of users accessing enterprise software.
- The solution should be able to support the company-internal standards defined for efficient operations and integration without problems (e.g., directory server standards, authentication standards, etc.).
- The solution should be able to easily integrate in related IT solutions according to **Varma(2008)**

As single sign-on provides access to many resources once the user is initially authenticated, it increases the negative impact in case the credentials are available to other persons and misused. Therefore, single sign-on requires an increased focus on the protection of the user credentials, and should ideally be combined with strong authentication methods like smart cards and one-time password tokens.

Single sign-on also makes the authentication systems highly critical. Their failure or an inability to reach them (such as in a network failure) can result in denying access to all systems unified under the SSO. This can make SSO undesirable for systems to which access has to be guaranteed at all times, such as security systems.

Results and discussion

In the publication Latvian University of Agriculture information systems was discussed. There was also discussed several methods for single authorization. Information systems used by LLU are written using different programming languages and software tools. It would be easier to introduce Virtual directory, because in that case there is no need for data synchronization mechanisms to be established for each information system. Unlike Meta-directory, Virtual directory requires fast network communication between user computer, authentication server and information system. Latvian University of Agriculture maintains fast enough network to afford “query/reply” communications in case of Virtual directory. Meta-directory is more fundamental solution, but it requires that each information system have specially developed synchronization mechanism to synchronize data in the directory service. Synchronization mechanisms must be regularly driven to collect meta-directory to-date information, and therefore the credibility of the information appears in the time shift.

Conclusions

Single authorization problems and opportunities are discussed in the literature previously. There are several solutions for the single authorization implementation. Single authorization benefits are clearly visible, but it is necessary to carry out research if introduction of such system is cost effective. University senior management has to adopt IT infrastructure development plan. Without such a plan, all expectations remain unrealized. University IT department's competence is sufficient to make the right decisions, but however there has to be a plan.

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SUPPORT PROCESSES OF WORK PLANNING FOR THE DEPARTMENT OF COMPUTER SYSTEMS

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Abstract

Nowadays it is very important to have a quick and qualitative support process for everyday tasks. To realize it most companies decide to model business processes and to implement them into information system. Therefore, the Department of Computer Systems decided to introduce a software solution, the main task of which is to make execution of the support process more efficient.

To be able to develop this system exploration of doable support process in the Department of Computer Systems has been made. The study showed that the department needs to perform four main support processes: request of study courses, normative study amount planning and accounting, planning academic staff's individual load for one academic year, learning process maintenance. One or several Latvia University's of Agriculture (hereafter LUA) regulations is developed as a result of each process.

By examining these documents, it was found that, the same information units are included in several papers. For example, a study course's name, faculty's name, study program's name, number of students, semester and amount of credit points per study course. The clerk, which makes a major part of these documents, has to write one and the same information several times, every time in a different document. Also it is difficult to obtain information about overall progress of work in the department – academic staff's average audience load for one academic year, academic staff's load's distribution allocation, breakdown by academic staff of separate study course, as well as other necessary data to do department work management, from separate documents.

These problems can be solved by developing an integrated planning of department work and accounting information system.

Key words: *Business processes, information system development, support process optimization.*

Introduction

Nowadays, using rapidly developing information technologies, many planning and accounting processes, which used to be done by using paper and physical effort, now can be done by introducing an information system. By introducing an information system, companies save working time, which is associated with document composition and their circulation. This process provides an opportunity to replace the old paper archives with a single database that stores all information about previous years. Consequently, this reduces searching time for previous year's documents, because they all are in one single database.

Following documents are prepared and maintained in the Department of Computer Systems, according to managerial requirements of LUA:

1. planned total normative load;
2. executed normative load;
3. planning proposals of the department's academic staff's load;
4. academic staff's timetable;
5. summary of planned load;
6. working time sheets;
7. study program's plan.

In addition to these documents, load planning and accounting is regulated by "Time rate of teacher's actual load calculations in hours."

Existing document circulation in the department is in paper or separate Word and Excel file format, and in this way all information about previous years is stored. Such way of information storage is related with some risks – damage of hardware or accidental file deletion, as well as it's difficult to use this information. An information system is being developed in the Department of Computer Systems to avoid mentioned risks, increase speed of data circulation and security, as well as to intensify academic and support staff's work.

Materials and Methods

The following key processes were detected as a result of ongoing process investigation in the Department of Computer Systems (figure 1.):

- study course request – the process which aim is to get requests for all faculties' study courses;

- normative study amount planning and accounting – the process which aim is to compose two types of normative study amount: planned and executed;
- planning academic staff's individual load – the process which aim is to compose load's planning proposal document;
- teaching process maintenance – the process that in the department takes place all study year round and whose aim is to compose and maintain an audience, academic staff's timetable and students' lessons timetable. During the process, academic staff creates monthly reports about the work done.

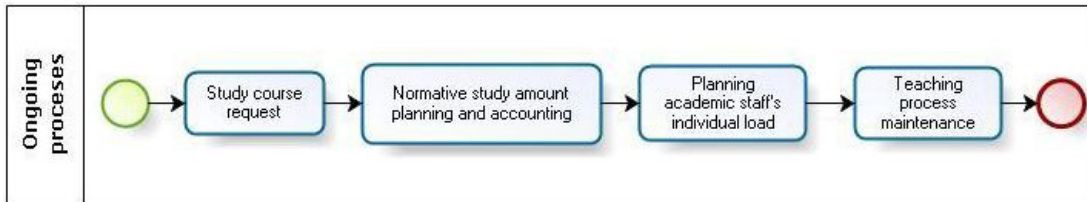


Figure 1. Ongoing processes in Department.

Requests for study courses is the first ongoing process in the Department of Computer Systems, which takes place in the previous academic year and it's done for the next academic year (figure 2.). All LUA faculties take part in this process by sending study courses' requests to the Department of Computer Systems. After receiving study courses' requests the department checks, whether ordered study course is registered in LUA information system (hereafter LUA IS). If requested study course is not registered in LUA IS, then the department informs the customer that such study course is not available. If ordered study course is registered in LUA IS, then the department confirms study course request.

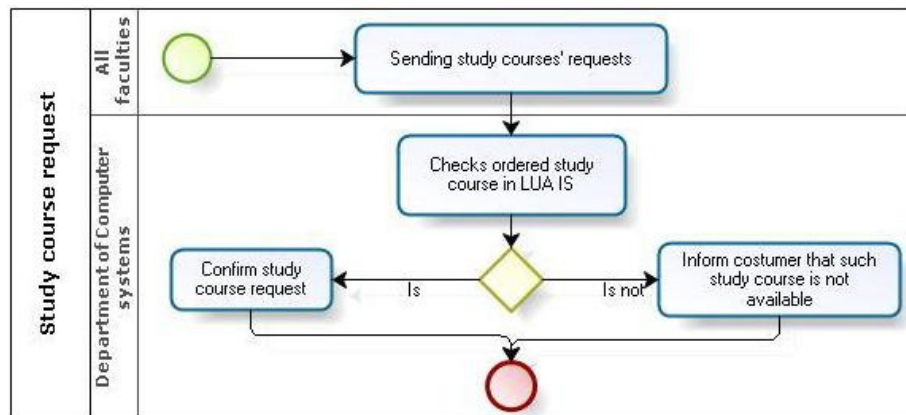


Figure 2. Study course request.

Normative study amount composition is the next ongoing process in the department. There are two types of normative study amount:

- planned normative study amount;
- executed normative study amount.

Planned normative study amount is composed in the second half of the study year for next study year and it's based on all LUA faculties' requests for study courses (figure 3.). Executed normative study amount is composed at the end of a study year (in June) about already completed study year and it's based on previously planned normative study amount (figure 4.).

To be able to compose planned normative study amount, the Study Department sends to the Department of Computer Systems a planning form, which may be slightly edited for current study year comparing with previous year. Expected amount of students for each study program is given in the study course request. After receiving the form, clerk fills it in and coordinates it with the head of the department, whose task is to check planned normative study amount correctness. Normative study amount planning and coordination is mainly done using electronic mail correspondence and sending the form to each other. As a result the planned normative study amount is composed and is handed over to the Study Department, which also checks planned normative study amount correctness and makes it coordination. In addition, in a separate document an explanation for planned study amount difference from previous year plan is prepared.

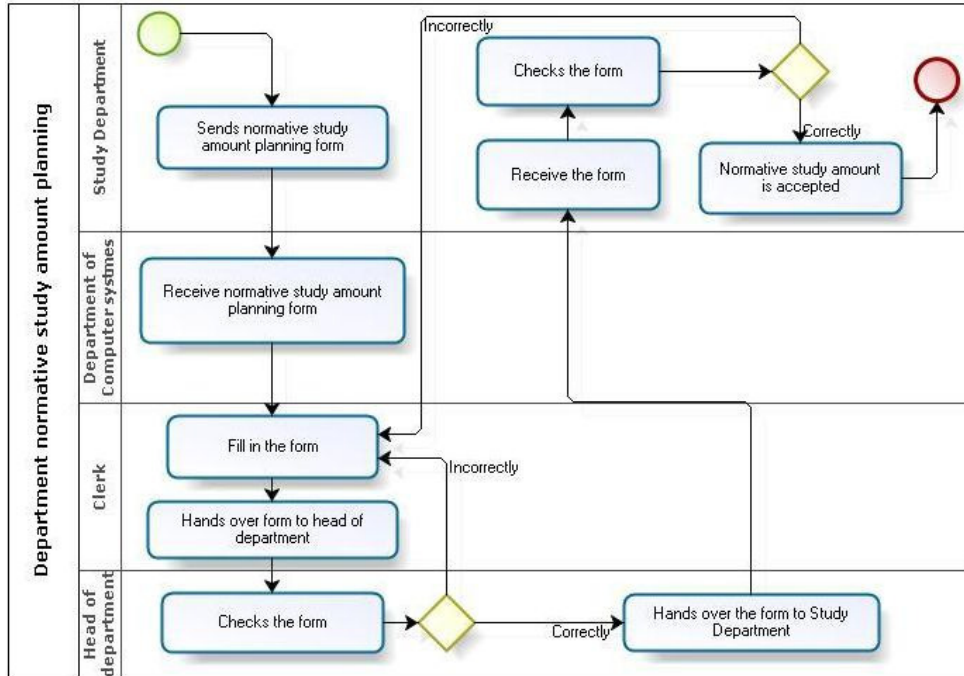


Figure 3. Planned normative study amount.

Sequence of actions for accounting executed normative study amount is similar – the Study Department sends a report form to the Department of Computer Systems. After receiving the report form, clerk ascertains the actual number of students from control sheets and fills it in based on previously planned normative study amount. Executed normative study amount report is checked first and then coordinated with the head of the department. The Study Department performs the highest level of control and coordination. Similarly how it was in the planned normative study amount, the head of the department needs to compose a separate explanation document about the differences in the execution plan.

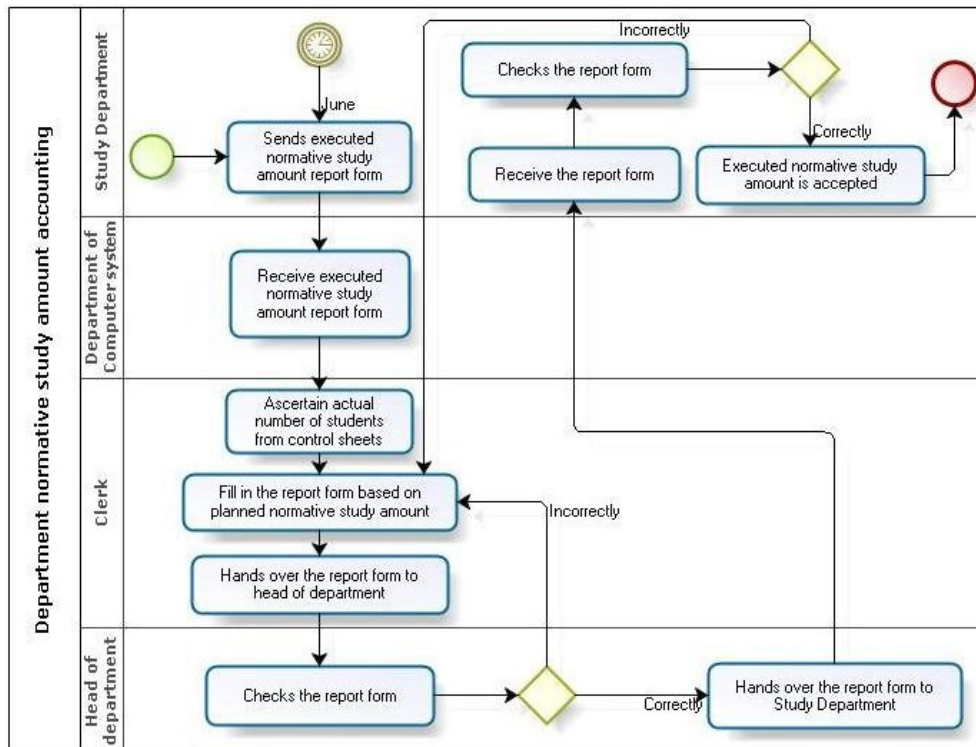


Figure 4. Executed normative study amount accounting.

Planning academic staff's individual loads is the next process after normative study amount composition. Unlike normative study amount composition, which is composed for all study year, the academic staff's individual

loads' planning takes place twice during one study year, for each semester a separate loads' plan is composed (figure 5.).

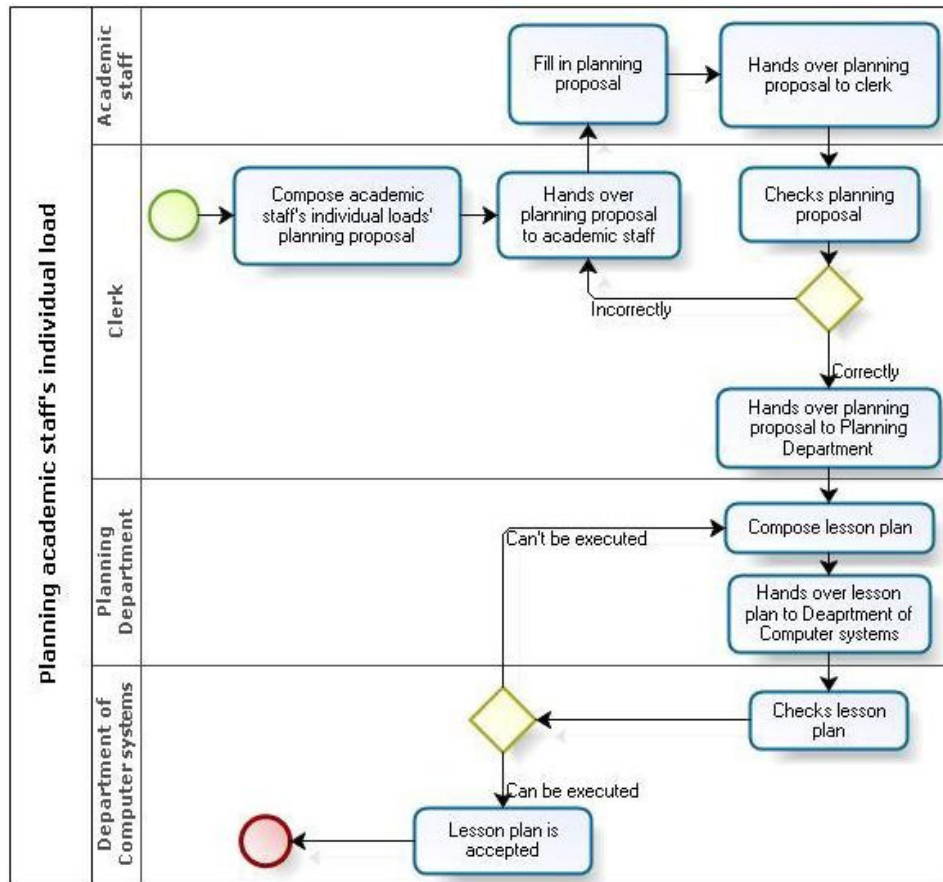


Figure 5. **Planning academic staff's individual load.**

Academic staff's individual loads' planning starts with clerk's composure of academic staff's individual loads' planning proposal document based on normative study amount plan and on the previous year's experience. After planning proposal composition, the clerk hands it over to the academic staff, which carries a detailed composition (currently in the Department of Computer Systems it is being carried out in Word and Excel files). Filling in the planning proposal, academic staff from the beginning ascertains whether all study courses have been planned (figure 6.). If not all study courses are planned, then the clerk adds the missing ones. If there are planned all study courses, then each member of the academic staff indicates the room, which is needed for the lecture, indicates desirable and/or undesirable lecture time, as well as add comments for additional requirements. After adding the comments academic staff signs planning proposal and hands it over to the clerk. After receiving the planning proposal the clerk checks whether the academic staff has composed it correctly. If planning proposal is composed incorrectly, the clerk hands it over to the academic staff, who corrects the mistakes. If planning proposal is composed correctly, then the clerk hands it over to the Planning Department. The Planning Department composes a lesson plan, based on received planning proposals, which is handed over to the Department of Computer Systems. After receiving the lesson plan the Department of Computer Systems checks whether the composed lesson plan can be executed. If the composed lesson plan can't be executed, then the Department of Computer Systems hands it over to the Planning Department, which recomposes the lesson plan. If the composed lesson plan can be executed, then the Department of Computer Systems accepts it and works according to it.

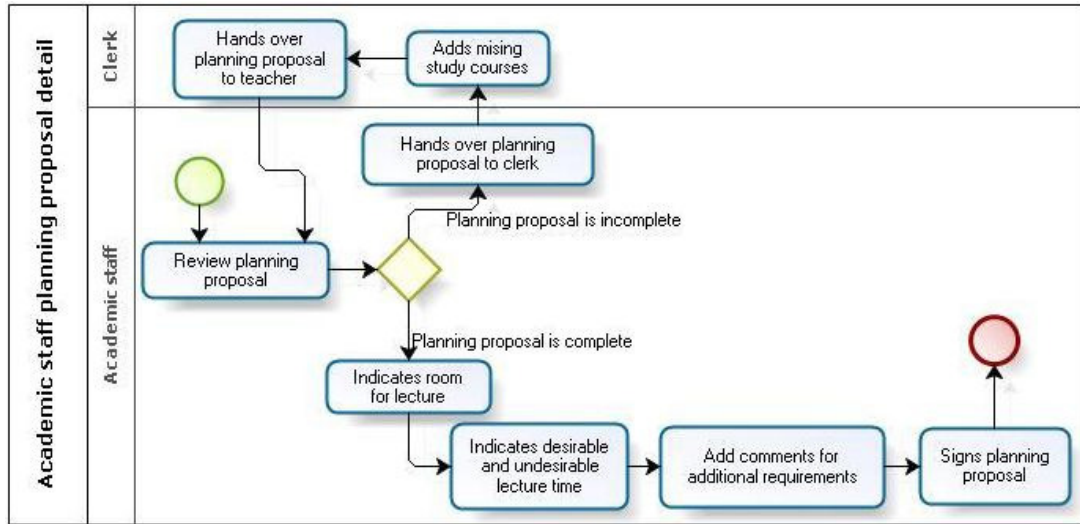


Figure 6. Academic staff planning proposal detail.

The teaching process begins when all study courses’ requests are received, planned normative study amount for the next study year is composed, executed normative study amount about previous study year is composed, planning proposal is composed and the lesson plan after which learning process will take place is received (figure 7.).

During the teaching process academic staff delivers lectures and participates in monthly department meetings, where questions about department activities are discussed, as well as composes a real-time report. The report is composed about one month, in which academic staff reports how much time is spent to deliver lectures. When the report is composed, the academic staff hands it over to the head of the department, who checks whether the report is composed correctly. If the report is composed incorrectly, then it is handed over to the academic staff, who corrects the mistakes. If the report is composed correctly, then the head of the department accepts the report.

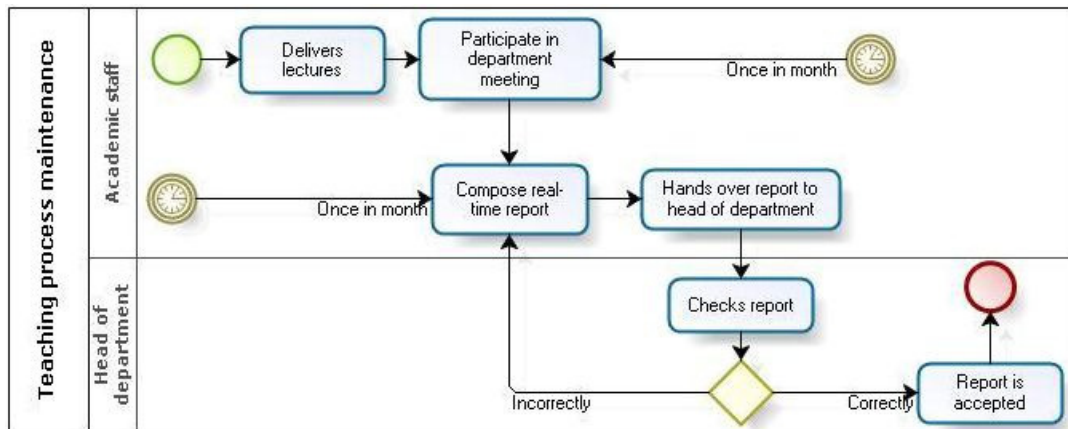


Figure 7. Teaching process maintenance.

Results and Discussion

All ongoing processes described above and their documentation are planned to integrate in the information system. The customer of the information system is the Department of Computer Systems, which establishes requirements and tasks for its development. The system must be designed with the Web user interface and system’s users must be divided into groups. The system data must be stored in a single database. The system must ensure all internal document composition and their maintenance.

In the development of the information system a team of three members is involved. Each member of the team is responsible for one system’s part description and prototype development. From a functional point of view, each team member is responsible for his or her internal paper development and its maintenance. The author of this paper is responsible for planning academic staff’s individual loads and development and maintenance of department level’s timetable. Other team members are responsible for normative study amount document and academic staff’s monthly reports’ development and maintenance.

From a usefulness point of view, the system must provide:

- handy and simple data input;

- data selection and searching by user driven criteria;
- data export to Excel software;

System “SLODZE” maintains 4 types of users:

- administrator;
- head of the department;
- clerk;
- academic staff.

Each user group has fixed rights to use any of systems functions. Administrator’s group has unlimited rights to work with the system. The head of the department and clerk’s group do not have rights to work with user control, but all other activities are permitted. While academic staff’s group has rights only to password control, data editing in academic staff’s individual load planning control and data input and editing in accounting load’s control (figure 8.).

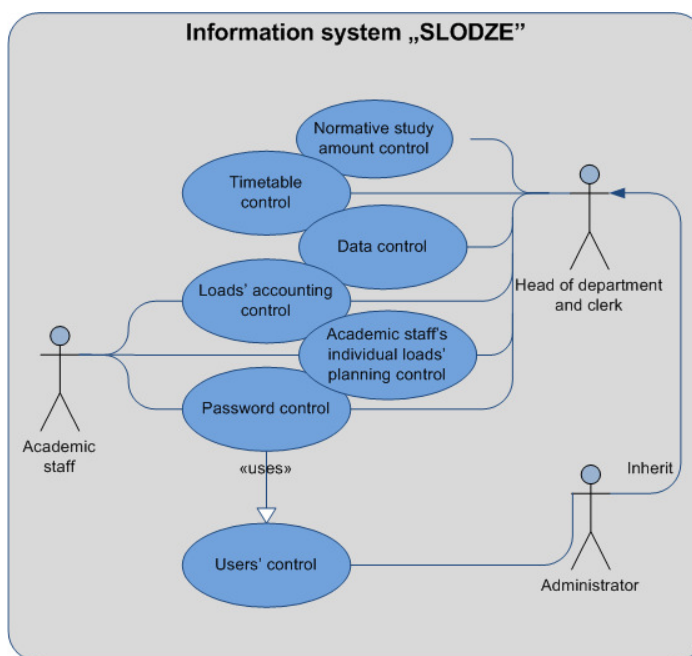


Figure 8. User characterization

The main activities of the system “SLODZE” are:

- normative study amount control;
- timetable control;
- data control;
- loads’ accounting control;
- academic staff’s individual loads’ planning control;
- password control;
- users’ control.

Normative study amount, timetable, data, loads’ calculating, planning academic staff’s individual loads and user’s control have the following main functions (figure 9.):

- data input – provides data input about management;
- data editing – provides data editing about management;
- data deleting – provides data deleting about management;
- data selection and searching – provides data selection and searching by user driven criteria about management.

Normative study amount, timetable, loads’ calculating and control of planning academic staff’s individual loads have the following additional function (figure 9.):

- data export – provides data export to Excel software about management, where data can be sorted and, if necessary, can be printed or saved as Excel document.

Password control has the following main function (figure 9.):

- password change – provides all users with password changing option.

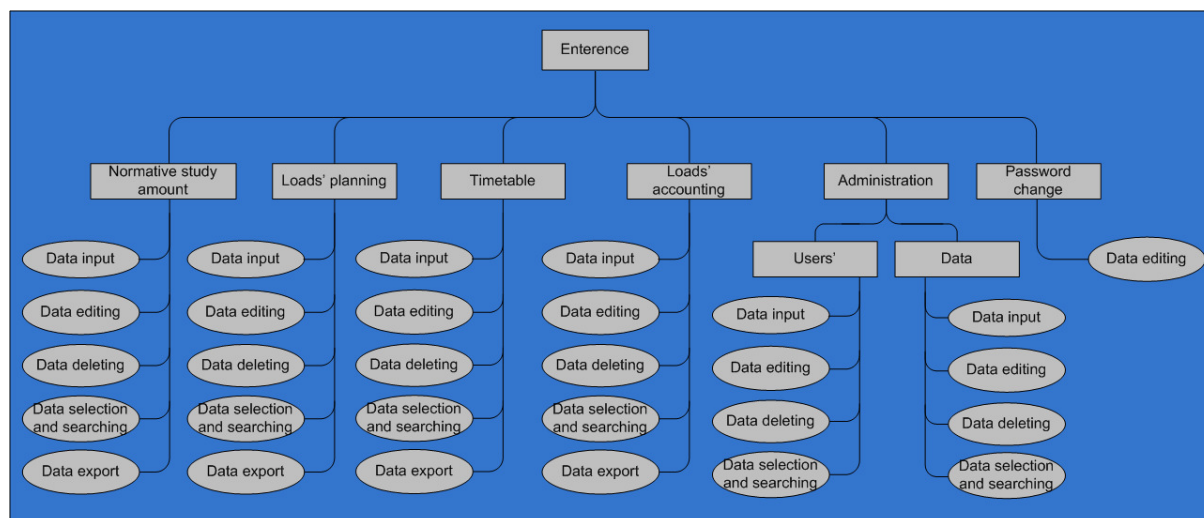


Figure 9. Functionality of controls

Conclusions

Study of ongoing processes in the Department of Computer Systems showed that a lot of time is consumed for documents' composing and their circulation.

The introduced information system will not fully automate all ongoing processes in the Department of Computer Systems, but it will promote its faster and simpler execution.

In the system realized process implementation will improve planning progress in the department, because for the clerk, who composes these documents, the number of operations will be reduced.

The system can be improved by introducing new functions like importing study courses from LUA IS using Web services.

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THE CONCEPT OF THE MODEL FOR BUILDING E-LEARNING SYSTEM

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Abstract

E-learning is a revolutionary educational paradigm based on the information and communication technology that is being dynamically researched, developed and applied as a part of the traditional instruction and as a complementary mechanism for lifelong and distance learning. E-learning process is supported by the e-learning systems (ELS) that can be observed regarding their implementation technology for delivering educational contents. E-learning systems represent an advanced learning and teaching environment adaptable to individual student's characteristics.

E-learning systems are generation of computer systems aimed to support and improve learning and teaching process in certain domain knowledge, considering individuality of a student like in traditional one-to-one instructional process. This process, also known as human tutoring has been confirmed to be successful and presents the most efficient learning and teaching process. The development of ELSs is, therefore, related to a number of serious problems, because proper implementation of 'human' tutor can be done only in relation to cognitive psychology, artificial intelligence and education. Knowledge is a key to intelligent behavior and, therefore, traditional ELSs are named as knowledge-based because they have:

- *domain knowledge;*
- *knowledge about teaching principles, methods, techniques;*
- *ability to apply all this to individual student.*

In this paper, one of the approaches to research, development and implementation related to intelligent E-learning systems with ability to customize the learning process for the needs of individual student is presented. The purpose of the article is to develop the concept of the model for building E-learning system in freely chosen domain knowledge.

Keywords: *E-learning, ELS, model, education, concept*

Introduction

In the course of the last decades, global economy has evolved from an economy based on production towards an economy based on services with knowledge at its epicenter (Tissen, Andriessen, & Deprez, 2000). This fact has given rise to a reduction of the useful life of acquired knowledge and abilities and implies that, in order to participate actively in modern society, we must continuously acquire new knowledge and aptitudes (European Commission, 2000). E-learning, which is the application of information and communication technologies in a wide array of solutions that improve knowledge and performance (Rosenberg, 2000), must therefore be focused on two student profiles: traditional pupils (i.e., people acquiring knowledge and abilities prior to the start of their professional life) and workers that have to acquire new knowledge or improve the knowledge they already possess in order to keep up with their job requirements (i.e., lifelong learning). These two profiles are logically present in all professional fields, and both can therefore benefit from the two very important advantages provided by e-learning:

- *irrelevance of the location where the course takes place and*
- *inexistence of the restrictions associated to a traditional timetable.*

It is in this context that numerous e-learning initiatives have recently appeared.

In spite of the fact that technological advances have reduced the above-mentioned temporal limitations and as such foment the progress of this type of training, technology must not be considered a goal in itself, but rather a means towards better and easier learning. Hannafin, Land, and Oliver (1999) confirm this by saying that technological means must be used in a way that is consistent with psychological and pedagogical premises. Mioduser, Nachmias, Oren, and Lahav (1999) warn against a tendency towards 'one step ahead for the technology, two steps back for the pedagogy'.

In short, the myth of technology as an all-round solution has transformed into the reality of technology as a facilitator, and it is becoming common ground that a good e-learning course does not only rely on technical aspects but also – and mainly – on pedagogical aspects. Therefore, and in the knowledge of the role that technology actually plays, efforts in the e-learning field must focus on the most adequate way of transmitting knowledge to those students that are in need of it by determining the elements that are the building components of this type of system and on their pedagogical organization. Thus, e-learning should exploit the already consolidated concepts that are proper of the pedagogical theories in the traditional education (e.g., cognitive conflict (Piaget, 1971, 1998) and zone of proximal development (Vygotsky, 1978)).

Nevertheless, the current approaches for e-learning system model development remain ill-structured in their definitions and descriptions, which can limit tutors in their choice and use of them (Oliver, 2002). The reason for this is that they are not explicitly supported by any pedagogical theory providing a solid theoretical basis, as can be seen in (Andrade et al., 2005), where the main approaches (e.g., those by Hannafin et al., 1999; Horton, 2000; Jonassen, 1999; Rosenberg, 2000) were analyzed. As an example, Jonassen (1999) applies the cognitive tools concept without deriving it from any pedagogical principle.

Taking into account the above, the purpose of this paper is to present a global architecture model (in the traditional software development sense) for any e-learning system that provides theoretical justification without losing generality; in other words, an architecture model that is valid for any type of didactical purpose. In the beginning the main approaches that currently guide the development process of an e-learning action are studied; then an attempt to identify and organize their content in a set of blocks for any e-learning system will be made.

The model is based on two disciplines close to e-learning: presential education and knowledge management (KM). With regard to the former, these are considered the main underlying concepts in the two major tendencies in pedagogical theories: behaviorism and constructivism. With regard to the latter, reliability on KM fundamentals, since this discipline, similarly to e-learning, is dedicated to determining the most adequate way to provide knowledge. In fact, several authors share this closeness between KM and e-learning (cf. authors such as Friss de Kereki, Aspiazu, & Silva, 2003; Marshall et al., 2003; Rosenberg, 2000), and even Rosenberg (2000) defines e-learning as the combination of both training and KM. The term KM was coined in 1986 by Wiig (Liebowitz, 1999) and formalized by Holsapple and Joshi (2004) in their knowledge management ontology (KMO). According to KMO, KM is defined as 'an entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value to the entity, in the sense of positive results in accomplishing its objectives or fulfilling its purpose'.

E-learning theoretical approach

There currently exist many approaches to the elaboration process of an e-learning action, i.e. to the confection of the elements that must be available to students in this context. Although there are other approaches (e.g., Clark, 2006; Kottler, Parsons, Wardenburg, & Vornbrock, 2000; Merrill, 2000), the following are considered for the present study: Hannafin et al. (1999), Horton (2000), Jonassen (1999), and Rosenberg (2000).

The reason for this selection is twofold: they are widespread approaches in the e-learning domain and they have a greater detail level in their description than other approaches (Andrade et al., 2005). Brief summary of the main features of each selected proposal:

Hannafin et al. (1999) define learning environments that focus on the student and are based on the activity and on four basic elements: context, resources, tools, and scaffolding. The context orients the student towards a concrete problem or a determined need, whereas the resources are reference material or human resources (experts, colleagues or tutors) that reinforce the learning. The tools allow students to operate with concepts and distinguish between processing tools (seeking tools, collecting tools, organizing tools, integrating tools, and generating tools), manipulation tools, and communication tools (synchronous and asynchronous). With respect to the scaffolding, these are processes that simplify the learning tasks, and can be classified in the following types: conceptual – what must be considered to solve a task –, metacognitive – how must the student reason during the learning process –, procedural – how are the resources and tools to be used –, and strategic – alternative approaches that may be helpful.

Horton (2000) considers an e-learning course as the combination of mainly lessons, activities, and collaboration mechanisms. A lesson is seen as a collection of experiences that accomplish one of the sub-goals of the course, and in this context the author describes the most common lesson structures and offers tips and guidelines for their use. Also, he presents the most usual learning activities, referring with this term to coordinated actions that exercise basic intellectual skills and can be used to teach, to exercise, and to test skills and knowledge.

On the other hand, collaboration can energize students, promote deeper learning, and make students more self-reliant. Finally, and apart from these three key elements, Horton indicates the need to monitor the progress of students, giving them incentives and providing feedback as soon as possible.

Jonassen (1999) establishes that knowledge is elaborated individually and socially by the students on the basis of the interpretations of their experiences. He defines the constructivist learning environments (CLEs) to conceive a problem, a question, or an example as the centre of the environment. Surrounding this centre are the related examples and information sources – which help to understand the problem and point out possible solutions –, cognitive tools – which help to interpret and manipulate various aspects of the problem –, conversation and collaboration tools – which allow the student communities to negotiate and collaborate in the elaboration of meanings –, and social/contextual support systems – which are useful for the elaboration of the CLEs; this entire environment is based on modeling, coaching, and scaffolding. Modeling focuses on showing how expert actors operate in a given situation, whereas coaching refers to the control and regulation of the student's performance, the perturbation of his designs, and the provision of motivating guidelines that help him achieve his goals. Finally, scaffolding represents a type of problem manipulation in which part of the student's task is carried out,

its difficulty is adapted, the nature of the exercise is transformed, and tools for a better understanding of the task are proposed.

This proposal defines e-learning as a combination of training and knowledge management (Rosenberg, 2000). Training is the way in which the instruction is transmitted in order to shape the learning process, whereas knowledge management refers to the use of additional information and performance support tools that help the students to learn and improve their work. More concretely, this author emphasizes a series of features that are indispensable for a good e-learning course, such as significant and motivating goals, authenticity of the content, and opportunities to practice (learning by doing). The system must also offer feedback, coaching, and models and stories from experts: feedback allows the student to recognize the consequences of a previous action and correct it, coaching reinforces the learning process at critical moments by supplying introspections and additional perspectives, and the stories teach the student how other persons have thought about similar situations and developed new ways to approach a problem.

Each of the above approaches proposes certain components that are indispensable for an e-learning training system. In spite of the various designations used by each author, these components can be organized into three main blocks: didactical material, follow-up and tutoring, and alternative learning.

Table 1

Components of e-learning theoretical approaches

Block	Theoretical approach by			
	Hannafin	Horton	Jonassen	Rosenberg
Didactical material	Context (problem and necessity); Resources (informative means, written information, and human resources);	Lessons; Activities;	Question, subject, example, problem or projects; Related examples Sources of information; Modeling (examples elaborated by experts)	Contents; Activities (learn by doing); Additional information; Models and histories of experts or colleagues;
Follow-up and tutoring	Tutoring; Reinforcement; Motivation;	Monitoring of the students progress; Motivation; Back-feeding;	Tutoring; Reinforcement;	Tutoring; Back-feeding;
Alternative learning	Tools (treatment, manipulation, and communication);	Collaboration and communication mechanisms;	Cognitive tools; Tools for conversation and collaboration;	Tools for performance Support;

The first block refers to the different sources of knowledge provided by the system to the student. The sources that contain explicit knowledge on a domain and those that allow the student to increase or refine his knowledge on a certain matter are distinguished. The purpose of the second block is the control and follow-up of the student's evolution, and the activation of the necessary actions to guide the student in his learning process. Finally, alternative learning refers to the use of the different tools that, without containing any knowledge themselves, serve as a vehicle for its construction. Table 1 briefly shows how each proposal treats the three detected blocks.

Unfortunately, these blocks inherit the problems of the components they comprise:

- there is little clarity and consistency in specifying the pedagogical principles that support them and
- the decision on how to structure each proposed component mainly devolves upon the developer.

In order to avoid these problems, this paper proposes an architecture model for the description of each identified block that is explicitly based on the principal pedagogical theories of presentational education and the mechanisms for knowledge transfer used in KM.

The concept of e-learning systems model

The research has started with studying the cybernetic model of the system that identifies the process, the reference value and the control. Modifying that cybernetic model according to the didactic principles of an individual instruction, the idea of expert systems, as well as the methods and techniques of knowledge management and presentation, enabled to develop a concept of e-learning systems model. Modifications to the original cybernetic model were made in order to become more adaptable to the process of students knowledge and skill acquisition (Fig. 1) and is called a model of instruction with a computerized tutor.

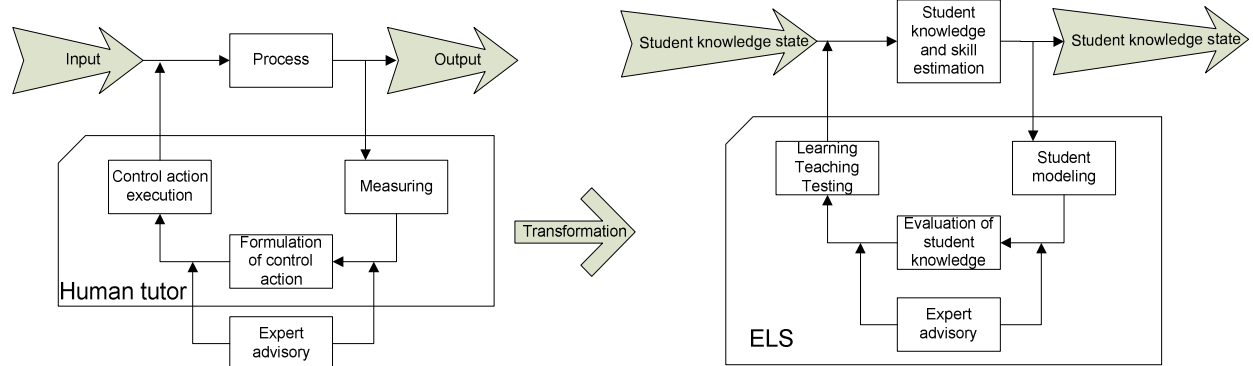


Fig.1. Cybernetic model of the human tutor to ELS transformation

The student's knowledge state is a manageable input and an output value of the process, regarding the actual subject matter unit of domain knowledge. The process in the model is the student's knowledge and skill acquisition. The referent value (reference) is defined through:

- goals and tasks of the subject matter, which need to be understood;
- the 'good' student's model based on the evaluation criteria that implicates the cognition of the specified student's knowledge level.

The computer tutor, as a replacement for a 'human' tutor, gives feedback and has to:

- build the student's model and diagnose the student's;
- determine differences between the actual student's knowledge and the referent model, as well as manage the activities states (evaluating student's knowledge);
- shift the learning and teaching to the next element of the subject matter (learning and teaching) or perform remedial teaching (learning and teaching) and start testing(testing).

The student interactively builds a learning and teaching environment according to the Piagetian paradigm 'guided free play' and the 'guided learning by doing' scenario in accordance with his individual capabilities. The model allows teachers to decompose domain knowledge in order to build hypermedia-rich cross-platform tutorials and learning environments for learning and teaching. Finally, the model is adaptable to individual needs of both students and teachers.

The pedagogical framework of the model is expressed with a continuing four-phase activity cycle: didactic, perception, diagnostic and evaluation, and finally help and remediation. The didactic phase involves a number of factors: the subject matter of teaching (What is being taught?), the object of teaching (Who is being taught?) and the method and strategy of adaptation of teaching to students individual needs (How is being taught?). The perception phase deals with the student's actual knowledge level (the student's knowledge states). The diagnostic and evaluation phase determines the level of student's knowledge. Misconceptions in the student's knowledge activate the help and remediation mechanism to minimize differences between the student's and the domain knowledge.

The model is knowledge-based because it includes:

- the domain knowledge with examples and explanations;
- the teacher's knowledge – the principles used for teaching and the methods used for applying those principles;
- the student's knowledge that is developed as a result of overlay with the teacher's knowledge, including misconceptions and missing conceptions.

This model exhibits intelligent behavior and therefore it has the characteristics of an intelligent system mainly because of the following statements:

- it deduces or solves a problem in the application environment of a chosen domain knowledge;
- it deduces the student's knowledge and skills;
- it has the strategy which enables minimizing differences between the student's and the tutor's knowledge.

The model has the following actors:

- students who are involved in the knowledge and skills acquisition process in an arbitrary domain knowledge;
- domain knowledge experts who create knowledge bases;
- teachers who use the created knowledge bases to didactically design subject matter or courseware;
- system administrator who monitors the system, the users and the ways of using the system.

The model's actors have the following main functionalities:

- domain knowledge design;

- subject matter or courseware design;
- learning, teaching and knowledge testing;
- system administrator functionalities.

These functionalities can be progressively developed and implemented into the e-learning system.

Analyses of architecture of the system developed from the model gives a development overview of the information and communication technology that has been used for the e-learning systems implementation in the last decade. Fig. 2 presents an architectural design of the systems developed and implemented according to the model.

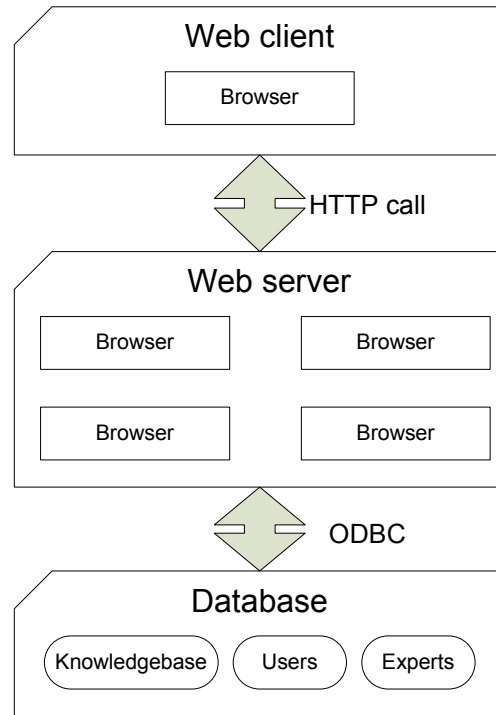


Fig.2 Architecture of ELS model

The technologies for dynamic generation of the Web documents contents have improved the capabilities of Web-oriented systems and in our case they are used for implementation of the ELS functions. An important advantage of the 3-tier client-server architecture is the possibility of deploying application tiers on several computers thus additionally reducing the system's load and speeding up the application itself. This is developed and implemented in the client-server architecture where the intelligent tutoring functionalities are separated from the user interface and the knowledge bases. The Web browser is the basic component of the user interface. The middle tier (learning and teaching, quiz and administration modules) generates a document to be distributed to the client according to a previously issued client query. The application logic tier is being run on a Microsoft Windows Server platform under the internet information server (IIS) comprising the active server pages (ASP). The application logic tier accesses the databases via the ODBC (open database connectivity) thus enforcing independence from the database management system.

Conclusions

The research on the concept of the ELS model that is presented in this paper can be summarized as follows:

- research and development of the ELS, influenced by the constant evolution of technologies, tools and methods;
- usage of ELS by students from a primary education to an academic level and lifelong learning;
- development of a special methodology for evaluating the systems educational influence using the students results in the learning and teaching process.

Currently, researches in the area of ELS have cleared directions for future model research and development:

- knowledge representation supported by natural language processing, specially natural language generator;
- mobile computing environment;
- student's environment for learning specific skills, for example programming.

All these areas require also new approach to their effectiveness evaluation. To conclude, brief elaboration on each of mentioned directions must be made.

First, the students involved in model's learning and teaching process usually have two major objections. If the student is first time user of ELS then he has to know the way that knowledge is represented, meaning he has to be familiar with the structure of semantic network with frames. Usually for such students short pre-lecture about such formalism should be made. Observations show that knowledge represented by semantic network is more easily accepted by the student from elementary school than the older ones. Another objection refers to the tests which are realized by dynamic question and answer generation. In fact, generated questions have incorrect syntax from a natural language point of view and it is sometimes very hard for student to understand its meaning. In order to deal with these problems, Web Ontology Language was chosen (OWL) because of its nature to provide graphical observation of described knowledge, as well as expressiveness realized by expressions equivalent to description logic axioms and facts. To provide fluent and intelligible reading of domain knowledge natural language processing techniques have to be involved between knowledge formalism and the student. Natural language generation system is the key component for such task. The main task of this system is converting knowledge formalized by OWL to natural language sentences. Another important task is to generate questions and answers from the test templates. One step forward to make ELS even better is to incorporate agent with conversation dialogue ability for tutoring the student. Whatever discovers emerges on a field of ELS, it is believed that activating natural language processing in ELS will make it much more acceptable and easy to use. Second, the systems derived from the model are not customized for eminently mobile devices such as mobile phones or personal digital assistants (PDAs). The mobile computing environment is namely very different with respect to the present traditional distributed systems bandwidth, delay, error rate, interference and the like, may change dramatically as a user moves from one location to another, thus changing the computing environment. The ELS mobile instance will be targeted to fit into a mobile learner's daily routine without disrupting his other activities, but conversely enhancing the effectiveness of learning in the context of handheld terminals of restricted capabilities.

Third, problems in programming teaching motivated to approach developing a prototype model of computerized tutor for learning and teaching programming. The goal of intelligent tutoring system for teaching procedural languages programming skills (VB, C#, Java) is to help student to build a cognitive model for solving programming problems. In order to accomplish this goal, a tutoring system has to:

- define programming tasks;
- determine from student's behavior what he knows and misunderstanding he has;
- interrupt student's work when his choice leads to errors;
- give help on student's demand;
- verify correctness of student's program;
- estimate student's knowledge and skill and advise what he should do and when he should proceed to new material.

The knowledge contained in knowledge base, as well as, programming tasks are universal, and the system has to adapt to selected programming language.

Finally, in order to develop and improve the model, and verify the effectiveness of the systems that will be developed according to mentioned directions for the model research and development, further experiments must be conducted. The following questions should be addressed by prospect experiments:

- are the experiments results influenced by subjects more than the system itself;
- is the system evenly effective regardless of domain knowledge;
- could the model be further improved in order to produce a more positive impact in every stage of the experiment.

The results from conducted experiments, as well as, results from new experiments that will be done in the future, will enable conduction of meta-analyses for determining overall effectiveness of ELS model regardless of the domain knowledge and age of the subjects used in studies.

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ICT IN EDUCATION PHYSICS

CORRELATION ANALYSIS OF DISTRICT HEATING PROCESSES USING TEMPERATURE CONTOUR APPROACH

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Abstract

The article deals with correlation analysis of district heating (DH) processes using temperature contour (TC) approach based on investigation of the functional dependence between outdoor temperature, T_{out} , as the regressor, and DH process characterizing thermal or hydraulic parameters, P_{DH} , as the regrestent, e.g., supply and return water temperature, T_S & T_R , as well as water mass flow, V . The time series of outdoor temperature, $\{T_{out}^i\}$, and supply water temperature, $\{T_{S}^i\}$, as well as T_{out} & T_S -scatter plots of $(T_{out}^i; T_{S}^i)$ -data set have been examined more in details. It has been shown that using TC-approach one can additively construct linear regression models corresponding separately to each TC, and thereafter combining these models together and creating full regression curve for whole T_{out} & T_S -scatter plot. Also frequency distribution functions (FDF), $dFr(T_{out})$ & $cFr(T_{out})$ and $dFr(T_S)$ & $cFr(T_S)$, have been calculated for different size TC in order to explore corresponding $(T_{out}^i; T_{S}^i)$ -data set immanent data structure. In the case of asymmetric TC it has been stated that $(T_{out}^i; T_{S}^i)$ -points most likely are uniformly distributed along TC base-interval. However, along TC contiguous-interval $(T_{out}^i; T_{S}^i)$ -points most likely are normally distributed.

Key words: district heating, correlation analysis, frequency distribution function, regression model, temperature contour, scatter plot.

Introduction

District heating (DH) systems provide heat for inhabitants of large cities and villages in a rational and economical manner. It is well known that heat from heat and power generating DH systems is cheaper than heat produced by individual low power boiler facilities. Large heat and power plants (CHP) producing heat for DH systems are generally equipped with high-efficiency combustion units reducing the greenhouse gases (GHG) emission into atmosphere. The GHG emission from small, local and dispersed sources using worse fuels is much higher than that from centralized large CHP. In Latvia district heating in large cities still dominates fortunately over local individual low power facilities. This is very important circumstance for reducing CO₂ emissions and for keeping atmosphere clean. Thus CHP as an area of utmost importance for Latvian economy provides heat for centralized heating systems which cover on average 70% of heat demand in cities of country. Therefore more than million citizens of our country use heat from heating networks which is produced by industrial and commercial heat of CHP as well as of municipal heat production plants as, e.g., of joint-stock Company "Rīgas Siltums".

Materials and Methods.

DH system consists of a heat producer as a heat source plant (HSP), of an external heat transmission network (HTN) built-up of thermo isolated pipes and hydraulic devices, as well as of many local heat substations (LHS) as internal heat distribution systems in which the heat from the DH supply water is transferred to the radiator circuit and to the hot water circuit of heat end user houses. Therefore one can split complicated DH system into three separate parts – HSP, HTN and LHS in order to reduce its complicity for investigation purposes. Thus HTN connects HSP with every LHS using both the supply water pipe and the return water pipe of the DH system. The input data for correlation analysis have been collected from HSP of DH system "Vecmilgravis" of city Riga as 6 thermal and 7 hydraulic DH process parameters, P_{DH} , time series as outdoor temperature, $\{T_{out}^i\}$, supply water temperature, $\{T_{S}^i\}$, heat load, $\{Q_i\}$, etc. of 4608 elements belonging to heating season (HS) 2008/2009 which endured 192 days from October till April or 4608 hours (h) long. DH process parameters, P_{DH} , time series were presented as data base of computer program "Microsoft® Office Excel 2003" containing 4608 records of 13 data fields (Kanders, Turlajs, 2009; Turlajs, Kanders, 2009). Thus the primary data set contains consequently about 60 thousand (59904 items) data field entries as parameter's 1-hour mean value. P_{DH} -time series have been graphically presented as HS-profiles respectively and compared one to each other. The time series of outdoor temperature, $\{T_{out}^i\}$, and supply water temperature, $\{T_{S}^i\}$, played important role in correlation analysis as the factorial variable called regressor and the response variable called regrestent respectively. Moving correlation coefficient, $R(mc)$, between HS-profiles of outdoor temperature, T_{out}^i , and supply water temperature,

T_{S_i} , has been calculated for different size of parameters' moving scatter vectors. In addition T_{out} & T_S -scatter plots of $(T_{out}; T_S)$ -points have been examined in order to create appropriate regression models for functional expressions between given regressor value and regressed mean value depending on regressor.

Results and Discussion

The time series of outdoor temperature, $\{T_{out_i}\}$, and supply water temperature, $\{T_{S_i}\}$, of DH system have been compared one to another and moving correlation coefficient, $R(mc)$, has been calculated between heating season profiles (HSP) - T_{out} & T_S -HSP. There are three types of the T_{out} & T_S -HSP smoothing extent considered in this paper. The first one is T_{out} & T_S -HSP built up of 1h-mean values (Fig.1), the second one is T_{out} & T_S -HSP built up of 24h-mean values (Fig.2), and however the third one is T_{out} & T_S -HSP built up of 168h-mean values of the DH parameters (Fig.3). All the T_{out} & T_S -HSP are calculated by 1h-time resolution that is high enough to reveal fine time structure in the much more as 1h-smoothed T_{out} & T_S -HSP as well. Smoothing is a pretty much used procedure to dampen or average out fluctuations in a time series to reveal a smooth component that reflects the systematic movement or some trend of the time series. One can be convinced that, e.g., outdoor temperature, T_{out} , oscillations are much more frequent as supply water temperature, T_S . By moving average method one can average out high frequency hourly oscillations shown in Fig.1 even during 1-day period (Fig.2), but much more smoothed tendencies one can reveal during 1-week period (Fig.3). Graphical presentation of T_{out} & T_S -HSP allow easy to compare DH parameters' HSP one to each other. In this connection it is easy to consider that daily (24h) and weekly (168h) T_{out} & T_S -HSP show very good synchronization between them. The 2nd-order parabolic regression lines, \hat{T}_{out} & \hat{T}_S , of the T_{out} & T_S -HSP manifest quite similar time dependence within whole HS. In addition the determination coefficients, R^2 , of parabolic regression lines, \hat{T}_{out} & \hat{T}_S , are close enough even during whole HS despite of October an April when outdoor temperature is high and therefore supply temperature does not follow outdoor climatic changes at all. Within time period Dec-Jan-Feb the outdoor temperature is overall low therefore it is very important so that supply temperature follows outdoor climatic changes. It is not difficult to find correlation coefficient, R , between outdoor and supply temperatures, T_{out} & T_S , for this 3-months time period which is as high as ' $R_{DJF}=-0,9053$ ' or determination coefficient, $R_{DJF}^2=0,8196$. These coefficient values are considerably higher as those values as, $R_{HS}=-0,8229$ and $R_{HS}^2=0,6772$, for whole HS. The correlation coefficient, R , here above and below has been calculated by Pearson formula-

$$R_{xy} = \frac{N * \sum x_i y_i - (\sum x_i)(\sum y_i)}{\sqrt{N * \sum x_i^2 - (\sum x_i)^2} * \sqrt{N * \sum y_i^2 - (\sum y_i)^2}}, \quad (1)$$

where ' x_i '- i -th element of the factorial variable or regressor X time series, observed in the subsequent time moments $\{\dots, i-1, i, i+1, \dots\}$; ' y_i '- i -th element of the response variable or regressed Y time series, observed in the same subsequent time moments $\{\dots, i-1, i, i+1, \dots\}$; ' N ' - the number of pairs $(x_i; y_i)$ of variables X & Y . In the case of daily (24h) and weekly (168h) T_{out} & T_S -HSP it has been respectively found that $R_{DJF}=-0,9320$ and $R_{DJF}^2=0,8690$ for daily mean values, as well as $R_{DJF}=-0,9274$ and $R_{DJF}^2=0,8601$ for weekly mean values. The outdoor and supply temperatures have very similar daily, T_{out} & T_S -HSP(24h), and weekly, T_{out} & T_S -HSP(168h), time dependencies and high values of the pair correlation coefficient, R , in general. Detailed information about pair correlation coefficient, R , concerning separate HS-month is given in Table 1 below. The month's R -values in Table 1 are sorted descending by R^2 -value showing January as the month in which correlative bond between DH parameters T_{out} & T_S is the strongest one while October R -value indicates the weakest correlative bond between T_{out} & T_S .

Table 1.

DH parameters' T_{out} & T_S pair correlation within separate month of heating season.

Month	R	R^2
Whole HS: Oct-Apr	-0.822861	0.6771
January	-0.943981	0.8911
February	-0.912140	0.8320
December	-0.847054	0.7175
November	-0.751332	0.5645
March	-0.695557	0.4838
April	-0.280713	0.0788
October	-0.067082	0.0045

As correlation coefficient, R , manifests strong correlative bond between DH parameters T_{out} & T_s , then it is good reason for building-up regression models and seeking functional dependencies between T_{out} & T_s that is shown in Fig.4-7 below. In addition moving correlation coefficient, $R(mc)$, between outdoor and supply temperatures, T_{out} & T_s , has been calculated using different size of DH parameters' moving scatter vectors. The use of moving scatter vectors on daily basis, i.e., on 24-point basis was not reasonably because calculated $R(mc)$ -values present very strong oscillations between -1 and +1 while moving scatter vectors on weekly basis (Fig.1 & Fig.3) and on 2-weeks basis (Fig.2) were good enough in order to assess correlation between DH parameters more in details. $R(mc)$ curves in all the cases (Fig.1, Fig.2 & Fig.3) demonstrate not only overall but even differentially strong correlation between outdoor and supply temperatures, T_{out} & T_s , with the exception of some short time intervals in which moving correlation coefficient, $R(mc)$, absolute values fall below 0.75-value.

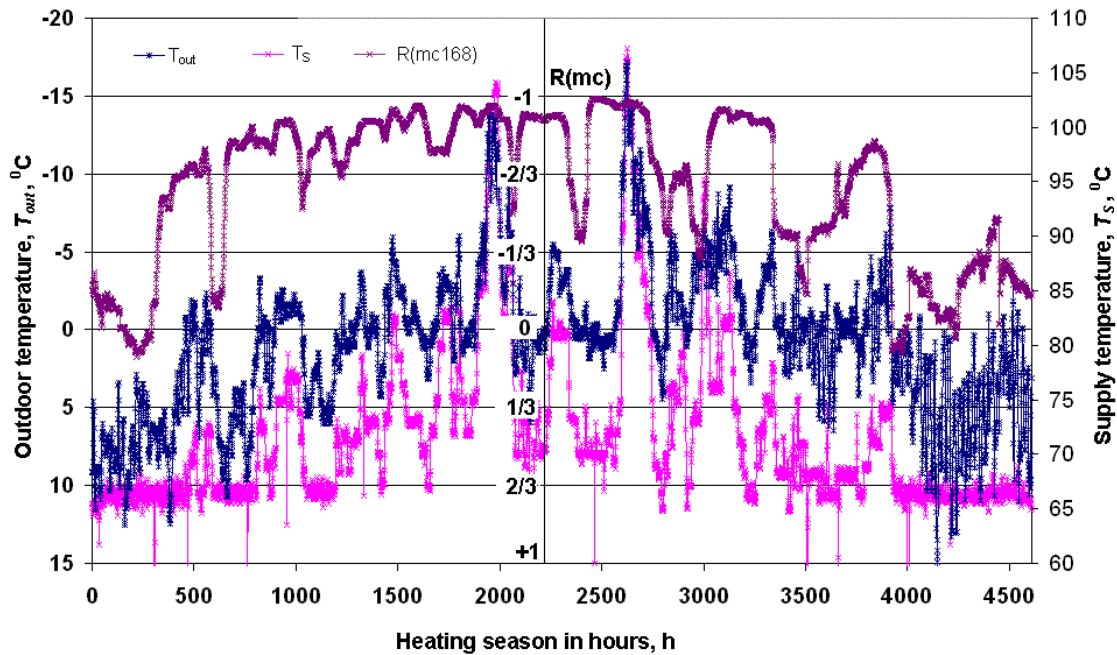


Fig.1. Outdoor and supply temperature heating season profiles (HSP) - T_{out} & T_s -HSP as 1h-mean values with 1h-time resolution. T_{out} & T_s -HSP correlation assessment by means of moving correlation coefficient, $R(mc168)$, on 168-point basis with 1h-time resolution.

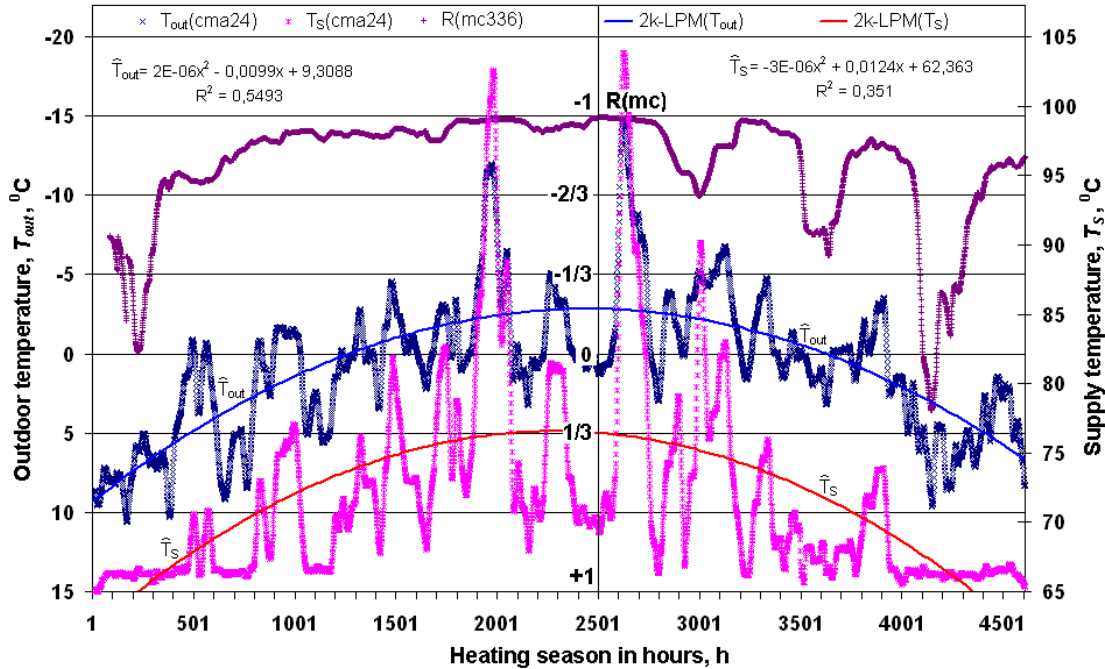


Fig.2. Outdoor and supply temperature heating season profiles (HSP) - T_{out} & T_s -HSP as 24h-mean values with 1h-time resolution. Parabolic regression curves and equations for T_{out} & T_s -HSP. T_{out} & T_s -HSP correlation assessment by means of moving correlation coefficient, $R(mc336)$, on 336-point basis with 1h-time resolution.

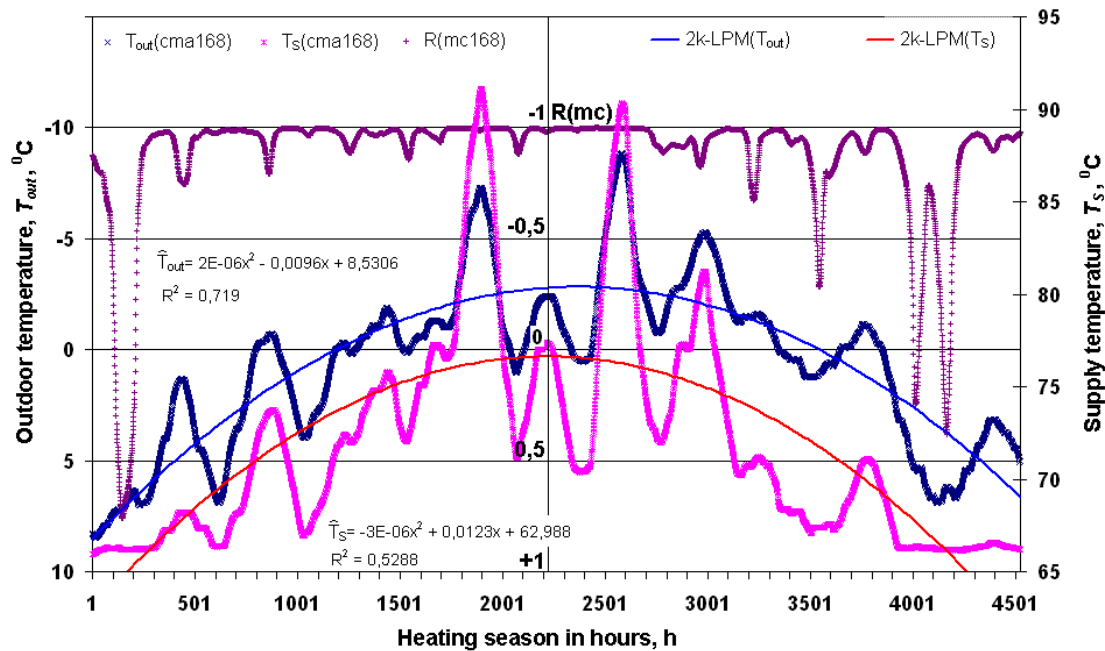


Fig.3. Outdoor and supply temperature heating season profiles (HSP) - T_{out} & T_s -HSP as 168h-mean values with 1h-time resolution. Parabolic regression curves and equations for T_{out} & T_s -HSP. T_{out} & T_s -HSP correlation assessment by means of moving correlation coefficient, $R(mc168)$, on 168-point basis with 1h-time resolution.

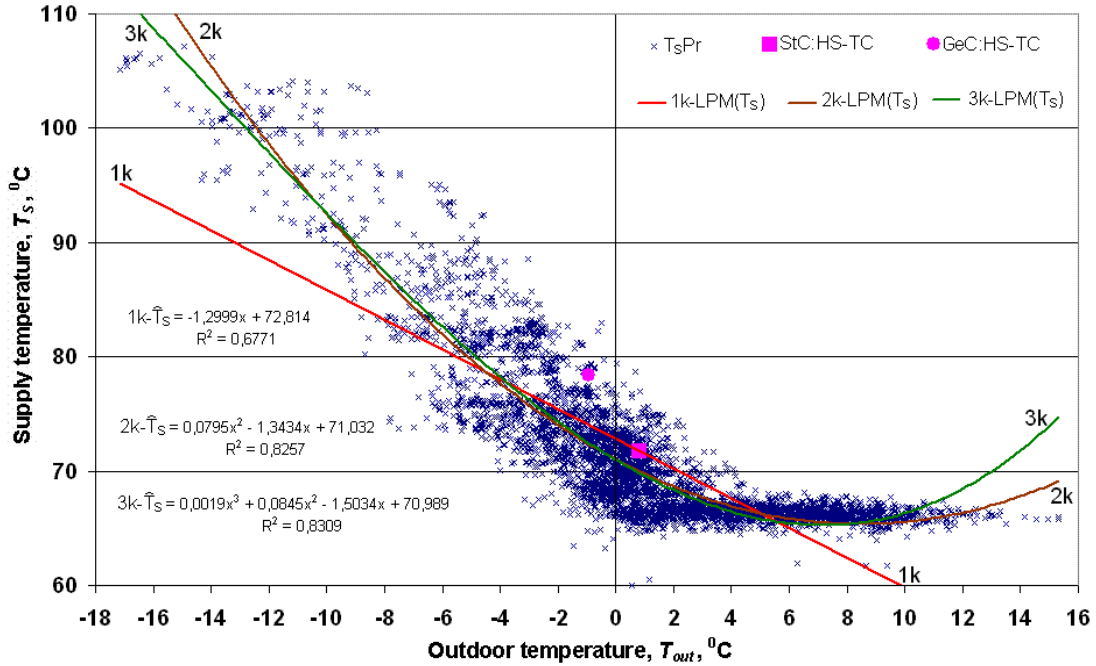


Fig.4. Outdoor and supply temperature T_{out} & T_S -scatter plot corresponding to whole heating season (HS) and three regression curves '1k', '2k' and '3k' with respect to linear polinomial regression models (LPM) concerning HS-TC. Statistical centre (StC) of the HS-TC is defined as averaged coordinates of $(T_{out;i}; T_{S;i})$ -point data set, whereas the geometrical centre (GeC) of the HS-TC is estimated as averaged coordinates of MIN&MAX values of $(T_{out;i}; T_{S;i})$ -point data set.

Outdoor and supply temperature T_{out} & T_S -scatter plot (Fig.4) corresponds to whole heating season (HS) from October till April hence the plot contains 4608 $(T_{out;i}; T_{S;i})$ -points. Linear least squares regression is by far the most widely used modeling method to fit a mathematical model to experimentally obtained data. There three types, 'NonPM(1)', 'NonPM(2)' and 'nk-LPM', of regression models, as well as six different orders of polynomial model 'nk-LPM', from '1k-LPM' up to '6k-LPM', of regression equations in Fig.5 are discussed in order to show how much sensitive is the choice of model with respect to determination coefficient. Thus two non-parametric models 'NonPM(1)' and 'NonPM(2)' which will be discussed below in Fig.8&Fig.9 manifests the highest determination coefficient, R^2 , within whole HS in comparison with 'nk-LPM' type models shown in Fig.4. With this respect one can examine three linear polynomial models (LPM) '1k-LPM(T_S)', '2k-LPM(T_S)' and '3k-LPM(T_S)' as polynomial equations of 1st-, 2nd- and 3rd-order (Fig.4) which are built-up using linear least squares method. In the same way regression equations '4k-LPM(T_S)', '5k-LPM(T_S)' and '6k-LPM(T_S)' have been created and corresponding determination coefficients estimated. As it is well definable from Fig.5 then determination coefficient, R^2 , go up rapidly by increasing LPM-equation's order from '1k' to '2k' then reaching quickly saturation. In the case of the T_{out} & T_S -scatter plot corresponding to 744 $(T_{out;i}; T_{S;i})$ -point data set of January determination coefficient's, R^2 , values are high even at 1st-order LPM equation '1k-LPM(T_S)'. Therefore dependence of determination coefficient on LPM equation's order is weaker and saturation effect is more distinguished.

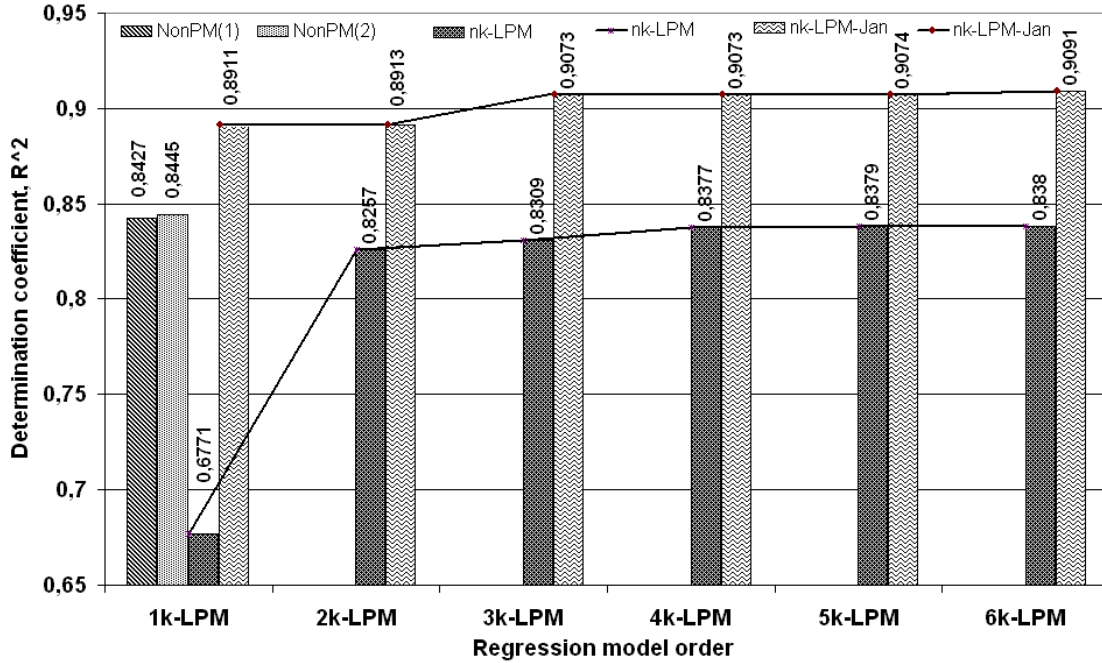


Fig.5. Determination coefficient, R^2 , dependence on regression model type and on regression equation order.

Essence of temperature contour (TC) approach is based on merging graphical representation of T_{out} & T_S -scatter plot of $(T_{out}; T_{Si})$ -point data set with statistical analysis of the same data set. Therefore one can imagine statistically defined $(T_{out}; T_{Si})$ -point data set in $T_{out} \times T_S$ -coordinates as geometrical figure called temperature contour (TC). In the case of whole HS the $(T_{out}; T_{Si})$ -point data set form HS-TC. Thus TC as geometrical and statistical object has simultaneously both geometrical and statistical properties. TC geometrical properties as width, height, or geometrical centre (GeC) have been estimated using MIN&MAX values and range of $(T_{out}; T_{Si})$ -point coordinates while TC statistical properties as statistical centre (StC) and central tendencies are defined as mean, median and mode of $(T_{out}; T_{Si})$ -point coordinates. Hence correlation analysis of district heating (DH) processes becomes more graphic, more visual and more demonstrative using TC approach. In addition TC approach helps split large $(T_{out}; T_{Si})$ -point data sets into smaller portions, namely, sub-TC (Fig.6) and build-up partial regression models providing effective investigation of the functional dependence between outdoor temperature, T_{out} , as the regressor, and DH process characterizing thermal or hydraulic parameters, P_{DH} , as the regressed, e.g., supply and return water temperature, T_S & T_R , as well as water mass flow, V . So HS-TC representing large $(T_{out}; T_{Si})$ -point data set in regard to whole HS can be divided into several smaller sub-TC_j with respect that union of all the sub-TC_j is equal to HS-TC (Fig.6&Fig.7) -

$$sub-TC_1 \cup sub-TC_2, \dots \cup sub-TC_j \cup \dots \cup sub-TC_M = HS-TC; \quad (2)$$

$$\sum_{j=1}^M N_j = N, \text{ where } j=1, 2, 3, \dots, M; \quad (3)$$

Parameter, M , is a number of sub-TC_j that in the case of T_{out} & T_S -scatter plot considered above in Fig.6 are as many as 34 vertical asymmetric sub-TC_j of the HS-TC, denoted here as $V(j)$ -TC. Each of these $V(j)$ -TC has 1-centigrade base-interval along T_{out} -axis and size, N_j , corresponding to the number of $(T_{out}; T_{Si})$ -points included TC. Each sub-TC_j, has its own label, 'j', e.g., '-17' for $j=1$ and '16' for $j=34$. The label, 'j', of the $V(j)$ -TC is derived from its base-interval's upper limit.

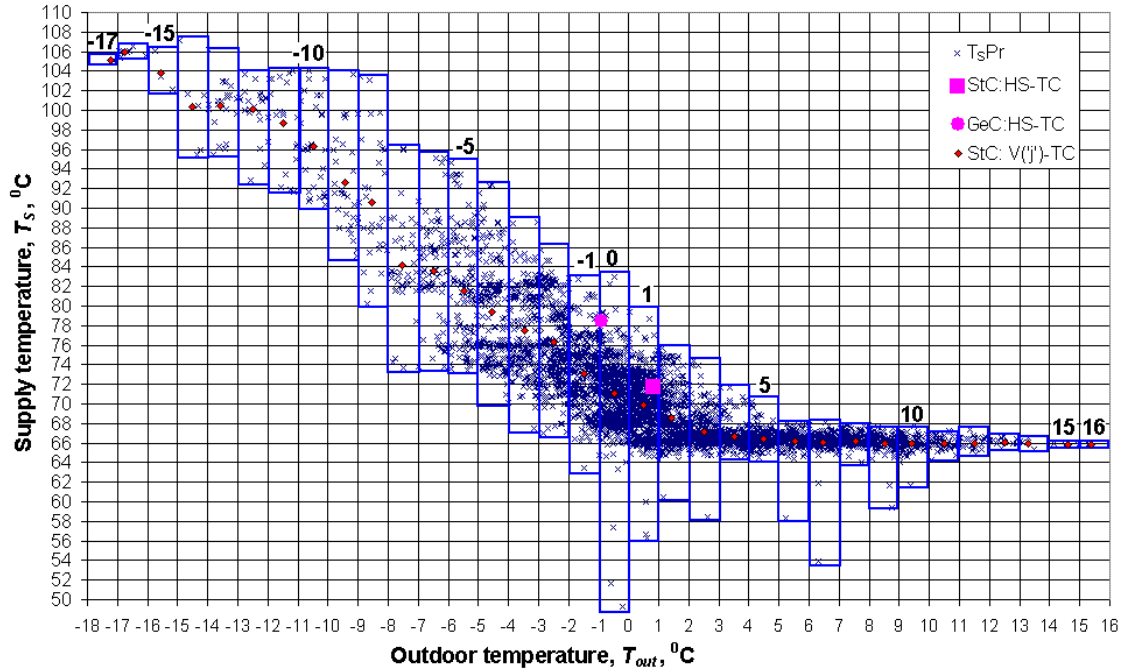


Fig.6. Outdoor and supply temperature T_{out} & T_s -scatter plot corresponding to whole heating season - HS-TC which is divided into 34 vertical asymmetric sub-TC_j of the HS-TC, V(j)-TC, having 1-centigrade base-interval and size N_j . Each sub-TC_j, has its own label, e.g., '-17' for $j=1$ and '16' for $j=34$ and its own StC. The label, 'j', of the V(j)-TC is derived from its base-interval's upper limit.

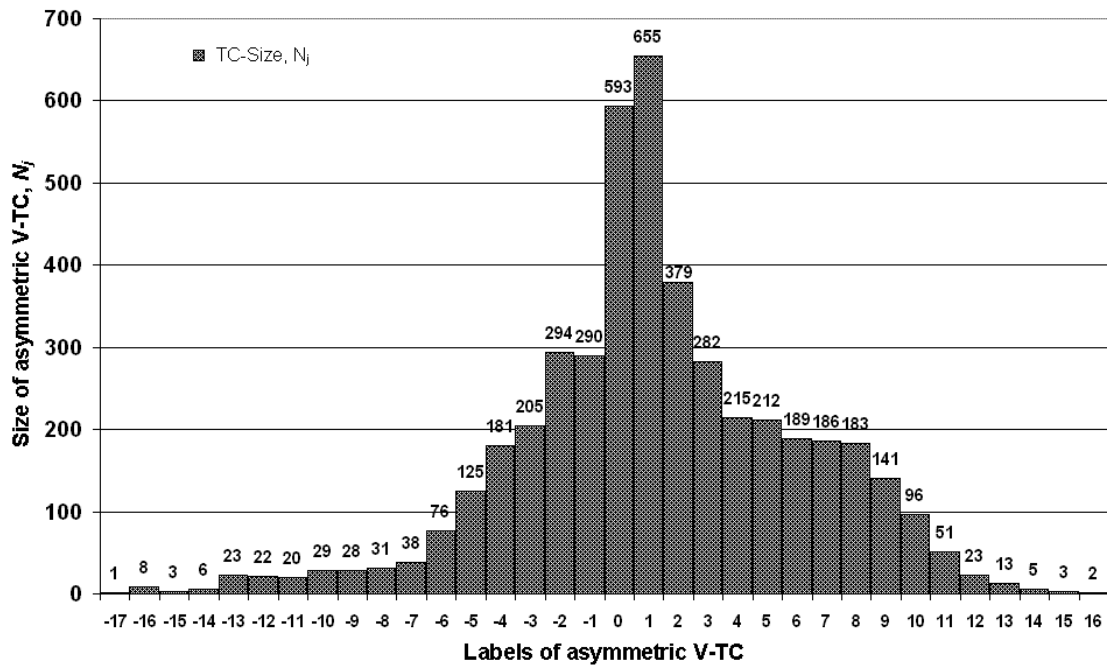


Fig.7. Distribution of all the 34 V(j)-TC corresponding to their 1-centigrade base-intervals with respect to outdoor temperature. The V(j)-TC are built-up as asymmetric sub-TC_j of the HS-TC and their size is determined by the number of (T_{outi} ; T_{Si})-points included in them. The label, 'j', of the V(j)-TC is created from the corresponding base-interval upper limit.

Histogram in Fig.7 can be considered either as differential frequency distribution function, $dFDF(T_{out})$, of outdoor temperature, T_{out} , or TC size distribution of all the 34 V(j)-TC corresponding to their 1-centigrade base-

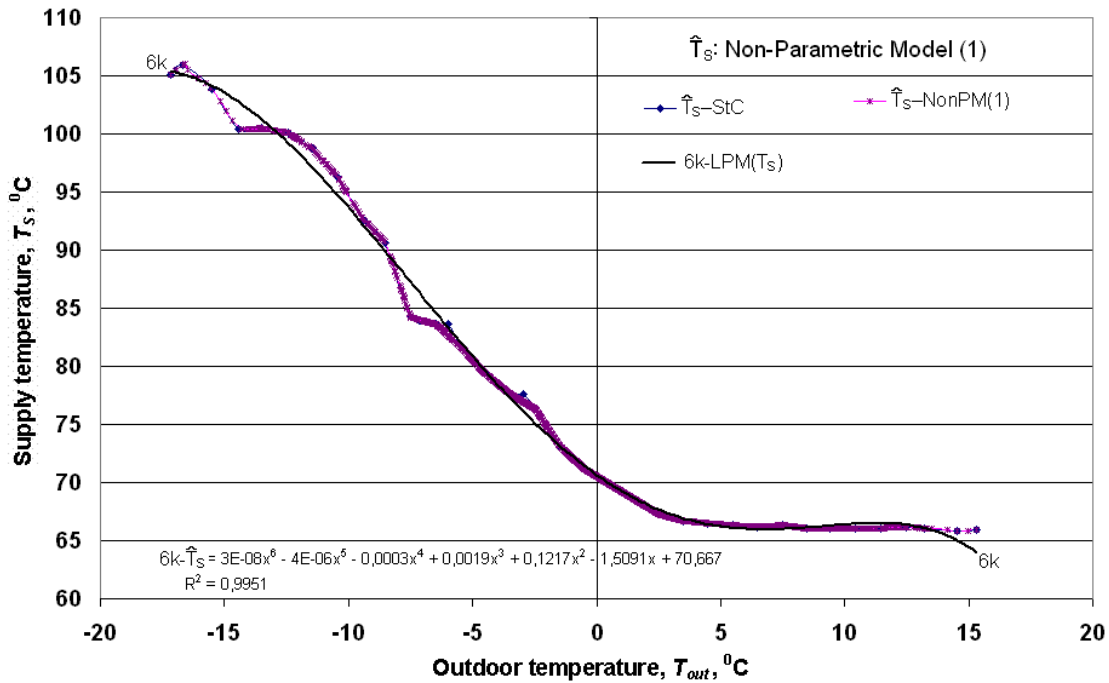


Fig.8. Regression models' backbone curve 'T_S-StC' - spline interpolation curve through statistical centres (StC) of all the 34 V(j)-TC. Non-parametric regression model 'T_S-NonPM(1)' for T_{out}&T_S-scatter plot of HS-TC built-up as linear interpolation between StC of asymmetric V(j)-TC. 6th-order trendline '6k-LPM(T_S)' for regression model 'T_S-NonPM(1)'.

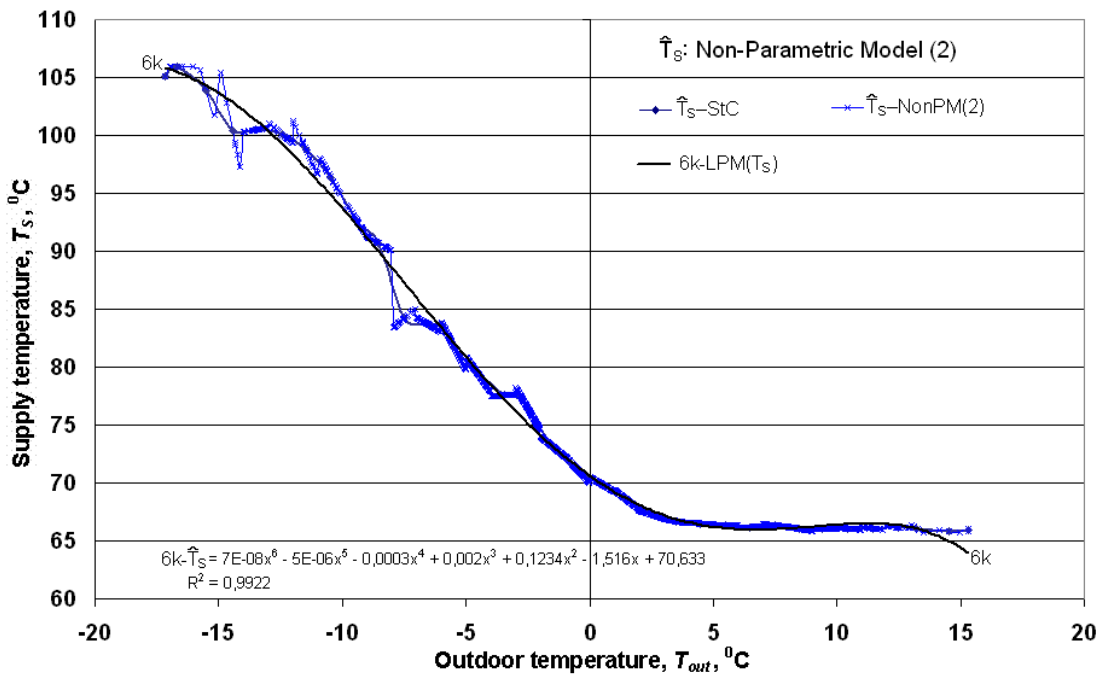


Fig.9. Regression models' backbone curve 'T_S-StC' - spline interpolation curve through statistical centres (StC) of all the 34 V(j)-TC. Non-parametric regression model 'T_S-NonPM(2)' for T_{out}&T_S-scatter plot of HS-TC built-up as linear combination of 1st-order regression line segments corresponding to each V(j)-TC. 6th-order trendline '6k-LPM(T_S)' for regression model 'T_S-NonPM(2)'.

intervals with respect to outdoor temperature. The V1-TC with base-interval T_{out}∈[0; +1] is the biggest one because contains the maximum of 655 (T_{out*i*}; T_{S*i*})-points whereas the smallest V(-17)-TC with base-interval T_{out}∈[-18; -17] contains only one (T_{out*i*}; T_{S*i*})-point. All the 34 V(j)-TC from V(-17)-TC up to V(16)-TC contain

together 4608 ($T_{out_i}; T_{S_i}$)-points that are as many as the HS-TC size. Thus, the regression model of the T_{out} & T_S -scatter plot surrounded by HS-TC can be set up additively, combining separate regression models associated with appropriate $V(j)$ -TC (Fig.8&Fig.9). Each asymmetric $V(j)$ -TC has its own StC_j as it was mentioned above in regard to the HS-TC in Fig.4. Thus, e.g., $V(0)$ -TC has StC_0 with coordinates (-0,4982; 71,1702) which are obtained by averaging 593 ($T_{out_i}; T_{S_i}$)-point coordinates included in $V(0)$ -TC. $V(1)$ -TC next to the $V(0)$ -TC has StC_1 with coordinates (0,4763; 69,9102) corresponding to averaged 655 ($T_{out_i}; T_{S_i}$)-point coordinates, and so on. So there are 34 StC_j of the 34 $V(j)$ -TC which can be connected in different way in order to create non-parametric regression line for the T_{out} & T_S -scatter plot. There are three types of interpolation considered in Fig.8&Fig.9 how 34 StC_j of $V(j)$ -TC are to be linked by line segment, by spline and by local regression line within asymmetric $V(j)$ -TC intersecting its StC_j ('StC: $V(j)$ -TC points in Fig.6). In the case of a linear line segment interpolation here denoted as 'NonPM(1)' one has to create 'M-1' linear equations for linking each pair of two closest StC_j . Thereafter regression line ' \hat{T}_S -NonPM(1)' has been calculated corresponding to each T_{out_i} -value. It means to estimate 4608 ($T_{out_i}; \hat{T}_{S_i}$)-points for regression line ' \hat{T}_S -NonPM(1)' shown in Fig.8. Determination coefficient, R^2 , between vectors $\{T_{S_i}\}$ and $\{\hat{T}_{S_i}\}$ reaches as high value as '0.8427'. In principle the regression line ' \hat{T}_S -NonPM(1)' is continuous but broken line in local StC_j -points by definition therefore in these StC_j -points does not exist 1st-order derivative. On the contrary the cubic spline interpolation gives smoothed continuous regression line having 1st-order derivative at each data point. The cubic spline interpolation giving curves ' T_S -StC' called here backbone curves in Fig.8&Fig.9 is mathematically more complicated method as a simple linear interpolation between StC_j -points. Despite of this it is easy to be convinced that there is very negligible difference between regression lines ' \hat{T}_S -NonPM(1)' and ' \hat{T}_S -StC' in Fig.9. Moreover, one can obtain more smoothed trendline '6k-LPM(T_S)' for the regression line ' \hat{T}_S -NonPM(1)' and other trendline for cubic spline ' \hat{T}_S -StC' not shown in Fig.8&Fig.9, as well as compare corresponding trendlines' equations (4) and (5) respectively:

$$\begin{cases} \hat{T}_S = 3E-08 T_{out}^6 - 4E-06 T_{out}^5 - 0,0003 T_{out}^4 + 0,0019 T_{out}^3 + 0,1217 T_{out}^2 - 1,5091 T_{out} + 70,667; & (4) \\ R^2 = 0,9951 \text{ for regression line } \hat{T}_S \text{-NonPM(1)}; \end{cases}$$

and

$$\begin{cases} \hat{T}_S = 5E-07 T_{out}^6 + 2E-06 T_{out}^5 - 0,0004 T_{out}^4 + 0,0007 T_{out}^3 + 0,1305 T_{out}^2 - 1,4696 T_{out} + 70,644; & (5) \\ R^2 = 0,9961 \text{ for regression line } \hat{T}_S \text{-StC}. \end{cases}$$

The trendlines' equations (4) and (5) differ very slightly that is negligible in a case of their graphic representation. The third type of interpolation is based on the drawing of a local 1st-order regression line through each StC_j within a range of the $V(j)$ -TC. In this case regression line ' \hat{T}_S -NonPM(2)' in Fig.9 is a piecewise continuous line within a range of each $V(j)$ -TC. The regression line ' \hat{T}_S -NonPM(2)' undergoes 'M-1' disruptions in the juncture points of the $V(j)$ -TC's base-intervals. It is worth to mention that such a piecewise continuous regression line ' \hat{T}_S -NonPM(2)' demonstrates the highest determination coefficient, $R^2=0,8445$, in comparison with other regression models built-up by linear least square method shown in Fig.4 or by different interpolation procedures between StC_j -points. The regression line ' \hat{T}_S -NonPM(2)' denoted here as non-parametric model of T_{out} & T_S -scatter plot like other non-parametric models ' \hat{T}_S -NonPM(2)' and ' T_S -StC' obtained by asymmetric TC approach manifest in principle higher determination coefficient, R^2 , as parametric 'nk-LPM' type models. One can obtain more smoothed trendline '6k-LPM(T_S)' for the regression line ' \hat{T}_S -NonPM(2)' and other trendline ' \hat{T}_S -6k-LPM' for T_{out} & T_S -scatter plot of HS-TC, as well as compare corresponding trendlines' equations (6) and (7) respectively:

$$\begin{cases} \hat{T}_S = 7E-08 T_{out}^6 - 5E-06 T_{out}^5 - 0,0003 T_{out}^4 + 0,002 T_{out}^3 + 0,1234 T_{out}^2 - 1,516 T_{out} + 70,633; & (6) \\ R^2 = 0,9922 \text{ for regression line } \hat{T}_S \text{-NonPM(2)}; \end{cases}$$

and

$$\left\{ \begin{array}{l} \hat{T}_S = 8E-08T_{out}^6 - 5E-06T_{out}^5 + 0,0003T_{out}^4 + 0,002T_{out}^3 + 0,1236T_{out}^2 - 1,5159T_{out} + 70,632; \\ R^2 = 0,8380 \text{ for } T_{out} \& T_S \text{-scatter plot of HS-TC.} \end{array} \right. \quad (7)$$

All the trendlines' equations (4)-(5)-(6)-(7) differ very slightly that is negligible in a case of their graphic representation. Deeper and more detailed picture about $(T_{out}; T_S)$ -point data set structure has been derived by calculating their frequency distribution functions (FDF) with respect to HS-TC (Fig.10& Fig.11).

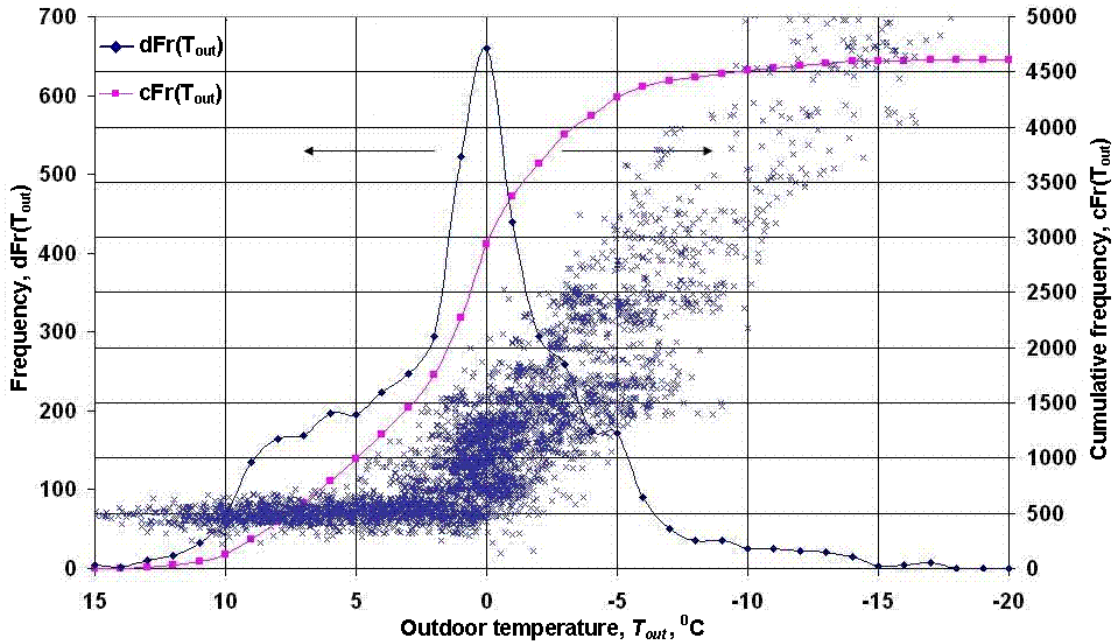


Fig.10. Differential and cumulative frequency distribution functions, $dFr(T_{out})$ & $cFr(T_{out})$, of the outdoor temperature, T_{out} , with the T_{out} & T_S -scatter plot of HS-TC in the background.

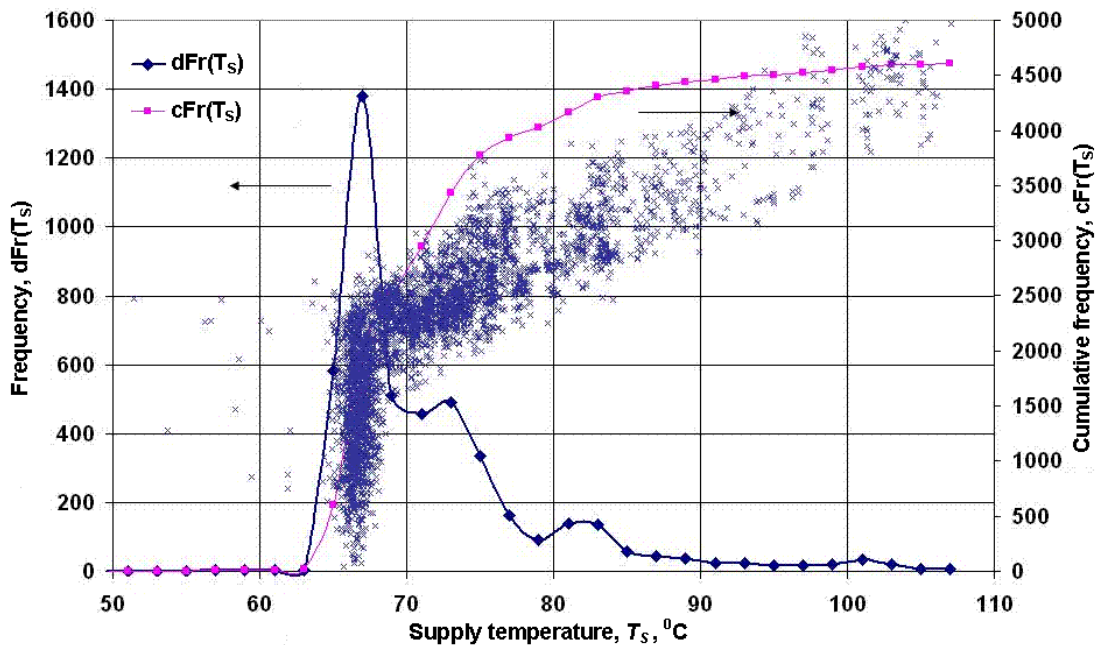


Fig.11. Differential and cumulative frequency distribution functions, $dFr(T_S)$ & $cFr(T_S)$, of the outdoor temperature, T_S , with the T_{out} & T_S -scatter plot of HS-TC in the background.

On the basis of empirical FDF was developed temperature spectroscopy of such DH parameters as outdoor temperature, T_{out} , supply and return water temperature, T_S & T_R , etc. Differential and cumulative (integral) FDF, namely, $dFr(T_{out})$ & $cFr(T_{out})$ in Fig.10 and $dFr(T_S)$ & $cFr(T_S)$ in Fig.11 corresponding to HS-TC have been calculated at least in 3%-high resolution because temperature class intervals of 1- and 2-degrees in length were used for T_{out} -axis and T_S -axis respectively. Vertical Y-axis on the left hand side of Fig.10 & Fig.11 relates to differential frequency, dFr , while other vertical Y-axis on the right hand side relates to cumulative frequency, cFr . T_{out} & T_S -scatter plot of HS-TC in the background of the FDF in Fig.10 & Fig.11 allows comparing peaks, local maximums and shoulders of FDF with $(T_{out}; T_S)$ -point spatial density. One can be convinced that peaks and local maximums correlate very well with $(T_{out}; T_S)$ -point spatial density spots. It is worth to mention that outdoor temperature, T_{out} , is distributed unequally pretty much because, e.g., interval $T_{out} \in [-2; +2]$ having only 4-centigrade length of 33-centigrade T_{out} -scale contains 1920 $(T_{out}; T_S)$ -points of HS-TC, i.e., 42% of HS-TC's size. In a similar manner a such kind temperature spectroscopy has been developed relating to asymmetric $V(j)$ -TC of different type and different size. Such approach was applied to investigate peaks and local maximums of FDF more in details. Moreover, such asymmetric TC approach was used to demarcate comparatively small areas of the complete T_{out} & T_S -scatter plot and to investigate local $(T_{out}; T_S)$ -point data set temperature fluctuations in circumstances where one of the DH-parameter, outdoor temperature, T_{out} , or supply water temperature, T_S , is greatly limited by small size of asymmetric TC base-interval, but other one may fluctuate without any restrictions.

In such a way it was possible to clarify the large-scale fluctuations by 33,40⁰C amplitude of the supply temperature, T_S , while outdoor temperature, T_{out} , was restricted within TC base-interval $T_{out} \in [-1; 0]$ in the case of $V(0)$ -TC. In addition to that two more other places of the complete $(T_{out}; T_S)$ -point scatter plot demarcated by asymmetric $V(-2,5)$ -TC at $T_{out} \in [-3,5; -2,5]$ and $V(-5,5)$ -TC at $T_{out} \in [-6,5; -5,5]$ showed a relatively large fluctuations of temperature, T_S , with the scattering amplitude $>20^0C$, while outdoor temperature, T_{out} , could change within 1-centigrade TC base-interval. It has been estimated by Kolmogorov-Smirnov (K-S) test that the both DH-parameters, T_{out} and T_S , were distributed uniformly along the asymmetric TC base-interval. By the same K-S test was confirmed that, however, temperature fluctuations along the asymmetric TC contiguous-interval were distributed normally like random variable.

Conclusions

Correlation analysis of stochastic district heating (DH) processes allows discover latent functional dependencies between weather conditions, on the one hand, and DH-system's energetic or hydraulic parameters, on the other hand. Hence the pair correlation between outdoor and supply water temperature, T_{out} & T_S , plays a special role as the most important DH-system's energetic parameters for heat load predictions. The input data set treated here contained DH-parameters', T_{out} & T_S , time series $\{T_{out}; i\}$ and $\{T_S; i\}$ including the whole heating season (HS) from October till April. DH-system parameters' T_{out} & T_S functional dependence has been built-up as a regression model for $(T_{out}; T_S)$ -point scatter plot obtained from corresponding time series $\{T_{out}; i\}$ and $\{T_S; i\}$. In addition to well known linear least squares parametric regression that is by far the most widely used modeling method to fit a mathematical model to experimentally obtained data new temperature contour (TC) approach has been developed as powerful tool for building-up non-parametric regression models. TC in T_{out} & T_S -coordinates is defined as object having simultaneously both geometrical and statistical properties. TC geometrical properties as width, height, or geometrical centre (GeC) have been estimated using MIN & MAX values and range of $(T_{out}; T_S)$ -point coordinates surrounded by TC while TC statistical properties as statistical centre (StC) and central tendencies are defined as mean, median and mode of the same $(T_{out}; T_S)$ -point data set. The most important feature of TC approach is a possibility to split large $(T_{out}; T_S)$ -point data set belonging to the whole HS, i.e., HS-TC into smaller portions, namely, into an array of subsequent sub-TC_i and build-up partial regression models on the basis of StC_j-points providing effective investigation of the functional dependence between T_{out} & T_S .

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EXPERIENCE OF MOODLE ALE SYSTEM IMPLEMENTATION AND COMPARISON WITH COMPUTERIZED TESTS AND OTHER CMS ALTERNATIVES

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Abstract

Article discuss different methods how to organize CMS (computerized learning systems) and concentrates on Moodle system implementation details, fine adjustment, typical errors and good praxis to exploit it.

Key words. CMS, ALE, VLE, Moodle, computerized tests, learning

Introduction

Does the outlined below is applicable to higher education? Presumably by 100%, as in the school with over 1,000 users, the system at the university of a few times of tat number of students, from the point of view of the computer, is the same size. The world's largest Moodle ALE systems are serving far over a million visitors a day, an average size system – around 5,000 students. Problems of learning motivation and learning habits of schools and universities are very similar, the discipline problems being much softer in the latter case. The difference may be in the number of courses, at school for each grade group may be close to 20 subjects and can be 4 or 5 parallells across the 12 classes – maximum 1200 courses. Since the teachers of most subjects in the school are far from the thoughts of using computer, the realistic count of university courses could be higher than at schools. So the point is whether or not a few terabytes of cheap HDD will be enough for all the courses. By comparison, the Institute of Atomic Physics and Spectroscopy of the University of Latvia magistrant education courses uses an autonomous sector of its server to locate more than 20 widely illustrated graduate courses consuming no more than 0.5 TB (the material can be accessed at www.asi.lv/students). If something may stand different, it is that schools usually prefer thecalendary layout, while universities – mostly (may be the authors inertia?) thematic layout. The difference is just a click in the corresponding Moodle menu box anyway.

Objective

Working for a "large" high school as a tutor in physics wthin five years I got certain feeling about the problems of a teacher (and/or lecturer) the general pattern of which was similar, yet less pronounced, under conditions of a motivated graduate audience at the university

- The students studying just 3 days before the end of the semester .
- Students listening to the tutor improperly and making notes badly
- To have an acceptable salary one has to take too much work to have enough time left for evaluating tests of each topic
- The students have no other (if any) motivation to learn except for grades
- The time necessary to improve the lessons/lectures is wasted evaluating zillions of foolish answers to test-works
- Students having been sick have no easy choices to catch up with the academic duties
- There is a strategy to attend only every second lesson – then the teacher cannot put any grade

Can it all be prevented?

It seems the easiest (yet not the best) solution is an automated test system, because:

- the problems referred to above, at least to a large extent, may be solved by computer-based tests for each (or at least each other) lesson of the topic,
- for dull, uniform and uncreative jobs (including evaluating), mankind has invented computers
- The main issue is the optimal choice of test-making software

Results and Discussion

Computer classroom?

- Only a few percent of school teachers in physics simultaneously teach informatics, thus having a free computer class.
- Conclusion: School computer classes typically have a limited access for non-informatic needs, at least during the lessons they ought be engaged in informatics.
- Only a few school physics classes are equipped with modern hardware.
- as an example, our school has managed to hook 20 machines 386 Series pre-Pentium. Even Internet Explorer seems to be too heavy to those while promises of brand new machines are heard from year to year.

Mostly if somewhere in the world the problem has been solved, the school is proud such establishments being minority.

- So, if used in a computer class, the testmaking software must be resource-economical.
- Therefore, better tests should be suitable to homeworks, hence – through the Internet.
- the end product being a grade, the more sensitive test file part (the answer part) should not reside in learner's computer, it is, the web-line is permitted in remote connection with adequate safeguards.
- The testmaking system should be an independent platform, since one establishment may simultaneously use systems from Win95 until Win7 mixture with a bunch of different Linuxes, yet each teacher should not make his/her own different individual learning environment.

Option: "Caune Tests"

- Tests *Caune* works greatly in the school local area network (intranet), but scores, in principle, can not be transferred through http compatible products (internet). At the user end a program fragment must be installed, at the control computer – a few more. Installation is easy. There exist at least two test versions.
- Peteris Caune responding to correspondence said that, technically, if time and money problems would be resolved, it could be possible to write any source code changes, but the University of Latvia having acquired the copyrights, may persecute the change by law.
- Tests do not assess the numerical calculation of the task provide and response is presented as a check box row like: does 2×2 is 8 or 16 or 4 or 2. For physics as the subject this is near the dead end, except for the least significant theoretical issues the question testmaking of which in this system for years has been successfully used in many schools. Generally, since the system is so easy and universal as just the simplest exe file, this system is widely used and popular.

Option: "Hot Potatoes"

- Freeware (latest versions are not free)
- Very versatile, very suitable for all subjects, including physics
- Unfortunately, for scores reporting via the Internet it is a paid service for all software modifications
- There is compatible freeware capable reporting scores based on SCORM Package (*ClosingCacher*). However, this program requires sharing between involved computers, so is useable only for Windows Professional, not Home Edition, and seems that students themselves will have great difficulties to configure their computers, while the teacher's home visits to 1,000 students is clear nonsense.

Thus, if any site will be resided into a home computer of the teacher, statistically more likely it will, taking into account the price difference between Home and Pro versions, push him/her to sin operating an illegal version of *Windows*. In the School Network usually based on *Linuxes*, the program will not work at all, and it cannot be emulated with *Wine* (already tested).

Option: "Sun Raw testmaker"

- Characteristics of the program surpasses even HotPotatoe, but it is not a freeware.
- Hacked versions are readily available on p2p and e2k networks.
- reporting grades will need to install MySQL + PHP + Apache support.

So, the system is a rather complicated, and blatantly illegal. Teaching children socially responsible behavior is even more important than the subject as the old folk wisdom says - which is better, high skill without high morality or high morality without any qualification?

Option: improvised DIY program?

- Caune was a highschool student when created his test system. Also the science training project of the R25-th secondary school students anno 2009/10 has established a similar (C++ based) program capable of processing responses in compliance with the assigned formula with randomized input numbers, plus everything else the *Caune tests* can. So the alternative may be made as a DIY (do-it-yourself). It works ... but it is still not perfect. Thus - yet it is too early to request a copy. The author orally said he wished to publish this work free of charge. Most likely the program `Lescinskis` some day will be found on the server *skolotajs.lv*.

• Although it would be national-patriotic to think that every homeland-made product will certainly be the best and most appropriate for Latvian conditions, a bitter experience has shown that a product that is being developed by tens of thousands of brightest minds of humanity sinerging online, the half a dozen of local professionals with a background a nation of just one and a half million in most cases may mistakenly emulate such a product. It is the author's private opinion that one of the greatest strategic mistakes of the Latvia Ministry of Education bordering with financial waste, there has been support to very useful, beneficial, good projects that, nevertheless, were able to take over the analogues of world products costlessly, investing just minor translating. As an example, the Ministry has supported the score archive management site *www.e-klase.lv*, and later two really elegant solutions to the learning environment, so that now there are at least two competing sites in Latvian: free site *www.mykoob.lv* and Windows supported paysite *www.skola.lv*. In fact, another even bigger fault of such generally not a bad solutions is that, under circumstances when the knowledge and the forces of the nation should be merged and consolidated, they are fragmented and divided between various resources instead. The strong paradigm about critical mass exists in computeristics. Dividing tactics surely weakens everyone involved.

Step higher, why ALE (VLE)?

- *Automated (Virtual) Learning Environment* provides both the test creation and grading archiving/reporting and learning website building (learning conspects, books, slideshows), plus content compilation/maintenance and many other functions which may be attributed to the category: *may sometimes be useful*.

- Most widespread (but not the only existing ones) are Moodle and WebCT

WebCT or Moodle?

- WebCT was the first CMS (*Course Management System* is almost the same as the ALE or VLE) used by the University e-courses engine status for several years

- Since 2007 the University recognized that WebCT was a managerial error, and migrated to Moodle, see www.Lu.lv/e-universitaate/eLearning/CMS

- Moodle has freeware status and annually increasing the additional options (addins) quantity/quality

- Moodle user-organisation counts over 320,000 schools in the world (<http://moodle.org>), registered Moodle web addresses: 47,348 (Latvian ... 30!); 3,318,925 courses; 33,392,824 students; 1,198,741 teachers; 20,756,654 publications, and 42,913,475 prepared tests. Whose shoes we, teaching staff and educational institutions, would prefer to go in here in Latvia – Namibian and Somalian (a few training sites) or American (8762), Spain's (4144), even Columbian (1088 sites).

Moodle Technical realization

It seems apparently difficult, but actually it is one of the easiest softwares to install. Choose a version (1.6 should be avoided, 1.9 is most widely used, 2.0 just begins being established and undergoes debugging), and your operating system - Mac, Windows or Linux. All the installation package is bundled, this package is called XAMP, it contains all the components that are themselves installed in the appropriate place and manner. In a result, computer develops MySQL database, the PHP engine based on it, and Moodle on top; what has the power ON and OFF buttons in the core directory. If a local area network is inaccessible, a web browser just trivially lets to write standalone address: localhost://(the address that you entered as Moodle website address). If network is accessible, ON activates correct address so the site is available on the network. Locally produced files (teacher may develop courses even while on the stump in the forest) can be uploaded (imported and exported) to the central machine, but more convenient is to cook courses straight online within link to the central server. With the rights of heavy experience should be highlighted the importance of regular content reserve copy-making (one button stroke) contrary to what the folks use to say: real macho never makes any backup copies. After virus infection in such case of carelessness may arise the wish to shoot oneself in the macho manner. Virus infections are very rare in Linux environment, but plenty Moodle v.1.6 users had suffered from such at end of 2009, the event that initiated a massive shift to v.1.9.

From the student's part it is just to know the address of the school's server, for example, www.r25vsk.edu.lv/moodle and its own individual password. For example, while public key of the mentioned resource is *ermuza*, one cannot see and perform tests and get the score after public entrance. Individual passwords are prepared as a listing in txt file, following the exact sample, the student data are extracted (usually from the Excel file, the most used to keep the data at school secretary). A good help is *randomized password generator*, and many of those found on the web are free and good. It is recommended to check the box "let imitate language sounds", if the option is available.

Important modules in the program openings

- TESTS (called quizz, see below)

- SCORES (and their accounts in many ways are more convenient than www.e-klase.lv, although some (may be substituted) functionality is missing. Unlike paysites like *e-klase.lv*, for Moodle services schools do not pay anything.

- Training materials may be published in plenty of formats (ppt, html, php, doc, docx, odt, xml, pdf, avi, mov, divx, waw, mp3, flac....) but most often are used just three.

- Often used method is to create *OpenOffice* file (or *Sun* or *Star* freewares) that can easy be converted (exported) to Adobe pdf, however plenty of small *virtual printer* freewares able to convert any Word document to pdf exist.

- Simplest, more convenient and memory saving way is to build materials with the internal PHP (WYSIWYG) tool. Only must be bolded that php composer allows for pictures with Ctrl+C and Ctrl+V, but it should NOT to be used, since the picture content is not put in the MySQL database, but remain as a link to the external resource. Namely, at any time, the image can "disappear" from your article or, worse, convert it to anything. The correct is to *import* picture into Moodle database and then just link to the text.

- Note that the file folder and sub-folder system in the course database is the most important work to be done from the very beginning, otherwise, after year, the author will blunder of his own system, it also applies to the quizz database file subfolders.

- Another commonly used format ppt, unless the teacher is not sufficiently erudite and the lesson file is not just a small fraction of his mighty knowledge. Otherwise, the teacher may be afraid that the "only competitiveness making tool" at any time can be copied, ouch - stolen. If so, it ought be understood as an irrational anachronic fear fighting the openness and transparency. Since the times of Makarenko, the Personality Power is the main

Distributable Product of the educational institution, not the leaflet he keeps in his hand. And deep woe if in some institution it stays contrary. Knowledge and skills are the only targets that this Product brings to students.

- Other (random and not so important) modules, such as social networks, forums, chats, supervisor achievements monitor, teacher report, classroom magazines, school magazines, archives, message boards, dictionaries, FAQ section, Help section, private counseling, online consulting, etc. Moodle advises emphasizes that this is even a more important pedagogical tool kind of a basic tool - perhaps it is a matter of taste or just being not grown enough to understand.

Moodle Pro & Contra

- Nevertheless, the piece is technically complex
- However, guaranteed work and no need for highly qualified support personell
- Extensive support network, online and offline (even too extensive to be capable to read it all), even in Latvian (see the University website), lots of good technical advices can also be obtained from co-author of this article (R25vsk.edu.lv website), lus within the last two years Wiley and Sons (*amazon.com*) have edited two wonderful books about Moodle usage.
- already over 90% Latvian-ized environment but separate screens or instructions have been left half-translated, yet at least with certain effort language can be embedded in 100% systemwide level.
- Quite hacker-safe environment (but v 1.6 is more vulnerable to virus-infections)
- Whether students will not cheat?? (For a whole rat, because it is a form of learning too, if only (!) Control Mechanisms exist:

Control Mechanism No.1

- Grade for semester = $\sqrt{\text{Aver}(\text{Test home}) \cdot \text{Aver}(\text{Test class})}$; used Excel formula syntax
- Modified: $G_{\text{sem}} = (\text{Aver}(T_{\text{home}}) \cdot \text{Aver}(T_{\text{class}})) \cdot \text{Aver}(T_{\text{small tasks}})^{0.333}$
- ...automatic calculation (Excel)... nothing personal... (lot of empty disputs for “rubber four” grade eliminated)
- Of course, that the statutes must be hanged out in classroom no later than September 1-st
- Home tests are to be many and small (to not learn to not learning), but a few class tests (consuming teacher's time)
- Examples of endorsements: home 10, result in class 1 gives 3; house 10 class 9 gives 10-; home 7, class 3 gives 5, thus a mean geometric algorithm ensures that everything stays more or less balanced or “honest”.
- Legally (Education Act): “*The teacher creates and carries the responsibility for fair, open and honest evaluation system.*” School directors often love to forget to read this place of law, but even if so, the system could be implemented at least experimentally, on time, but not without “blessings” of the director, preferably written (see the cause below).

Experience

- Complaints about the unusual system is unexpectedly low. But they come from colleagues of professions, for which mathematically sound arguments are empty
 - Scores like to clasterize eg 150 pcs `1`, 850 pcs `5`, 200 pcs `10`. And another rarity!
- Conclusion: Tasks must be supplemented by large numbers of simple (focus type) questions, otherwise the claim WILL be objectionate.

Control mechanism No.2

- Built-in random variant generator with two clicks may spread Your example task from some 300, or let 30,000 variations. The student receives a random order generated by a login therefore for cheating is not from whom.
- but there are still common task frames (the fable)....
- unfortunately ALREADY cracked by students (within the first two weeks!). One 9-grader in Pascal (!!?) made calculator for each test in his class group, guessing correct answer formula, (with Excel he wasn't familiar enough ...).
- *Fighting Type A*: The following curiosity is very easy to find with Moodle analyzer window. Tiny business of ice cream for genial child ... But nonacceptable And not difficult to kill.
- *Fighting Type B*: if a lot of questions included in a reply by idea, not just calculus, then numeracy ability alone does not make a big share into the grade. If the main reason to teach physics in school is to catch out next engineers, all the rest have enough just to understand clearly that they hate calculations and, therefore, will find a profession as far from technical disciplines as possible, thus for my humble opinion the grade 6 and 7 is the sharp boarderline between real knowledge and just imitation of knowledge. In other words, it ought not be allowed to get score 7 if the child cannot solve calculus tasks, and it ought to be permittable to get 6 if he is dysmathematical but in frames of logic understands physical principles. For minimum (imitation score) 4 may be played the Solomon`s game – if the the student does not know elementary things but is clever enough to shut mouth at the right time, let be 4, if he boldly spells fools tales all the time – let it be 3. Thus, count of boldly wrong answers never ought be the same as count of just incorrect answers. Take it in consideration allways when planing a score set for each quiz.

- *Fighting Type C*: the task maximum diversification, which as the function is built into Moodle, but quite difficult to use (random pick-up from tasks folder). This area is strategically important to be developed, and may be in the next Moodle versions it will be altered.
- The quiz answer response interval (which, if the student response `hits` then evaluation gets 100%) is adjustable or as a percentage, or vice versa - in absolute terms. Partial score weight factor for each task question is adjustable as percentage of end-score. Allowable iteration (guessing) number of times and the penalties for repeat are adjustable for each test. However, it can not be adjusted, for example, that punishment at the third attempt is greater than at the second attempt. Hope the future versions of Moodle this defect will be corrected.

Quiz types:

Test shapes in one of the many types of task wizards:

- Multiple Choice: students choose one of the offered answers
- Short answer: the student enter a word (sentence), the machine compares with the teacher entered set of alternative responses phrase shapes. Upper / lower case chooses to distinguish or not. Understands star. Allows to use figures in answer.
- Numerical: differs from the previous only in that it is possible to define the permissible response accuracy range
- True / False: the issue may contain images from the list to be checked or not (or more than one)
- Matching: Series of questions and series of answers must be aligned right
- Close embedded Answers: Flexible import / export format, like from HotPotatoe or SunRaw
- Random short answer matching: contains a number of randomized questions compiled by ShortAnswer, always make a separate folder where to keep those subfiles for one quiz
- Random: a randomized question from all the categories (means folder). Therefore, the teacher from the very beginning ought to create a wise folder system, and label them with quiz names to easy navigation)
- Calculated: student receives individual input numbers and a common task frame. Machine compares the responses match with teachers programmed formula result for the input values. Possible to adjust measurement units, accuracy and to evaluate even derived units (ie 10 grade although if answer of 10 kg, and 10,000 g, and 0.01 tons, but zero grade for answers 10 or 10,000 or 0.01). Then teacher must show in quiz template let the machine to know the t and ton and tons is the same thing, some are prohibited for use and some are half-prohibited (example – sec, sek, s).
- Essay: Evaluation must be done by the teacher (eye and hand) but he can type comments (little Peter you are finally oats); among other, pedagogically correct is to say - it was great, at least about detail, and give very little criticism not to kill the enthusiasm).

`Calculated` v.s. `Choice`

- In the field of Physics calculation tasks are essential, Moodle provides to learner randomized input data and verify the accuracy of the set range. Teacher enters `invisible` formula (which resides only on the server under hardly secure cryptography). Unfortunately, if you want an interim control of HOW the student got his result, then I have so far not succeeded. Just at the moment of the first answer random input generator nullifies, and second part of this task will use ANOTHER input values unknown to the student. If one of You knows the way to overcome this serious defect, please, let me know. Moodle forums may be read about, just reckon that it will have billions of records, so the chances to find useful is not great ... Just 2009 Wiley Publishing House has laid out a great thick book on the Moodle system administration which substitutes earlier 2006 edition. For serious users it is possible to loan it from (janis_59@inbox.lv).
- Optional tasks while more appropriate for theory (principle understanding), questions
- There are many types of quizzes, and the number in each new Moodle version is growing up.

Drafting of quiz task

- Does draw up a formula with the gear, which however is much more clumsy than Excel mathematics. However, the syntax is similar to, and may be learned intuitively or with the Help file. • Brace within means of the variable that random generator may vary for each student. The terms of the text written by the quiz author: "From the forest runs {a} wolves after {b}+2 rabbits". Then one student will read this as "From the forest runs 1.3 wolves after 8231.6 +2 rabbits", and another student will receive both figures completely different. Digit count can be adjusted simultaneously by sense (defining) interval and the approximation exactness, and/or later edited by the hand at harsh need. Example: randomize between minus 3 and plus 103 with 0,1 accuracy.

Practical experience (positive)

- Successful classes without cheaters and tasks were quite diverse - both calculated type and a reply. Marks scattered "at all shelves", and well correlated with teacher opinion of each student's abilities.
- Poll 2008: of the 990 students only six have NOT computer with Internet available at home, yet it is available after lessons at school. Sic!, In the fall of 2009 this figure dropped very much, indicatively only 50% connected to the Internet, yet computer is still available. So severe signs of insolvency of families budget in the capital. It should not be ignored. Solution - the school computer classes after lessons MUST be widely open.

- About 50% of students have technical problems, because forbidden cookies and incorrectly configured the Firewall, of which ~ 90% are Vista users, and the computer becomes so clumsy and incompatible with other systems. Fortunately, after the Win-7 outbreak Vista loses its positions (for obvious reason), so this problem will soon be to ignored.

Practical experience (not so positive)

- Whether the class has a well masked front singer, or question diversification is too narrow. All grades are either 10, or 5 or 0.
- Conclusion: ALWAYS ! supplement numerical question with one catchy theory question (with a slight weight ratio) and one to a few simple (which allows earn at least between the top three and the bottom four).
- For example, near the optimum seems: calculation gives 60%, catchy theory 15%, a trivial theory 25% (of the whole grade). Take in consideration that some answers may be guessed, so a partial grade will be got with penalty factor. Even a weak-tail has a chance.

System default settings

- How many times a test may be answered, after it no longer opens for this student. Originally had 2 (too little), now has 4 (too much). Expected optimum is 3. Moodle delivers a cookie blocking the student's computer backspace knob for a while, this option is active when "safe mode" choice is checked. If the student violently blocks the cookie, the quiz (and grade) is blocked.
- How many times each filling can give an answer (because even zero grade makes sense to experiment some 1000 times to understand the task principle). Currently there I use 2 to 5 times ... no idea yet, let experiment.
- How many penalty points for the re-up. Unfortunately, the penalty points that 10-th time is identical to the 2-nd time, and is NOT summed up (!) - that's a very mistakeful thing in Moodle, yet may be cured in future. Was 5 points (too much), it is now 1 (too little). May be start to check with a 3?
- How many penalty points for the current answer guessing. Similarly, not summed up. If does not come the first time – guess while become old, if not checked forbidding regime. Was 1 (too little), now at 5 (too lot). Should be experimented 2 and 3. The students rarely understand the difference between (one) answer guessing penalty and whole quiz re-up, it ought be clarified to the audience.
- Which grade to report: Average, Last attempt, First attempt?? Today is the Last. Maybe better will work Average? But confidence is lacking.

"Politically-correct" problems

- Be aware that approximately 20-30% of weak-tail students will do all they might invent to rebel against such system demanding real learning, they will discredit, complain – and, primarily, to parents as the general customers of the education services. Absolute majority of those claims will be easily clarifiable lies and parents return home happy.
- Yet, due to above-said, the school administration should have excellent and detailed understanding(!) of implementation of the project, the security mechanisms and policy endorsements - to be able giving the parents satisfactory explanations, including that the classical paper work tests are not to be removed and those new tests may be performed at one of 86 school computers if not at home. Only a few parents were aggressively convinced that any computer deadly damages kid's eyesight, and any home task does not allows the kid to breath fresh air outside. Thus, a manœuvre should be in reserve that it is allowed to substitute a home test with after-lesson test (unsaid, far more difficult). This is the main reason why introduction of the ALE system ought to be ensured with appropriate paperometric valuables with right signatures and seals, this would save blaming the poor signalman.

Conclusions

Educational content and form (or reform?)

The famous Lincoln Presidential Axe was so old and famous that it has had to replace the handle already 27 times and the blade – 8 times. However, it still is the Lincoln's ax. The education is similar. Even if the shape is changing. If that, then in the official textbook "General Pedagogy" reprinted by the Daugavpils Pedagogical University in 1998 I found a fantastic funny quote from the lexicon of 1960-ies I give by memory: "The use of computerized testing in education is the secret weapon of the capitalist system by which to deprive the class struggle of the working people of a qualitative education; the mighty Communist party leadership of the Soviet Union regards it as something neither possible nor acceptable" (I hardly refuse to use capital letters, although lynch me / JB). I am sure such a stance in the book came only due to editor's negligence when preparing the reprint of another epoch, however some weed may be greener than it looks. Thus, concerning computers (and education especially) it is time to let the stalinistic dogma regarding all computers as false-science to follow its creator in the grave. It was so long ago that is no longer true. And who else but if not we - the teaching staff, starting with schools and ending with the universities will explain the simple truth to the "poor proletarians" with our true deeds - by implementing such brilliant tool as Moodle in our everyday job. Gentlemen, let start to push it now, come on to computers .

This material may be downloaded in the presentation format (with pictures) in Latvian from website:
www.asi.lv/pandora/r25/Moodle2k9.ppt

Literature

Specified above in the plain text

INVESTIGATION OF ABIOTIC PARAMETERS IN-SITU OF CULTIVATED GRASSLAND, USING PHYSICAL MEASURING METHODS

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Abstract

In order to understanding a fluctuation of the physical processes, it is necessary to analyze a lot of physical parameters: temperature of atmosphere and soil, gas concentration (O₂, CO₂ and ethylene), soil solidity, dependency of the wind velocity on the height and density of plants, humidity of the soil, plant albedo variation dependency on the surface topography, vegetation period and other factors. Our experiments have been done using data collection according to the national USDA's Forest Health Monitoring Program [1]. Cultivated grassland as the target of the investigation has been taken. The data have been collected in a real time using digital sensors of the humidity, pressure, gas concentration, solar intensity, wind speed and temperature. The all dependency of the various physical data was valuated according on the plant growth. All picked data set should be used analyzing ecological drivers on the fluctuation of the climate. Soil structure influenced humidity, which affected traffic ability, compaction and nitrogen retention. Measurement of properties that affect fluid storage and transport, such as macro porosity, provided soil quality indices that helped in recommending suitable soil management systems [2].

Keywords: *plants, ecosystem, measuring methods*

Introduction

It is widely recognized plant cover and biota are distinguished by their abundance and diversity. However, there is a surprising lack of knowledge on the precise functional roles played by multiple abiotic factors on plant and soil organisms [3; 4]. A disturbance of the fragile temperate grassland ecosystem has often resulted in considerable changes in the species composition of the vegetation especially when humans have 'assisted' by introducing new species under the mistaken belief that they can 'improve' the ecosystem. Some essential features of the terrestrial hydrologic cycle and ecosystem response are signed out by confronting empirical observations of the soil water balance of different ecosystems with the results of a stochastic model of soil moisture dynamics. There are a lot of factors influence Earth's weather - the extent of snow and ice cover; the surface temperature of the oceans and the velocity of their major currents; the type of ground cover and the soil moisture content; the amount and type of cloud cover as it affects the reflection and absorption of the incoming solar radiation and the absorption of the outgoing infrared radiation from the Earth; the effect of major fires or the ejected from major volcanic eruptions; and the dynamic state of the atmosphere and its composition - including infrared absorbing molecules such as water vapor, carbon dioxide, methane, and oxides of nitrogen. That's just naming a few of the things that we take into account. We don't profess to understand or always incorporate all of these and other factors into our Almanac forecasts. However, we are continually striving to improve our methods. The interaction of plants within their physical surroundings is one of the most important concepts within Environmental Science. During the changes of the ecosystem, concerning of the household practice, the rise has born to find others new methods to investigate the growth of the plants. These investigations would optimally let us to evaluate the environment of plants – soil, its humidity during the rainfall stock is changed, temperature, lightness, atmospheric pressure and others factors.

This paper reports preliminary results from a project designed to investigate the interactions between the activity of plant, biota and soil temperature, density, humidity etc. The approach is based on the investigating the impact of environment physical indices on plant productivity. The aim was to evaluate effects of environmental factors (climate and soil) on grassland productivity.

Materials and Methods

Biosphere-atmosphere interactions were investigated on a light deeply carbonate washed light loam soil (*Bathihypogleyi–Calc(ar)ic Luvisol*) in semi natural and intensive grassland ecosystems (54°52' N, 23°50' E) of Training farm of Lithuanian University of Agriculture in 2009 (Fig 1). Humus horizon was 25 cm deep. Physical measurements of abiotic parameters were run in June, when meteorological conditions were optimal for intensive plant and soil biota physiological processes, in absence of frosts stress.

The experimental site at an elevation of 250 m of the nearest buildings in experimental grass field is situated on experimental grass field of Lithuanian University of Agriculture in Kaunas. The vegetation at the site semi natural grassland (dominated *Poa pratensis*), developed on an neutral soil which has been cultivated in the past. Time of investigations was completed during active vegetation period - June. The plants height is 15 ~ 20 cm. Fresh mass (FM) weighting and drying (105°C) was used to obtaining dry mass (DM, %) and grassland productivity (g m⁻²).

The Campbell and Pasco instruments were used. Physical parameters of environment have been arranged using sensors: humidity sensor PS 2174, Compaction meter SC 900, Campbel temperature probe CM 107, soil humidity sensor Hydrosemse CS-620, Radiometer CNR2. Results were processed with Excel and "Data Studio". The inter-dependency and correlation of albed, solar intensity, temperature of environment, pressure, and wind speed, soil density were investigated. The results were collected several times, evaluating change of the humidity, temperature etc. during 7 days in the time of dry period. The 8 experimental sites have been choose (Fig. 1), which were in many different places of the relief in the grassland, handing different humidity and density of the soil. The investigations of the soil density have shown that the structure of the measured soil is very different depending on the relief and depth.

Results were evaluated statistically by using package Statistica (StatSoft for Windows) programme ANOVA. The confidence limits of the data were based on Student's theoretical criterion at the level of statistical significance $p < 0.05$.

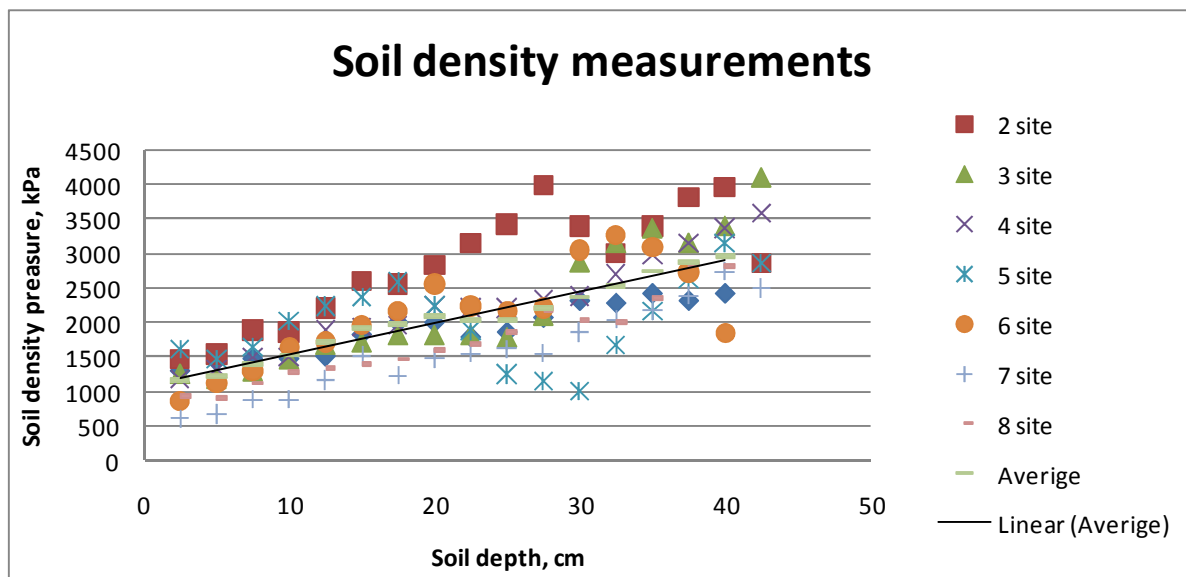


Fig. 1. Soil Density Measurements

Results and Discussion

Compared grassland ecosystems, differering in the degree of anthropogenization level and abiotic factors, the least yield of fresh mass (FM) and dry material (DM) was obtained in semi natural grassland (Table 1).

Table 1.

Yield and botanical composition of semi natural (1-8 site) and intensive grassland (IG)

Site	FM, g m ⁻²	DM, %	Botanical composition, %		
			Gramineae	Legumes	Forbes
1	957.5	19.9	35	35	30
2	892.5	22.8	50	3	47
3	1002.5	23.5	75	0	25
4	1102.0	23.6	71	0	29
5	1520.0	12.7	70	0	30
6	1700.0	22.7	40	50	10
7	1355.0	25.3	80	0	20
8	2127.5	23.3	35	55	10
IG	3020.0	27.4	97	0	3
LSD ₀₅	87.55	0.6	1.04	0.53	1.18

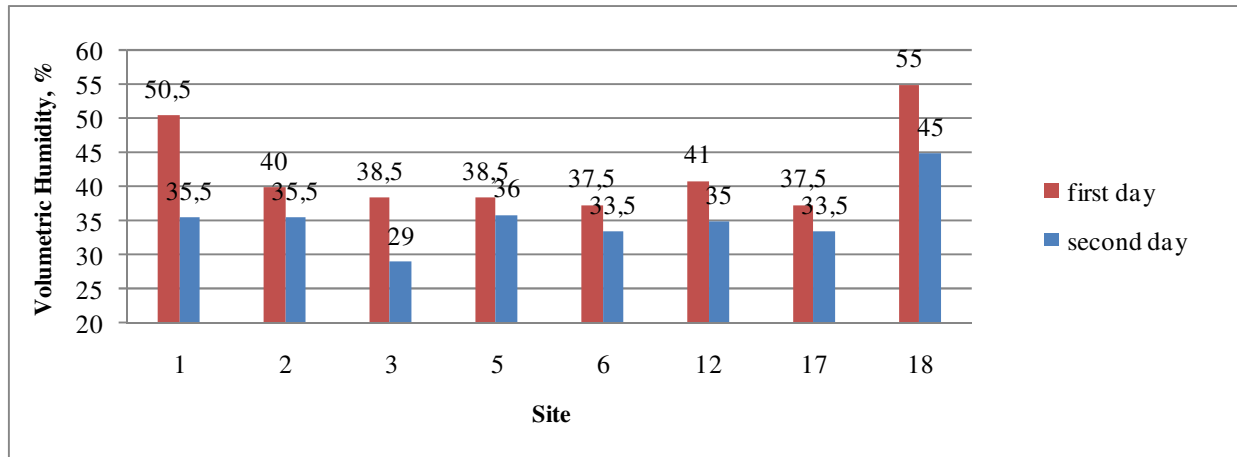


Fig. 2. Soil Humidity

The can see the total amount increase of the soil density according to the depth. That is logical. Measurements of soil humidity in the same 8 different places verified non homogeneous increasing of density at the same time, and then the dept of the measuring is increasing too.

The highest moisture alteration was observed in places 1, 3 and 8 (~12%) (Fig. 2) these measurements are directly correlating to investigations of the soil density, shown in Fig. 1. In the last (others) measuring places moisture variation was about 5%.

Analyzing the environment of the plants, influencing the changing of the moisture, the solar intensity, environment temperature, moisture, wind speed and absolute pressure investigations were arranged also. The data of these measurements are shown in 1-6 Fig..

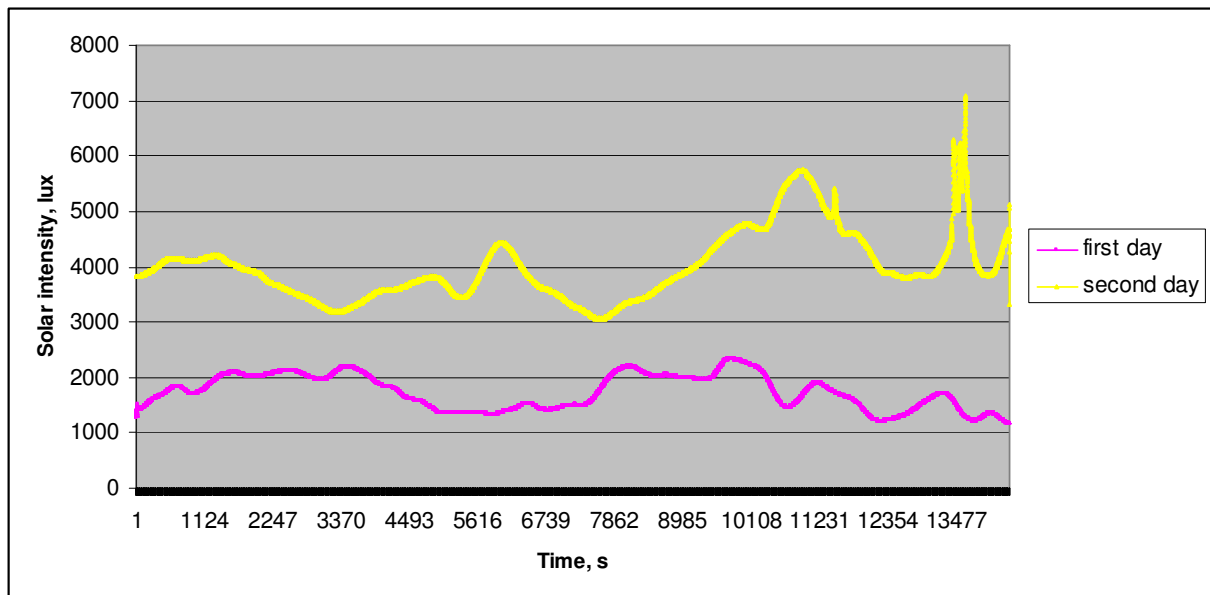


Fig. 3. Solar intensity. The results are according to „first“ and „second“ days measurements

As we see, the ambient temperature directly depends on the weather temperature and solar intensity. The experimental measurement has been arranged during dry period of the day. The medium ambient temperature was 23-27 C° - first day and 28-23 C° - second day (Fig. 3 and 4). The average soil temperature was 17, 5 C°, during the experiments. The wind speed approximately was changing for 0, 1-0, 3 m/s.

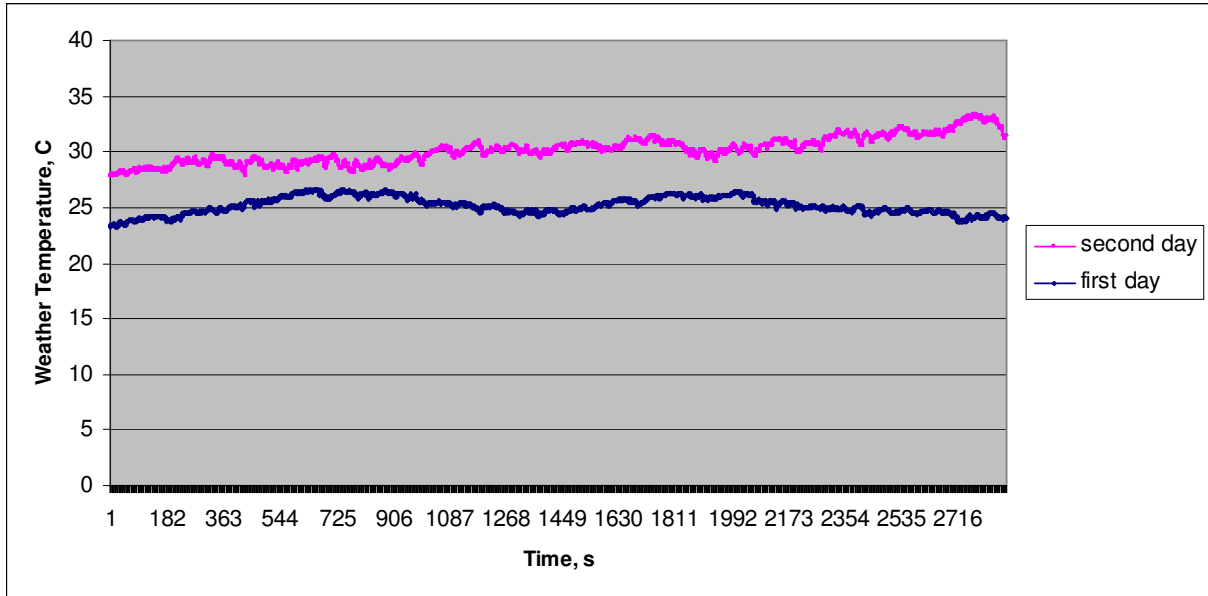


Fig. 4. Weather temperature. The results are according to „first“ and „second“ days measurements

We estimated, when no rainfall is, the weather humidity (Fig. 5) is changing depending on the relief and density of the soil (Fig. 1). This effect is very important for the growth of plants and the height. In the 1st, 3rd and 8th fields, where density of the soil is highest, the height of plants was for 5 – 7 cm. less. This shows the humidity of plants directly depending on the density of the soil.

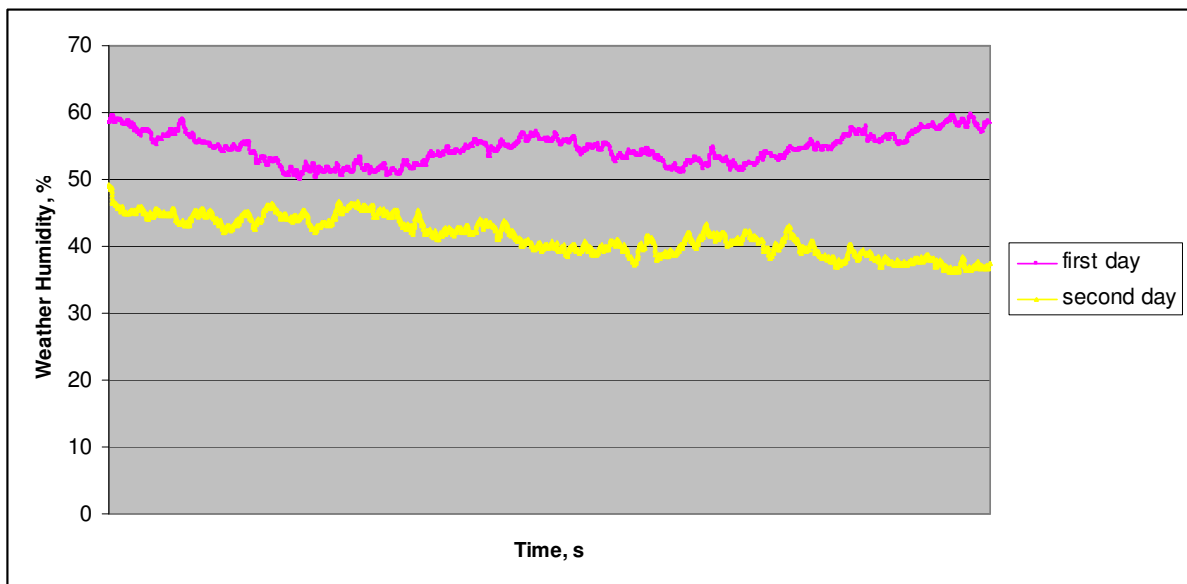


Fig. 5. Weather humidity. The results are according to „first“ and „second“ days measurements

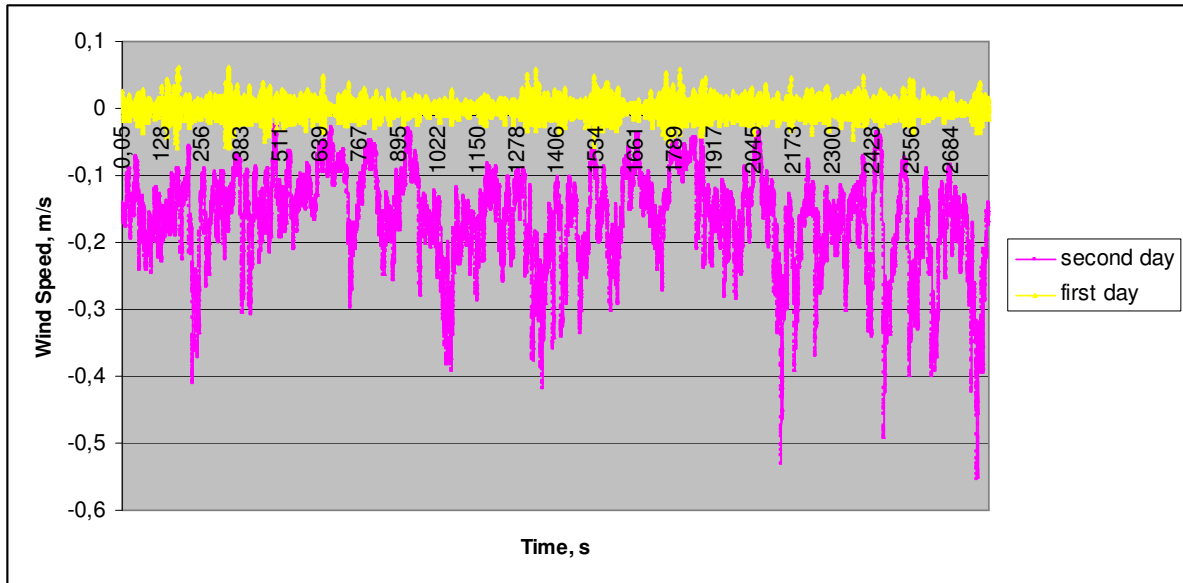


Fig. 6. Wind Speedy. The results are according to „first“ and „second“ days measurements

Conclusions

We have to notice that data of the environment factors in grassland ecosystems were collected putting in one place all equipment under the plant cover. It have been noticed that even more humidity in the soil and air, even better vegetation condition for plants. All viewed methods let us to analyse many both physical parameters which are associated between and appreciate correlations.

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MODELLING OF NEW CONSTRUCTIONS OF SOLAR COLLECTORS

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Abstract

Align with others environment-friendly renewable energy sources the solar energy is widely used in the world and also in Latvia. However, in Latvia because of its geographical and climatic conditions are some features in comparison with traditional solar energy using countries. In Latvia at summer the length of day excides twelve and maximally reaches seventeen hours, accordingly is also long path of sun. There is frequently considerable nebulosity.

Therefore usual constructions of solar energy receivers are not efficient enough in Latvia, and new constructions are required, that would be able to collect energy from all sides as well as to use the diffused radiation more efficiently.

For better elaboration and evaluation of new constructions of solar collectors, also new, more precise, complete and convenient methods for calculation and forecasting of the received energy are required.

This article deals with theoretical calculations of the energy received by the solar collector.

These calculations includes at first calculations of coordinates of sun. Then energy received by some surface at clear sky conditions can be calculated. Orientation of the surface can be taken into account as effective surface area. Also model for taking into account nebulosity has been developed.

These calculations have been verified with experimental data, measured with pyranometer and semi-spherical solar collector. Good coincidence has been obtained.

Received energy of several surfaces – flat surface at variable orientations, semi-spherical, spherical and cylindrical one - has been calculated using this method. User's choice between these constructions depends on particular needs and possibilities.

Key words: solar energy, collector, modelling, semi-spherical

Introduction

Align with decrease of reserves of fossil fuel, as well as impact of use of fossil fuel on climate, in the world more attention has been paid to renewable sources of energy, including solar energy.

Also in Latvia the solar energy has been used, mostly in solar collectors for hot water production (Kancevica et.al. 2006; Ziemelis et.al. 2004). However in Latvia because of its geographical and climatic conditions there are some features in comparison with traditional solar energy using countries (Pelece 2008; Pelece et.al 2008) . In Latvia at summer the length of day excides twelve and maximally reaches seventeen hours, accordingly is also long path of sun, but rather small height of sun (maximally 56 degrees above horizon) and therefore also small intensity of solar radiation.

There is also frequently considerable nebulosity. At winter the height of sun is very small (10°) and the length of day 7 h, therefore use of solar energy at winter in Latvia is not possible.

Because of mentioned above features traditional flat plate collector without tracking to sun is not appropriate enough for use in Latvia, but new collector constructions are required, that would be able to collect the energy from all sides as well as to use the diffused radiation more efficiently.

For a better elaboration and evaluation of new constructions of solar collectors, also new, more precise, complete and convenient methods for calculation and forecasting of the received energy are required, capable to calculate received solar energy of surface of any shape and orientation, taking into account also the nebulosity. Such method is proposed in this article. Calculations consist from three steps. At first, solar coordinates at every moment must be calculated. These calculations are based on astronomical considerations (Zagars and Vilks 2005). Second step is calculations of the energy received by some surface, depending on its shape and orientation. There an idea of the effective area of the solar collector can be used. Third step is evaluation of impact of clouds. There is a new improved model of taking into account impact of the nebulosity used in these calculations.

This method has been used for calculation of energy received by flat collector at several tilt angles, semi-spherical, spherical and cylindrical collector.

The method has been verified by comparison of results of calculations with experimentally measured values. A collector with the semi-spherical absorber has been used in these measurements.

Materials and methods

Calculations of the received energy of several surfaces have been performed in this article. These calculations are based on astronomical considerations (Zagars and Vilks 2005) and data of nebulosity from Latvian

Meteorology Centre. The nebulosity in meteorological stations has been evaluated visually, after every three hours, in grades. Ten grades scale has been used, where 0 grades corresponds to absolutely clear sky, 10 grades – absolutely overcast. In our calculations mean value of nebulosity of daylight time of every day was used. An intensity of the solar beam radiation on surface perpendicular to the sun rays at every moment at clear sky conditions can be calculated from well-known formula

$$I_B = I_0 \cdot P^m, \quad (1)$$

where I_B – intensity of solar beam radiation, $W m^{-2}$;
 I_0 – solar constant, $I_0=1367 W m^{-2}$;
 P – lucidity of the atmosphere, assumed to be equal to 0.78 relative units (Pelece et.al. 2008^{a,b});
 m – air mass, relative units.

An air mass accordingly to Young (1994) can be calculated as

$$m = \frac{1.002432 \cos^2 z_t + 0.148386 \cos z_t + 0.0096467}{\cos^3 z_t + 0.149864 \cos^2 z_t + 0.0102963 \cos z_t + 0.000303978}, \quad (2)$$

where z_t – true zenith angle of the sun, degrees.

Although the intensity of solar radiation consists of direct and diffused one, and the direct radiation on horizontal surface depends only from that on surface perpendicular to sun rays (formula 1) and the height of the sun, an intensity of the global radiation on horizontal surface can be calculated as

$$I_{GH} = I_B \sin \delta + I_D, \quad (3)$$

where I_{GH} – intensity of global solar radiation on horizontal surface, $W m^{-2}$;
 I_B – intensity of beam radiation, $W m^{-2}$;
 I_D – intensity of diffused radiation, $W m^{-2}$;
 δ – height of the sun, degrees.

The intensity of diffused radiation has been assumed independent from direction and time and equal to $50 W m^{-2}$ (Pelece et.al 2008^{a,b}).

These calculations are valid at clear sky conditions. But in Latvia often is great nebulosity (Figure 1), therefore results of these calculations must be corrected taking into account nebulosity.

In literature (Younes and Muneer 2006) several formulas for this correction can be found. As the most appropriate the Kasten-Czeplak model (Younes and Muneer 2006) has been found (Pelece 2008)

$$I_G = I_{GC} \left(1 - A \left(\frac{N}{8} \right)^B \right), \quad (4)$$

where I_G – global solar radiation at cloudy conditions, $W m^{-2}$;
 I_{GC} – global solar radiation at clear sky conditions, $W m^{-2}$;
 N – nebulosity, oktas;
 A and B – coefficients, varying from geographical conditions.

Corrections in this formula must be done because of varying coefficients A and B , and of measuring of the nebulosity in grades (ten grades scale) instead of oktas.

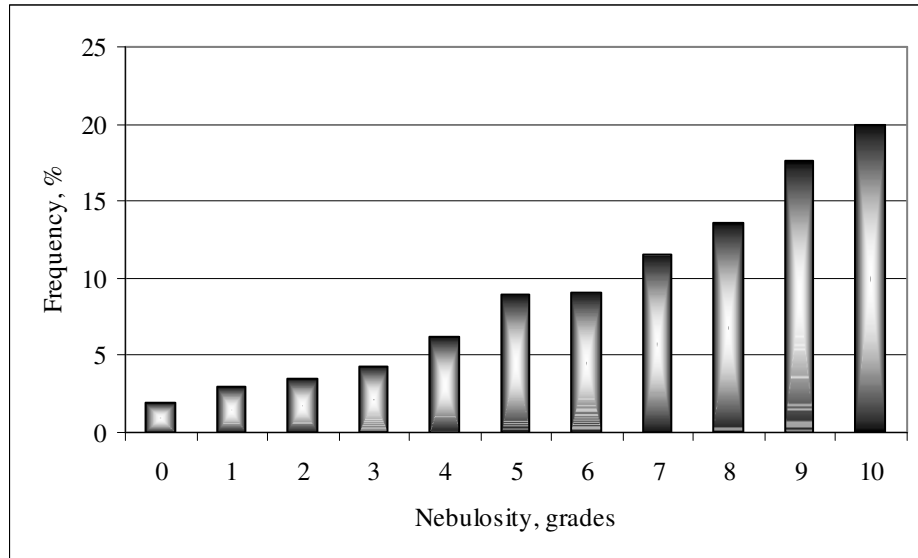


Figure 1. Frequency of values of nebulosity in Latvia, 2003 – 2009 (Latvian Meteorology Center)

Results of calculations have been verified by comparison with measured data of the global solar radiation. The intensity of the global solar radiation has been measured using an ISO 1. class pyranometer CMP 6 from 'Kipp & Zonen'. Measurements have been performed automatically, taking intensity of radiation after every 5 minutes and accumulating data in a logger. Thereafter from these data the daily energy density has been calculated. Measurements have been carried out from April 2008 till November 2009.

Evaluation of adequacy of calculations can be evaluated using graphical method (Younes and Muneer 2006). This method consists of plotting of calculated values via measured ones and then drawing the best fit line. On accordance of the model indicates the slope of this line (must be near to one), intercept (must be near to zero) and coefficient of determination R^2 (must be near to one).

Calculations have been verified also by comparison with measured energy received by solar collector. Measurements of the received energy of the solar collector have been performed using a new construction – solar collector with a semi-spherical absorber (patented: Iljins et.a. 2007), shown in Figure 2.



Figure 2. Semi-spherical solar collector.

The collector is made from a copper sheet (thickness 1 mm) shaped as semi-sphere and coloured black. Inside the dome is a copper tube shaped close to dome. Diameter of the tube is 10 mm, length 21 m. In this tube flows heat remover – water, transporting heat to the reservoir. The collector is covered with transparent polyethylene terephthalate (PET) dome. Radius of the collector is 1.12 m, what corresponds to 1 m² base area. For control of surface temperature of absorber 24 thermocouples have been mounted onto surface of absorber, and temperatures have been measured automatically with interval of 5 min. In order to determine the received energy

of collector temperatures of incoming and outgoing water have been measured after every 5 min. Water flow ensured a pump, which productivity was 30 l/h. Measurements with the semi-spherical solar collector have been carried out at 2009 from 1 May to 1 August without water and from 1 August to 31 October with water flow.

Results and discussion

For calculation of the air mass, as well as energy received by any surface not only perpendicular to solar rays, the elevation and the azimuth of the sun are required. Ecliptic coordinates of the sun are $\beta=0$ and λ , which changes evenly from 0 at vernal equinox to 360° during year, i.e., 365.25 days. Transforming from ecliptic coordinates to horizontal (Zagars and Vilks 2005) we obtain the elevation of the sun

$$\sin \delta = (\cos s \cos \lambda + \sin s \sin \lambda \cos \varepsilon) \cos \varphi + \sin \lambda \sin \varepsilon \sin \varphi, \quad (5)$$

where δ – height of the sun, deg;
 s – sidereal time, deg;
 λ – celestial longitude, deg;
 ε – longitude of the place, deg;
 φ – latitude of the place, deg.

The azimuth of the sun can be calculated

$$\sin A = \frac{\sin s \cos \lambda - \cos s \sin \lambda \cos \varepsilon}{\sqrt{1 - \sin^2 \delta}}. \quad (6)$$

Then the global solar radiation on the horizontal surface can be calculated using formula (3). Nebulosity has been taken into account by formula (4). Nebulosity in oktas in this formula must be substituted with used in Latvia grades in ten grade scale. Coefficients A and B in formula (4) must be experimentally evaluated for local conditions. In result we obtain following expression

$$I_G = I_{GC} \left(1 - 0.76 \left(\frac{M}{10} \right)^{1.7} \right), \quad (7)$$

where I_G – global solar radiation at cloudy conditions, W m^{-2} ;
 I_{GC} – global solar radiation at clear sky conditions, W m^{-2} ;
 M – nebulosity, grades.

This expression is valid for both intensity and daily energy sum. Accordance of the model to experimental data can be evaluating plotting calculated values via measured ones (Younes and Muneer 2006). Then on good accordance indicates the slope of best fit line (must be near to unit), intercept (must be near to zero) and coefficient of determination R^2 (must be near to unit). Such plot for all daily energy sums of year 2009 (from 1 January to 31 December) is shown in figure 3. On horizontal axis values of daily energy sum calculated using formula (7) have been shown. On vertical axis there are values measured with pyranometer and summed for every day. In our case slope of the best fit line, drawn using method of smallest squares, is 0.944, intercept 0.138 and R^2 0.877, which all suggest of good accordance.

The solar beam irradiance on any surface can be calculated as

$$I = I_B \cdot \cos \beta, \quad (8)$$

where I – solar beam irradiance on surface under consideration, W m^{-2} ;
 I_B – solar beam radiation on surface perpendicular to solar rays, W m^{-2} ;
 β – angle between solar rays and the normal of the surface under consideration, deg.

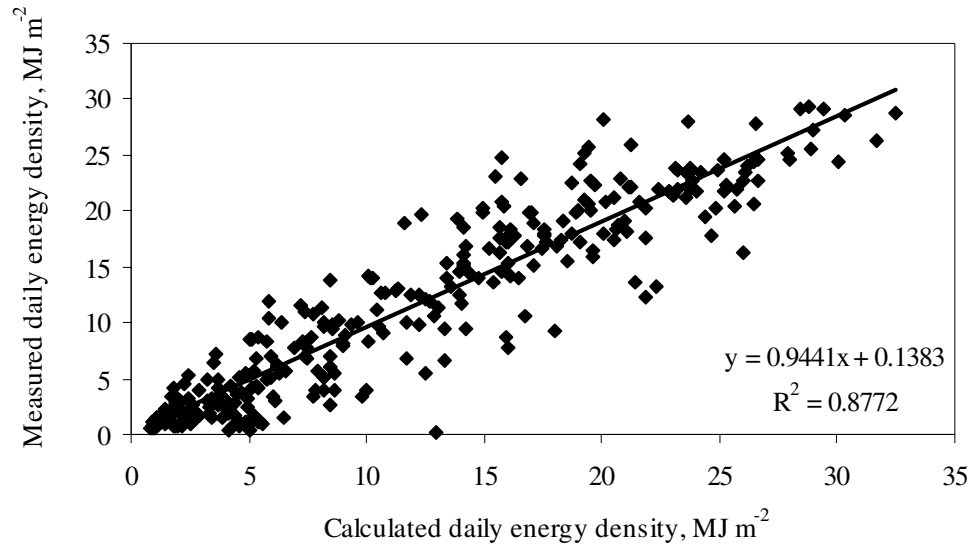


Figure 3. Calculated and measured values of daily energy density.

These calculations give, for example, for semi-spherical surface distribution of the received energy shown in Figure 4.

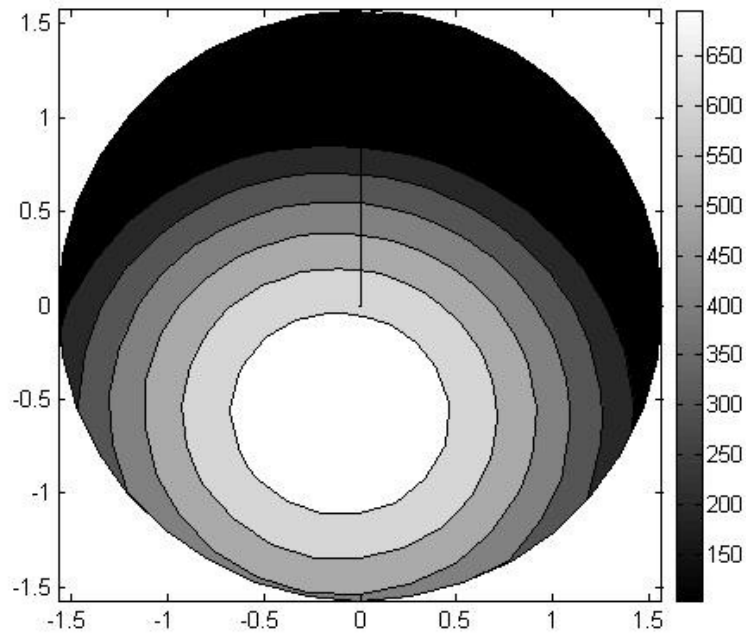


Figure 4. Calculated distribution of the received energy of semi-spherical solar collector.

This distribution is similar to the measured distribution of surface temperature of the semi-spherical solar collector (Figure 5).

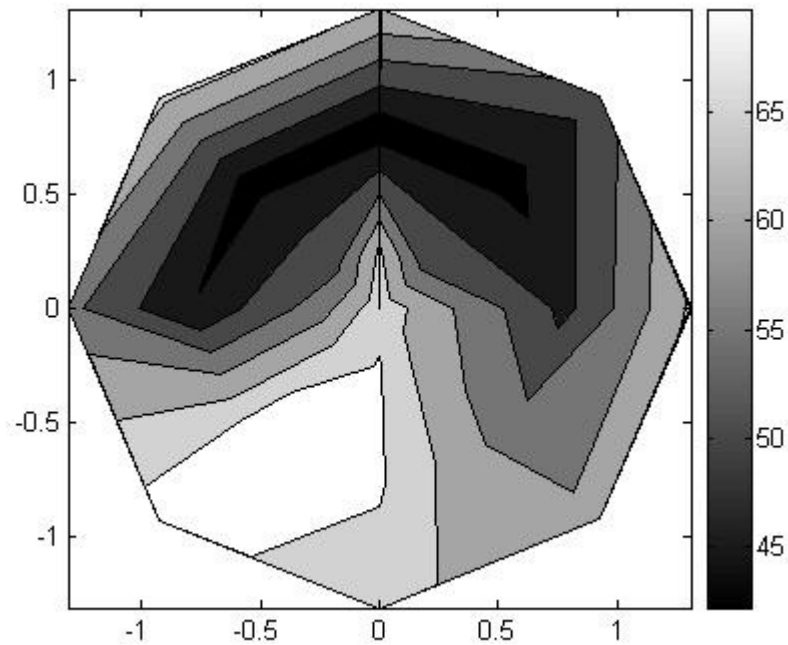


Figure 5. Distribution of surface temperature of semi-spherical solar collector at 17. June 2009, 13:00.

These results of calculations shows also good accordance with results of measurements of water heating using semi-spherical solar collector. These results are shown in Figure (6).

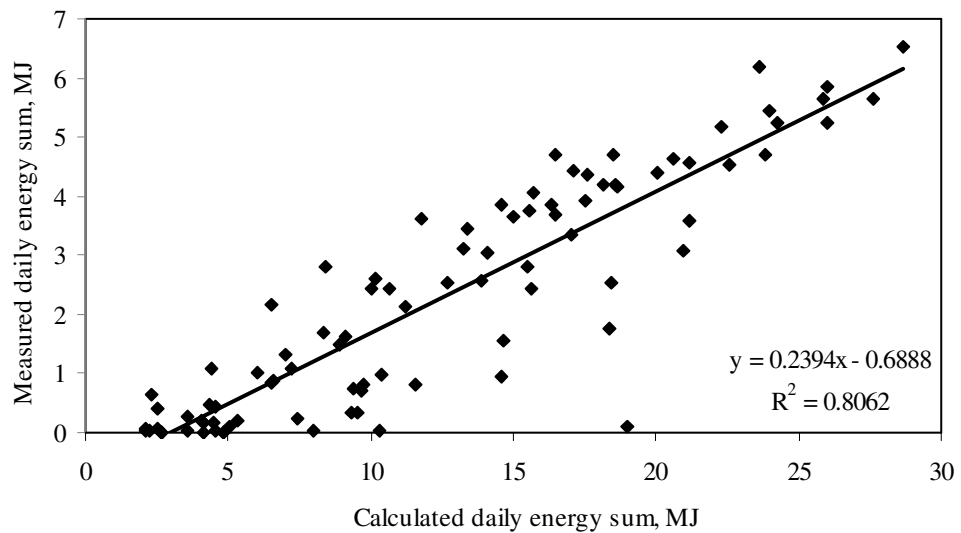


Figure 6. Calculated and measured daily energy sums of energy received by semi-spherical solar collector.

In this case slope of the best fit line 0.239 indicates not so much on accordance of the model, but rather the efficiency of the collector. The intercept -0.69 and coefficient of determination R^2 0.80 indicate good accordance between the model and experimental data.

Other way to calculate energy received by any surface is the method of the effective area (Pelece et.al. 2008^a). This is an area of the surface, what is visible from the sun (Figure 7), or the projection of the surface under consideration on plane perpendicular to solar rays.

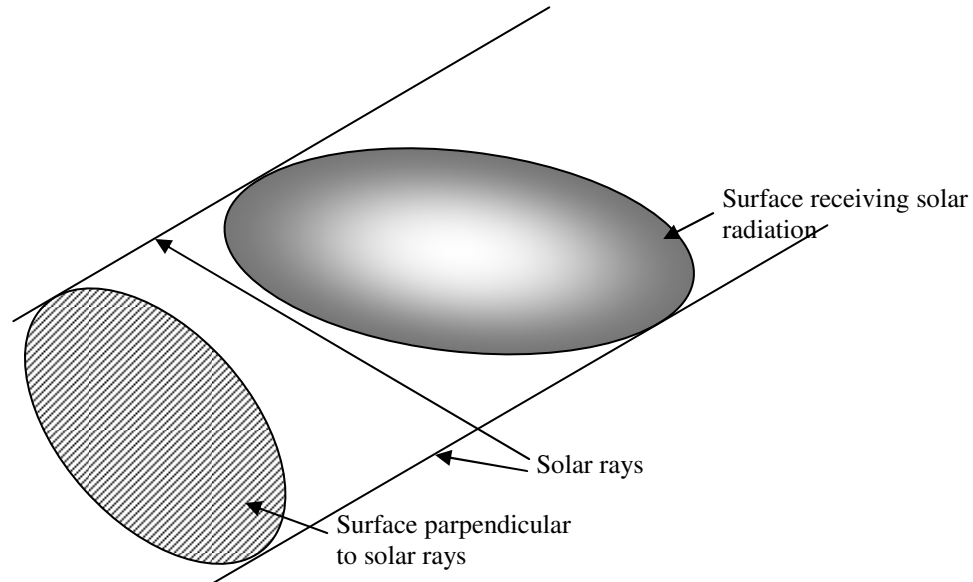


Figure 7. Effective area of the receiving surface.

Then received energy of the surface can be calculated as product of the beam energy and effective area of the receiving surface. The diffused radiation is considered to be invariant from direction.

This method is rather simple for comparison of several shapes of solar collectors, as well as several orientations of flat plate solar collector. Results of this comparison are given in table 1.

Table 1

Effective area and calculated received energy of several receiving surfaces

	Semi-spherical	Spherical	Cylindrical	Flat horizontal	Flat 34°	Flat 40°	Flat 56°
Radius, m	0.564	0.564	0.5				
Surface area, m ²	2.00	4.00	3.14	1	1	1	1
Mean effective area, m ²	0.74	1	1	0.5	0.48	0.47	0.41
Maximal effective area, m ²	0.9	1	1	0.83	1	0.99	0.92
Mean effective area, %	37	25	32	50	48	47	41
Energy, MJ	36	45	45	27.9	28.8	28	24.6

This table shows an effective area and theoretical energy gain at clear 22. Juny day of several solar collectors. The effective area is of course not only criteria for evaluation of the collector. Important is also full surface area of the collector because of heat loss from all area. For example, both spherical and cylindrical collectors have the effective area 1 m² (if axis of cylinder is perpendicular to solar rays) and therefore equal amount of received energy, but cylindrical collector has smallest full surface area and therefore smallest heat loss.

Another interesting question is on optimal tilt of flat plate solar collector. Many authors, for example, Hobbi and Siddiqui (2009) consider, that optimal tilt angle of the solar collector is equal to locations geographical latitude. Such opinion may be right if solar energy is used all year round, but in Latvia use of solar energy in winter is unlikely, therefore tilt angle must be smaler. Dependence of calculated energy gain at all season (from 1 March to 31 October) on tilt angle is shown in Figure 8.

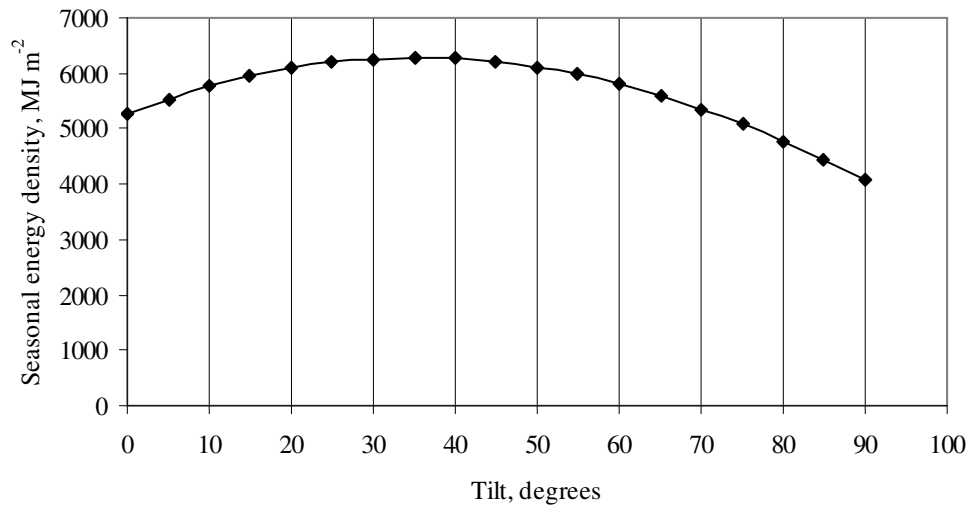


Figure 8. Dependence of calculated seasonal (1 March to 31 October) energy gain on collectors tilt angle.

This graph shows, that in Latvia optimal tilt angle of the flat plate collector is from 30° to 40°. But there can be some peculiarities depending on special needs of consumer.

Conclusions

1. A method for the forecast of the received energy of any surface taking into account nebulosity suitable for Latvia local conditions has been developed.
2. This method is usable for comparison of energy gain of several solar collectors.
3. Optimal tilt angle of flat solar collectors in Latvia is 30° to 40°.

Acknowledgement

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STABILIZED SOURCE OF VUV-SPECTRA FOR A NOVEL MEASURING DEVICE OF IODINE CONCENTRATIONS IN ATMOSPHERE AND COMPUTER MODELS OF ITS DEVELOPMENT

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Abstract

Article makes roundup on role and problems of iodine impact on Global atmospheric ecosystem, tells about significant project TOAST and novel instrument made for it, and shows samples how to solve typical RF electronics problems with lot of modelling tools.

Key words iodine, fluorescence, ozone, ICP lamp, Spice, circuit modelling

Introduction

The need to determine the iodine concentration in the atmosphere ought to be seen in the context of all halogen oxides and their role in the atmosphere. The interest in atmospheric halogen oxides rose in the 70-ies of the last century after *Krutzen P. J. 1970* landed on the idea of stratospheric ozone depletion by catalytic cycles and the subsequent evidence of the dominant role of halogen oxides in the processes *Stolarsky RS, Cicerone, R. J. 1974*. The subsequent evidence of halogen oxides causing the ozone hole in Antarctica *Farman J. C. et.al. 1985* caused a rapid increase of research in atmospheric and stratospheric photochemistry.

Although iodine is naturally occurring mainly in sea water, exploring its implications in the processes of MBL (Coastal Marine Boundary Layer) began only recently *Platt and Hönninger 2003, Carpenter 2003*.

Molecular iodine and its compounds issued from seaweeds after photolysis become a source of iodine atoms reacting with ozone to form iodine monoxide IO. Under field conditions I₂, IO, and other iodine compounds have so far been measured by instruments based on the DOAS. Satellite-based measurements of SCIAMACHY detect 20-30 pptv IO concentration scale *Saiz-Lopez et.al. 2007* (pptv = parts per trillion by volume).

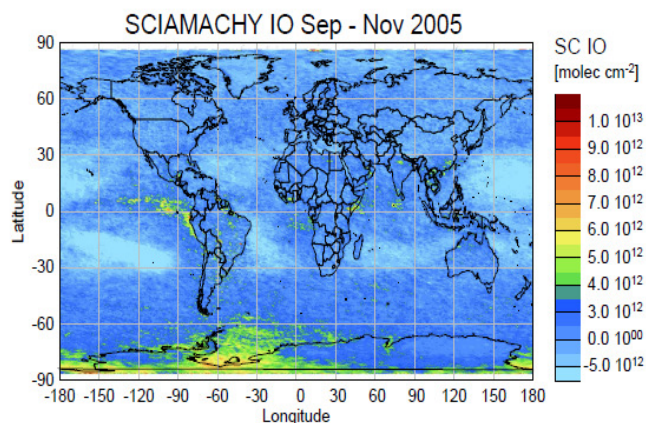


Fig.1. Iodine oxide concentrations from SCIAMACHY, the monthly average values Schoenhardt et.al. 2008

Figure 1 shows that the IO is also found in the Eastern tropical Pacific area. This higher IO concentration correlates with the so far unexplained ozone concentration decrease in the area. Strong upward air currents formed under certain weather conditions over the ocean in a warm area may raise the halogen-containing compounds from the troposphere to stratosphere. At the same time there is a mismatch between the individual concentration of ozone measurements and model calculations requiring a more detailed specification of halogens, including research of iodine and possible sources of it.

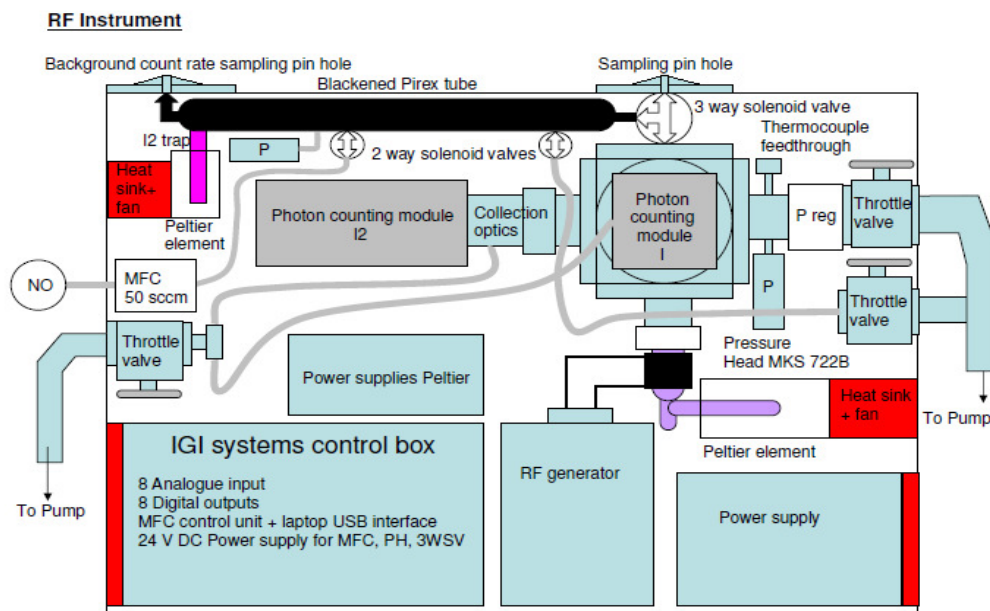


Fig. 2. Block diagram of RF unit for iodine detection

The TOST Project

A group from Toledo in Spain participates in a detailed study of atmospheric processes at the Eastern tropical Pacific region by a massive measurement campaign TOAST (*Tropical Ocean Atmosphere Study*) coordinated by the British National Centre for Atmospheric Science.

Our colleagues from the Atmospheric and Climate Research Laboratory (FGMA) in Spain are developing a novel device (Fig. 2-5) for field measurements of the vacuum ultraviolet (VUV) spectra of iodine. The device has to be equipped with a radiofrequency (RF) induced source of the iodine resonant band (Fig.6) developed by the group of Atmospheric and Chemical Physics of the Institute of Atomic Physics and Spectroscopy of the University of Latvia. The RF excitation is found to provide a narrower band, is more stable and cheaper compared with alternative microwave-induced VUV emission band.

So far, a number of field measurement methods of iodine compounds with DOAS has been used to average over space (the length of optical path), or averaging over time. Yet for detailed studies of iodine and its compounds the source and the process are required to provide detection of concentration locally and in a short time, within a few minutes at least.

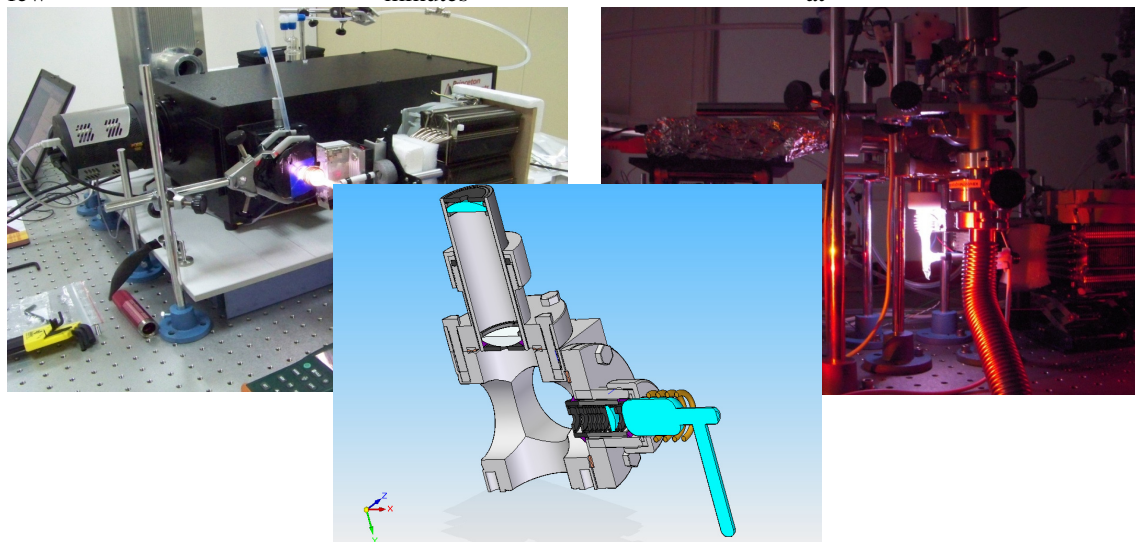


Fig. 3. With SolidEdge software designed RF connection to iodine cell

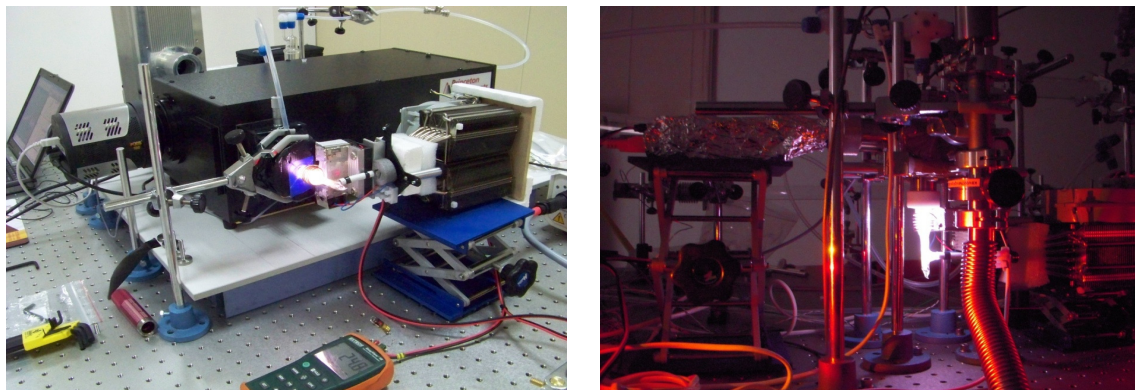


Fig. 4 and Fig. 5. Outlay of the cell

The first local atomic iodine concentration field measurements performed by the RF method of *Bale et al 2008* reached detection limit of 5.3 pptv. The installation used a resonance flow tube, which is relatively expensive and technically difficult under field conditions.

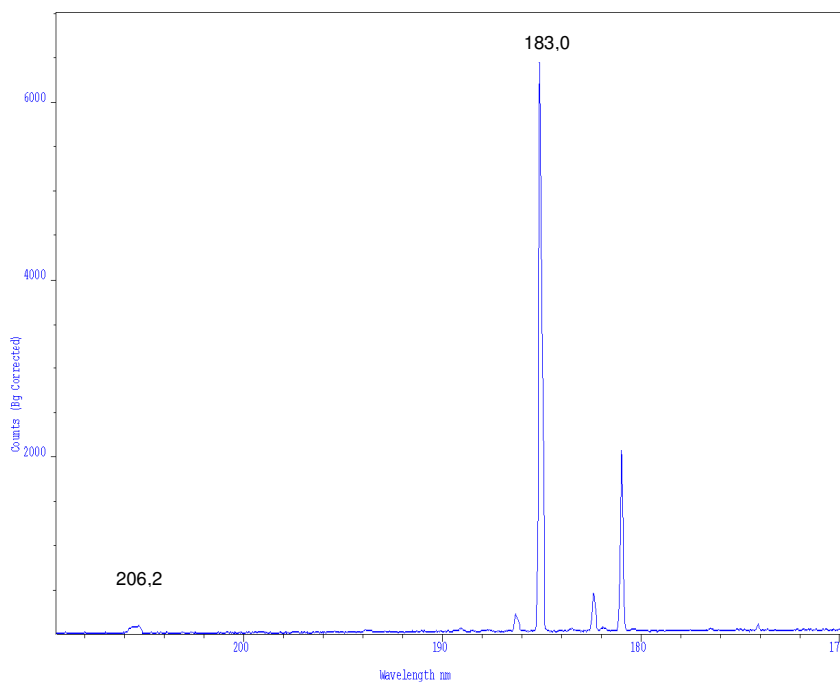


Fig. 6. VUV spectra of iodine at $T = -40\text{ }^{\circ}\text{C}$

Discussion. *The system of using resonance fluorescence for iodine detection*

A new unit headed by Dr. Alfonso Saiz-Lopez of the Laboratory for Atmospheric and Climate Science (FGMA) in Toledo, Spain, started research in September 2009. Being aware of the experience with iodine VUV resonance sources of the Institute of Atomic Physics and Spectroscopy of the University of Latvia he invited the latter to work on the new equipment for detection of iodine concentration under field conditions (Figure 2). The principle of resonance fluorescence detection has been offered by colleagues of Dr. Juan Carlos Gómez Martín in Engl (*C.S. Bale et al 2008*). Tasks set for the new device included measuring atomic iodine and the I_2 molecule concentrations (Fig. 7- 8), reducing the time of detection, and lowering detection threshold to the level of a few pptv. The Institute of Atomic Physics and Spectroscopy contributed to the project the source of the iodine resonance fluorescence radiation, the RF generator, and the cooling/temperature stabilization units.

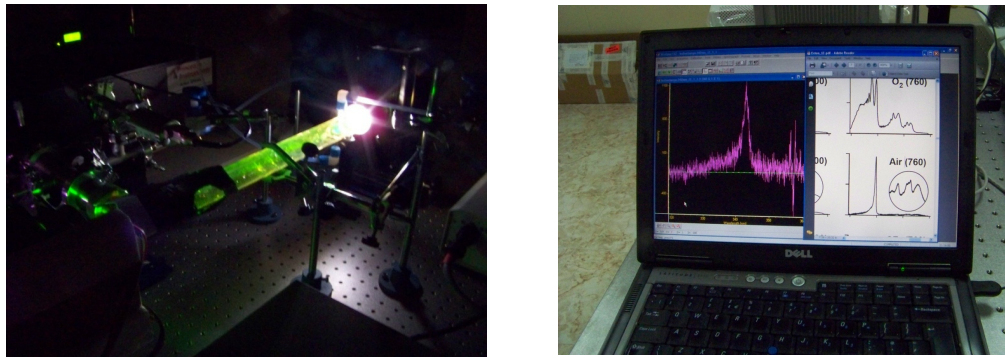


Fig. 7. and Fig. 8. Equipment overview with iodine and process of adjusting the registration

Problems and solutions of electronics

ICP Current-Voltage (load impedance) graph

For decades it has been believed that RF-discharge sources works in the E mode and H mode, the first being 'unnecessary', the second – desirable. However, the H without the E is impossible to achieve. This year we succed to find in `Gogle Books` a certain 10 years old book (Kim J.,1997) the chapter *Argon Results of Plasma Characteristics at 27 MHz* of which shows exact graphs for impedance matching.

At figure 9. yellow: RF oscillator incident Current-voltage characteristic, whose accurate analogy - a light bulb connection to the battery cell, causing the voltage dropdown, or "two regimes". For example, the minimum criteria being 65A and 8,5 V in case of argon @ 1 atm, the load resistance becomes by 4 orders higher at 10 Torr. Red – graph for small pressure, black – graph for large pressure.

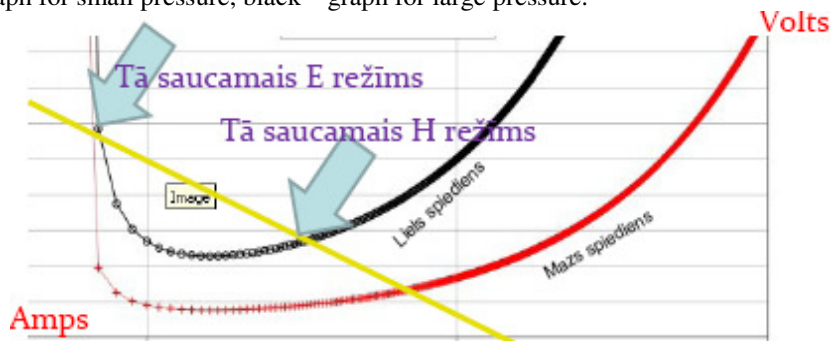


Fig. 9 . Load curve of the ICP lamp.

Serial vs. Parallel resonance and usage of SPICE™

If the ICP bulb is fed by parallel resonance, the stronger the lights the higher the circuit Quality factor. Thus, the bulb shines even stronger. Result - a difficult startup ending with short circuit. When feeding is made from a series resonance, the lamp starts from Q-fold increased voltage (many kV), but as Q diminishes, the elf-

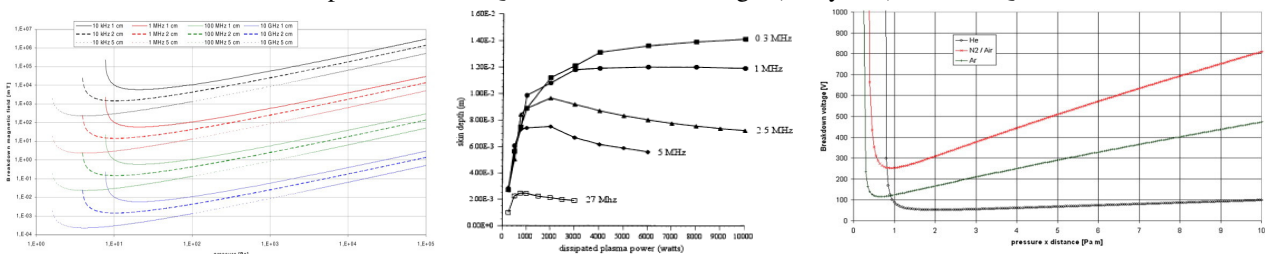


Fig. 10. Breakdown voltage of the magnetic mode v.s. argon pressure and other parameters (at fixed frequency and container radius).

© Elsevier BV (2008): Breakdown magnetic field in an inductively Coupled Plasma

© Karel Burm (1970), a Corus Research Development and Technology, CA Ijmuiden, Netherlands

ballasted working point is achieved at lower voltage, and power loss is minimal since the reactive power oscillations in the circuit fade mainly due the (active) load.

Therefore, the Clapp Oscillator schematics was chosen and modelled by *SPICE-LT* software. Since it is a freeware, capable and universal, it may be recommend to anyone analogue electronics constructor as much as a

pen or calculator to a student. It not only accelerates the finding of optimum parameters of design, but protects from errors caused by lack of experience allowing to make dozens of changes to the scheme and evaluate the impact short time by means of virtual measurements, such as charakteriograph, time, current and voltage oscillograms etc. Also it saves substantially on, sorry to suspect, burnt expensive HEXFET components. Unfortunately, the Spice database has no data on components the made in USSR, therefore, designpng circuits of such components one may use knowledge on twin Western counterparts or enter values by hand, which is labor-consuming. The components database means that data are given even with all the parasitic parameters.

Class E mode in Clapp oscillator

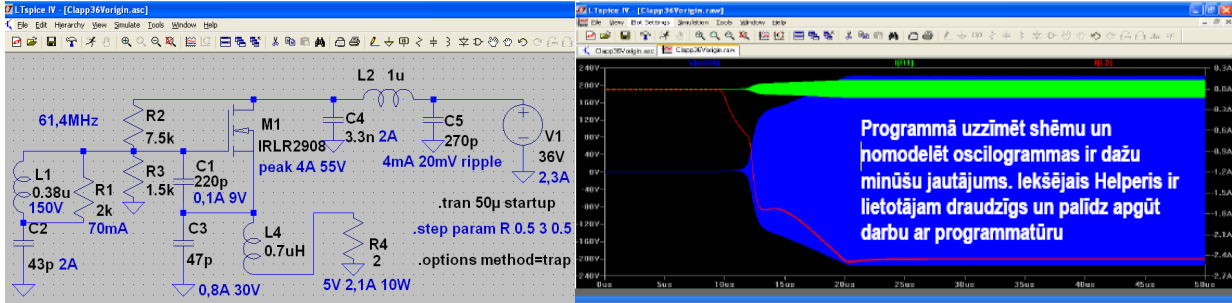


Fig. 11. SPICE main screen and the modelling results screen. Be aware, topology of the circuit shown in the picture and the nominals are fictional, the currently used into the product are confidential.

In the past, designers did not see amazing similarities between Clapp tank and the Class E output cascade. However, the choke mode is not only a way to set the Class E output cascade or traditional Clapp oscillator relations between tank, resonant and transfer capacities. Although the solution is choosing precisely the choke regime, there are opportunities to set choke into full or partial resonance with the tank capacity. In some applications it gives considerable advantage. L. Tonne™ freeware can be used to find class E circuit nominal data, thus useful for Clapp oscillator tank capacity modeling, allows to optimize output power, efficiency and squeeze up by a couple of times the operating frequency of output MOSFETs as normally it should be able

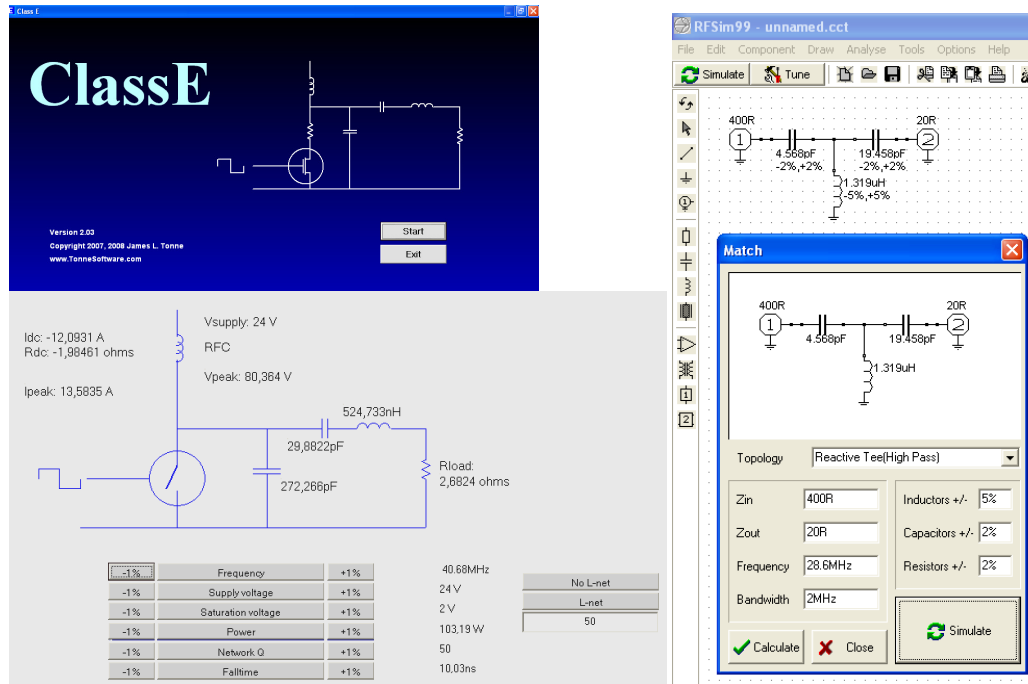


Fig. 12. Tonnes software operational windows.

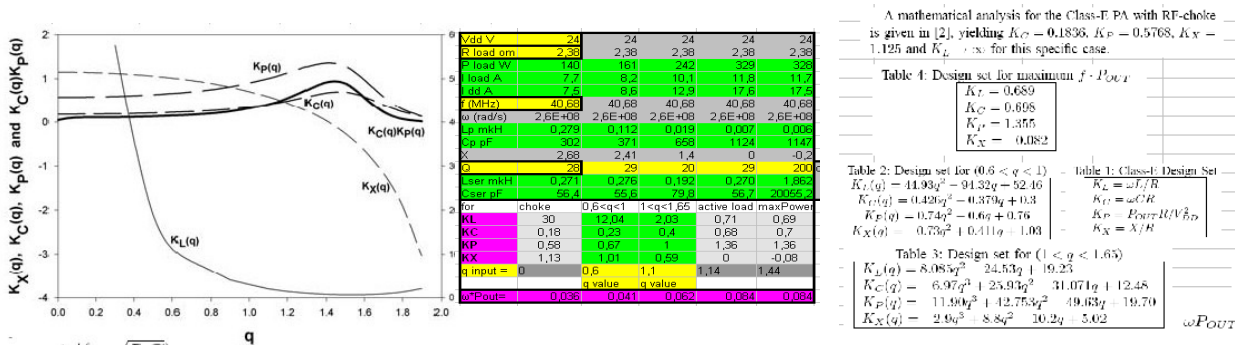


Fig. 13. Partial choke / resonant mode, depending on the constructive parameter q, and the effect on inductance and capacity required nominals. The Excel calculation matrix (input data yellow, output data green);

Facsimile of the calculation methodology and used symbols.

for(!). Since power IRF series HEXFET critical frequency is between 1 and 10 MHz, the fact that they were forced to work between 30 and 80 Mhz alone is an interesting experience. Since the loads are very critical to these estimates in the resonant contoure, the correct transform must be re-calculated between serial and parallel representations of the active resistivity. It is easy in the Excel environment using relation $R_{ser} \cdot R_{par} = X_L^2$.

E-class adjusting options

E-class steering system for the calculation is mathematically complicated and freshly evolved in electronics. Completest of calculation methods we know can be found in *Mustafa Acar, Anne Johan Annemie, Bram Nauta: The Design Equations for Class-E Power Amplifier, University of Twente, Netherlands*. On this basis we created the Excel calculation template with adjustable q values, however later we chose $q = 0$. We think this is a competitive modelling tool comparing to Tonne software.

popularly: what is the output cascade modes

Class A: conduction angle $\Theta = 360^\circ$ i.e., active element of all time (more or less) is half-opened. Therefore cascade is completely linear, but of very low efficiency.

Class B: conduction angle $\Theta = 180^\circ$ i.e., active element half of the time is in linear mode, and closed the other half. For push-pull schemes it does not make any problem. However, when the signal is close to zero, the complementary transistor suffers from crossover distortions.

Class AB: Same as B, only to reduce the crossover distortions the biasing is set to a small `zero` current, hence conduction angle of $\sim 182 \dots 185^\circ$. Depending on the "zero" current amount can be used indices AB1, AB2.

Class C: Runs less than 50% of the time, can achieve the efficiency above 90% (such as used at megaphones). Distortions are inevitable. For RF uses the signal form is improved by output impedance equalisation network, so there is the best C-class application domain. Signal polarity only determines whether a transistor opens or closes, but the input signal intensity is irrelevant. There exist tuned and untuned C-class versions (in the Figure untuned). Distortions are reduced by reactive (LC) load, setting the average level at `zero` (therefore, named a `clammer`). At the central frequency of the resonance curve distortions are smallest.

Class D: or `switching Amplifier` at pulsed mode. Distinguished by its superior efficiency over 90%. Active elements have only two positions - fully off or fully on. Analogue output signal is formed by the PWM (pulse width modulation), or alternatively by a sigma-delta modulation to improve both the distortions and efficiency.

Class G / Class H: The Advanced Class D for heavy duty equipment with internal power supply voltage is step-like quantified or linearly changed as the input signal changes. Such kiloWatt equipment minimizes the end transistors warmup.

Class E / Class F: Specific RF applications, with importance of energy efficiency. It is used for L or Pi impedance tuning network for signal harmonics. They can be considered a Class C subversion.

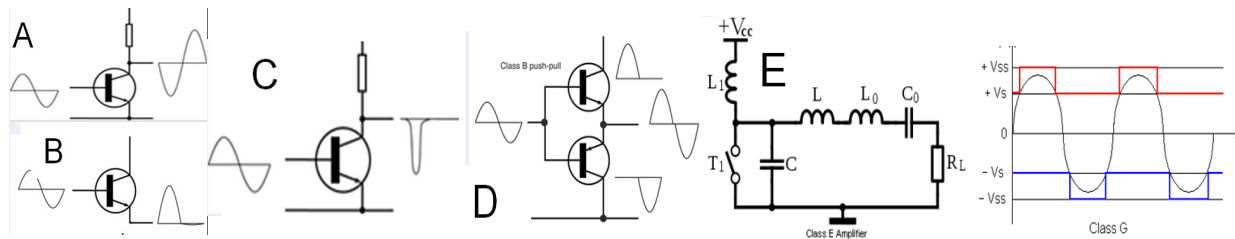


Fig. 14. Output cascade regimes, from A to G.

Class F and even harmonic problem: at E-class pushpull cascade, even harmonics neutralize themselves. Since the meander consisting only odd harmonics (so the Fourier spectral analysis) the Class D cascade in output filter blocks all harmonics, thus the higher frequencies see `loose load`, therefore just a small input signal of higher frequency generates a large output voltage, i.e. distortions. While F class allows for transistor parasitic parameters to be optimized for the entire system as a whole, thus harmonics as the source have a high impedance giving a small voltage in the output. Then the first harmonic appears a quite clean sinusoid. Therefore, the output filter should be set as the leading below the cut-off frequency, and as cutting/reflecting above it. If the conduction angle is below 50%, then it is possible to amplify AM (amplitude modulated) signal, only – as degradation of meandric form begins, transistor will heat up.

Class E is used for a reasonable amount of second harmonics, which reduces pushpull circuit blow-through currents. Second harmonics power flows from the load to the transistor, in contrast to how it is in conventional circuits. Essentially, a class E cascade is F cascade with simplified output filter and larger distortions. It was invented in 1972 by Nathan O. Sokal and Alan D. Sokal and described the 1975th.

RF-Sim99 modelware for impedance matching network design

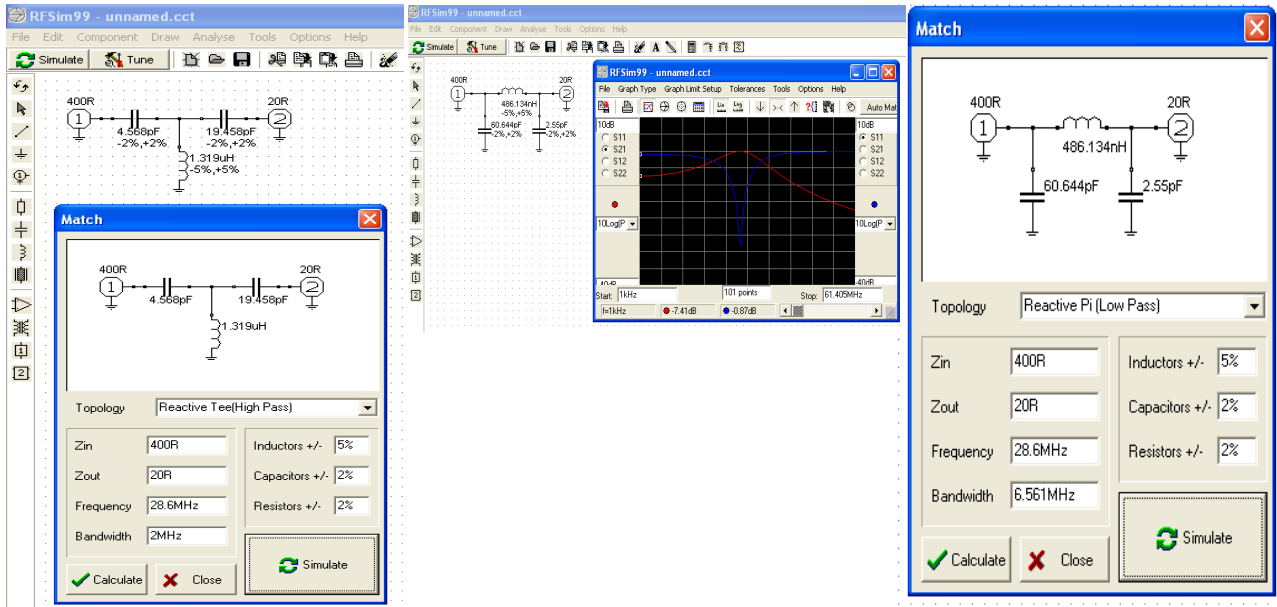


Fig. 15. RF Sim99 menu windows at two examples.

RF modeling is Sim99 freeware for modelling RF reflection S parameter system thus being very handy for impedance matching network calculation. Although the S parameters of their mathematical nontriviality once undeservedly half-forgotten, now it is intuitively easy to use that system for fast and accurate RF and UHF range specific issues modeling tool seriously competing with Spice.

Optimization and calculations of coiled elements :

High power RF coils for ICP are not easy to check with ordinary bridge, ought to be made for accuracy of tens of nanohenrys, but their accuracy impacts on the circuit work, especially if bigger Q (quality factor) are used. Thus, it is very important to figure out exactly coil inductance and coil dimensions to optimize the Q. Again, we set up Excel worksheet for optimisation, but a more handy match with follow-up measurements are shown with the freeware Induct v.1.0 and companion optimization program found at the Volgograd ham radio website, by which and the Solver techniques optimizes coil wiring data depending on the coil dimensions (or vice versa) at an assigned inductance. In our case, only slightly altering the dimensions of constructive, managed to maximize Q for nearly tenfold. For inductance measure we tried two methods – measure the frequency of simple oscillator made on be measured coil, but transistor parasitic capacitance played too great a role. A better way was to use a heterodyne indicator of resonance connected to the frequency meter – it is a great, inexpensive and very accurate method.

Transistor working point simulation by the App-CAD

The equipment will work under unexpected thermal conditions as in the tropics, the thermal stability of circuit could tip the whole project, putting the ocean liner drive across half the world back for spare parts. However, calculation by hand in this area is very time-consuming.

The Agilent developed freeware AppCAD is a unique tool for almost all popular biasing techniques allowing to enter a series of datasheet figures and to model scenarios: what will happen if the scheme of given nominals is brought to xy degrees Centigrade. And allows to realize the opposite order, what nominals should be used let work-point does not drift away more than xz per cent.

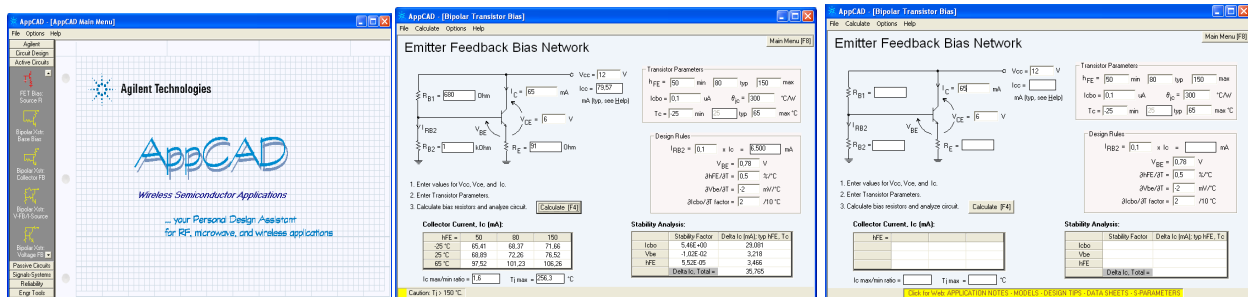


Fig. 16. AppCAD windows and menus.

Thermal modeling of on-line (radiators)

Our cooling equipment should not use the classic "tail" cooling system with liquid nitrogen, in a distant voyage and long time to keep a bunch of Dewars would be too unhandy. When considering whether to use the freezer, for size criterion was selected Peltier element, in particular because of the relatively reasonable price between 100 and 200 euro is a commercially available very strong elements of 106 to 111 degree temperature difference for 20 to 300 W cooling power. However, after first experiments occurred problem - it appears such Peltiers have unusually high energy flux density per unit area. This half of kilowatt is to be channeled from a few square centimeters, without having a large temperature drop.

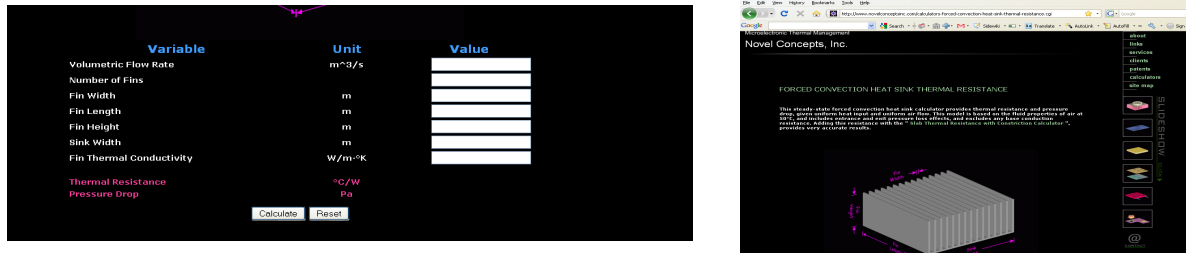


Fig. 17. Novelconcept calculator menu.

If the worst expectation is +60 °C daytime shade temperature and our aim is minus 50 °C, the radiator should not be wasting more than 6 degrees. Namely, the thermal spreading resistance of the radiator must be very extreme. For simulations we used two elegant heat modeling programs. To own them one must payed but online they can be used free at: www.novelconceptsinc.com/Calculators-Forced-convection-heat-Sink-thermal-resistance.cgi

This calculator has a nice advantage allowing to estimate the required fan end-pressure and the aerodynamic resistance of blow. Another, similar, but more detailed in results of fan flow vs. The cooling effect and more likely to consider the radiator shape and size specifics is found at: www.frigprim.com/online/natconv_heatsink.html and www.frigprim.com/online/forcedconv_heatsink.html. This calculator allows modeling of both gravity convection and forced flow regimes.

However, experimentally we proved that even big enough radiator can not provide a sufficiently small contact area, and results in higher losses in the transition than Peltier is capable of producing. Namely, the tip initially cooled after a time is going to melt. Therefore, after an appropriate modelling of the data we chose for factory-made cooling module with six heatpipes, made for supesize multi-core computer processors, after being equipped with a more powerful fan. Special patented alloy, shiny glanced surface, beryllium paste, and heatpipe effects brought together was sufficient, within a few degrees drop on the radiator we got resistance of 0.04 °C/W for 380 W thermal flow.

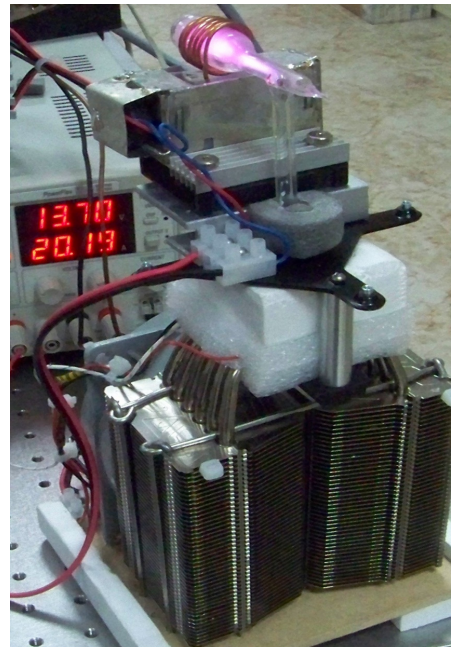
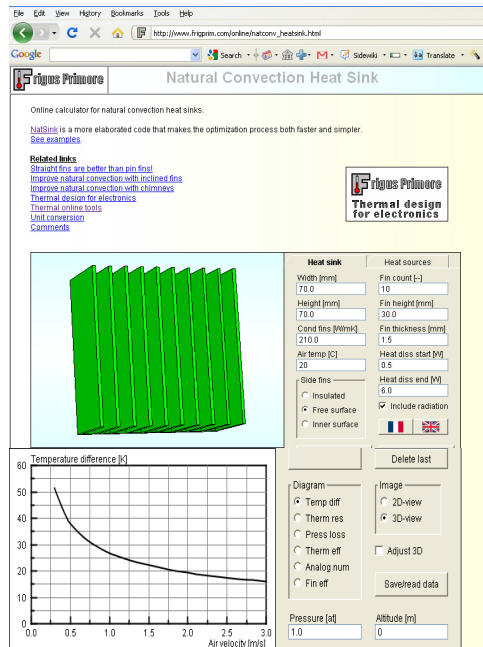


Fig. 18. Prim calculator windows for gravity convection mode and ICP bulb "tail" submerged in cryo-camera, and the radiator.

PID controller as the last problem

The technical challenge was to stabilize the temperature of the bulb "tail" at minus 40 °C with a maximum drift of ± 0.1 °C. Initially, as the thermal inertia did not seem large, we tried elementary "bang-bang" type regulator with hysteresis. However, the accuracy better than 20 degrees was impossible to achieve, just a complete fiasco. Probable reason is that sensor weight within a few milligrams is comparable with the weight of tail, tens of milligrams. Thus, the sensor system itself brings in a significant time delay. Therefore, acquiring a manufactured adaptive PID controller is the best choice. It has programmable modes with a choice between on/off mode and proportional quasi-analogue character. Whereas 14 Ampere steering would require another overhaul radiator, we started trying out a less accurate (relay) mode. And it turned out that the accuracy is close enough, although the initial stage, while the controller days-long "learned" correctly steer the load. In conclusion: never make themselves something that can be bought for just 39 USD and is excellent and may be implied the regulation accuracy being increased, if someone needs, at least tenfold, which 20 years ago seemed an unrealistic fantasy.

Results / Conclusions

A new, stable, inexpensive, easy repeatable RF power source is elaborated developing 10 to 30 W power at ~ 100 MHz for 12 , 24 or 36 V power source and is sufficiently robust for field conditions, capable for ignition startup by several kilovolts, which is sufficient in almost all reference spectra calibration sources developed at the Institute of Atomic Physics and Spectroscopy (as seen in the introductory part of the article, the chemical elements emitting spectral bands have different ignition potentials).

A new iodine vapor pressure control (cooling) system is elaborated, which operating within the accuracy of tenths of centigrade by forced convection in six Peltier loaded heatpipes the regulation of which is based on use of an adaptive PID controller an external power booster and does not require water,.

Summarized methodology and many of the best possible tools for computer modeling of the ICP and RF oscillator calculation, allowing rapid adjustment of the circuit parameters for almost any given parameter of the light source.

The manufactured unit installed in the iodine measurer of the University of Toledo (Spain) will serve to study the Global Warming Effect for better understanding and (hopefully) better preventive strategies. A similar topology is used to elaborate a kilowatt power ICP argon melting device for Australian scientific projects.

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THERMOPHYSICAL PROPERTIES OF SAMPLES MADE OF THE MIXTURE OF SAWDUST AND SAPROPEL

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Abstract

Thermophysical properties of samples made of the mixture of sawdust and sapropel have been investigated. It is established that heat conductivity, density and capacity of absorption are proportional to the amount of sapropel in forming mass of samples. While applying linear regressive analysis it has been established that the amount of sapropel has larger influence on the average of density and heat conductivity (standardized coefficients $Beta=0,913$ and $Beta=0,852$) than on the humidity of a sample ($Beta=0,497$ and $Beta=0,501$), and keeping above the water has larger influence on absorption ($Beta=0,833$) than the amount of sapropel in a sample ($Beta=0,256$).

Keywords. *Heat conductivity, density, capacity of absorption, sapropel*

Introduction

Sapropel can be widely used in various fields of life: chemical industry, medicine, construction, etc. Possibilities of its usage in the production of building materials have been investigated in Belarus (Вирясов, 1997), Latvia (Бракш, 1971), Lithuania (Gurklienė, 2004; Gurskis, 1996, 1999, 2000, 2002, 2004; Iljins, 2005; Mandeikytė, 1997; Žvironaitė, 1997), and Russia (Лопотко, 1985).

It has been established that organic sapropel is the most promising of all because of its sticky properties (Navickas, 2005; Курзо, 2005) that are determined by free amino acids and the structure of humus acids molecules. While increasing the amount of hydrolyzed molecules the ramification of peripheral part also increases. Therefore, strong connections are comprised in forming production and the molecules of humus acids are becoming more and more elastic; they involve hard particles of forming material and provide stability (Курзо, 2005).

In the process of manufacturing various additives were grinded down, sticky materials were added and dry products were heated (Вирясов, 1997; Mandeikytė, 1997; Žvironaitė, 1997). Such process enhances the cost of production.

The purpose of our work was to investigate the dependence of thermophysical properties on the amount of sapropel (25, 30, 35 and 40 %) in samples made of sawdust and sapropel.

Methods of investigation

Desiccated sawdust and organic sapropel (further – sapropel) taken from Dobilia Lake Kaunas District has been used in the production of samples. Dry substance made about three per cent of the mixture of sapropel and water. Sapropel has got $pH=5,9$, ash-content 58%, content: organic substance – 79,8-90,8% (average 85,3%); chemical composition of ash %: SiO_2 – 13,1, Al_2O_3 – 1,5, Fe_2O_3 – 2,3, CaO – 2,6, Mg – 0,5, SO_3 – 0,8, N – 3,3, P_2O_5 – 0,4, K_2O – 0,3. Metals have been found in sapropel. Their amount in dry sapropel are as follow (mg/kg): Pb – 4-9, Cd – 0,3-0,9, Ni – 5-10, Cr – 3-9, Zn – 49-50, Cu – 3,8-9,8, Mn – 45-75 (Katkevičius et al, 1998).

The plates having measurements of sides equal to 102x102 mm and thickness 12 – 14 mm (dependently on the amount of sapropel) were made from the mixture of sawdust and sapropel. Digital analytical scales EK-610i with preciseness of 0.01 g have been used to weigh substances and formed samples.

On purpose to establish the amount dry substance in sapropel it was heated at the temperature of 105 °C. Sawdust has also been dried at the same temperature. Forming mass of samples has been prepared applying sapropel with 90% of relative humidity. The amount of dry sapropel in samples amounted to 25, 30, 35 and 40%. The plates were pressed 15 seconds applying universal experimental apparatus R-5 applying 1.4 MPa pressure. Samples taken from matrices were dried at room temperature till they reach constant mass. Dried samples were put into impermeable vessels and cooled to 20 °C. Both sides of the surface of dried samples was polished keeping constant thickness because of good contact between the samples and horizontal isothermal plates of heat conductivity meter at two different temperatures (35 °C and 30 °C).

After that the samples were kept in a thermostat above water at temperature 32 °C for 9 days, and were being measured each 24 hours till the mass of samples became fixed (Navickas et al, 2005).

Later the dependence of heat conductivity on absolute humidity of samples (further – humidity) was investigated. Heat conductivity of each sample was measured 9 times in a day. The samples were weighted before each measurement and after it, and their humidity was measured.

Heat conductivity of samples was measured applying calorimetrical method. The measurements were carried out using heat conductivity meter FOX 200 from Laser Comp Company (Kasperūnaitė et al, 2009). Then density of samples was established. Samples were dried at temperature 105 °C, weighted on air and coloured with water-proof coating spraying it on surfaces. After desiccation the samples were weighted on air and in water and the density of samples was calculated applying Archimedes's principle. The package of statistic programmes SPSS-15 has been used in the linear regressive analysis of investigation results.

Results of investigation

It was established that the amount of sapropel makes influence on density of the samples made of the mixture of sawdust and sapropel (Fig.1).

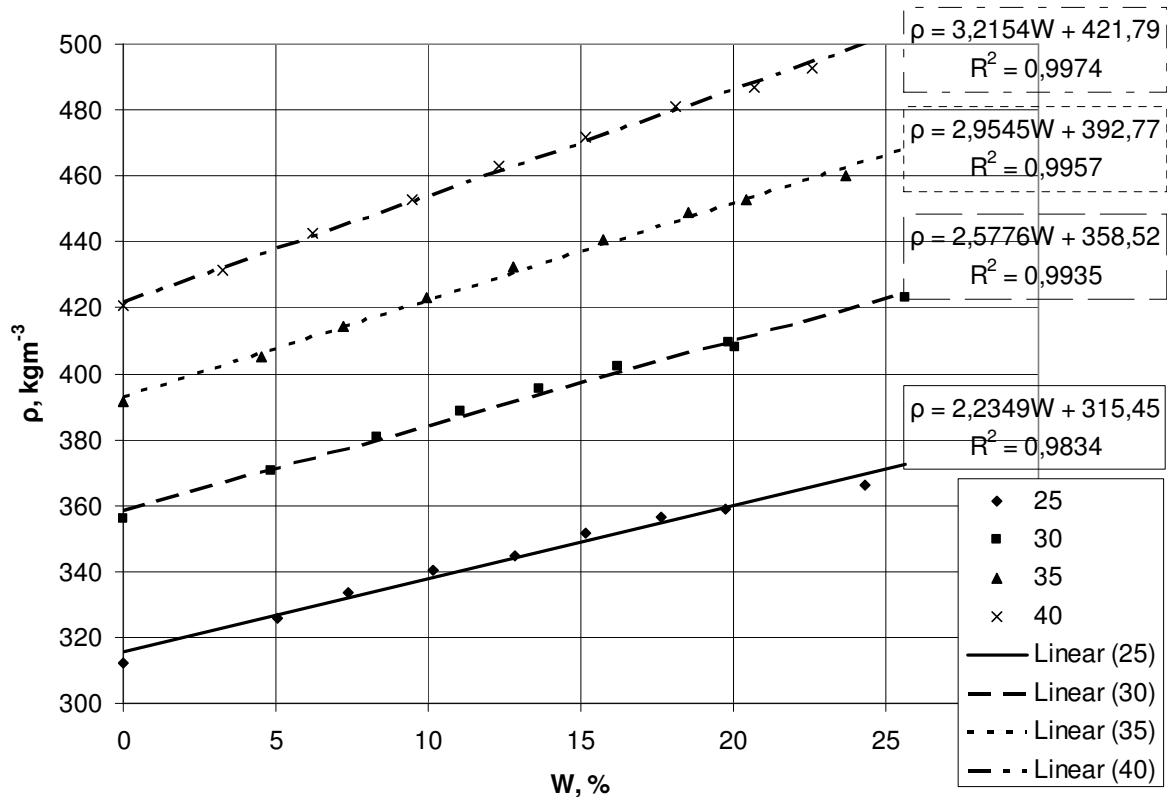


Fig.1. The dependence of the density of a sample on its humidity when the amount of sapropel is different in forming mass: 25 – 25% sapropel, 30 – 30% sapropel, 35 – 35% sapropel, 40 – 40% sapropel. (25), (30), (35) and (40) – trendlines, calculated according to the line equation for dependencies 25, 30, 35 and 40 respectively.

From the presented results it can be seen that when absolute humidity of samples (further – sample humidity) increases, the density of samples increases in a linear way (the coefficient of determination in the equation on the above-mentioned dependence is larger than 0,98). The larger amount of sapropel in a sample is, the more density depends on sample humidity. It can be explained by the geometrical dependence of samples on the amount and humidity of sapropel (Navickas, 2005).

The results of the influence of the amount of sapropel and the humidity of a sample on the average of density of samples are presented in Table 1.

Table 1. The influence of the amount of sapropel and the humidity of a sample on the average of density of samples

Factors	Coefficients	Non-standardized coefficients	Standardized coefficients	p
		B	Beta	
Constant		115,494	-	0,000
The amount of sapropel		7,883	0,913	0,000
The humidity of a sample		2,773	0,427	0,000

The coefficient of determination of a model is $R^2 = 0,990$. It proves that 99,0% of density scattering can be explained according to the model of linear regression. The amount of sapropel and humidity of samples are statistically significant to the average of density ($p < 0,001$). The humidity of samples influences average of density less (Beta = 0,427) than the amount of sapropel in samples (Beta = 0,913). Turning non-standardized coefficients to advantage a linear equation of regression for the prognosis of sample density ρ has been got:

$$\rho = 115,494 + 7,883x + 2,773W . \quad (1)$$

Here x – the amount of sapropel in samples %;

W – the humidity of samples %.

The dependence of heat conductivity λ on the humidity of sample W when the amount of sapropel differs is presented in Fig.2. It can be observed that when the humidity of samples increases, heat conductivity increases in a linear mode (the coefficient of determination R^2 changes in the range of 0,9607 – 0,9944). The speed of heat conductivity growth ($\Delta\lambda/\Delta W$) depends on the humidity of a sample. Calculations proved that in the interval of 10 – 15% humidity it is minimal ($3,5 \cdot 10^{-4} \text{ Wm}^{-1}\text{K}^{-1}\%^{-1}$). When the amount of humidity differs from the one mentioned above, the speed increases. The larger amount of sapropel, the larger is the growth of speed. It is believed that when the amount of humidity is large ($W > 15\%$), diffusion of water vapour and transport of secret heat start; whereas, when the amount of humidity is inconsiderable heat conductivity decreases regarding the slowdown of heat transport from particle to particle because of reduced heat contact among particles.

The amount of sapropel influences heat conductivity irregularly. Fig.2 presents that the minimal influence of sapropel on the speed alteration of heat conductivity is observed when 25 – 30 % of it is worked into a sample (for dry samples $\Delta\lambda/\Delta x = 3,2 \cdot 10^{-4} \text{ Wm}^{-1}\text{K}^{-1}\%^{-1}$). The greatest influence of sapropel on the speed alteration of heat conductivity is observed when 30 – 35% of it is worked into a sample ($\Delta\lambda/\Delta x = 1,4 \cdot 10^{-3} \text{ Wm}^{-1}\text{K}^{-1}\%^{-1}$). Further increasing the amount of sapropel from 35 to 40 % the influence of this additive $\Delta\lambda/\Delta x$ decreases ($1,0 \cdot 10^{-3} \text{ Wm}^{-1}\text{K}^{-1}\%^{-1}$).

The results of linear regressive analysis how the amount of sapropel and the humidity of a sample influence heat conductivity are presented in Table 2.

Table 2. The influence of the amount of sapropel and the humidity of a sample on heat conductivity

Factors	Coefficients	Non-standardized coefficients	Standardized coefficients	p
		B	Beta	
Constant		0,022	-	
The amount of sapropel		0,001	0,852	0,000
The humidity of a sample		0,001	0,501	0,000

The coefficient of determination of a model is $R^2 = 0,946$. It proves that 94,6% of heat conductivity scattering can be explained according to the model of linear regression. The amount of sapropel and the humidity of samples are statistically significant to the average of heat conductivity ($p < 0,001$). The humidity of samples influences the average of heat conductivity less (Beta = 0,501) than the amount of sapropel in samples (Beta = 0,852). It can be seen that the humidity of samples and the amount of sapropel are slightly less significant to heat conductivity than to the density of samples. Applying non-standardized coefficients a linear regression equation to the prognosis of heat conductivity λ is got:

$$\lambda = 0,022 + 0,001x + 0,001W . \quad (2)$$

here x – the amount of sapropel in samples %;

W – the humidity of samples %.

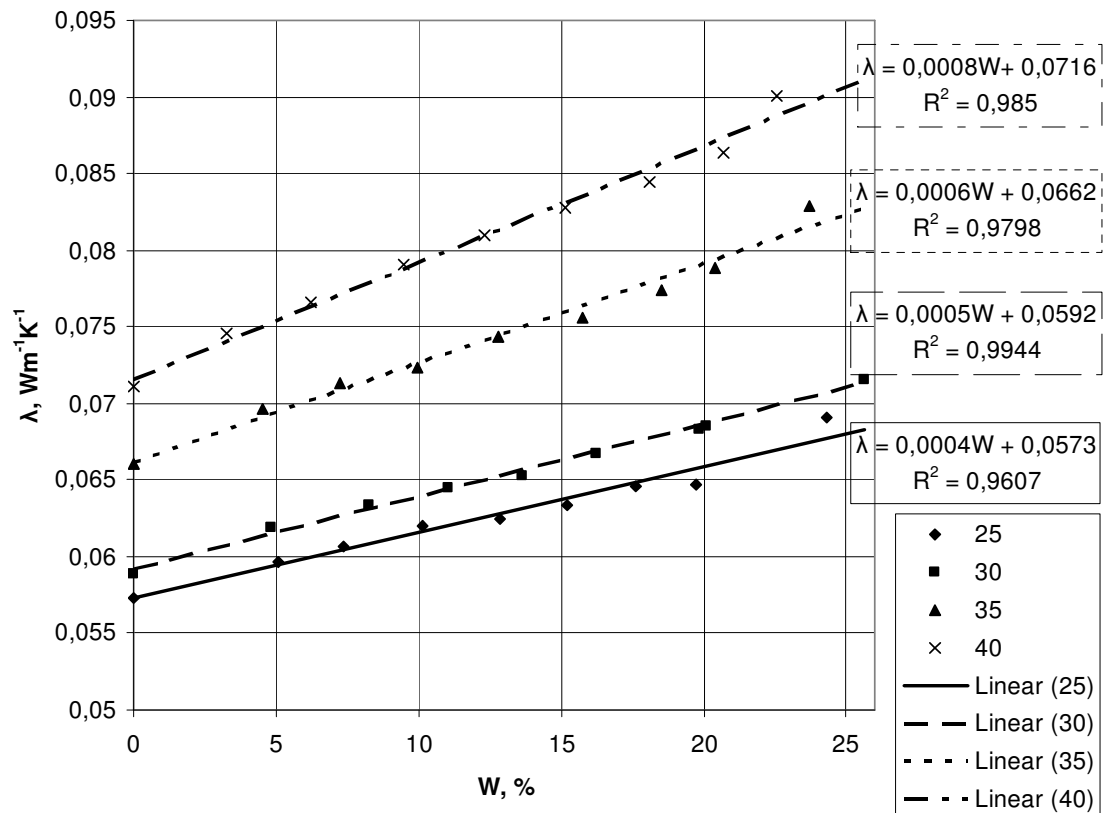


Fig.2. The dependence of heat conductivity λ on the humidity of a sample W , at 25, 30, 35 and 40% of the amount of sapropel: 25 – 25% sapropel, 30 – 30% sapropel, 35 – 35% sapropel, 40 – 40% sapropel. (25), (30), (35) and (40) are trend lines, calculated according to the line equation for dependencies 25, 30, 35 and 40 respectively.

After analysing the dependence of heat conductivity on the density of samples it has been established that when the amount of sapropel is 30 – 40 % and when their humidity changes from 0 to 25 %, this dependence is expressed by linear equation in which the coefficient of determination is $R^2 = 0,986$. The results of water vapour absorption are presented in Fig.3.

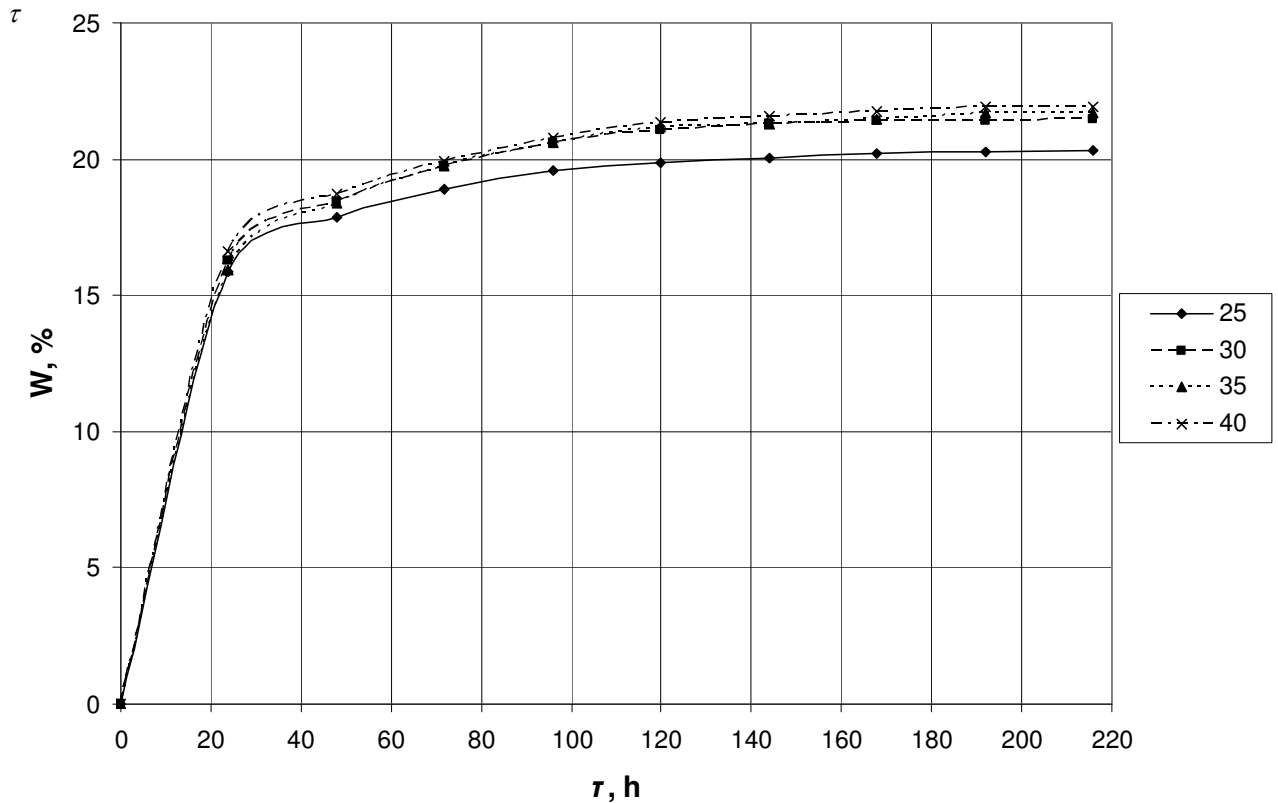


Fig.3. The dependence of the humidity of a sample W on the duration of keeping it above water τ . The amount of sapropel in samples: 25 – 25 % sapropel, 30 – 30 % sapropel, 35 – 35 % sapropel, 40 – 40 % sapropel

It can be seen that the largest capacity of absorption $\Delta W / \Delta \tau$ has been observed during the first day. Later the capacity of absorption is slowing down approaching to the condition of saturation. The capacity of absorption is proportional to the amount of sapropel in a sample, and this dependence is the most-significant when the amount of sapropel changes from 25 to 30%. It is believed that such change of absorption capacity can be related to the lessening of capillaries diameter and to the alternation of their change. The results of linear regressive analysis of the influence of the amount of sapropel and the humidity of samples on the average of absorption capacity of samples are presented in Table 3.

Table 3. The influence of the amount of sapropel and the humidity of a sample on the absorption capacity of a sample

Factors	Coefficients	Non-standardized coefficients	Standardized coefficients	p
		B	Beta	
Constant		14,663	-	0,000
The amount of sapropel		0,079	0,256	0,005
Duration of absorption		0,023	0,833	0,000

The amount of sapropel and the duration of keeping above water (absorption) are statistically significant to the average of absorption capacity ($p < 0,01$). The amount of sapropel is significant to a lesser degree on the average of absorption capacity (Beta = 0,256) than the duration of keeping above water (Beta = 0,833). The coefficient of determination of a model is $R^2 = 0,745$. It proves that 74,5% of absorption capacity scattering of a sample can be explained applying the model of linear regression.

Findings:

1. The density of samples made of sapropel and sawdust is proportional to the amount of sapropel and the humidity of a sample.
2. The amount of sapropel has larger influence on the average of the density of samples than the humidity of samples has (standardized coefficients Beta are 0,913 and 0,427 respectively).

3. The humidity of samples has smaller influence on heat conductivity than the amount of sapropel has (standardized coefficients Beta are 0,501 and 0,852).
4. The dependence of samples made of the mixture of sapropel and sawdust with the amount of sapropel 30 – 40 % with changeable humidity from 0 to 25 % on the density is described applying linear equation, which has the coefficient of determination $R^2 = 0,986$.

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THE USE OF APPLIED INFORMATION AND COMMUNICATION TECHNOLOGY IN TEACHING PHYSICS AT SECONDARY SCHOOL.

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Contemporary education system (also secondary education) cannot be imagined without the extensive use of information technology.

One of the possibilities how to provide learners with the better understanding of the theoretical knowledge is to use information technology in

- Explaining the new material
- A pupil's self-studying process
- Doing laboratory and practical work
- Making virtual experiments
- Working out research papers
- Solving tasks
- Making presentations

The use of information technology in physics lessons makes the lessons more attractive for the following reasons:

- Pupils are able to visualize the teacher's explanations;
- It is possible to go back to some drawing, illustration, formula, task solving or another explanation;
- Easy to demonstrate the pictures of different processes, equipment and phenomena etc. It is easy and simple to show pictures, carry out laboratory work and experiments
- There is no need to write formulas, draw pictures etc. on the board
- It is possible to solve tasks step by step , letting pupils find the solving process themselves and then check it using the screen of the projector;
- It is possible to get fast information in tables and schemes necessary for solving tasks or comparing different physical phenomena;
- By the help of Hyperlinks intensively use the Internet and CD resources about the corresponding theme
- Possibility to carry out virtual laboratory work
- The learning process can be actualized and activated by the use of interactive boards and remote controls
- It is possible to switch on relaxing elements if necessary.

This teaching method could also have negative effects:

- Pupils do not get the right impression about the accomplishment process of a drawing or scheme if it is shown ready made.
- Some pupils could understand better when listening to the teacher's presentation.
- Pupils can have problems with eyesight.

THE USE OF MATHEMATICAL PHYSICS IN SOLVING ENGINEERING PROBLEMS

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Abstract.

The article deals with the problem solving of mathematical physics using the variable separation method optimizing heating element – heating wire coil or tube layout heated with electricity or hot water in housing of concrete heating panel. Distribution of heat over the work surface of the panel at different position coordinates of heating elements was calculated, and using MS Solver software search process of coordinates of heating elements was automated, on condition that the temperature distribution over the work surface of the heating panel is even.

Keywords: separation of variables method, heating distribution, MS Solver

Introduction

Nowadays due to progress in computer hardware performance mathematical physics plays ever bigger role in description of various physical processes what was not feasible in the previous decades because of the large computational workload and insufficient speed of calculations.

Solution of problems of mathematical physics can be found both numerically and analytically. Although application of analytical methods has a number of significant restrictions, they are more effective if the problem is not too difficult, and furthermore applying analytical methods it is easier to perform process of reverse calculation - gathering information about descriptive constants of system by using experimental data.

Most frequently used from analytical methods is so-called the variable separation method, which was already known in 18th century by Bernoulli and Euler, but first who started to use it systematically was Fourier in beginning of the 19th century (Riekstiņš, 1969). In this article, as an example, this method (with following reverse task: optimization of the placement of heating elements) for the calculation of rectangular area with point heaters (section of concrete heating panel) will be used.

Materials and methods

The problem of mathematical physics always contains a certain equation – specific problem, it is equation of heat conduction

$$\Delta T = 0 \quad (1)$$

where $\Delta \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ - Laplace operator; T – temperature, °C ;

Problem is being solved on following limit conditions (Fig. 1):

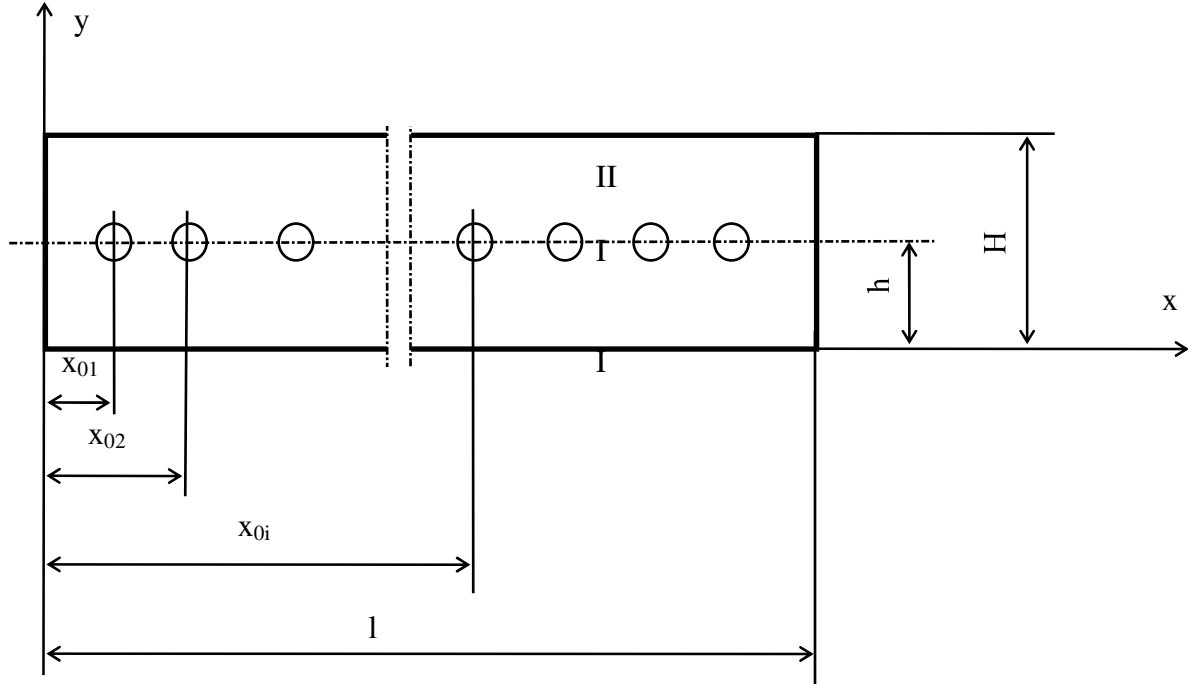


Fig.1. **Calculation scheme:** H - panel thickness, m; h – depth of heating elements (tube), m; $x_{01}, x_{02}, \dots, x_{0i}$ - coordinates of coil of heating elements, m; l - panel width, m; I, II – calculated areas of the temperature

$$\lambda \frac{\partial T_I}{\partial y} \Big|_{y=0} = \frac{\varphi}{l} \sum_{i=1}^n q_2 = Q \downarrow; \quad (2)$$

$$\lambda \frac{\partial T_{I,II}}{\partial x} \Big|_{x=0} = \alpha_s (T_{I,II} \Big|_{x=0} - T_0); \quad (3)$$

$$-\lambda \frac{\partial T_{I,II}}{\partial x} \Big|_{x=l} = \alpha_s (T_{I,II} \Big|_{x=l} - T_0); \quad (4)$$

$$-\lambda \frac{\partial T_{II}}{\partial y} \Big|_{y=H} = \alpha_v (T_{II} \Big|_{y=H} - T_0), \quad (5)$$

where

T_0 - ambient air temperature, $^{\circ}\text{C}$;

λ - concrete thermal conductivity coefficient, $\text{W}/(\text{m}\cdot\text{K})$;

α_s, α_v - heat transfer coefficients of side and upper surfaces of the panels, $\text{W}/(\text{m}^2\cdot\text{K})$;

φ - constant coefficient;

l - panel width, m;

q - specific heat flow of the heat source, W/m^2 ;

$T_{I,II}$ - the panel's temperature in the areas I (below heating element) and II (above heating element);

n - number of coils of heating elements;

$Q \downarrow$ - heat flow from the panel to the bottom, W/m^2 .

We are using so-called sew conditions. At contact place of areas I and II, the temperatures should be equivalent

$$T_I \Big|_{y=h} = T_{II} \Big|_{y=h}, \quad (6)$$

but for the heat flows, we can write the following condition:

$$\lambda \frac{\partial T_I}{\partial y} \Big|_{y=h} - \lambda \frac{\partial T_{II}}{\partial y} \Big|_{y=h} = \sum_{i=1}^n q_i \delta(x - x_{0i}), \quad (7)$$

where q_i - specific heat flow from i -th coil of heating element, W/m;
 $\delta(x - x_{0i})$ - Dirac delta function, m^{-1} , which has the characteristic

$$\int_0^l \delta(x - a) f(x) dx = f(a) \quad (8)$$

Using solution of equation (1) (the variables separation method) for areas I and II separately, we obtain each of the districts - under (I) and above (II) of heating element in form (Iljins et al., 1999)

$$T_I = T_0 + \sum_k A_k^I \cos(\xi_k x + \varphi_k) (\text{sh} \xi_k y + B_k^I \text{ch} \xi_k y); \quad (9)$$

$$T_{II} = T_0 + \sum_k A_k^I \frac{(\text{sh} \xi_k h + B_k^I \text{ch} \xi_k h) \cdot \left(\text{sh} \xi_k (H-y) + \frac{\lambda \xi_k}{\alpha_v} \text{ch} \xi_k (H-y) \right)}{\text{sh} \xi_k (H-h) + \frac{\lambda \xi_k}{\alpha_v} \text{ch} \xi_k (H-h)} \cos(\xi_k x + \varphi_k) \quad (10)$$

Constant A_k^I is calculated by formula (Iljins et al., 1999):

$$A_k^I = \frac{2\varphi \sum_{i=1}^n q_i [\sin(\xi_k l + \varphi_k) - \sin \varphi_k]}{\lambda (\xi_k l)^2 \left[1 + \frac{\sin 2(\xi_k + \varphi_k) - \sin 2\varphi_k}{2\xi_k l} \right]}. \quad (11)$$

Constant B_k^I is calculated by formula (Iljins et al., 1999):

$$B_k^I = \frac{1}{\text{sh} \xi_k h + d_k \text{ch} \xi_k h} \left\{ \frac{\xi_k l \sum_{i=1}^n q_i \cos(\xi_k x_{0i} + \varphi_k)}{[\sin(\xi_k l + \varphi_k) - \sin \varphi_k] \varphi \sum_{i=1}^n q_i} - (\text{ch} \xi_k h + d_k \text{sh} \xi_k h) \right\}. \quad (12)$$

Value d_k is calculated by formula (Iljins et al., 1999):

$$d_k = \frac{1 + \frac{\lambda \xi_k}{\alpha_v} \text{th} \xi_k (H-h)}{\text{th} \xi_k (H-h) + \frac{\lambda \xi_k}{\alpha_v}}. \quad (13)$$

Eigen (specific)-value ξ_k is calculated by formula (Iljins et al., 1999):

$$\text{tg}(\xi_k l) = \frac{2\alpha_s l}{\lambda (\xi_k l) \left[1 - \left(\frac{\alpha_s l}{\lambda (\xi_k l)} \right)^2 \right]}. \quad (14)$$

Constant φ_k is found out from equation (Iljins et al., 1999):

$$\varphi_k = -\arctg \frac{\alpha_s}{\lambda \xi_k}. \quad (15)$$

Results and discussions

Assuming that the thermal conductivity coefficient of concrete is $\lambda=0,85 \text{ W/(m}\cdot\text{K)}$, width of the panel $l = 1 \text{ m}$, the heat transfer coefficient from the side surface $\alpha_s=5 \text{ W/(m}^2\text{K)}$, from the work surface $\alpha_v=10 \text{ W/(m}^2\text{K)}$, the coefficient of heat flow downward $\varphi = 0.07$, the air temperature in a pigsty $T_0=17 \text{ }^\circ\text{C}$, the thickness of the panel $H = 0.1 \text{ m}$, the insertion depth of the heating elements $h = 0.03 \text{ m}$, the number of coils of heating elements $N = 8$ and the specific heat capacity of each coil of the current meter $q_i=20 \text{ W/m}$, the temperature on the panel work surface using computer software was calculated.

Initially step between coils of the heating element was taken as a constant. At this situation the temperature value in the middle of the panel was significantly greater than in the edges. Changing the placement of the coils of heating element, the required coordinates for each coil were determined so that fluctuations of temperature on the work surface should be within $1\text{-}2^\circ\text{C}$ (Fig. 2).

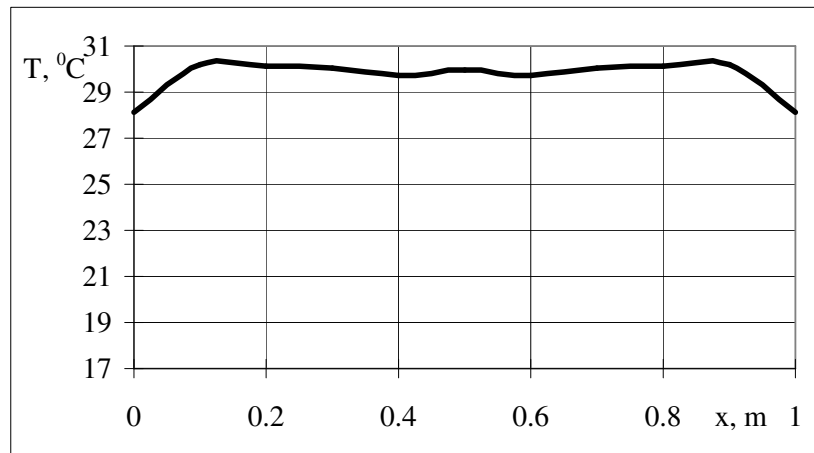


Fig. 2. The temperature distribution along the panel surface at the specific capacity 160 W/m^2

To obtain the temperature distribution over the panel surface as shown in Fig. 2 (accuracy of calculation of temperature $\varepsilon = 0.001$), the coils of heating element should be placed as follows: $x_{01}=0,020 \text{ m}$; $x_{02}=0,145 \text{ m}$; $x_{03}=0,280 \text{ m}$; $x_{04}=0,435 \text{ m}$; $x_{05}=0,565 \text{ m}$; $x_{06}=0,720 \text{ m}$; $x_{07}=0,855 \text{ m}$; $x_{08}=0,980 \text{ m}$.

Using "Solver" (software tool of Microsoft Excel), we can try to automate the calculation of the coordinate x_{oi} . For this purpose we compile the integral of squared deviations

$$S = \int_0^1 (T(x, H) - T_0)^2 dx, \quad (16)$$

which we minimize with a "MS Solver" tool assistance. Calculated by formula (21) value of the sum of deviations, shown in graphic Fig.2, gives the value of 262, but if we minimize (21) with additional conditions, where the minimal distance between two heating elements cannot be lower than $0,12 \text{ m}$, so that the temperature distribution along the surface of the panel should be even, calculated coordinates are $x_{01}=0,020 \text{ m}$; $x_{02}=0,140 \text{ m}$; $x_{03}=0,297 \text{ m}$; $x_{04}=0,433 \text{ m}$; $x_{05}=0,566 \text{ m}$; $x_{06}=0,703 \text{ m}$; $x_{07}=0,860 \text{ m}$; $x_{08}=0,980 \text{ m}$ with sum of deviations $S=261$. The resulting temperature distribution on the sample surface is shown in Fig. 3.

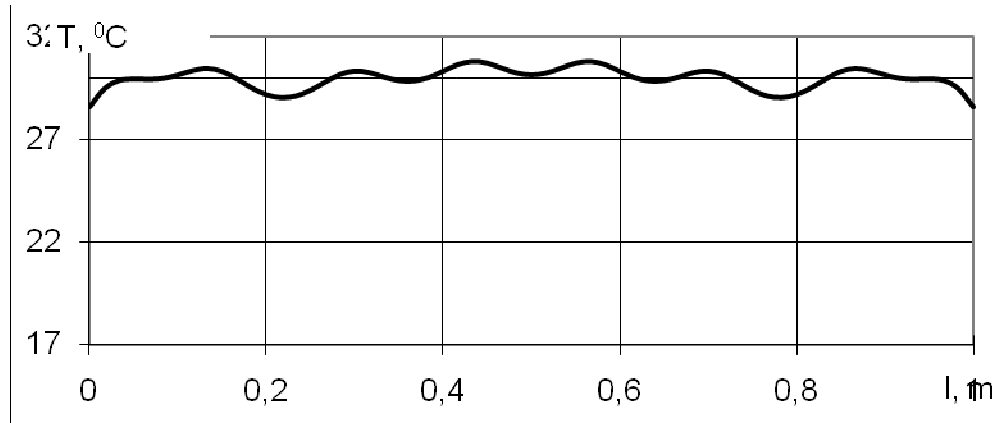


Fig. 3. Temperature distribution along the panel surface at the specific capacity 160 W/m^2 where the coordinates are calculated with the program "MS Solver"

Conclusions

1. The variables separation method for solving the problem about optimization of the placement of heating elements has been used.
2. With the help of MS Solver software it is possible to estimate the placement coordinates of the heating elements taking into consideration additional conditions.
3. Microsoft Solver software makes it possible to minimize the amount of deviations.
4. MS Solver software calculation results proved that carried out optimization tasks in the previous works were close to optimal.

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ICT TOOLS AND METHODS

APPROVAL OF RECOGNITION ALGORITHMS FOR THE DEVELOPMENT OF THE TRACES SYSTEM

ATIS SAULE

Abstract

The TRACES system, like many other systems, collects information on companies. The TRACES system also collects data on the international transportation certificates for animals, as well as on the import of produce and non-food consumer goods into the EU Member States. However, a company may be entered into the system several times due to the inattention of inspectors; thus the database content is needlessly increased, preventing complete information on this one company from being gathered. The “repeat company” search and replace tool Sanclean was developed to resolve this issue based on the Levenshtein algorithm. Sanclean was submitted for the approval of Member States representatives.

Introduction

The TRACES system [1] is a system used by all EU Member States. The system stores information on international transportation certificates of live animals, as well as information on the import of produce and non-food consumer goods into EU Member States. As the system is not related to the databases of EU Member State national registers, inspectors enter data on companies into the system manually. Destination companies must be entered into the system; because the system is intended for international trade, destination companies are usually located in a different country. As such, the inspector must enter data on a company from a different country. Inspectors have the search engine for existing companies in the database at their disposal, but as inspectors are often unable to find the company they are looking for, the company is simply entered into the database again. This results in situations wherein the system contains several entries for the same company and in several ways. For example, SIA Rimi, RIMI SIA or just Rimi. Such a situation can be seen in a large number of information systems in Latvia. Because of this, the developed algorithm could also be applied to systems in Latvia. A project was implemented to develop a tool to delete repeated companies – *Sanclean* – to maximally reduce the number of repeated companies and to alleviate the database. *Sanclean* was developed by representatives of the European Commission in cooperation with representatives from Member States. The system was then submitted to the Member States for testing. The deleting tool *Sanclean* was developed as an independent application: data from the TRACES system are uploaded to the application, processed, then exported back to the TRACES system (see Image 1). The author is participating in the project as a representative of the EU Member States who will test the developed system in a testing environment and give his evaluation and possible suggestions for eliminating any problems.

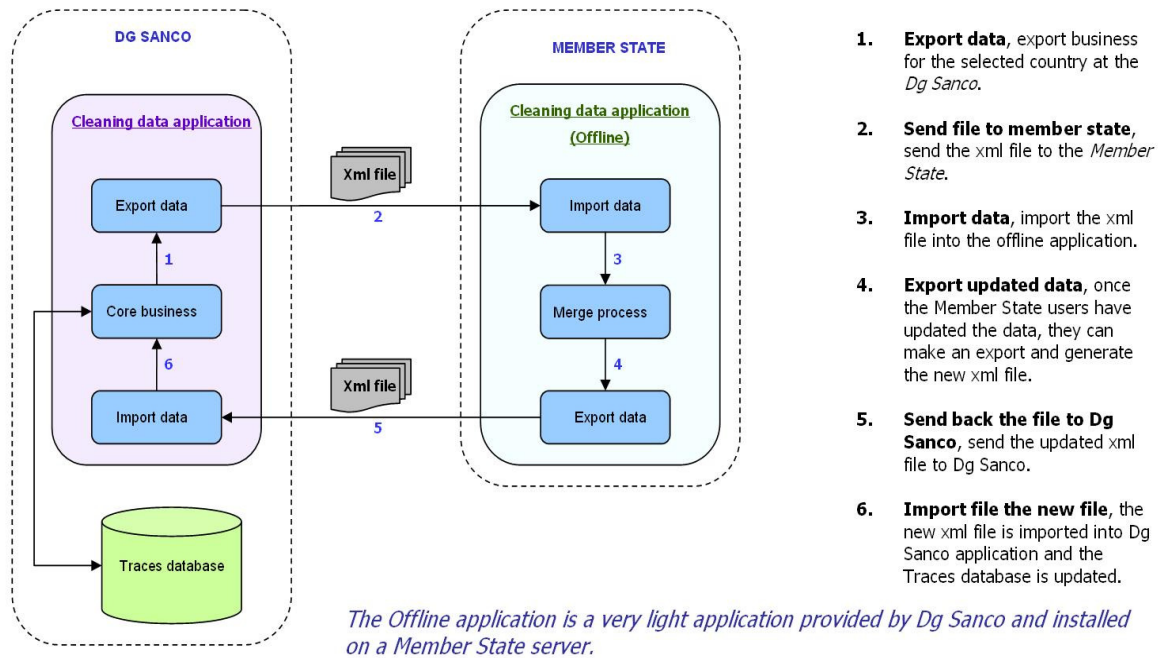


Image 1. Sanclean Operation Process Layout

Goal of the article – approval of the developed recognition algorithm and recommendations for the development and improvement Sanclean to ensure it operates effectively.

Tasks set for attaining this goal:

- Analyse the architectural make-up of the TRACES system's operation and side-effects with other DBs and ISSs.
- Analyse existing recognition algorithms.
- Develop testing examples.
- Prepare recommendations for the improvement of the Sanclean system.

Recognition Algorithm in the Traces System Sanclean Tool

The deleting tool Sanclean [4] was developed to help locate repeated companies in databases and to take decisions on replacing the repeated data. The following was done to achieve this:

- Database analysis.
- Potential algorithm analysis.
- Setting up the system in a testing environment.
- Testing.
- Identifying errors.

Each Member State must install the application on its server [5]. The application is used either by the employees of a respective Member State's host centre or by the employees of local institutions. The system's interface is shown in Image 2.

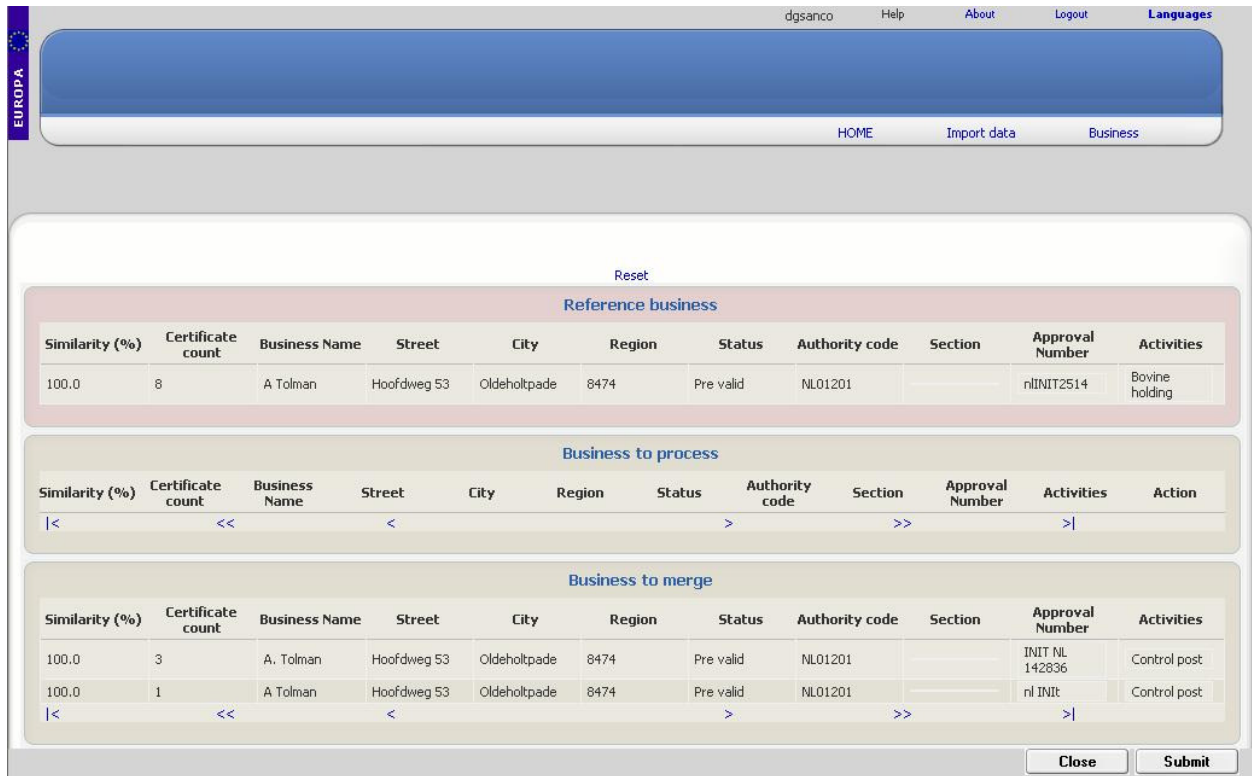


Image 2. Sanclean System Interface

The algorithm is based on the Levenshtein [2] [3] Algorithm, with which it is possible to determine how many actions are necessary to change one word into another. For example, the Levenshtein distance between the words “post” and “coast”:

- post -> cost – replacement action
- cost -> coast – inserting action

Thus the Levenshtein distance between the words post and coast is 2.

The following fields are taken into consideration when comparing companies:

- Company recognition code.
- Name.
- Street.
- Postal index.
- City.

For each company (see Image 3 for a list of two companies from the database), all of this information is connected in a single, long row of symbols; when comparing two companies, two rows are compared.

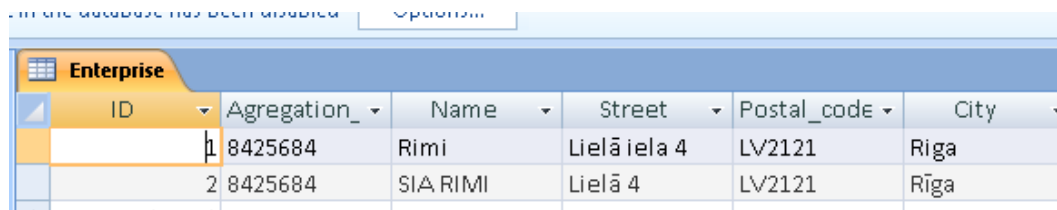


Image 3. Information on a Company in the Database.

The rows of symbols are looked at when comparing the two companies. The row of symbols for company ID 1 is “Rimi Lielā iela 4 LV2121 Rīga”, whereas the row of symbols for company ID 2 is “SIA RIMI Lielā 4 LV2121 Rīga”.

All companies are compared in this manner and groups are formed of those companies that are the most similar. The main company is determined for each group, which is then used to replace the “repeat companies”. The main company is chosen based on the following criteria:

- The company’s status in the system.
- The number of certificates a respective company has.
- The date the company was entered into the system.

Then the correlation threshold of the companies is determined. All companies that have a 95 % or larger correlation are automatically offered to be replaced by the main company. However, an inspector can change this at any time if there are two different, but very similar companies.

Testing Examples

Information on three companies was compared during testing. A main company was determined based on the abovementioned criteria and companies that were to be replaced by this main company were established. The companies used in the first testing example are shown in Table 1.

Table 1.

	Company A	Company B	Company C
Recognition number	4588745	1258766	8455321
Name	Rimi	SIA RIMI	Elvi
Street	Lielā iela 4	Lielā 4	Saulriešu iela 5
Postal index	LV2121	LV2121	LV4353
City	Riga	Riga	Riga
Text for determining Levenshtein distance	Rimi Lielā iela 4 LV2121 Riga	SIA RIMI Lielā 4 LV2121 Riga	Elvi Saulriešu iela 5 LV4353 Riga
Common correlation of companies	98 %	98 %	29 %
Company's status in the system	Valid	New	Valid
Number of certificates for the company	10	2	1
Date company was entered into the system	23.04.2009	13.07.2009	10.10.2009

In the first testing example, company A is chosen as the main company – this is because its status in the system is “Valid” and it has the largest number of certificates. Company B is replaced by the main company because the correlation between the companies is greater than 95 %. Company C is not replaced because the correlation is less than 95 %.

The companies used in the second testing example are shown in Table 2.

Table 2.

	Company A	Company B	Company C
Recognition number	9547821	5648726	1697851
Name	Maxima	SIA maxima	Lats
Street	Saules iela 6	Saules iela 6	Kalna iela 5
Postal index	LV2233	LV22233	LV4343
City	Riga	Riga	Riga
Text for determining Levenshtein distance	Maxima Saules iela 6 LV2233 Riga	SIA maxima Saules iela 6 LV2233 Riga	Lats Kalna iela 5 LV4343 Riga
Common correlation of companies	96 %	96 %	31 %
Company's status in the	Valid	New	Valid

system			
Number of certificates for the company	10	2	12
Date company was entered into the system	13.02.2009	23.03.2009	03.11.2009

In the second testing example, company C is chosen as the main company – this is because its status is “Valid” and it has the largest number of certificates. Companies A and B are replaced by the main company because the correlation of the companies is greater than 95 %.

Conclusions

When testing the system, it was determined that the system incorrectly chooses the main company that will replace other identical companies. Initially, the system forms a group of similar companies and chooses a main company from this group. Then the system compares the group of companies and replaces those companies with a correlation greater than 95 % with the main company. The process can be broken down as follows:

1. Similar companies are selected (even if their correlation is less than 30 %).
2. A main company is chosen from the selected group based on a set of criteria.
 - a. The status of the company in the system.
 - b. The number of certificates the specific company has.
 - c. The date the company was entered in the system.
3. The companies are compared to one another.
4. Those companies with a correlation greater than 95 % are replaced by the main company.

A problem arises in situations wherein the main company is chosen before the group of companies is compared to one another. This means that the system could designate a main company that has a correlation level less than the required 95 %. The correct operational process of the system would be as follows:

1. Similar companies are selected (even those with correlations less than 30 %).
2. **The companies are compared to one another.**
3. A main company is chosen from those companies **with a correlation greater than 95 %** and based on a set of criteria.
 - a. The status of the company in the system.
 - b. The number of certificates the specific company has.
 - c. The date the company was entered in the system.
4. Those companies with a correlation greater than 95 % are replaced by the main company.

Thus system users can be sure that the main company has been chosen from among the most similar companies. The introduction of such a process to the system would eliminate situations in which ten identical companies are replaced by a company that is not even remotely similar to the said ten companies.

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AUTOMATED MULTI – MEASUREMENT SYSTEM FOR RESEARCH OF DRYING PROCESSES

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Abstract

Scientists almost of all science sectors have the same problem: several devices mutually incompatible, is not possible to make automatic data acquisition and processing by own needs and also experiments are able to observe only in presence. It is therefore very important to create an easily manageable system, connecting many devices, retrieve and store data in electronic format. Finally process data by own needs for example, create a diagram, where is possible to investigate research result. We create our own computer system: investigated apples (research object) drying process, we measured two electrical components – capacity and resistance, temperature, humidity and mass of research object. At the end of the experiment we created several diagrams by our computer system to analyze obtained data.

Keywords: *IT, Computer science, Computer control, multi-measurements, LCR.*

Introduction

Nowadays, science sector occupies a major role in human development. There are being conducted experiments and studies, which can lead to significant discoveries and inventions. The integral part of these processes is to fix and analyze measured data. The measurement results can be achieved by reading them from the measurement scales or an electronic display, what during the experiment becomes a routine job. Today in reliable studies it is more wisely to use computerized systems for performing automated measurements without human direct interference in the measurement process. As students of faculty of Information Technologies of study program Computer Science and Computer Control, we set ourselves the objective of creating computer systems which perform mentioned functions: automated measurements, measurements storage on the physical computer memory, the obtained data further processing and graphics creation. Chemical and physical properties of substances can be studied using various direct measurements such as temperature measured by thermocouples, to determine the mass by scale, etc. In such experiments there also can be used indirect measurements - measurements of the electrical parameters, such as active resistance or capacity, when after the calibration, we obtain information about the object humidity (Моин et al., 1988, Петров et al., 1985). Our experiment is related to dynamics of various porous objects' drying processes, which have emerged in both food technology (Моин et al., 1988, Петров et al., 1985, Гинзбург et al., 1980) and building material manufacturing processes (Ијјинс et al., 2009, Ијјинс et al., 2008, El-Beltagy et al., 2007). Our study is devoted to measure dynamics of apples' drying processes.

Materials and Methods

In this experiment's development stage we offer a method, where we use a modern gauge and familiar software packages. Since the research is specific, we had to program our own software, because manufacturers' software was unusable for our research. In experiment was used: electronic multimeter - LCR HiTESTER Hioki 3532-50, electronic scales - Kern 572-33, electronic temperature and humidity gauge - TFA Dostmann 30.3015. By Hioki Hitester were measured two electrical parameters: Rs – serial circuit active resistance and Cs - serial circuit capacity. Scheme of automatic measurement system in Figure 1 is presented.

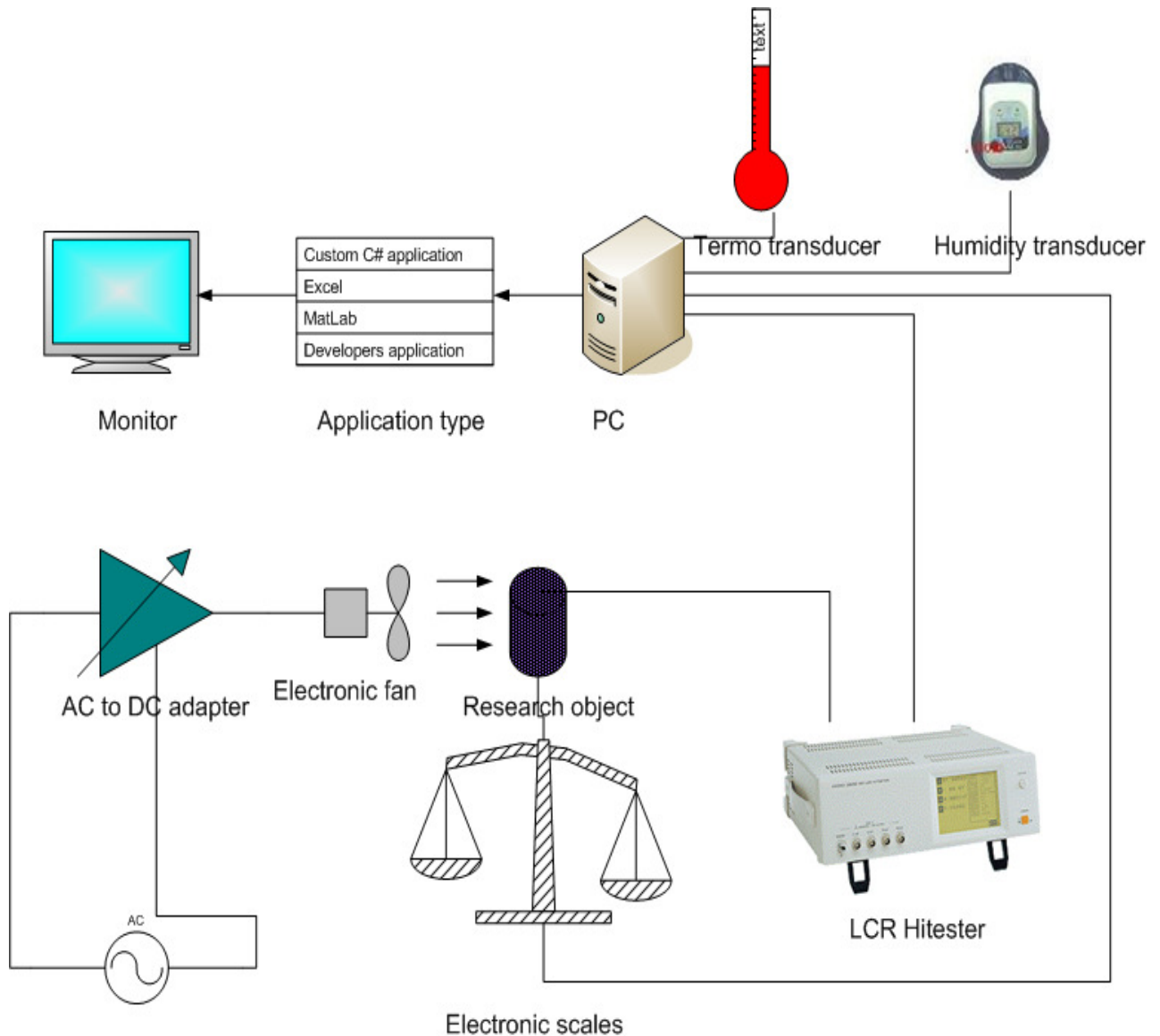


Figure.1. Scheme of automatic measurement system.

These values were measured at alternating current flowing which is proportionally dependent on the resistance of apple and at 1v pressure at 58 different frequencies in the range from 42Hz to 1MHz. Electrical parameters were measured every 10 minutes, but frequency was switched every one second so all measurements at whole frequency range were performed at about one minute. To automate the measurements we use a manufacturer's software which store data in Microsoft Office Excel workbook. For processing obtained data we create our own software using C# programming language and special MATLAB.dll reference library which read data from Excel's workbooks' worksheets and then transfer data to MATLAB (v. 2009a) plot through which the measurement results are represented in the 3D graphs. MATLAB is a numerical computing environment and fourth-generation programming language, and C# is multi-paradigm programming language encompassing imperative, functional, generic, object-oriented (class-based), and component-oriented programming disciplines, which was developed by Microsoft within the .NET initiative and later approved as a standard by Ecma (ECMA-334) and ISO (ISO/IEC 23270).

Dynamics of Apple's active resistance as function of time and frequency and dynamics of apple's capacity as function of time and frequency in Figure 2 and Figure 3 are presented.

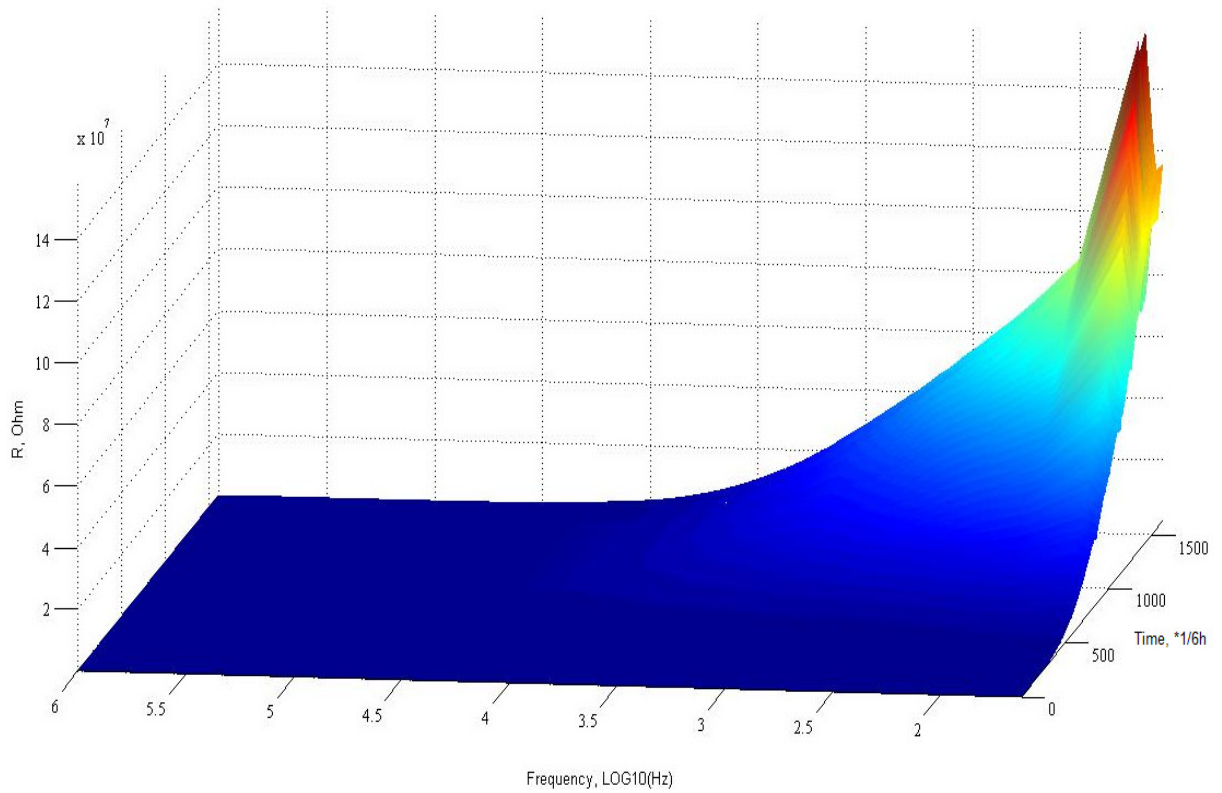


Figure.2. Dynamics of apple's active resistance as function of time and frequency.

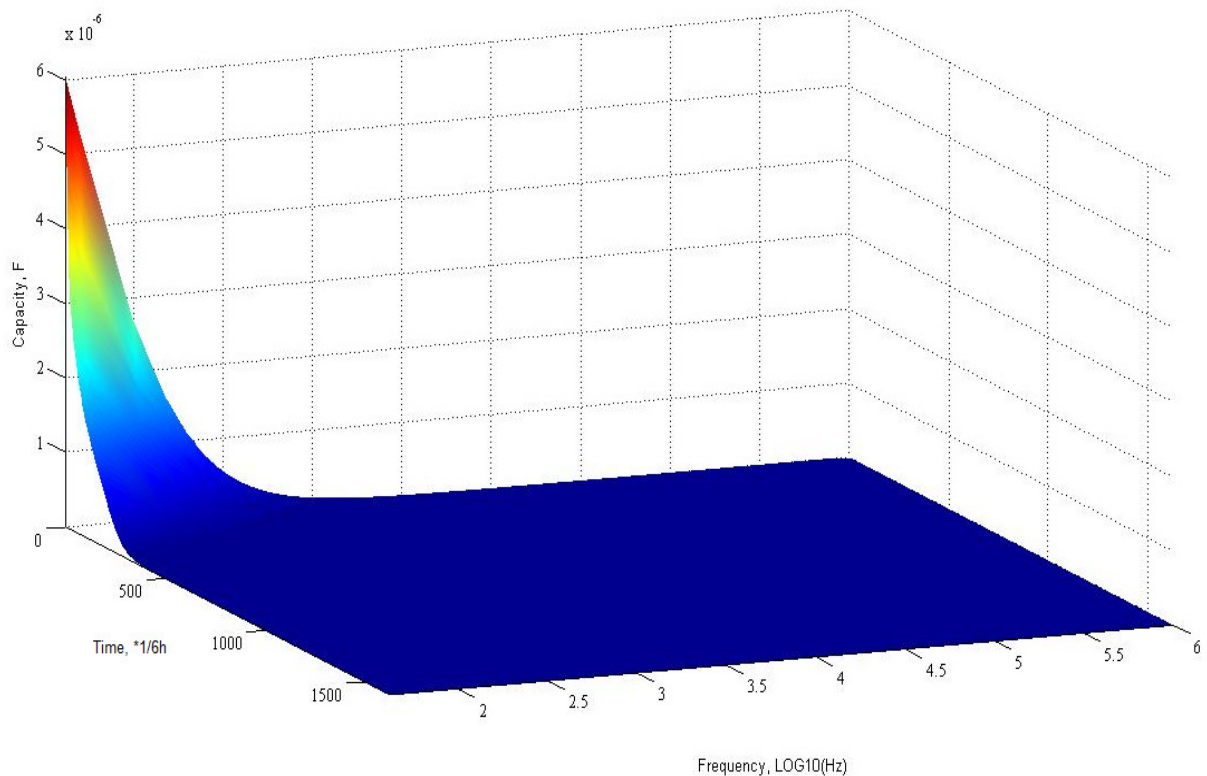


Figure.3. Dynamics of apple's capacity as function of time and frequency.

Also C# programming language we use to create our own software to control the electronic scales Kern 572-33, that is to send balance command to scales and receive back readings in electronic format and store them in text file. The balance commands were sent every ten minutes. Indoor temperature and humidity were fixed by TFA Dostmann 30.3015 device every two hours and in the end of measurements were imported to computer for

further processing. Throughout the course of the experiment if necessary it was possible to connect remotely to the computer system and observe the research and make the processing and analyzing of already acquired data, using MS Windows Remote Desktop Connection utility from any location where the Internet was available.

To accelerate the water evaporation from the apple, it was cut, and for research was used middle part of the apple without peel, and also we conducted additional air circulation - artificially created air flow with 5V electronic fan that was focused on research object.

The research occurred from 25.02.2010 to 11.03.2010 and there were made 1620 Cs, Rs and mass measurements and 180 indoor temperature and indoor humidity measurements. Dynamics of indoor temperature as function of time and dynamics of indoor humidity as function of time in Figure 4 and Figure 5 are represented.

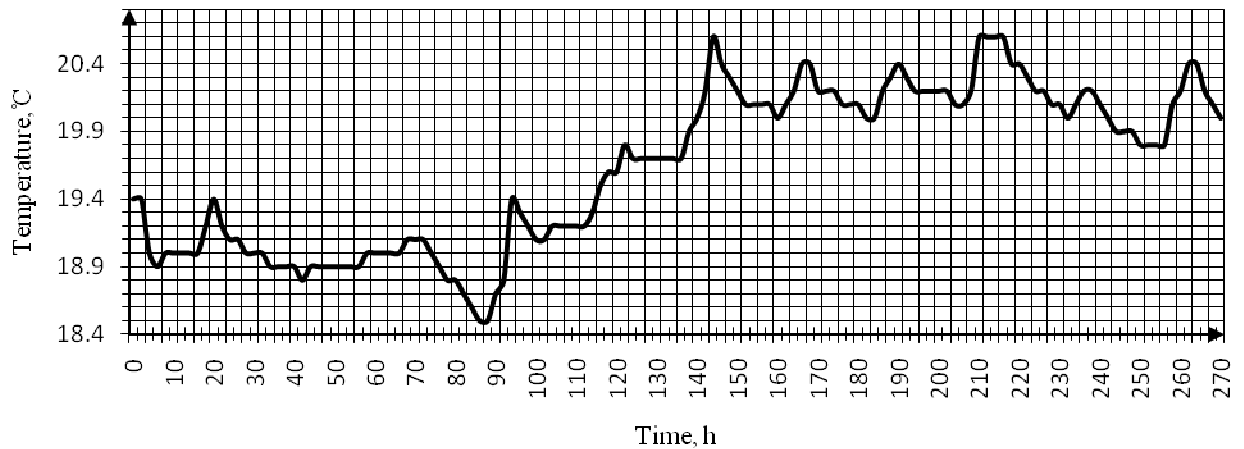


Figure.4. Dynamics of indoor temperature as function of time.

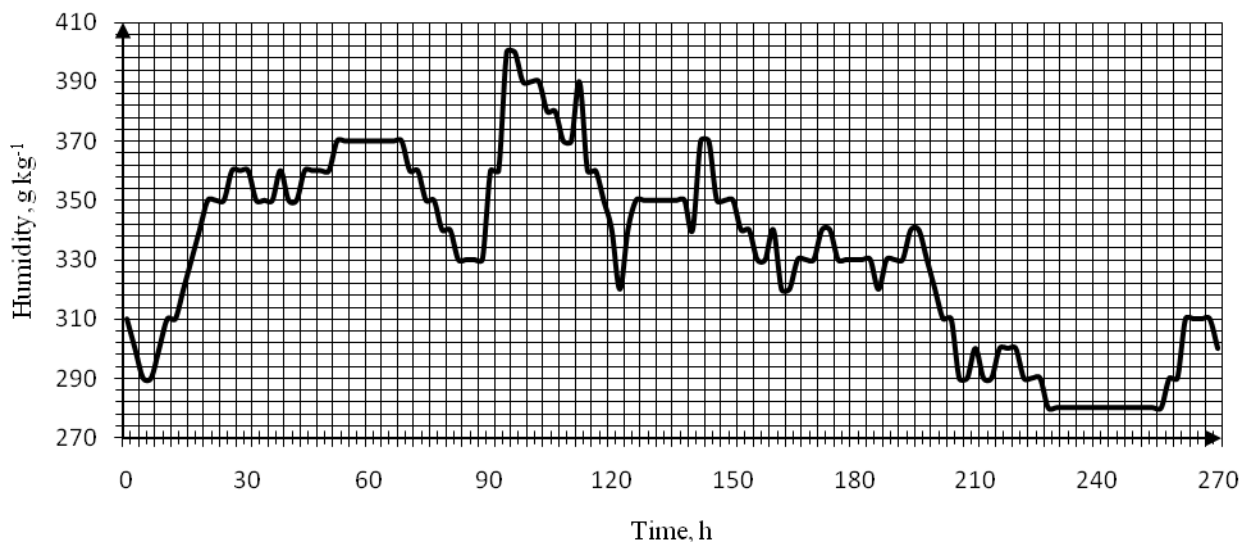


Figure.5. Dynamics of indoor humidity as function of time.

Similar experiments, where the computer automated system perform measurements, the researchers carried out using various methods (Hellerstein et al., 2001, Mamaev et al., 2005). One of them is to perform measurements and data analyzes by using LabView software (Laboratory Virtual Instrumentation Engineering Workbench), what is a platform and development environment for a visual programming language from National Instruments. With Lab view is possible to perform multiple measurements by connecting the relevant sensors to the special interface cards (Johnson et al., 2006).

Results and Discussion

Before carrying out the experiment we have performed test measurements when the AC frequency range was from 42Hz to 5Mhz. Apple wasn't peeled and wasn't cut as a result in two weeks the moisture loss was negligible and also in the test final part from resistance diagram was observed that the active resistance is declining that shows that humidity has risen in apple. This could be explained by starting of the decay process. In the both charts (active resistance and capacity charts) we see that, by increasing the frequency, measurements

become less sensitive therefore does not make sense to perform research at very high frequencies (above 1 MHz). We concluded that the drying process should be researched with apple that has no peel, so then the water is easier to evaporate, and promoting drying by changing external conditions - heating or generating additional air flow. At the heating case the electronic scales heats up too as a result scales were showing the wrong data, while creating additional air flow (in our case with the 5v electronic fan) weight readings are not affected. Obtained information in the test measurements coincides with the observations of other scientists (Моин et al., 1988, Петров et al., 1985).

Moisture detection methods used by researchers are different (Моин et al., 1988, Петров et al., 1985, Гинзбург et al., 1980). Scientists in their publications (Петров et al., 1985) write that in the practice it is useful to gather active resistance and capacity data, in addition, each in different phase, also measurements must be done at the alternating current and at working frequency of 50Hz (can be used frequencies up to the limit of audibility (20kHz), because with higher frequencies the sensitivity decreases and the measured data changes are virtually invisible (Figure 1, Figure 2). Using the direct current for long time to measure active resistance, the electrodes start to polarize, resulting that active resistance begins to rise and causes errors in measurements. Drying Process can be divided into two phases (Iljins et al., 2009, Моин et al., 1988, Петров et al., 1985).

At the first phase vaporization continuous at a constant speed and the apple's mass chart is linear function (Figure 8), which can be explained by a sufficient amount of water at surface of the apple. In this phase, the active resistance is insensitive (Figure 7), so it is appropriate to analyze the capacity (Figure 6). This is explained by the fact that the environment's (water) dielectric permeability $\varepsilon = 81$, and according to formula (1).

Formula of capacity for capacitor is

$$C = \frac{\varepsilon \varepsilon_0 S}{d} \quad (1)$$

where $\varepsilon_0 = 8.85 \times 10^{-12}$, C^2 (N m²)⁻¹ - electric constant; ε - dielectric permeability of the environment, C^2 (N m²)⁻¹; S - condenser surface area, m²; d - distance between capacitor plates, m².

In the second phase the water evaporation rate depends on the diffusion process through the apple's pores towards it's surface, and curve is changing the nature from linear to logarithmic (Figure 8). In this phase chemical composition and particle size begin to play a major role, which is not directly related to the humidity of the surveyed object or substance, therefore, it is necessary to begin to analyze the active resistance R, Ω . In the second phase, by decreasing humidity, resistance begins very rapidly increasing (Figure 7). It is also important to note, that, when in the apple was been left very little moisture, the active resistance became dependent on the ambient humidity (Figure 9)

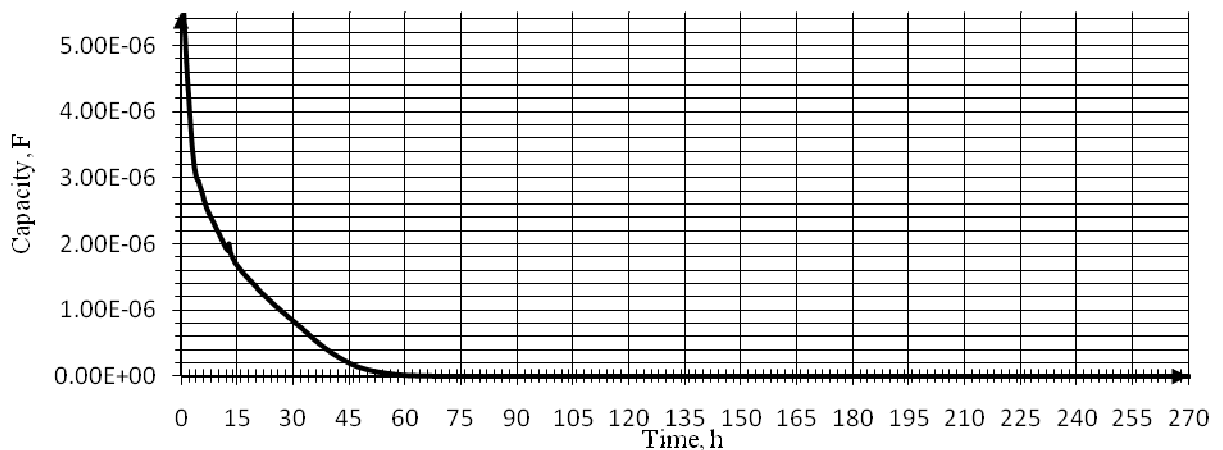


Figure.6. Dynamics of apple's capacity as function of time at frequency of 42Hz.

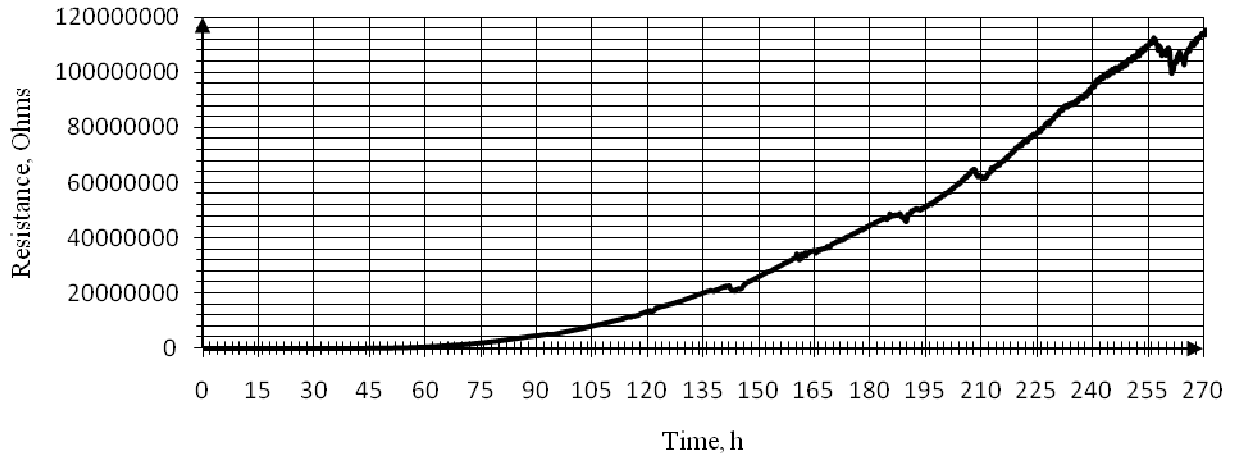


Figure.7. Dynamics of apple's active resistance as function of time at frequency of 42Hz.

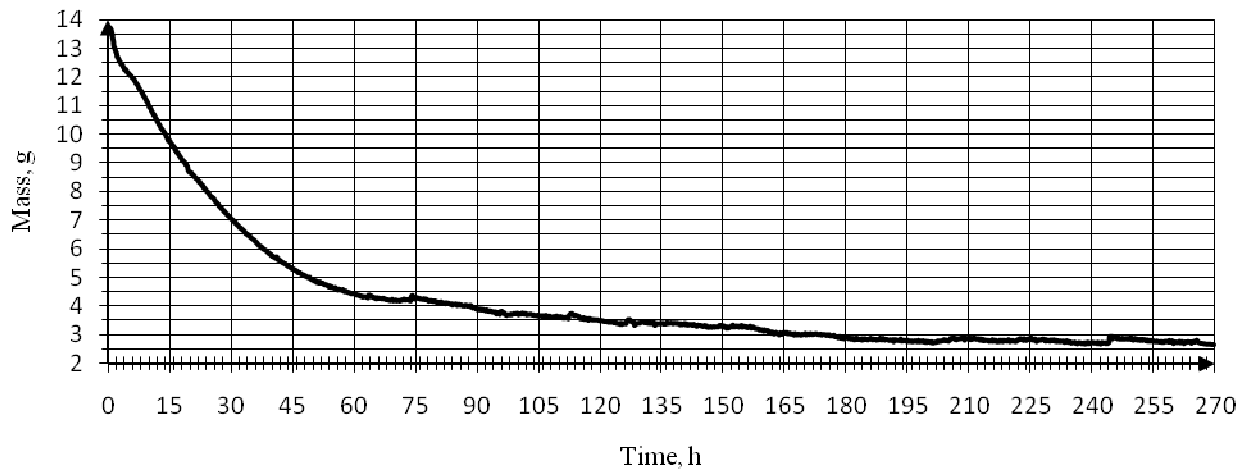


Figure.8. Dynamics of apple's mass as function of time.

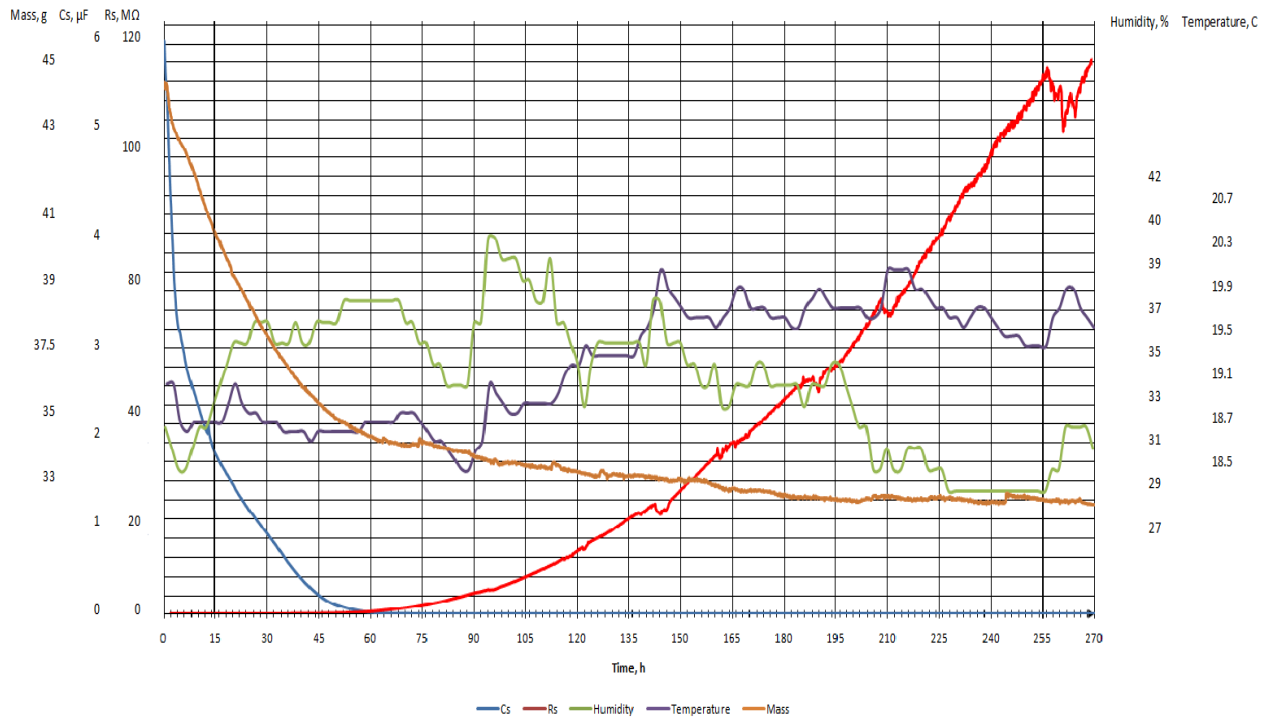


Figure. 9. Dynamics of all measurements as function of time at frequency of 42Hz.

Conclusions

Our primary objective was to find a solution for automated measurement managing, which was based on the apple drying process dynamics. We have created our own system that is able to automatically take measurements without human presence at predefined terms and parameters, thus solving the problem, which often experienced engineers. We have complemented our experience in working with measuring instruments, programming and automated computer control. After the study we see the possibility of the development and improvement, for example, where there are errors in data reading, or other type of software problems, the system can send electronic messages via e-mail or mobile SMS system. Also could be installed surveillance cameras in the laboratory, for reason when, for example, is unexpected temperature changes, the computer could switch on video surveillance and record it, and send the report to researchers in the same way like previously mentioned.

Returning to the measurements, our experimental results coincide with findings of other scientists. There are two phases in the apple's mass chart (Figure 8), when curve is changing it's characteristics during the experiment, which is directly related to the evaporation of moisture from the apple. Increasing frequency, both - active resistance and capacity become insensitive during the evaporation at time (Figure 2, Figure 3). Most stable performance is at the lowest possible measuring frequency 42Hz, in the curves characteristics there are no large spikes. Active resistance begins to rise sharply in the second phase, but the capacity varies very little, while in the first phase, the opposite phenomenon occurs when the active resistance is insensitive, but the capacity rapidly decreases, while apple is losing humid (Figure 6, Figure 7). Although the room humidity and temperature were not constant (Figure 4, Figure 5), which is reflected in the mass chart, and indiscriminate mass increases for short times (Figure 9). From our study, we concluded that the measurement can be taken at frequencies up to 20 kHz, but the best option is to do measurements at 42 Hz frequency (Figure 2, Figure 3). It follows that similar experiments may be carried out with a much cheaper and more portable device, than HIOKO 3522, because the measurements at high frequencies are senseless. Once again, we were convinced of the truth of life - any experiment cannot be perfectly accurate, because there is no the environment free of side effects from other factors: temperature, humidity, vibration, thermo-radiation etc.

Acknowledgements

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DESIGN GUIDELINES OF WEB INFORMATION SYSTEMS FOR PEOPLE WITH DISABILITIES

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Abstract.

The purpose of this paper is to identify problems of using available Web information systems for people with various types of disabilities and develop corresponding system design guidelines for developers. The types of problems are not related to the scale or type of Web information systems. World Wide Web Consortium is one of the leading organizations that manage project called Web Accessibility Initiative. This project provides draft support materials to help developers identify problems and design more accessible Web information systems. Paper focuses on determination of problem groups, existing guidelines analysis and development of possible solutions for particular groups of people with disabilities. By acquiring practical experiences, key result technical guidelines for Web information systems developers are revealed and discussed.

Keywords: *Web information systems, usability, accessibility, information system development, people with disabilities.*

Introduction

As the technological progress past, present and future tendencies show, using services that are provided by rapid grow of Web, has become everyday for huge number of citizens in various countries. Miniwatts Marketing Group (Miniwatts Marketing Group, 2009) published research results are one of the examples about how huge, by the means of users, the Web environment has become. As for September 2009, estimated World population was around 6,7 billion people. From this group, approximately 1,7 billion have Internet connection and use some sort of services, which are provided by Web. This is good motivation for people to bring more and more of their everyday business processes online. Banking, stocks market operations, auctions are just a few examples of business processes that are brought online.

One of the main tools in bringing business process online is to create information system that works online and manage certain operations. There are many aspects to take in notice before bringing such processes online. One of the most important is to deliver particular service to particular group of users in particular quality. So the questions about service usability and accessibility become important matter to solve.

Certain need, in matters that relate Web information system usability and accessibility, is to determine profile of user who will use the service. This task is almost impossible to solve completely, because if the information system is brought online, it is brought for huge user group that can be identified only partly. Compared to classical interpretation of information system, in process of Web information system functioning, Web itself becomes a major component, which leads to rules that comes with the term 'online' (see Figure 1). System that is brought online can be accessed by various users in various geographical locations with various hardware and software environments.

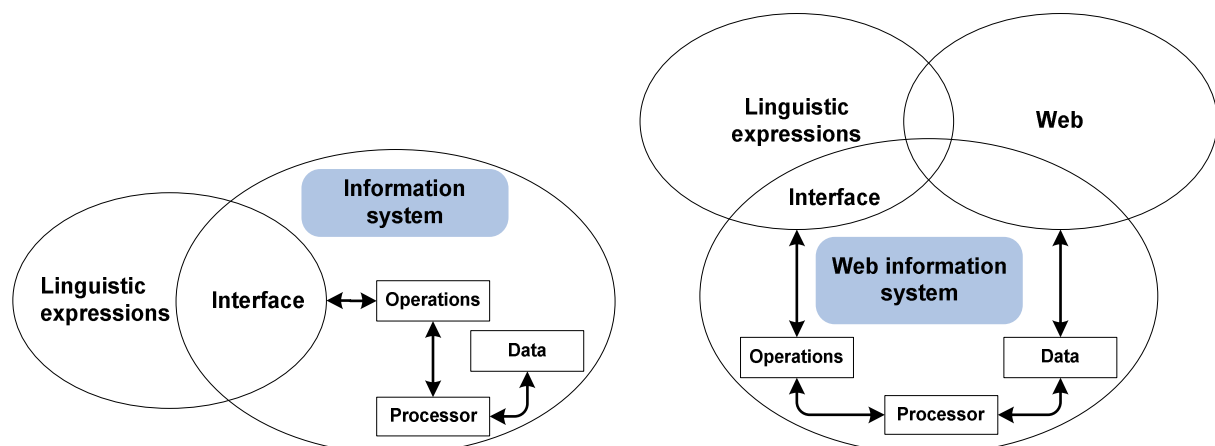


Figure 1: Information system components versus Web information system components.

As it is seen from Figure 1, which was developed by taking concepts from sketch by M. Jackson (Taniar and Rahayu, 2004), we can look at information system as an object that consists from three main parts. Part that is named 'linguistic expressions', which indicates real world linguistic type expressions that people want to deliver to the part of 'information system' in the type of data through medium environment called 'interface'. Interface stands between user and system. In Web information system, fourth component named Web becomes a vital part of functioning.

Web component gives information system developer extra tasks to solve. As previously mentioned, important task is to develop information systems that can be usable for various groups of people. It leads to the need to know more about potential groups of people and their needs against Web information system that they use.

At the same time, besides the main idea of making more usable Web information systems, various kinds of restrictions can be applied for certain information systems. For example, in countries like Australia and United Kingdom, there is government issued laws and policies that define also developer responsibility about Web information system accessibility to all user groups. (Vision Australia Author Group, 2009)

The aim of this paper is to determine problems that people with disabilities meet when using Web information systems and develop corresponding design guidelines for information system developers. To reach the aim, following tasks had been brought forward:

1. Identify web information system user groups with disabilities and problems that these groups meet when using Web information systems.
2. Analyze existing guidelines and requirements.
3. Develop guidelines – possible solutions for Web information system developers for solving identified problems.

Materials and methods

As a user group for this research, people with disabilities were chosen. If this group of people are more analyzed, it is seen and understood that besides extra needs for people who have some sort of disability, they also include needs that average Web user have. From the perspective of needs against Web information systems, they can be seen as an extension of average user needs. (see Figure 2). These extensions can be divided in groups that address some sort of disability. Also at the same time there can be a possible group of unidentified needs. If merged, view of needs formation can be seen, which gives the Web information system developers more complete understanding about accessibility matters for development process of usable system.

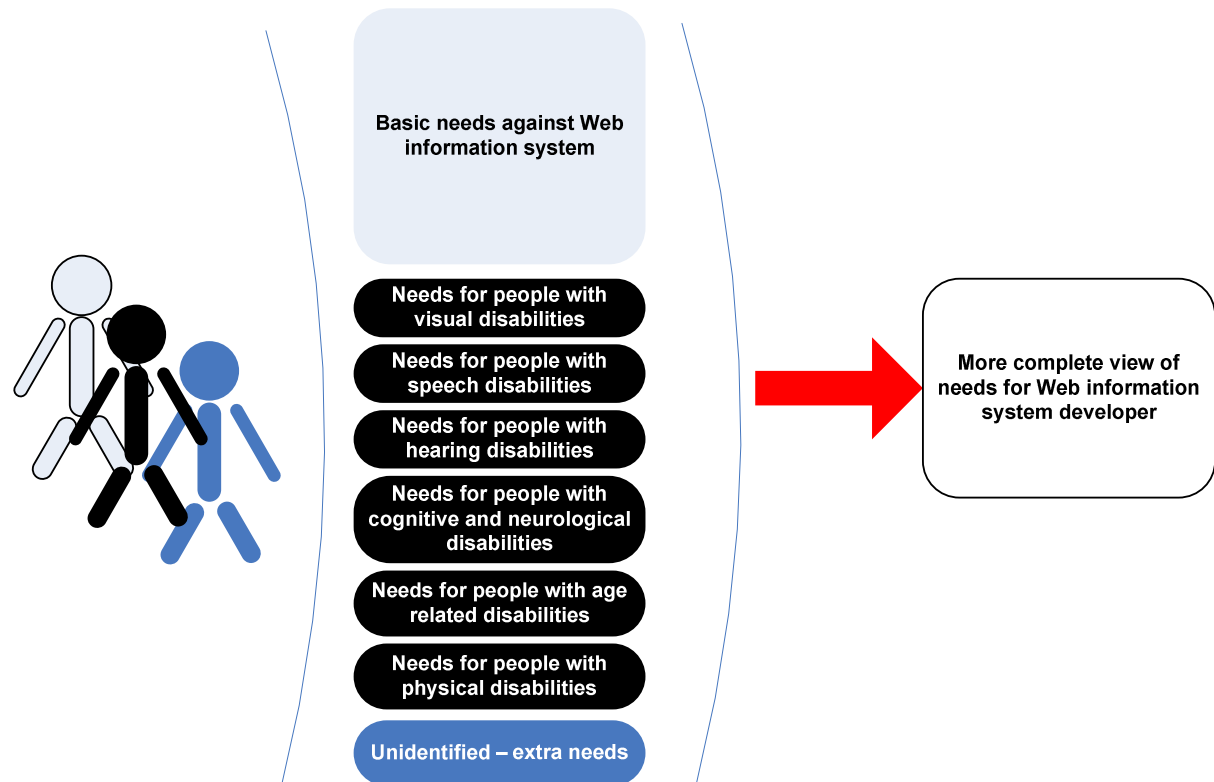


Figure 2: View formation for Web information system developer from extensions of user needs.

In industry there are available international standards and guidelines as well implementation measuring techniques that relate to the matters of users basic needs against information systems. At the same time also extended view of needs are researched. One of the main organizations that research such topics is World Wide Web Consortium (W3C) with project called Web Accessibility Initiative (World Wide Web Consortium, 2009). But until start of year 2010 there are no worldwide official completely published document that in full depth relates these matters. However tendency shows that many available draft and local meaning documents keep forming global view of problems and possible solutions.

Extended needs groups that are shown in Figure 2 are made by analyzing various locally provided research results by Latvia organizations such as APEIRONS (Apeirons Author Group, 2007) and at the same time by analyzing international publications, such as Web Accessibility Initiative published researches and others (World Wide Web Consortium, 2009; Pernice and Nielsen, 2001; Slatin and Rush, 2002). The need groups cover most of commonly met disabilities, but fact that has to be kept in mind is that in real life, there can be users with mixed disabilities, for example a internet bank user with a visual and hearing disability.

If each of mentioned extensions of needs are more analyzed, the problems that individuals from each group meet, can be brought forward:

People with visual disabilities – many of them rely on screen readers and speech synthesizers, refreshable Braille display and text-based Web browsers.

Problems that they may meet on Web information systems:

- images that do not have alternative text;
- complex images that are not adequately described;
- video that is not described in text or audio;
- tables that do not make sense when read serially;
- frames that do not have meaningful names;
- forms that cannot be tabbed through in a logical sequence or that are poorly labeled;
- browsers and authoring tools that lack keyboard support for all commands;
- browsers and authoring tools that do not use standard applications programmer interfaces for the operating system they are based in;
- non-standard document formats that may be difficult for screen reader to interpret;
- Web pages with absolute font sizes that do not change easily;
- Web pages that, because of inconsistent layout, are difficult to navigate when enlarged, due to loss of surrounding context;
- Web pages, or images on Web pages, that have poor contrast, and whose contrast cannot be easily changed through user override of author style sheets;
- text presented as images, which prevents wrapping to the next line when enlarged;
- color that is used as a unique marker to emphasize text on a Web site;
- text that inadequately contrasts with background color or patterns;
- browsers that do not support user override of authors' style sheets;

People with hearing disabilities – many individuals rely on captions of audio content, amplification of audio, adjustment of volume for an audio file.

Problems that they may meet on Web information systems:

- lack of captions or transcripts of audio on the Web, including webcasts;
- lack of content-related images in pages full of text, which can slow comprehension for people whose first language may be a sign language instead of a written/spoken language;
- lack of clear and simple language;
- requirements for voice input on Web information systems;

People with physical disabilities – many individuals rely on specialized mouse, a keyboard with a layout of keys that matches their range of hand motion; a pointing device such as a head-mouse, head-pointer or mouth-stick; voice-recognition software; an eye-gaze system;

Problems that they may meet on Web information systems:

- time-limited response options on Web pages;
- browsers and authoring tools that do not support keyboard alternatives for mouse commands;
- forms that cannot be tabbed through in a logical order;

People with speech disabilities - many individuals rely on voice recognition, someone with a speech disability needs to be able to use an alternate input mode such as text entered via a keyboard.

Problems that they may meet on Web information systems:

- Web information systems that require voice-based interaction and have no alternative input mode;

People with cognitive and neurological disabilities - many individuals rely on getting information through several modalities at the same time. For instance, someone who has difficulty reading may use a screen reader

plus synthesized speech to facilitate comprehension, while someone with an auditory processing disability may use captions to help understand an audio track.

They also may need to turn off animations on a site in order to be able to focus on the site's content. May take more time on a Web site, may rely more on graphics to enhance understanding of a site, and may benefit from the level of language on a site not being unnecessarily complex for the site's intended purpose.

May rely on a consistent navigational structure throughout the site and turn off distracting visual or audio elements, or to use screen magnifiers.

Problems that they may meet on Web information systems:

- lack of alternative modalities for information on Web sites, for instance lack of alternative text that can be converted to audio to supplement visuals, or the lack of captions for audio;
- distracting visual or audio elements that cannot easily be turned off;
- lack of clear and consistent organization of Web sites;
- use of unnecessarily complex language on Web sites;
- lack of graphics on Web sites;
- lack of clear or consistent organization of Web sites;
- distracting visual or audio elements that cannot easily be turned off;
- Web pages with absolute font sizes that do not enlarge easily;
- use of visual or audio frequencies that can trigger seizures;

As it is seen from named problems, a lot of them directly matter information and element layouting or design of Web information system. Therefore for a Web information system developer accent on client side programming language usage skills should be made.

Results and discussion

Web developers can develop Web information systems with client side and server side programming languages. For layouting visual elements and texts, client side languages such as HTML, CSS, XHTML and JavaScript are used. (Lane J et al., 2008) This research accent is put on client side language examination as a possible problem solving tool. Many of named needs could be tried to solve with a use of knowledge about basic Hypertext Markup Language, JavaScript, Cascading Style Sheets and logical layouting of provided data.

As previously commonly met problems for people with disabilities when using Web information system is identified, it is possible to bring forward solutions for particular group of people with disabilities.

Persons from group of people with visual disabilities mostly have three types of disabilities. Blindness - involves a substantial, uncorrectable loss of vision in both eyes. Low-vision – there are many types of low vision: clouded vision, tunnel vision (seeing only the middle of the visual field) and others. Color blindness – these people have lack of sensitivity to certain colors. Common forms of color blindness include difficulty distinguishing between red and green, or between yellow and blue. Sometimes color blindness results in the inability to perceive any color. (World Wide Web Consortium, 2009; Pernice and Nielsen, 2001; Slatin and Rush, 2002) Possible solutions for people with visual disabilities are brought together in Table 1.

Table 1

Corresponding guidelines for developer taking in notice group of people with visual disabilities

Corresponding guideline for developer	Type of solution
Usage of ALT attribute for elements, such as images. ALT attribute should contain explanation text about, for example, image content. It is preferable to add detail description for important images. (Krug, 2006)	Can be done with basic knowledge of HTML or XHTML tags and attributes.
For multimedia files, it is required to add text with a description. Preferable to add and transcript of a multimedia file content.	Can be done with basic knowledge of HTML or XHTML tags and attributes. If text is not put in attributes, then just basic knowledge of HTML document structure is required.
If tables are used on Web site, there is a need to order table in logical order, especially if table read serially.	Can be done with basic knowledge of HTML or XHTML tags.
Avoiding FRAME element usage can improve usability. But if frames are used, there is a need to have understandable frame names.	Can be done with basic knowledge of HTML or XHTML tags and attributes.

Corresponding guideline for developer	Type of solution
<p>If information filling forms are created in Web site, there has to be used HTML attribute TABINDEX to define serial tabbing order of filling designed form. Also developers should pay attention in using HTML tag LABEL to clearly define meaning of form element.</p>	<p>Can be done with basic knowledge of HTML or XHTML tags and attributes.</p>
<p>There is a need to use relative font size, so users can change font size using internet browser. One method would be to set a relative font size on specific containers or apply relative font sizing to specific elements. Both are done using Cascade Style Sheets. For example: <code>h1 {font-size: 160%;}</code></p>	<p>Can be done with basic knowledge of CSS version 1.</p>
<p>Use liquid layout instead of frozen layouts of Web information system pages. Liquid layout means that all containers on the page have their widths defined in percents – meaning that they are completely based on the viewport rather than the initial containing block. A liquid layout will move in and out when internet browser window is resized. (York, 2006)</p>	<p>Can be done with extended knowledge of HTML or XHTML tags, attributes and CSS version 1.</p>
<p>Allow user override of styles. CSS possibilities can be used to allow such feature. If user's style sheet contains operator "!important", it takes precedence over any applicable rule in an author's style sheet. For example code example from CSS file: <code>P { font-size: 24pt ! important }</code> Following rule specifies a 24 point font size for paragraph text and would override an author rule of equal weight</p>	<p>Can be done with extended knowledge of CSS version 1 and version 2.</p>
<p>There is a need to avoid using text presented as images. The practices show, that developers time by time use such method in bilingual or multilingual Web information systems for presentation of existing, but less used language on certain page. If creating multi-language Web site, considering UTF-8 as main encoding option can solve some usability problems. For example, code from HTML page meta data section <code><meta http-equiv="Content-Type" content="text/html; charset=UTF-8"/></code></p>	<p>Can be done with basic knowledge of HTML or XHTML META data tags and attributes.</p>
<p>When layouting pages, multi-marker idea should be taken into consideration. For example in form layouting not just using "color" attributes to mark obligatory filling fields. There should be at least one more marker that defines obligatory fields, for example special symbol. As a common practice, many Web sites use (*) symbol for marking.</p>	<p>Can be done with basic knowledge of HTML or XHTML tags and attributes. If text is not put in attributes, then just basic knowledge of HTML document structure is required.</p>

Persons from group of people with hearing disabilities mostly have two types of disabilities. Deafness - involves a substantial uncorrectable impairment of hearing in both ears. Some deaf individual's first language is a sign language, and they may or may not read a written language fluently, or speak clearly. Hard of hearing – people with a mild to moderate hearing impairment. (World Wide Web Consortium, 2009; Pernice and Nielsen, 2001; Slatin and Rush, 2002) Possible solutions for people with hearing disabilities are brought together in Table 2.

Table 2

Corresponding guidelines for developer taking in notice group of people with hearing disabilities

Corresponding guideline for developer	Type of solution
For multimedia files, it is required to add text with a description. Preferable to add and transcript of a multimedia file content.	Can be done with basic knowledge of HTML or XHTML tags and attributes. If text is not put in attributes, then just basic knowledge of HTML document structure and data input is required.
When inserting long portions of sophisticated text, adding more accents in implementing corresponding images with, for example, IMG tag would be more preferable. For information structuring HTML tags, such as TABLE or LIST should be used.	Can be done with basic knowledge of HTML or XHTML tags and attributes.

Persons from group of people with physical disabilities mostly have one type of disability. Motor disability – can include weakness, limitations of muscular control, limitations of sensation, joint problems, or missing limbs. Some physical disabilities can include pain that impedes movement. These conditions can affect the hands and arms as well as other parts of the body. (World Wide Web Consortium, 2009; Pernice and Nielsen, 2001; Slatin and Rush, 2002) Possible solutions for people with physical disabilities are brought together in Table 3.

Table 3

Corresponding guidelines for developer taking in notice group of people with physical disabilities

Corresponding guideline for developer	Type of solution
Although it is not directly related to HTML or CSS, but when developing forms or other user interaction with server elements, settings on server time-limits should be reconsidered and given at least 30% longer time-limits – sessions than for average user needs. JavaScript can be used to develop script which shows user how long is the session for current Web site.	Can be done with extended knowledge of JavaScript and Web server configuration.
If information filling forms are created in Web site, there has to be used HTML attribute TABINDEX to define serial tabbing order of filling designed form.	Can be done with extended knowledge of HTML or XHTML tags and attributes.

Persons from group of people with speech disabilities mostly have one type of disability. Speech disability - can include difficulty producing speech that is recognizable by some voice recognition software, either in terms of loudness or clarity. (World Wide Web Consortium, 2009; Pernice and Nielsen, 2001; Slatin and Rush, 2002) Possible solutions for people with speech disabilities are brought together in Table 4.

Table 4

Corresponding guidelines for developer taking in notice group of people with speech disabilities

Corresponding guideline for developer	Type of solution
If multimedia Web information system is developed with a, for example, voice-based login to particular system, there should be alternative login mechanism available, for example, using HTML forms and allowing user to login by typing data	Can be done with extended knowledge of HTML or XHTML tags and attributes.

Persons from group of people with cognitive and neurological disabilities mostly have six types of disabilities. Visual and auditory perception, including dyslexia (learning problems) disabilities – people may have difficulty processing spoken language when heard and also difficulty with spatial orientation. Attention deficit disorder disabilities – these people may have difficulty focusing on information. Intellectual disabilities (including Down

syndrome) – people may learn slowly or have difficulty understanding complex concepts. Memory impairments – people may have problems with short-term memory, missing long-term memory, or may have some loss of ability to recall language. Mental health disabilities – people may have difficulty focusing on information or difficulty with blurred vision due to side effects from medicine that they take. Seizure disorders (including some types of epilepsy) – people can be triggered by visual flickering or audio signals at certain frequency. (World Wide Web Consortium, 2009; Pernice and Nielsen, 2001; Slatin and Rush, 2002) Possible solutions for people with cognitive and neurological disabilities are brought together in Table 5.

Table 5

Corresponding guidelines for developer taking in notice group of people with cognitive and neurological disabilities

Corresponding guideline for developer	Type of solution
For multimedia files, it is required to add text with a description. Preferable to add and transcript of a multimedia file content.	Can be done with basic knowledge of HTML or XHTML tags and attributes. If text is not put in attributes, then just basic knowledge of HTML document structure is required.
If implementing animations or other “moving” visual elements, control over them should be developed. For example, using JavaScript onMouseover event handler or if multimedia file is shown, there should be player software, that can allow user to manage the file. (Lane J et al., 2008)	Can be done with basic knowledge of JavaScript or server-side programming language.
When inserting long portions of sophisticated text, adding more accents in implementing corresponding images with, for example, IMG tag would be more preferable. For information structuring HTML tags, such as TABLE or LIST should be used.	Can be done with basic knowledge of HTML or XHTML tags and attributes.
There is a need to use relative font size, so users can change font size using internet browser. One method would be to set a relative font size on specific containers or apply relative font sizing to specific elements. Both are done using cascade style sheets. For example: <code>h1 {font-size: 160%;}</code>	Can be done with basic knowledge of CSS version 1.

These guidelines cover almost all previously mentioned needs. There is still left some needs without guidelines, but these needs are addressed towards user environment, particularly Internet browsing software. For example need of browsers and authoring tools that lack keyboard support for all commands could not be solved by using basic developer tools and directly not address Web information system developers.

If the overview of guidelines ratio against for previously mentioned needs is made, it is seen, that from 34 mentioned needs, only 12% is left without guidelines for developer or more precisely do not directly address developer.

Conclusions

As it is seen from tables of corresponding guidelines for developer, most of 88% published needs that can be solved by basic knowledge of HTML, CSS and JavaScript, which is requirement for Web information system developers. Yet more, many of solutions just require more careful code writing and do not require fundamental changes in Web developing techniques.

Solutions that are mentioned in this paper can solve named problems, at the same time there can be additional solutions to particular problems. Solutions made with different programming language or different element usage techniques.

There is also need to more research solution effectiveness in various types of projects.

Even it is seen that Web information system developer can use these guidelines to improve accessibility, in many projects it still remains a question of requirements for system and target of business process.

But as the tendency shows, governments and other legal institutions take actions in form of regulations, policies and even lawsuits against Web information system developers who develop public systems with low accessibility, including for people with disabilities.

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E-GOVERNMENT APPLICATION AREAS – THEORY AND PRACTICE

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Abstract

Electronic government also known as e-government is a diffused neologism used to refer to the use of information and communication technology to provide and improve government services, transactions and interactions with inhabitants and businesses. Electronic government or e-government is one of the most important elements on the current public sector reform agenda.

As e-government is more than technology or electronic media, the basic dimensions of e-government can be derived from the functions of government. Government need to implement exercises of authority in a political system. Government is needed to maintain law and order, to provide citizens with public services, and to safeguard civic rights and democracy.

Managerial oriented e-government processes are promoted through such generic technologies and applications as groupware, intranet and extranet solutions, databases, e-mail, global network sites, and other services of Internet.

In E-government foundation base is a vision of Latvia as a developed, dynamic and prosperous country, which is one of the key features of the needs of the people-oriented, democratic and effective government, which can provide the Latvian state and its people's competitiveness and prosperity in the information age. Considering global changes in world which are related with information society, as well as current Latvian government failures, Latvian government as a priority task bring forward state government modernization or e-government development program, which is based on information technology resources.

The aim of this paper is to analyze e-government processes and functionality, as well as to analyze Latvia's planned e-government conception and set up tasks in it.

Key-words: *e-government, information system, databases*

Introduction

Electronic government or e-government is one of the most important elements of the current public sector reform agenda. It reflects public sector organizations need to find opportunities for modernization, globalization and information society development challenges. E-government is no longer a matter of choice but is a necessity for any country that wants to 21st century log in as a competitive nation in the world. E-government refers to the political administrative structures and processes, which are used for information and communication technologies (ICT).

Today's state administration is an essential feature of customer-orientation. In the administration process optimization as important for the customer are considered client (citizen, entrepreneur, investor, etc.) interests. This means cardinal rearrangement process managing, making it easier directly of the government customer's point of view. E-government can be divided into the following processes, each of which has its own functionality:

- Company's active participation in public administration – the Internet allows the public direct participation in decision-making and provides government transparency and accessibility;
- Customer orientation (orientation to the client) which means customer satisfaction - a result of work of public authorities and measure, as well as fundamental national institution's internal culture change;
- Service integration in the life events model reference – a person must be able to get his specific problem in one place and the state should provide the individual service integration;
- Multi-channel including Electronic services administration – presence repairs, as well as Internet, telephone digital TV products, etc. exploitation and the private enterprise involvement of providing services, competition;
- Equal opportunities for all (inclusion and non-discrimination) – education and Internet access should not create new inequalities in society;
- Focus on core tasks and outsourcing – today the state mission is a fundamental economic and social development with customer service, infrastructure maintenance and routine support functions may be entrusted to specialized companies. [4]

In Latvia has been performed e-service summary provided by state or local authorities. Thus, it is set to electronization levels, as well as challenges and recommendations to increase electronization levels. [6]

As the basis to determine e-services were used an EU electronic services, but in addition were identified and analyzed other e-services by the institutions already providing or planning to do so soon. Electronization degree determined using the internationally accepted method.

For each of the services are used a little specified measuring scale, but overall, general assessment may be carried out using explanation of electronization levels (Table 10).

Table 10**E-Services electronization levels**

Electronization level	Explanation
0	The responsible instances are not publicly accessible and comprehensible to all web pages or existing web pages, that can not be characterized by above listed 1-4 level criteria
1	The required information, that is necessary for receiving services, is available and understood by the websites in responsible instances.
2	In the web pages of responsible instances is possible to obtain the shape-form to start the service received in non-electronization way.
3	In the web pages of responsible instances is possible to electronically submit specially developed electronic forms to start receiving the service.
4	In the web pages of responsible instances is possible to carry out the full procedure, which involves the receipt of the service electronically. File processing, decision making and standard procedures for the purpose of providing the service is possible to take over the network. There is no need to perform any other work with documents.

The aim of this paper is to analyze e-government processes and functionality, as well as to analyze Latvia's planned e-government conception and set up tasks in it.

For this purpose achievement the following tasks are defined – to discuss situation in Latvia's e-government and to consider Latvia's e-government development in region context, as well as to inspect e-services in Latvia.

The Latvia's e-government development in region context

At present, many developed countries as a national priority for e-government is carried out modernization of public administration, which are developed within different projects and programs.

The report "Global E-government Readiness Report 2008" includes 189 countries. [3] E-government development is evaluated based on three main criteria, which are related to the administration web page access, telecommunications infrastructure and human resources. [1]

The world e-government average index continues to grow (Table 11), because more and more countries are investing in developing information web sites.

Table 11**E-Government Readiness for Northern Europe**

Country	2008 Index	2005 Index	2008 Ranking	2005 Ranking
Sweden	0,9157	0,8983	1	3
Denmark	0,9134	0,9058	2	2
Norway	0,8921	0,8228	3	10
United Kingdom	0,7872	0,8777	10	4
Estonia	0,7600	0,7347	13	19
Finland	0,7488	0,8231	15	9
Ireland	0,7296	0,7251	19	20
Iceland	0,7176	0,7794	21	15
Lithuania	0,6617	0,5786	28	40
Latvia	0,5944	0,6050	36	32
Region	0,7721	0,7751		
World	0,4514	0,4267		

Most countries have an e-information about policies, laws and archives division about the portal / website. The gap between e-information, e-consultations and e-decision-making process is still widely between developed and developing countries. Economic and Social Department (DESA) compiled the latest e-government index, in which Latvia is taking the 36th place, falling behind Estonia and Lithuania. Current situation (Figure 6) stipulates that the company has its own e-mail, record keeping, file systems, as well as business or sector-specific system.

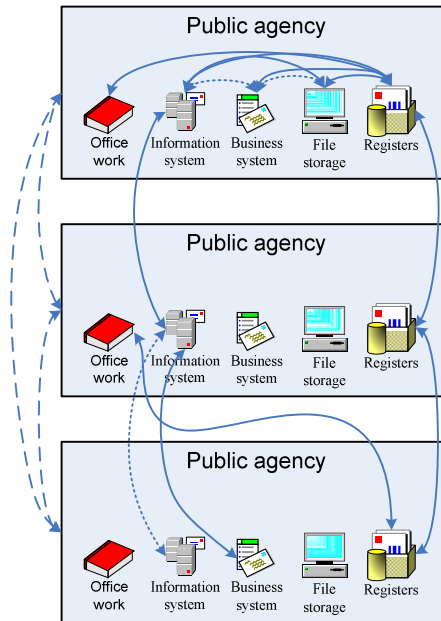


Figure 6 The current situation in the institutions
[Author developed image]

In the current situation is combined different national institutional systems and it is happening in a very long time. It does not address the option that each ministry set up its computing centres and centralize it within the ministry. [2] The biggest benefit would be if the people should not go from one institution to another with reference, but they trust their data as they trust each other, that in the IT field would eliminate interdepartmental barriers (Figure 7).

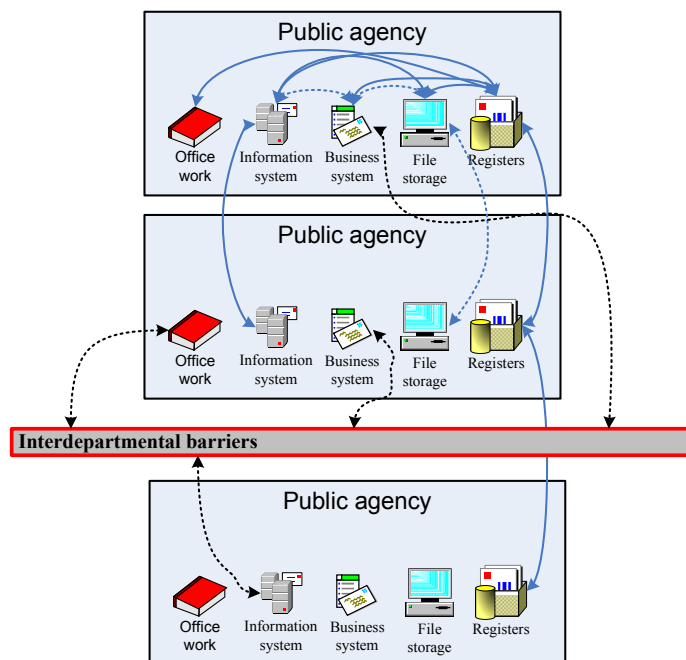


Figure 7 Inter-institutional links
[Author developed image]

Continuing the e-government implementation, the next two years are planned all the public administration related services for citizens and businesses provide in one-stop agential in municipalities. One of the key ways to encourage state and local services is to develop and implement e-services that are available in one place - online in portal www.latvija.lv. Recently, there has developed an e-service - declare the place of residence on the Internet. This service can now be used not only to persons who have an e-signature, but any internet bank user. Declaration of residence place on the Internet will be accessible and convenient, and this service will help state and local authorities. Already there has been observation, that people have great interest in the new option – in the one day since the service is implemented, it has been used by 89 residents, which is even more than in the past half-year received electronically signed declarations.

Developing e-services, residents will be given the opportunity in the electronic environment find out their data in the register of diabetes patients, Health Compulsory Insurance State Agency, as well as data on their family physicians and required immunizations. Also will be given the opportunity to find out the accumulated information in the State Social Insurance Agency and have begun negotiations with record companies about the possibility to create e-services business registration.

Latvia's planned e-government conception and set up tasks in it

For e-government establishing in concept the following objectives are set. Gradual public service rendering in electronization since year 2002-2007, that includes public access to information on the Web in a systematic and integrated manner until year 2002; 20 basic services until year 2004 and all services until year 2007. Also e-democracy mechanisms introduction must be done until year 2006 (elections, referendums, questionnaires and political communication on the Web). It is said, that service integration and subordination according to clients' life situations, using a one-stop shops, call centres, as well as electronic means of communication - up to 2005. Take public administration transformation of customer-oriented organizations, significantly increasing their operating efficiency and Latvian administrative institutions alignment with the European Union structures and cooperation with other countries until year 2005.

In order to achieve pre-defined e-government development tasks, the Latvian government as a priority task (mission) brings forward national government modernization or e-government development program realization, based on IT capabilities and e-business-specific operational principles in public administration, ensuring the quality of public services and improving efficiency, and increase public participation in public administration. [5]

Available e-services in Latvia (Figure 8) have been developed in collaboration with the Citizenship and Migration Affairs, the Interior Ministry of the Information Centre of the State Land Service, National Police, Court Administration, Riga and Ventspils local authority.

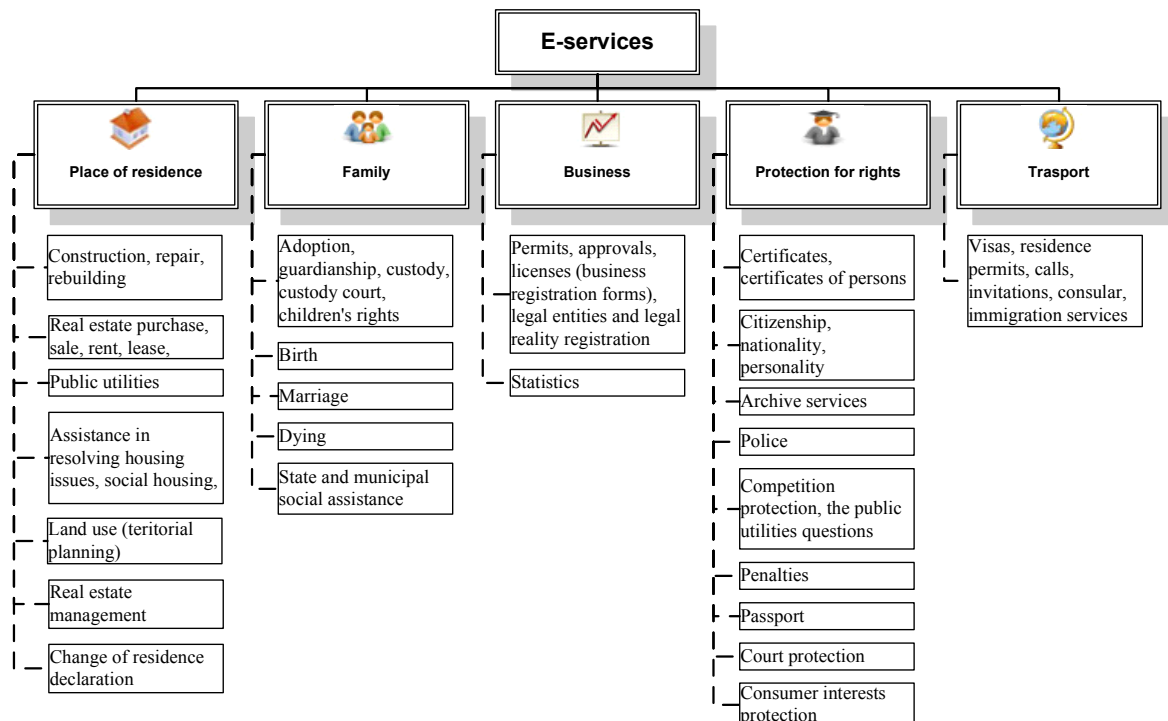


Figure 8 Available e-services in Latvia

[Author developed image]

The available e-services should be available to a wider audience. In year 2010 plans are to attract other banks to provide access to e-services. Now www.latvija.lv authentication is available with SEB, Swedbank and the Latvian Savings Bank Online Banking Authentication.

In e-service group *Place of residence* are included nine e-services. The Submission of declarations of residence service enables a person to declare himself, his minor child, guardianship or dependent persons residing in Latvia. The Application for registration of residence abroad service enables a person to notify the Citizenship and Migration Affairs himself, his minor child, guardianship or trusteeship occupant residential address abroad. Tree cutting permits collection provides the possibility of a natural or legal person (the property owner or authorized person) to request the City of Ventspils on the tree cutting permit. Declared persons in my property the service enables individuals to obtain information about persons registered in the Land of properties, their composition, cadastral numbers, addresses and people who have valid registration in home (or declared after the authorities recorded the initiative of residence) in property addresses. My data in Cadastre – the service enables users to receive from the State Real Estate Cadastre Information System current text of the cadastral data for your real estate and construction, which does not include any real property constituted under the State Real Property Cadastre Law. My data in the municipality - this service within the city of Riga and Ventspils municipality provides the information, which is electronically stored in its use of existing information systems. If the municipality uses public significance registry information, the municipality indicates the data synchronization date with the national interest register. I or my personal data are represented in the population register – the service enables a person to know what information about their minor children, guardianship or trusteeship of the persons included in the Population Register. Verification whether the person has valid registration in home address indicated – the service enables the user to verify the data contained in the Population Register, whether the person with the user's personal code is the registration of the user's indicated home address. Fence construction permits collection – in this service you can electronically submit requests for authorization of the construction fence in Ventspils city municipality.

In e-service group *Family* are defined five services. Orphans' Court decision duplicate require – in this service is being offered the opportunity to electronically submit a request in Ventspils and Riga City of Orphans' Court decision duplicate receipt. Obtaining birth certificates repeated require – this service have the opportunity to Riga or Ventspils City electronically request a birth certificate re-issuance of a certificate or an extract from the civil status registers and get the laws prescribed order. Statements about dietary subsistence level require – this service is being offered the opportunity to electronically submit a request for the Municipality of Ventspils on the certificate of minimum food service. Obtaining a marriage license repeated require – in this service person within the municipality of Riga or Ventspils electronically request a marriage certificate, a certificate or an extract from the civil status registers and receives its laws and regulations prescribed order. Obtaining death certificates repeated require – in this service person within the municipality of Riga or Ventspils electronically request the death certificate, a certificate or an extract from the civil status registers and receives its laws and regulations prescribed order.

In e-service group *Business* are defined four services that are used in other groups.

In e-service group *Protection for rights* are defined fourteen services including five services, which are in other groups. Document verification in the Invalid's register – the service provides the possibility to check whether the document about Latvian Republic persons and rights is not registered in Invalid document register. An application about an injunction or a permission to use the person's body, tissues and organs after death - the service enables a person to notify the Citizenship and Migration Affairs its will on the prohibition or permission to use their body, tissues and organs after death. Application for State Police – this service provides an individual to electronically submit an application (application, complaint, question or proposal) to the state police and get an answer to the requirements of regulatory enactments. Obtaining certificates for individuals convictions – this service includes a request to electronically submit the certificate of natural persons obtaining convictions. Collection of individual cognitive administrative penalties – this service includes a request to electronically submit the certificate of an individual to receive administrative penalties imposed. Check whether the person is entered in the Population Register, and whether or not the message of death – the service enables the user to verify the data contained in the Population Register, whether the person with the user's personal code is entered in the Population Register and, if included, a person of the population register data is not dead. Municipal council decision duplicate collection – in this service is possibility to make a request of Riga and Ventspils City Municipal Council for a decision on the duplicate issue. Request to receive inquiries from the Population Register about the person or represented person – the service allows a person to request a statement of his, his minor child; guardianship or dependent persons in the population register included information. Request to receive inquiries from the population register as a third person – the service allows a person to request a statement of the third-person information contained in the Population Register.

In e-service group *Transport* are defined two services. Approval of the Invitation for application - the service provides the opportunity to submit an application for approval of the invitation, which need to be a foreigner apply for a visa for entry into the Latvian Republic. Call Approval of a residence permit – the service provides

the opportunity to submit an application for approval of the call, which is necessary for a foreigner to apply for a residence permit Latvian Republic.

Conclusions

The current situation in the state administration has shown that for modernization and improvement are few financial resources, and possibly in the future will be even less. To ensure a more efficient public administration development, is undoubtedly a need for information and communication technology (ICT), which requires not few finance. The current position of public administration reflects the fact that the power management functions and the division is realized in some of them, giving subordinate bodies, as well as the local authorities. There is a fragmentation and duplication between ministries and agencies. To effectively use provided government services, need to combine information technology infrastructure, standardize services and data interoperability, as well as reorganize functions. To achieve efficiency in public administration, it would be necessary to carry out internal centralization - a single data centre, IT staff and functions; the country to purchase outsourced services; promote partnerships with private firms - high quality services of democratic price and offered solutions how to achieve it.

Efficiency involves the reduction of service time, which includes client and service provider resources and service delivery cost reduction. In Latvia there have been opinions that the e-government implementation is costly and inefficient, but there is an opportunity to consolidate resources, which is even necessary. To make further efficiency improvements, it is possible to create one-stop agencies and to create a single information and communication technology (ICT) resource management.

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HOW TO CRACK MD5 ALGORITHM USING ADVANCED BRUTE FORCE

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Abstract

MD5 hash algorithm and few of its weaknesses are described in this paper. Popular attacks are also explained in it. This algorithm is possible one of most used hash algorithms in the web applications at the moment. MD5 is mostly used for password hashing for user authentication. The paper based on new technology and tool developed by author how to crack MD5 passwords in possible less time than other guaranteed attack. All work is created only for educational and to improve web security purposes only. Described technology and tools can be modified and used for any hash algorithm to check it resistance for this kind of attack.

Key words: md5, hash, crack, brute force, password, tool

Abbreviations used: MD5 – Message Digest algorithm 5.

Introduction

Since computer network has grown in geometrical progression and the Internet has born – the most important thing for the people are data security and protection of all data and personal information. There are different encryption methods and hashing algorithms for every period of time and computer power. Security is most important thing for all algorithms. How persistent algorithm is against different kind of attack? Experience shows that for some algorithms cracking is time consuming, but for others it is just complexity that no one has cracked yet. After each significant development in computer speed and power, there always will follow some interesting development in the field of computer security. Whatever new ideas and tools are for good or bad intentions, the result will be more secure communication for users in some period of time.

MD5 Algorithm and Most Used Attack Methods

Message-Digest algorithm 5 (MD5) is very popular and widely used cryptographic hash function with a 128-bit hash value. This function is next generation of message-digest algorithms after MD4. MD5 released in April of 1992 (RFC 1321). The algorithm takes as input a message of arbitrary length and produces as output a 128-bit ‘fingerprint’ or ‘message digest’ of the input that at the moment commonly are known as hash. An MD5 hash is typically expressed as a 32-digit hexadecimal number. It has been shown that MD5 is not collision resistant (X. Y. Wang et.al. 2005) algorithm, so MD5 is not suitable for applications like SSL certificates or digital signatures that rely on this property. However it is often used in digital signatures in many variations.

Commonly used attack methods are for MD5 hash cracking:

- Brute force – brutal force, this method consists of walking through each possible input in the method and comparison with the outcome result for current algorithm. This method is very slow, time consuming, but it is very effective and also 100% accurate to get necessary result. One of its problems is collision detection – it means, that this method not only can find a plain text, but also every collision and user probably will never know whether result is necessary plain text or just one of its collisions
- Rainbow tables – method which use previous generated tables with lookup intervals and search in this table using some kind of cryptanalysis to get short cut to the result. This method is useful and fast if you have pretty enough time to generate lookup table or using already in online public generated rainbow tables. The problem is that practically this method is not 100% successfully but theoretically it could be 100% success.
- Dictionary attack – attack using previously listed words. This method usually is very fast, but also very rare possible to work.
- Hybrid attack – very different and variable attack way that usually mix up different kind of attacks. In the Internet there are very many tools and articles about hybrid type of attack.

The Problem Description and MD5 Cracking Task

There are many problems to solve for finding true plain text from given hash with known charset. If we are using brute force attack then there is possibility to find also collisions and in some times collision plain text could be useless. There are times, when attacker knows some information about plain text, for example most common things are text length, some information about possible charset, is it word or sentence, even there could be

known some symbols in that plain text. But at the moment I could not find online any tool or description how to solve this problem. So for those reasons to solve some of these problems I will set one task with different options and develop software for fast attack and we will see is it possible to make a brute force attack for really complex or long passwords in real life not spending years on calculating plain text. If the experiment will be successful then we could make conclusions and learn something from it.

One of the participants of the experiment was asked to give all necessary information to test cracking in real life. MD5 hash was given by him: 3cefe9eb7d4567ebcb495ef1f0a792ac. It is known that the plain text is in Latin alphabet and there are upper and lower case letters. The text is a normal sentence in English, which consists of 41 symbols and there are four symbols with known positions 5-o, 9-e, 25-a, 37-i given and the last symbol is exclamatory mark '!' – so it is in position 41. For this kind of task there is no any known online tool or database which could possibly crack longer passwords than 15 symbols in few days. There of course are methods like Rainbow tables, but for this task to use them, these tables should be created what also needs some time. And after generation of tables it is necessary to spend some time to search and analyse the result. There is no 100% guarantee that the plain text will be obtained, because normally when generating Rainbow tables not all range is covered, but only 96% to 99% at the best situation, because 100% covering take a lot of time. It was decided to create experimental software for this kind of tasks for education reasons.

Information analysis

Before coding should be carried out some analysis on what is known about the plain text and conclusions obtained from the information received to make the range as short as possible for getting job done as fast as possible.

Some important conclusions about plain text are (could be useful later):

- Text is in English.
- Text is a normal sentence, so there should be some spaces.
- As it is known that the plain text is 41 symbols long there have to be more than one word. According to calculations there could be at least 4 words so it means that there are at least 3 spaces. And it is also known that the spaces should not be together and will not be in the first or last position of the plain text.
- At the end of sentence there is exclamatory mark.
- It is known that the text is in English then probably most other common things concerning the language could also be used, for example:
 - The words will not begin with two equal symbols
 - Very rare are situations, when two or more symbols are next to each other with some exceptions (the authors exceptions are: ll, ee, ff, gg, tt, pp, ss, cc), but all other cases practically are not used or they is very rare (aa, bb, dd, hh, ii, kk, mm, nn, oo, rr, uu, qq, vv, ww, xx, yy, zz). These symbols are chosen by the author. For more arguments probably the following website could be used: <http://www.morewords.com/pair/> (last checked 19.02.2010) – any word can be found there which contains a specified pair of letters.

Solving of the Problem

There is no such an elastic and powerful publicly available tool for solving such a kind of tasks, for breaking hashes, that are longer than 20 symbols and being able to use all known information about the plain text including text analysis. So it was decided to create such a tool by which the most of known information could be used. Developed software is only for education reasons and therefore it was programmed in C# and PHP language, because these two are best known for author. Otherwise it would be better to make such a tool in C with some part of code coded in highly optimised Assembly to get the maximal possible calculation speed per second.

For this kind of task it was decided to use Server and Client type technology. In this way it would be possible to solve task on multiple computers and also by other software in different programming languages. See figure 1.

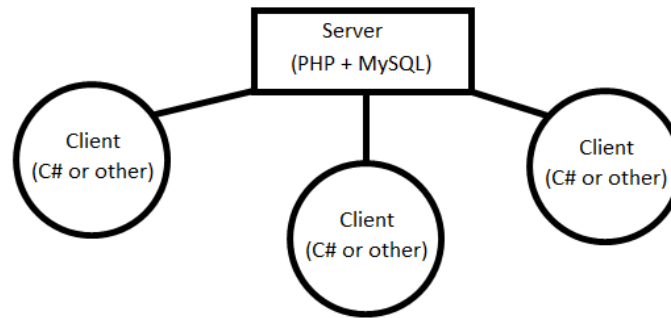


Fig. 1: Server and Client type schema

Working according to the schema above more clients can be added any time to solve the problem faster by splitting the task into smaller ones. The whole idea is about creating a web server with some smart functionality, which is a split task into smaller parts. The client application will be connected to the server, to get the small task and solve it. After that or even in the process the client will send some results back to the server. The server will log and process all data.

For the server, a simple LAMP (Linux + Apache + MySQL + PHP) configuration was used.

Database ER Diagram

For every information system, it is necessary to store data, therefore especially in the case of MD5 cracking, it is necessary to save all data. There are few possibilities to create such a solution for a client-server application. On the one hand, that could be only logging, on the other, that can be also to get settings from the server. To get both ideas to work, an ER diagram was created (see figure 2).

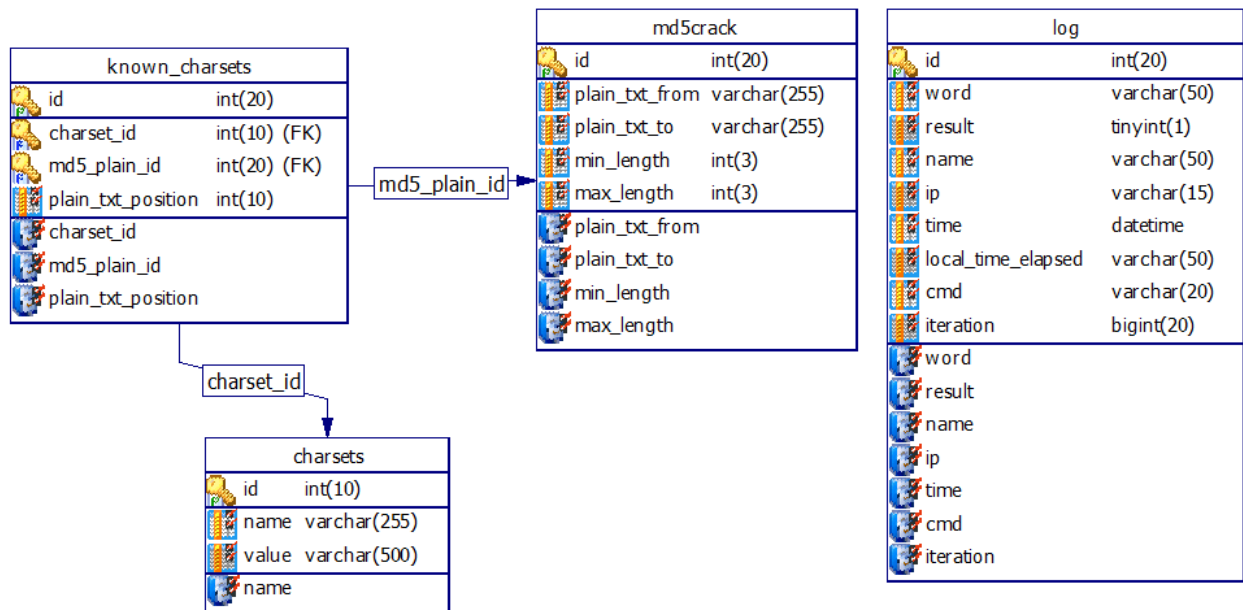


Fig. 2: Database ER Diagram

Only four main tables are shown in figure 2:

- charsets – information about possible character sets and their short names;
- known_charsets – information about known possible characters in position x;
- md5crack – information about the first and the last text for current range of the plain text list (current task), for this task there could also be some known characters that is a link to other table;
- log – table for logging all information that server will get from clients.

NB! This is only a proposal just for imagination for education reasons, the true tables may be a little different and store more data.

There are indexes for every table, primary and foreign keys to make sorting and lookup functions work as fast as possible.

If such a project could be published there would be some more features even if it is only for scientists, for example – gaming features could be added like set up some teams and for every solved task some points or other advantages are given. This idea is good to get people do things for somebody, but they can use the project and get some fun like it is done in Peekaboom (L.V.Ahn et.al. 2005) and other games with the purpose when you can use human computing or their computers to get the work done while they are playing around with your project.

Server Side Logic

As it was mentioned before, that for this task LAMP server was used. First of all it was created an API with PHP. There were three different major tasks for server to be done. Firstly it was logging of all possible data about the client to identify its tasks and even thread, but the logging had to be with smart choice because of huge amount of data to be transferred and not all of them had to be stored for later use. Secondly after all necessary information was stored, it had to be decided whether to give simple answer or command for next actions. Thirdly if decision was to give the answer, then just to give the answer that everything is ok. If there is a command, then there all current data have to be processed (usually it is already done in the background of this kind of tasks) and give the next task to solve.

Many connections with the server for every task are possible to give current status and check is it even actual to continue task or should any steps be skipped and the next task got or should it be standby until next conversation.

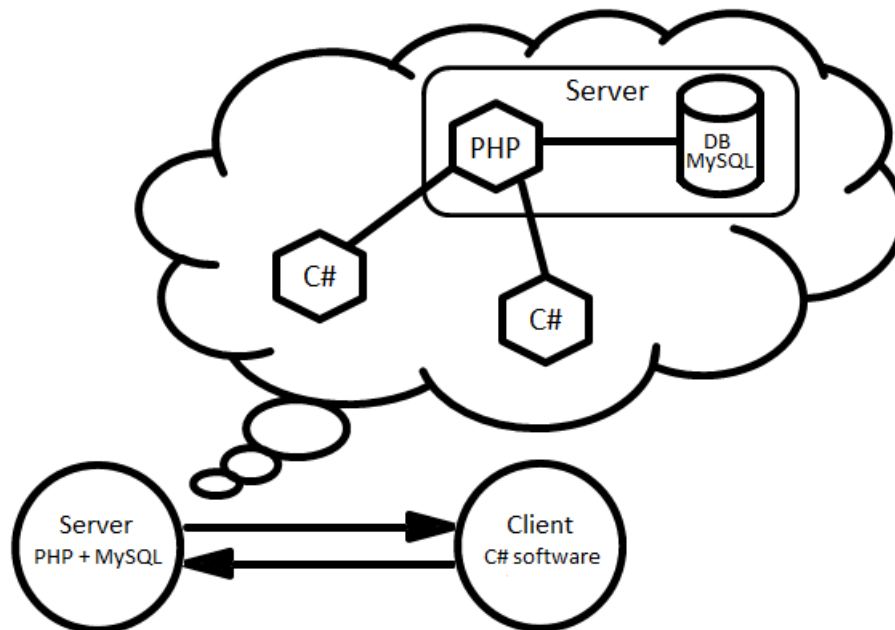


Fig. 3: Server – Client communication

In current situation all smart choices can be controlled and provided only by server (Fig. 3). Just for the idea there is a simple PHP script with small basic functionality.

```
<?php
require_once('func.mysql.php'); //Get all functionality for database
$response = "";
//... some security code excluded
$word = $_REQUEST['word'];
$res = $_REQUEST['res'];
if($res == "true")
{
    $res = "1";
}
else
{
    $res = "0";
}
$workTime = $_REQUEST['workTime'];
$ip = $_SERVER['REMOTE_ADDR'];
```

```

$name = $_REQUEST['name'];
$cmd = $_REQUEST['cmd'];
$iteration = $_REQUEST['iteration'];

$sql = "INSERT INTO `log` (`word`, `result`, `name`, `ip`, `time`,
`local_time_elapsed`, `cmd`, `iteration`) VALUES ('".$word."', '".$res."',
'".$name."', '".$ip."', NOW(), '".$workTime."', '".$cmd."',
'".$iteration."');";
sqlQuery($sql);

if($cmd == "initial")
{
    //$response = "mbox|Connection established!";
    $response = "statusbar|Connection established!";
}
if($cmd == "save")
{
    $response = "statusbar|processing...";
}
if($cmd == "stop")
{
    $response = "statusbar|stoped...";
}

/*****
//example how to set next word for client that he will continue at
//here can use any other logical expression
if($iteration == 5000000)
{
    $response = "nextWord|bbbbbbbbbbbbbbbb!";
}
*****/

echo $response;
?>

```

Client Application

For client application simple graphic user interface (GUI) was created (see figure 4).

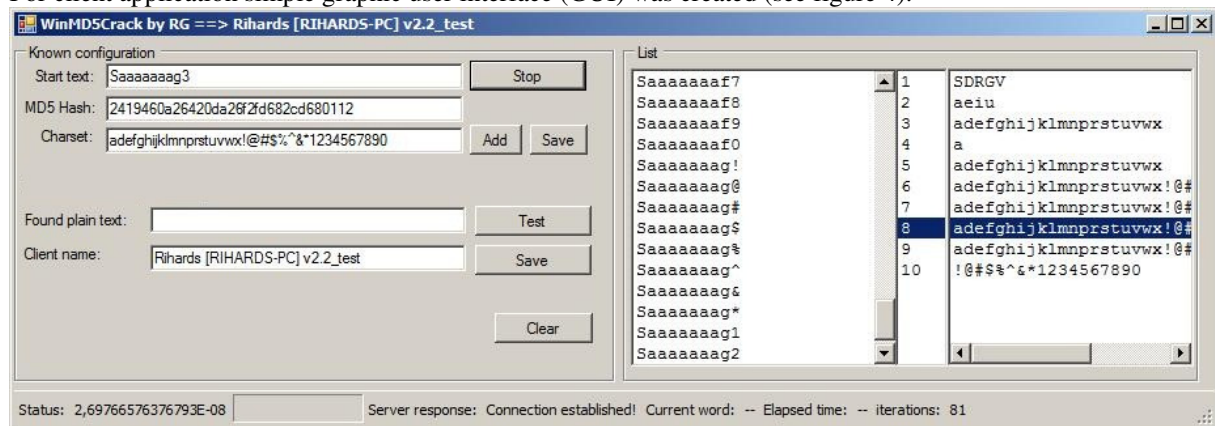


Fig. 4: Client Application GUI

This one of the first test versions for the GUI, but it does all the necessary work for this experiment. In the picture (fig. 4) are shown that in the program there are:

- start text – input start text for the task, if the server has not already set the initial task, but always it is possible to edit start text

- MD5 hash – hash that the user is trying to crack
- Charset – current charset of selected position on the right side of lists, where the user can edit it for all positions or add additional charset for next position
- Found plain text – if task is solved, then the user will get the result here (of course, result is also stored on server)
- Client name – user can set up their thread name, but if user has not done it then it will be automatically generated from user name on current computer and computer's name.
- List – this is only for showing (and debugging) progress and words after some number of iterations, but by turning it off better performance can be achieved

There are two different ways to filter wrong words. One is with regular expressions, but other is with many logical ifs or switches. For current version there are many ifs, because they are faster than switches like it was discovered after some benchmarks and also easier to understand code for educational reasons comparing to regular expressions.

Currently this tool runs in multiple threads one with internet connections and other for calculations. If user gets dual or more core computer and wants to try at the maximal speed, then at the moment he can run it twice or more and solve that task with different start and stop texts.

The Results and Performance

For current alpha version the performance is inconsistent. It is changing from 60 000 to 2 000 000 words per second in one thread. At the moment when algorithm is skipping words it will run with maximal speed, but for every word that needs to be compared to hash it will slow down because of complex hash script (there are many iterations).

Even with current maximal speed there have to be some more optimisations developed to crack more than 20 symbols in some reasonable time. So it was necessary to check the algorithm on smaller tasks. That is why some independent participant of the experiment was asked to create some hash with 10 symbols including upper and lower case letters, some digits and some special symbol. But like it is in situations when it is possible to see how victim inputs his password – which attacker cannot remember, but can set a closer range of charsets for different parts of password, also get some hints for different charsets (see figure 4).

So the new hash was '2419460A26420DA26F2FD682CD680112'.

For the experiment 4 different computers were used:

- Intel Core 2 Duo CPU E8500 @ 3.16 GHz, 4 GB RAM, Windows Server 2008 64 bit
- Intel Pentium 4 CPU @ 2.67 GHz, 1.43 GB RAM, Windows XP 32bit
- Intel Core 2 Duo CPU T9300 @ 2.5 GHz, 4 GB (3 usable) RAM, Windows 7 32bit
- AMD Athlon 64 X2 Dual Core Processor 5000+ @ 2.6 GHz, 2 GB RAM, Windows Vista 32bit

Task was separated into four subtasks and it was solved in 20 hours 3 minutes and 21 seconds. The plain text for this hash '2419460A26420DA26F2FD682CD680112' is 'Rihards2**'.

For the author it was faster than he thought, because his best forecast was from 42 hours to 30 days. For example, the same task with well known and popular tool 'Cain & Abel' v4.9.34 from oxid.it would be accomplished in ~430 years for given charset using simple brute force. Even in test version it is a good result. It was done so fast probably because of advantageous split into smaller regions. The full region was split so that first letters for every start word were different for every computer. Actually the Windows server got start word with 'R' in first position, so to get true password from that starting point the process was accomplished in the mentioned above 20 hours 3 minutes and 21 seconds.

Other Ideas

Hash cracking problem can be solved in many ways. In one as already mentioned before, but other could be by using such a powerful thing like databases. Even for this there are several ways including horizontal and vertical data storing and searching. Procedures and other fast issues can be used or not. For another small experiment multiple database tables were created, each one for every position in plain text. Necessary character sets for current position were inserted in every table. After that SQL query was written and waited for the answer. But in this simple experiment there is no easy and correct way to get some performance or speed benchmarks. Just for educational reasons there is very simple example below:

- Create some table for first position in plain text, this position will be described in table 'a':

```
CREATE TABLE `a` (`id` int(11) NOT NULL auto_increment,
`char` varchar(1) NOT NULL, PRIMARY KEY (`id`), UNIQUE KEY `id` (`id`),
KEY `char` (`char`)) ENGINE = MyISAM DEFAULT CHARSET = utf8;
```
- Insert all necessary characters:

```
INSERT INTO `a` (`id`, `char`) VALUES (NULL, 'a'), (NULL, 'b'), (NULL, 'c'), (NULL, 'd'), (NULL, 'e'), (NULL, 'f'), (NULL, 'g'), (NULL, 'h'), (NULL, 'i'), (NULL, 'j');
```

- Create analogical another tables for other positions and fill them with charsets
- Finally run SQL select with hash in it to start the process:

```
SELECT CONCAT(`a`.`char`, `b`.`char`, `c`.`char`, `d`.`char`, `e`.`char`, `f`.`char`, `g`.`char`, `h`.`char`, `i`.`char`, `j`.`char`, `k`.`char`) AS str, MD5(CONCAT(`a`.`char`, `b`.`char`, `c`.`char`, `d`.`char`, `e`.`char`, `f`.`char`, `g`.`char`, `h`.`char`, `i`.`char`, `j`.`char`, `k`.`char`)) AS md5  
FROM `a`, `b`, `c`, `d`, `e`, `f`, `g`, `h`, `i`, `j`, `k`  
WHERE MD5(CONCAT(`a`.`char`, `b`.`char`, `c`.`char`, `d`.`char`, `e`.`char`, `f`.`char`, `g`.`char`, `h`.`char`, `i`.`char`, `j`.`char`, `k`.`char`)) = 'feb9c6013351a5617c9cb5f0a520cb6b'
```
- Get the result from select. In current example for 'feb9c6013351a5617c9cb5f0a520cb6b' it is 'abcdefghijj';

Conclusions

- It is very important to skip as fast as it possible all incorrect strings that do not match with the definition. It will save a lot of time and computer power.
- In case of the appropriately split task half of the task is already done.
- While experimenting with database it is much easier to get logical part, but also much more difficult to get this process be split on multiple computers at the same time. For those reasons database cluster or any other improved idea can used.

Further ideas in this project can be found on <http://www.digihome.lv/md5crack/> or by contacting with the author by email rihards@digilabs.lv

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IMPLEMENTATION OF HACCP PROCEDURE USING WEB BASED INFORMATION SYSTEM PROTOTYPE

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Introduction

Hazard Analysis and Critical Control Point (HACCP) is a food production safety system. HACCP is a methodology, which describes management of business process during the whole production chain, starting from the raw materials up to end product delivery to customer. According to the HACCP procedure it is needed to systematically review all known biological, chemical and physical risks and provide appropriate control actions. Control actions are required to prevent risks or minimize them to acceptable level. On it's own ideology this system is like a warning system, which main aim is to prevent situations, when the hazardous products are delivered to the end customers.

The purpose of the HACCP is to focus control at the critical control points (CCP). CCP is the production stage, where control will remove or minimize possible risks causes to acceptable level. It is needed to separately apply HACCP procedure to each specific operation. Every time when some changes are made to product or process, it is needed to review and update HACCP procedure.

The Regulation of European Committee (EC) No 852/2004 requires that food business operators shall put in place, implement and maintain a permanent procedure or procedures based on the HACCP principles.

Latvia's agriculture risk management information technology system is developed within Latvian Science Council co-project Nr. V33/06.0040.1.4 „Latvia's agriculture risk and crisis management systems”.

The main aim of the cooperation Project was to clarify the development trends and implementation principles of the Latvia's agriculture risk management system. One of the tasks was to implement the HACCP procedure using the WEB based information system prototype.

Importance of the information system

Food production companies need HACCP information system (IS), because analyzing the current situation it was discovered, that all registers and other HACCP procedure related information are stored in paper form instead of digital data storage. Such situation really effects and complicates process of making the changes.

Storing the HACCP system data on paper is not really rational method. However this do not affect the implementation of the HACCP procedure in small or average companies, but when the production is large, the time used for HACCP procedure is growing fast.

One more important problem is low data protection level; because paper stored information do not comply with data safety guidelines. And of course it is very hard to search information on paper.

To solve mentioned problems it is recommended to implement HACCP IS. The new IS will allow reviewing the information about HACCP procedure conveniently and in fast way. IS will help to find the needed data and allows changing information in easy and comfortable way.

HACCP information system prototype

As a result of research the HACCP system prototype was created. This prototype helps to summarize data about HACCP procedure in the production company. The main aim of the system is storage and systematization of the information about production process.

Based on HACCP, the IS has to grant the possibility to view and change the data about HACCP procedure, it has to help to search for needed information.

We cannot say that system prototype is wholesome HACCP system, because prototype provides only minimal required functionality. This functionality is:

- data storing about products and their components;
- data storing about risk identification and prevention (microbiological, chemical or physical factors, that can be hazardous for people health);
- data storing about critical control points;
- monitoring log storage.

This functionality is minimally required, because it is enough to start implementation process of HACCP procedure in the company. System could be modified and upgraded. Possible improvements and future development are described in “Future development” part of this publication.

HACCP tasks and IS functionality can be found in table 1.

Table 1

HACCP tasks and IS prototype required functionality

HACCP task	IS functionality	HACCP Web Demo compliance
HACCP team data storage	System users management	Comply
Product components data storage	Product components data management	Comply
Product data storage	Product data management	Comply
Control point data storage	Defining the control points	Comply
Critical control points data storage	Defining the critical control points	Comply
Creation of production scheme	Uploading of the completed production scheme	Comply
Creation of the monitoring system	Monitoring data storage	Comply
Creation of the HACCP plan	Forming of the HACCP plan	Not comply
Informing the user when some accident happens	SMS, e-mail, notification system establishing	Not comply

HACCP plan is exact document, which define what activities are carried out to ensure control on product or process. Plan stores the information about one CCP. In the table 2 example of the HACCP plan can be seen:

Table 2

Example of the HACCP plan

Process stage	Pasteurisation	
CCP Nr.	1	
Risk source	Microbes	
Critical limits of measured parameter	Temperature from...to	
Monitoring	What?	Temperature
	How?	Automatically
	How often?	Every time
	Who?	Special device
Comments	Contact person is A.Ivanovs	
Correction actions	Product have to be pasteurised repeatedly	

Functionality of HACCP information system prototype

Developed system has user access control. There are three user roles: administrator, data manager, HACCP user. Each system user can combine one or more defined user roles. System user can make different actions, it depends on granted roles.

One of basic system functions is information storage. User can enter data about product components, consumer groups, product packages, also user can define risks. If it is needed this list of data can be modified.

HACCP system main object is product (for example juice, milk, meat and others), because of that the next function of system is product data storage. Product description mainly is created using the predefined product components and other parameters.

HACCP system is based on critical control points, that's way system have to store information about them too. It is possible to upload production diagram to the system. This diagram shows all production stages and user seeing this, can define control and critical control points more easily.

One of the most important system part is monitoring data writing, where information of each critical control point is fixed, based on critical limits. This information is needed to help to find out if process is going without problems. If data showing that some problems are occurred at the CCP, it is needed to make some corrections before risk is appeared. Observations and measurements can be done constantly or with intervals. If measurements are not fixed constantly, then it is needed to define how often measurements have to be done to provide acceptable information and data.

Today measurements are done manually by responsible person, but more effective it would be to complete this process automatically, for example programmable logic controllers could do this task and transfer data to information system.

Realization of system prototype

HACCP system prototype (<http://haccp.itf.ltu.lv/>) were developed using the WEB technologies. WEB were used because it has some advantages over regular systems, which do not use WEB realization. Firstly, WEB based

program do not require many resources from user side. Usually user needs only internet browser, which can be installed on stationary computers and also on mobile devices, such as mobile phones and communicators. Secondly, Web based systems can be developed and maintained conveniently. This is so, because all logical components of the system are concentrated in single environment at application server. Also it is possible to place those components on various application levels logically structuring them by system modules. At last, WEB based systems has high availability and prevalence, because it is accessible on the Internet. In case of HACCP IS this aspect is very essential and it contributes spread of HACCP methodology. Mainly HACCP system prototype is data storage and its structure can be seen below (Figure 1)

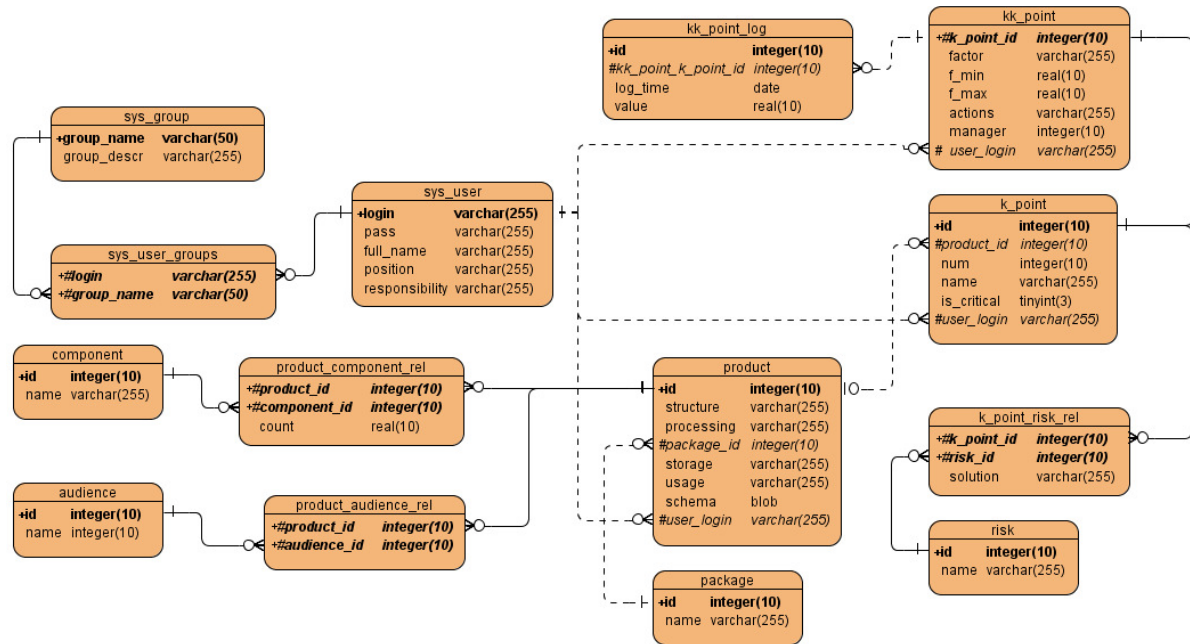


Figure 1 HACCP system structure

System available functionality is offered to the user depending on its role in HACCP concept implementation process. That's why one of the important system parts is user data management module. User main data is stored in the database table named *sys_user*. There are user identification (*login*) and MD5 encrypted password, which allows safety storage of sensitive information and password could be easily checked at the time of authorisation. In *sys_group* table all available user roles are described. These roles can be assigned to the exact user in the *sys_user_groups* table ("many to many".relation type).

Different types of classifiers are used for data processing. In developed prototype such classifiers as: product package types, product components, consumer groups, risks are used. These classifiers are stored in the database tables: *package*, *component*, *audience* and *risk*.

Product is the main object of the HACCP concept. All control points of the production process should be described and monitored. *Product* table stores general data about product, such as it's name, characteristics, processing, usage and storage properties, and also links to previously mentioned classifiers are stored too. Each product has its own production process, which in fact is a set of control points. All control points are stored in database table with name *k_point*. Some risks and its prevention techniques could be assigned to each control point.

According to HACCP methodology some control points can be defined as critical control points. Critical factor and its allowable limits, prevention actions and responsible person are defined in each critical control point and this data is stored in table with name *kk_point*. At last, HACCP system should have monitoring procedure. This means, that all CCP are monitored for problems and all data of monitoring are stored in table *kk_point_log*.

To all system data are added information about the user, who is created specific object, and this information are stored in special field named *user_login*.

Testing of the system prototype

Testing was needed to check that system prototype is working completely and correctly. Testing was completed using the self developed test examples. All system functionality was tested.

One of the tasks was user interface testing. For system testing some test examples were created, there were defined: task of the testing, description, needed data, expected result, test result and comments. In case of unsuccessful test result date of repeated test were predefined.

		Testa izpildes versijas nr.	V03	Testa apraksts		
		Testētājs	Ilona Odziņa	Ar lietotāja tiesībām izveidot jaunu produktu, augšupielādēt diagrammu un noteikt kontroles punktus		
		Testēšanas datums	02.10.2009			
		Testa izpildes vieta	Jelgava, LLU			
Funkcionālā norāde		Izpildāmā testa apraksts un nepieciešamie dati	Testa detaļas	Rezultāts		Testa atkārtošana
		Sagaidāmais rezultāts		Atbilst	Neatbilst	Komentāri
Tests						
1	Pielēgšanās sistēmā	Atverot sistēmu, ievadot lietotāja vārdu un paroli ir jāielogojās sistēmā. Nepieciešamais lietotāja vārds un parole paziņoti sistēmas aprakstā: lietotājs:user, parole:user	Atverās sistēmas lietotāja profils	A		
2	Jauna produkta izveide	izmantojot saiti : Izveidot jaunu produktu, jānedefinē jaunā produkta: nosaukums, raksturlielumi, apraksts, iepakojums, glabāšana, lietošana, lietotāju grupas, komponentes. Lietotājam, lai nedefinētu jaunu produktu ir jāzin produkta raksturojošas īpašības. Kad informācija ievadīta, jāaktivizē saite: Saglabāt.	Tiek izveidots jauns produkts ar aprakstošo daļu	A		Lai nedefinētu jaunu produktu, ir jābūt nedefinētiem visām produkta komponentēm, kuras lietotājam būs jāizmanto un to sistēmā ievada lietotājs - manager. Ja lietotājs - manager nav ievadījis komponentes, tad produkta komponentes nevar nedefinēt, tātad nevar nedefinēt jaunu produktu
3	Diagrammas augšupielāde	Izmantojot saiti: augšupielādēt diagrammu, atverās sistēmas logs, kur, izmantojot pogu Browse, jānorāda ceļš, no kuras vietas tiks augšupielādēta diagramma, pēc ceļa norādes izvēles izpilda komandu augšupielādēt.	Pēc diagrammas augšupielādes jāparādās ielādētajai diagrammai		N	Būtu nepieciešams aprakstīt kāda formāta attēlu var augšupielādēt un cik liela izmēra attēlam ir jābūt
Kopā:				2,00	1,00	04.10.2009

Figure 2 Test example

All system user roles and its functions were inspected. It was scheduled to complete three test examples, repeating tests if it is needed. Tests contained all functions for one specific role. Tests were for administrator role and its functions, for manager role and its functions, for HACCP user role and its functions. During the testing process using the description in the HELP some failures were discovered, but all failures were resolved.

During the system testing one of the problems was that this is demo version of the system and it was not developed to process a large amount of data. And that's why it was not possible to create a new system user. In the future this problem was resolved.

Usage of the HACCP system prototype from user view is comfortable and understandable. All necessary information is given in about HACCP system part and also in the system HELP part.

In result of testing some failures of the IS prototype were found and proposals for solving them were defined. For example, it was needed to modify Help part of the system adding the information about uploading of the production diagram, mentioning the type and the size of the uploaded picture. As one of the HACCP system tasks is monitoring data reviewing, important recommendation was as follows: completed the test, which checks user function – monitoring, system allows inserting measurements for specific critical control point, but it is required after inserting the data to identify if this measurement is critical or not. Also was offered to show which risk factor is measured by adding additional column in the table. This will allow user to monitor many products at one time without searching for appropriate risk factor.

All mentioned proposals were developed in the HACCP system prototype. Detailed examples of tests can be found in project report.

Demonstration of certain application

Developed IS prototype is accessible at LUA homepage: <http://haccp.itf.llu.lv/>, system for now is developed only at local Latvian language. Administrator's role is to define and terminate users: to define a new user it is needed to fill information about user and its responsibilities (figure 3).

Esī sveicināts, Sistēmas administrātors!

[Sistēmas lietotāji](#)
[Par HACCP sistēmu](#)
[Atteikties](#)

Jauns lietotājs

Lietotāja vārds:

Parole:

Parole (apstiprināšana):

Pilnais vārds:

Lomas: Administratori
 Datu menedžeri
 Lietotāji

Amats:

Atbildība:

[Saglabāt](#) [Atcelt](#)

Figure 3 Defining a new user

When a new user is created, it can be seen in whole system users list (figure 4)

Esī sveicināts, Sistēmas administrātors!

[Sistēmas lietotāji](#)
[Par HACCP sistēmu](#)
[Atteikties](#)

Sistēmas lietotāji

[Izveidot jaunu lietotāju](#)

Lietotāja vārds	Pilnais vārds	Amats	Atbildība	
admin	Sistēmas administrātors	Administrātors	Sistēmas uzturēšana	Rediģēt Dzēst
lietotājs	Ilona	Laborants	nav	Rediģēt Dzēst
manager	Vienkāršs menedžeris	Menedžeris	Klasifikatoru uzturēšana	Rediģēt Dzēst
user	Vienkāršs lietotājs	Lietotājs	nav	Rediģēt Dzēst

Figure 4 System users

Manager role is required to define in the system such things as: product components, consumer groups, risks, product packages. Defining a product and monitoring process is for user role. It is possible to assign one or more roles to each system user.

All needed information for product defining is created by manager, but a new product can be created by HACCP user. The process for defining a new product can be seen in figure 5

Esī sveicināts, Vienkāršs menedžeris!

[Komponentes](#)
[Patērētāju grupas](#)
[Riski](#)
[Produktu iepakojumi](#)
[Produkti](#)
[Uzraudzība](#)
[Par HACCP sistēmu](#)
[Atteikties](#)

Jauns produkts

Nosaukums:

Raksturlielumi:

Apstrāde:

Iepakojums:

Glābšana:

Lietošana:

Patērētāju grupas: Bērni Kaķis Pusmūža cilvēki Sievietes Sportisti Vīrieši

Komponentes:

Komponente	Daudzums	Rediģēt
Piens	100.0	

[Saglabāt](#) [Atcelt](#)

Figure 5 Defining a new product

When a new product is created it can be seen in whole system product list. Future tasks are completed also from this list. Those tasks are: diagram uploading and control point determination.

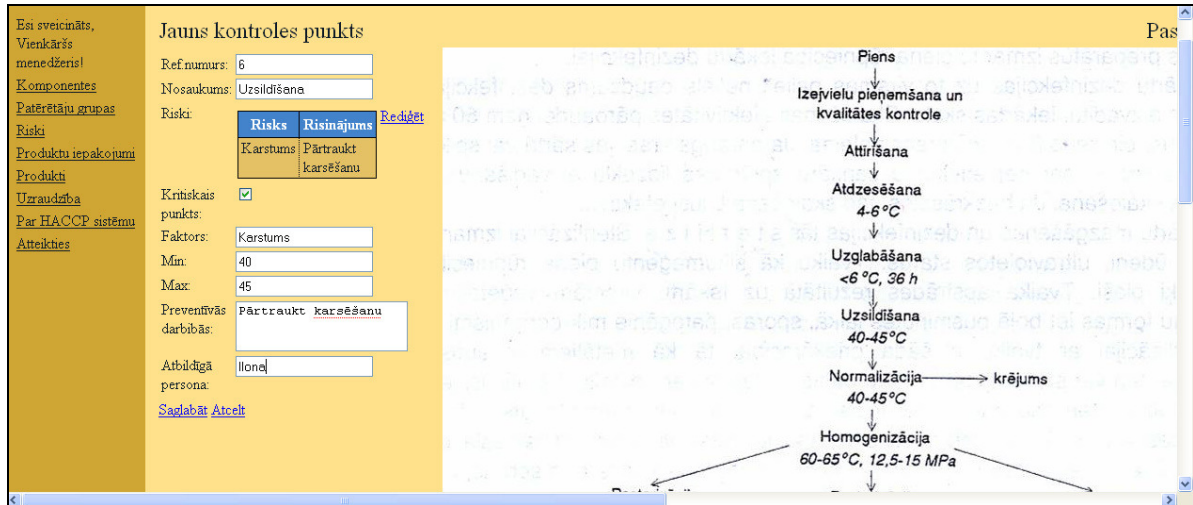


Figure 6 System product list

When diagram is uploaded it is needed to define control points, where to make monitoring and defining if point is a critical control point. If point is critical point, then it is needed to add additional information for point description. This information can be seen in the figure 7.

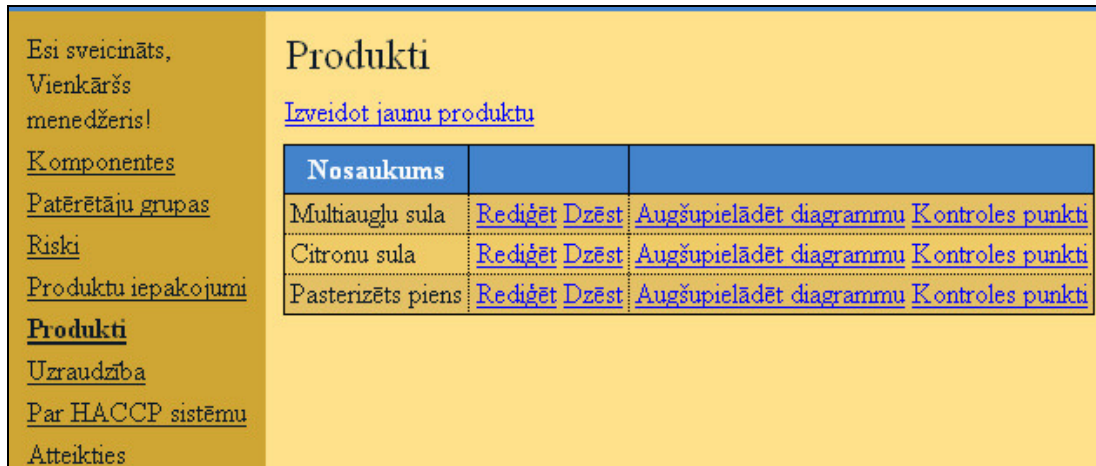


Figure 7 Defining a CCP

When CCP are defined it is needed to monitor them. In the monitoring part of the system user has to choose specific CCP of the product and write down the measurements of the process stage. Measurements table can be seen in the figure 8. After the table is filled in user can make data reviewing and analyzing.

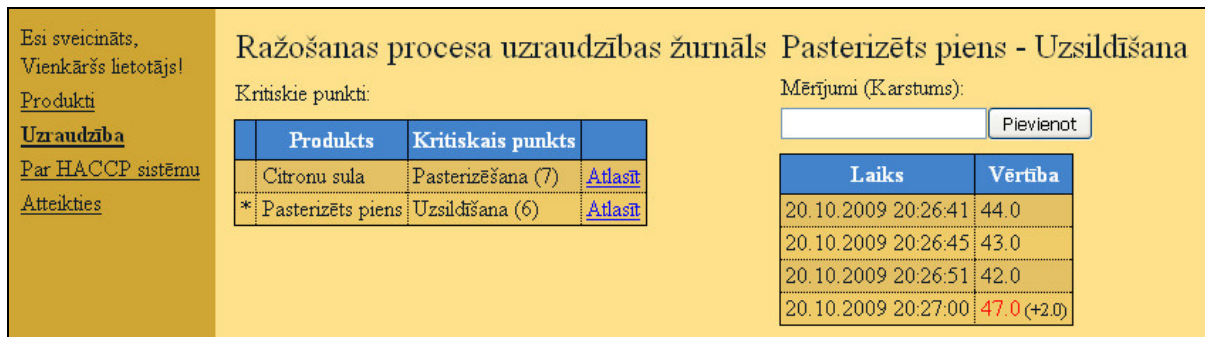


Figure 8 Monitoring data of the production process

Future system development

To provide complete implementation of the HACCP procedure it is needed to modify system prototype from functional and from logical sides.

One of important system features would be the possibility to integrate it with present enterprise systems, such as production process management system or with accounting system. This will allow using present data to implement HACCP procedure.

The next important part of the system would be HACCP documentation management module, which would help to create process and review all the needed HACCP documentation in easy way.

One of the important HACCP system functions is CCP monitoring. In the prototype is developed option, when user manually registers factor values, but full automation of this function would significantly reduce involved human resources and improve the whole system accuracy. This can be done, for example, by using the various types of sensors.

Modules mentioned above mainly supply HACCP system storage with data. However HACCP concept covers also data processing. Therefore important part of system would be data analysis module which is used to interpret received data and to generate various types of reports for future planning. Also this module could provide data for preventive action module, which is about to be used in emergency cases.

Also it would be appropriate to provide the user with information procedure when measurement in CCP reached the critical limit. To provide such information SMS or e-mail notification could be used to inform responsible person. In the figure 9 all future module scheme can be seen.

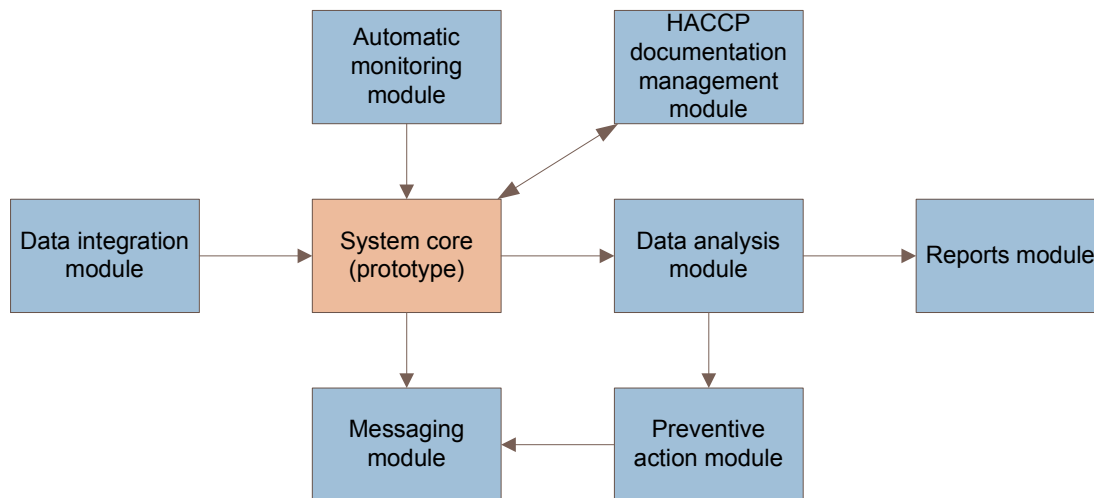


Figure 9 Possible module scheme for HACCP system

Conclusions

With HACCP information system prototype implementation wins not only production enterprise, whom risk controlling process is relieved, but also end consumer, who will receive safety and high quality product.

Implementation of HACCP IS helps to control and minimise production risks at the company.

The main feature of the system prototype is that it can be used almost in any company. It can be defined as universal system, because it is not related to specific production process.

The future development of this information system depends on specific company requirements, production specification and organisation of safety actions.

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IS AGILE BETTER? RESEARCH OF STUDIES

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Abstract

Lot of Agile development methods practitioners say that software developed using these methods are better. But classic waterfall method still has strong ground and is very wide spread – especially in large corporations and public sector organizations. So question “Is Agile better?” arises. One way to answer this question is to try to implement in some project delivery. Other way is to look around what other people have said. Agile development methods have been around for some while so it is natural that there have been some field studies and comparisons with classic waterfall method.

In this paper, some most cited studies and researches have been studied. These studies can be classified in two types. One type gives evidence that Agile methods are better. Other type looks if waterfall really fails.

If we look “under the hood” then we can name all Agile methods as iterative and incremental development with key point – showing intermediate results to end users or project owners. Sure enough that you can prove almost everything but facts are facts and research shows that using Agile development methods is somehow better and more efficient – mostly because practitioners tend to cut large and complex projects into smaller and less complex subprojects. On the other hand waterfall is still being promoted because it gives illusion that is more manageable and controllable.

Keywords: *agile development methods, iterative and incremental development methods, waterfall method*

Introduction

Development methods have been interesting topic for some while. It becomes more interesting especially today – IT organizations need to be more effective and deliver software development projects in time, on budget and without defects. Most of larger IT organizations use classic waterfall development method. But there have been Agile software development methods around, too. A lot of research has been done whether Agile is better or not. But still it can't provide enough evidence to convince top management that Agile is better. Most conservative ones are public sector organizations and large organizations (by large I mean companies which employs more than 1000 employees or have turnaround more than 100 million Latvian Lats).

In Latvia it is very hard to talk about best practices in IT software project delivery. No extensive studies can be made due to two reasons – lack of very large software development organizations and lack of long software development history. So I looked at studies done abroad. There is no need to do such study by you – a vast amount of time and resources is already spent in researching this topic. I mostly looked at accomplished researches that try to provide evidence which is based not only on theoretical judgments but on real life projects. I looked at two types of research Iterative research and Waterfall failure research. First type of research mostly aimed on questions like “Is iterative better?” and “What makes iterative better?”. Second, looked at projects delivered by Waterfall method failure factors.

After looking at all these studies I'm surprised why waterfall is still being so widely accepted and used.

Iterative and incremental development is better

Alan MacCormack from Harvard Business School has done several studies. In one of the study (MacCormack et al., 2001) the question, "Does evolutionary developments, rather than the waterfall model, result in better success?" was explored in a two-year in-depth analysis of projects. One of the report's conclusions was “Now there is proof that the evolutionary approach to software development results in a speedier process and higher-quality products. ... The iterative process is best captured in the evolutionary delivery model proposed by Tom Gilb.”. The study has identified four practices that statistically delivered most successful projects:

1. An iterative lifecycle with early release of the evolving product to stakeholders for review and feedback.
2. Daily incorporation of new software and rapid feedback on design changes (daily builds with regression testing).
3. A team with broad-based experience of shipping multiple projects.
4. Early attention to an overall architecture of modular and loosely coupled components.

First and second practices are core principles of Agile development. Third practice I would say is a “must have” for every project and activity. Fourth is base element for Rational Unified Process.

In following study (MacCormack et al., 2003) MacCormack and others have examined effect of previously detected practices on productivity and defects reported by customers, including Iterative Development and

releasing partial system early for evaluation. Projects overseen ranged from standalone applications to embedded systems with median work estimate about 10 man years (6-10 developers for 12-18 months). 75% used iterative development, 25% the waterfall. One of the conclusions:

“In this study, we find that releasing [the result of iteration] at an earlier stage of development appears to contribute to both a lower defect rate and higher productivity. Given this measure consistently predicts several different dimensions of performance across different samples of projects we conclude that it represents a software development "best" practice.”

Other interesting conclusion was that detailed design specifications were not very valuable: “We find a weak relationship between the completeness of the detailed design specification and a lower defect rate”. On the other hand practice used in my everyday work so called “peer review” and examined in this study showed that it significantly reduces defect rates.

Study also shows magnitude of impact on project success if software is developed using following iterative-related practices:

- Releasing a partial system (for evaluation, not for operations) when 20% of the functionality is complete as opposed to waiting until 40% (the sample median) is associated with a decrease in defect rate of 10. By “10” is meant 10 defects per month per million lines of code
- Integration and regression testing at code check-in (the XP practice of continuous integration) is associated with a reduction in the defect rate of 13.

Also if we look at productivity factors, over 50% of variation in productivity was related to two factors, both found in iterative practices:

- Releasing the partial product earlier with less functionality (early iteration internal release for review) was better than waiting for more functionality. An increase in productivity of 8 occurred when released at the 20% rather than 40% complete level. By “8” is meant 8 more lines of source code per person-day.
- The use of daily builds with integration and regression testing is associated with a productivity improvement of 17.

In one quite old study (Harrison et al., 1996) made by Bell Labs, researchers found a consistent pattern on highly successful projects:

- Iterative development with customer evaluation and feedback each iteration.
- Simple organizational structure; fewer roles than average.
- Even distribution of communication among people, more direct involvement of developers with other stakeholders, and more overall communication sharing.

Organization Shine Technologies Pty Ltd in year 2003 published interesting survey report. The survey found that:

- 88% of participants stated that quality was better or significantly better when using Agile methods
- 83% stated that business satisfaction was better or significantly better
- 93% stated that productivity was better or significantly better
- Only 5% stated that Agile processes had a negative effect on cost
- Most common Agile methods were Scrum and XP.

Another large study (Johnson et al., 1998) illustrating the value of iterative-related practices is the Standish Group's CHAOS study of project failure and success factors, analyzing 23000 projects. In the CHAOS TEN list of the top ten factors for success, at least four of the top five factors are strongly related to Iterative and Incremental Development practices. Follow-up study (Johnson et al., 2000) done in 2000 confirms that (Table 1).

Table 12:

Top five CHAOS TEN success factors

Success factor	Weight of Influence, 1998	Weight of Influence, 2000
User involvement	20	16
Executive support	15	18
Clear business objectives	15	12
Experienced project manager	15	14
Small milestones	10	10

High user involvement is core of Agile methods; short iterations with demos, reviews, evolutionary requirements refinement, and client-driven iterations are key practices. Executive support is promoted by these practices and especially through the demonstration of early, tangible results; people like to be associated with projects that show quick value and progress. Clear business objectives is supported by adaptive client-driven iteration planning. By asking each iteration "What is most valuable?" and building it, the business objectives are clarified

and realized, and the project aligned with them. Small milestones is fundamental principle of Agile methods. Experienced project manager is corner stone to success to every project. I would add that not only experienced but also committed to success project manager is needed to every project.

Waterfall Failure

Studies show that lot of IT projects fail. In 1995 Barry Boehm published a paper “Anchoring the Software Process” which summarizes failures of the waterfall, with advice to use a risk-reducing iterative development approach combined with three milestone anchor points around which to plan and control. These are Life Cycle Objectives, Life Cycle Architecture and Initial Operational Capability.

The USA Department of Defense (DoD) requires all software projects to be delivered in accordance to the standard DOD-STD-2167 which is waterfall lifecycle. A report (Jarzombek, 1999) on failure rates in a sample of earlier DoD projects concluded that 75% of the projects failed or were never used. As a consequence new task force was established led by Dr. Frederick Brooks. He concluded in report that it is recommended to replace waterfall with iterative development.

In a study (Thomas, 2000) of failure factors on 1027 IT projects in the UK, scope management related to attempting waterfall practices (including detailed up-front requirements) was the single largest contributing factor for failure, being cited in 82% of the projects as the number one problem. M. Thomas suggests “...the management of expectations is poor and the approach of full requirements definition followed by a long gap before those requirements are delivered is no longer appropriate. ... The high ranking of changing business requirements suggests that any assumption that there will be little significant change to requirements once they have been documented is fundamentally flawed, and that spending significant time and effort defining them to the maximum level is inappropriate.”.

As a conclusion from these studies arises three prime reasons why waterfall projects fail:

- Users are unable feedback during software development project extensively. They are limited to waterfall milestones.
- Changes in external environment especially business environment occur during project delivery.
- Lack of extensive communication between development team and business operation people. Lot of misunderstandings occurs during requirement gathering and even in acceptance test defect fixes.

Conclusions

Lot of studies has shown that iterative and incremental development (corner stone of Agile) methods are less prone to project failures. Software development projects could be more successful if they would be dived in smaller projects and intermediate results would be presented to software users and project stake holders.

Smaller projects tend to be more manageable and it’s usually easier to ensure they meet success criteria.

After looking at evidence shown in cited studies one fundamental question arises “Why waterfall is still being so promoted and accepted?” I can guess that main reasons could be:

- The waterfall is widely taught and used. It is very easy to plan and stick to the plan: gather requirements, do design and then implement. In iterative development there is factor of chaos – change can be done almost at every development point.
- Top management comes with manufacturing background. In manufacturing it is common that everything can be specified, planned and then built. Software development is more like research and development process – something new is created in every development project
- Management favors waterfall because it gives the illusion of an orderly, predictable, accountable, and measurable process, with simple document-driven milestones.
- The Project Management Institute (PMI) early Project Management Body of Knowledge (PMBOK) content had a tone of "plan the work, work the plan," phases, and predictive planning more consistent with predictable manufacturing projects and the waterfall, than with evolutionary methods for high-change inventive projects.

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MULTIDIMENSIONAL INFORMATION ANALYSIS USING OLAP PIVOT TABLES

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Abstract

OLAP technology, Pivot table and Microsoft Office Web components (OWC) are described in this article.

The Pivot table is the most powerful tool with which is possible to effectively analyze a plenty of data. It is possible to show the clearly information which is necessary for analyze using Pivot tables on Web pages. These tables are enabling for dynamically analyze and display of multidimensional information. The aim of this article is to create a Web page with an example of Pivot table, which displays plan of studies of LLU ITF. Main tasks are:

- Explore and describe the OLAP technology, Pivot Tables and OWC;
- Construct and describe the object model of OWC PivotTable component;
- Programming the OWC PivotTable component.

Microsoft Office Web Components allow creating interactive Web pages with Pivot tables. This article gives an example of how to create and design a Microsoft Office Web components Pivot tables.

Keywords: OLAP, Pivot table, OLAP cube, OWC

Introduction

The major function of OLAP technology and the Pivot tables is the storage and analysis of multidimensional data. The innovative methods of the information display enable users to view multi-dimensional information and take the appropriate decision. Dimension is the value of the sequence and simultaneous analysis of some dimension is defined as multidimensional analysis. The creation of Universal Tables offers Summary Tables or the so-called Pivot Table tool.

One of the OLAP Cube inventors is E.Codd, who described multidimensional data cube design principles in his book. OLAP cube is specific data source, which data are reported in the structures, which may have more than two dimensions. Pivot tables are able to use cubes as a data source. E. Kodds formulated basic requirements of OLAP technology. Despite that term OLAP appeared in 1993, OLAP approach as the multiplication table was used in practice much earlier. The multiplication table is a table listing the columns and rows containing multipliers, but the table cells containing the appropriate multiplication factor results.

Table 13

A part of the multiplication table

x*y	0	1	2	3	4	5
0	0	0	0	0	0	0
1	0	1	2	3	4	5
2	0	2	4	6	8	10
3	0	3	6	9	12	15
4	0	4	8	12	16	20

The table given in the example is the classical multiplication table, where one multiplier is arranged vertically, while the second multiplier horizontally. The multiplication results are arranged in multiplier junction cells. Of course, are still several possibilities as to reflect the data in Table, for example, another option of data representing is shown in the table below:

Table 14

A part of the multiplication table in tabular view

x	y	x*y
1	1	1
1	2	2
1	3	3
1	4	4

x	y	x*y
2	1	2
2	2	4
2	3	6
2	4	8

x	y	x*y
3	1	3
3	2	6
3	3	9
3	4	12

Here, multipliers and results are in columns, or arranged vertically. Arranging them vertically and horizontally, table becomes more compact, than table, in which the data are arranged only in vertical dimension. In addition, in the first table (Table 1) the multipliers are not repeated. In this case, to avoid repetition of data makes the table more transparent. Of course, this is one particular case.

The following tables can find in books, Web pages and other data sources, they are static tables.

Tables static means, that with a table is not possible to execute no actions (to filter, put in order data), some kind is given to the table create in moment, such will be so.

Tables static means, that is not possible to carry the table out any activities (filter, sort data), the appearance of an establishment is assigned a table at the moment, such, it will also be. Sometimes better to arrange the data in table horizontally and vertically, sometimes just to arrange the data only vertically, depending on the specific situation.

Very often, in the table is not necessary to see the value of all operations, but a limited number of values, when one of the arguments of the operation in a range of, for example, multiplier interval of multiplication table can be from 2 to 4. In this case, table can be found in the results set, which owns the multiplier interval (2 - 4), this set will look like a multiplication table under table:

Table 15

A subtable of the multiplication table

x*y	0	1	2	3	4	5
	0	0	0	0	0	0
	0	1	2	3	4	5
2	0	2	4	6	8	10
3	0	3	6	9	12	15
4	0	4	8	12	16	20

If the multiplier will not be successive intervals, for example, {1, 3, 5}, then will be difficult to find the results, this table will not be well-reviewed because of the unnecessary multiplier.

Universal Table creation offers Pivot table tool. Paul Spinks invented the Pivot table in 1979. Today, one of the most popular programs, which have realized the possibility of the use of Pivot table is MS Excel. MS Excel Pivot table creation tool is so popular that many think, that the Pivot table concept was established Microsoft corporation. Microsoft first began using the term Pivot table. Pivot table component appeared in Microsoft Excel 5, but other software developers Pivot table already existed under other names, such as, Lotus Development Corporation (IBM) called this tool Lotus Improv, Brio Technology – DataPivot, Borland - Quattro Pro. Pivot table looks following:

Table 16

The Pivot table with multiplication table data

x * y	y						
x	0	1	2	3	4	5	Grand Total
0	0	0	0	0	0	0	0
1	0	1	2	3	4	5	15
2	0	2	4	6	8	10	30
3	0	3	6	9	12	15	45
4	0	4	8	12	16	20	60
5	0	5	10	15	20	25	75
...
Grand Total	0	15	30	45	60	75	225

A Pivot table example represents already described multiplication table. Unlike normal table, Pivot table realize total output calculation (*Grand Total*). The Pivot tables can be used for aggregate functions (*SUM*, *AVG*, *MIN*, *MAX* and *COUNT*) calculating.

The Pivot table is a dynamically-interactive table. This means that the user can easily and quickly change the view and content of the table. This dynamic includes dimension sorting, data filtering and calculation of totals. For example, the user can choose which values of x and y needs to show and hide, change the look of the table, moving the field y from column to row axis. It is possible to arrange two dimensions in three variants:

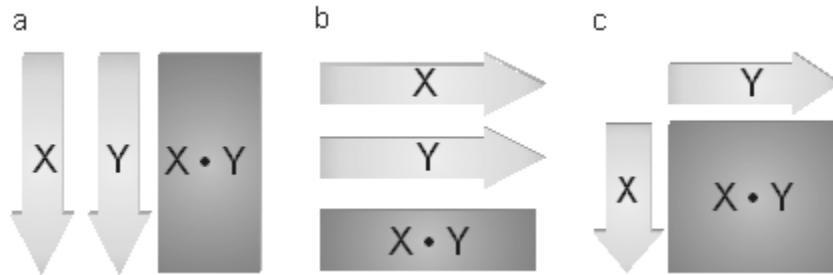


Figure 9. Arrangement of two dimensions in a Pivot table.

In variant a of figure 1 all the table fields are arranged on the row axis, this table is very high and narrow. In variant b of figure 1 all fields are in the column axis, this table will be very wide. On figure 1 c X dimension is arranged on row axis, Y dimension on the column axis, but X and Y multiplication result on data axis. The Pivot table in addition has the filter axis, if this axis is filled with a dimension, then the table is filtered according to the selected values of the dimension.

In this way, the Pivot table is a tool through which a flat-table can be functionally extended with a dynamic behavior, such as filtering, aggregation, arrangement of columns horizontally or vertically with the appropriate data sorting. This means that a total results of rows and can be added to the table, vertical and horizontal column values can be sorted in ascending or descending order, some values can be removed at all, but required values can be shown. However, this may not be necessary in the multiplication table, but there are many situations where it needs to do to analyze the data and take appropriate decisions.

OLAP is the online analytical processing technology that uses the collection, storage and multidimensional data analysis methods and tools, to implement the decision-making processes. OLAP technology is used to process the query because of the high speed. Relational database stores data in separate normalized tables. This structure is conveniently used in relational databases, but the complexity of the queries are fulfilled more tables rather slowly

Multiplicity of the dimension provides data displaying in multi-dimensional model. Simultaneous analysis of some dimension is defined as a multi dimensional analysis. Multidimensional data model is represented in OLAP cube. Cube is a relational database tables in an abstract representation. Edges of cube are dimensions, but the cells are cube measures. Edges are the values that are numerically characterized by analyzed facts.

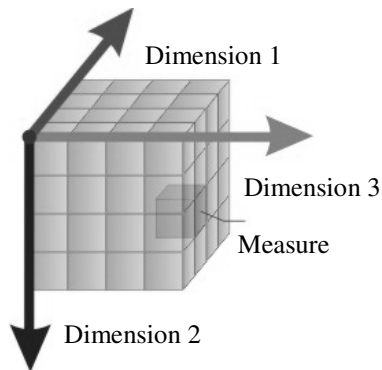


Figure 10. OLAP Cube

Traditionally, OLAP dimensions are shown as three-dimensional cube. This does not mean that the dimensions are limited by the value of three. When the dimension number is two, it will be flat two-dimensional table. The term of hyper cube is used in the OLAP terminology if there are more than three dimensions.

Materials and methods

Office Web components (OWC) is a set of components that implement the functionality of MS Excel. It is possible to use OWC in Windows applications and Web pages. OWC has created on COM-based technology, they are COM objects or ActiveX components. All the popular Microsoft programs (Internet Explorer, Visual Basic, Visual Studio etc.) can work with OWC. If a program uses OWC components, they called on the OWC component container. OWC consists of four components, and they are: SpreadSheet, PivotTable, Chart and Data Source component.

One of the main OWC component is SpreadSheed, it implements MS Excel spreadsheet functionality, fulfill the role of the table. The second component of the OWC is PivotTable, it implements an Excel Pivot table functionality. This feature allows you to perform the following functions:

- Tables expansion and collapse functions,

- Perform a dynamic filtering, sorting and grouping of data,
- Run the automatic aggregate function calculation,
- Build a chart which reflects the dynamic changes in the table.

Third component is Chart that allows viewing graphics or charts as a static image or dynamic charts. The fourth component Data Source implement the data source functionality, it does not have a visual appearance Data Source provides a connection to a data source.

PivotTable can use different data sources, such as data from relation database tables (MS SQL Server, MS Access), data from OLAP cube and data from XML files. PivotTable component can be divided three stages of use. They are: connection to a data source, data visualization and data analysis. To connect it to data source is necessary to indicate the data providers and data source address. PivotTable property `ConnectionString` returns or sets the connection to the data source.

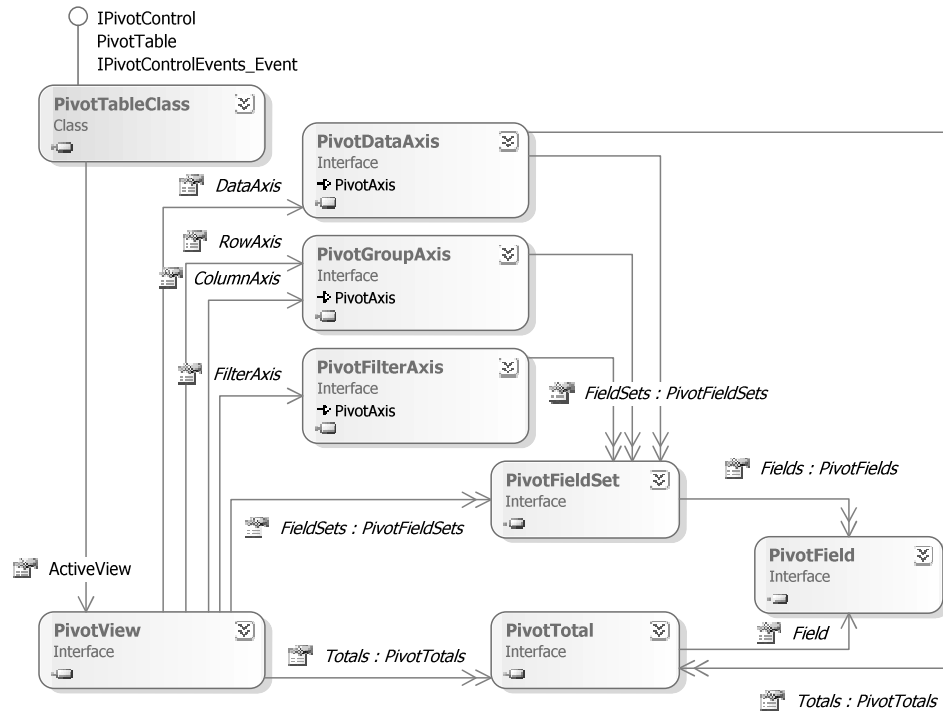


Figure 11. Diagram of a PivotTableClass

The picture shows the diagram, which represent classes and properties, which are necessary for the construction of the Pivot table, when it is already filled with data and it is necessary to visualize it.

`ActiveView` property of `PivotTableClass` class, return `PivotView` object. This is the main property that represents the Pivot table appearance. Dimensions of the cube are arranged on axis and visualize data in an appropriate style and format. The property `ActiveView` is a collection, which consists of elements of type `PivotFieldSet`. The Pivot table allows a combination of one or more dimensions in separate groups. In this case, `PivotFieldSet` is the group which consists of one or more dimensions, with `PivotField` data type.

For example, property `pt.ActiveView.PivotFieldSet.Count` return number of dimensions in Pivot table, but the property `pt.ActiveView.PivotFieldSet[i]` refers to the dimension of the index `i`. All dimensions are divided into two collections `RowAxis` and `ColumnAxis`, which determine how to visualize dimensions. This collection with data type `PivotGroupAxis` has a collection of dimensions with a data type `PivotField`. The property `DataAxis` return `PivotDataAxis` object, it arrange data in data axis of Pivot table. Pivot table property `Totals` return a collection with the data type `PivotTotals`. This collection stores fields with the calculation result of total.

The Pivot table can have one or more dimensional filters. Dimensional filtering mechanism is implemented by property `FilterAxis`. Property `FilterAxis` is a filter that is associated with one specific dimension. One filter allows limiting the number of value of dimensions. In this way, `PivotView` classes include components that are associated with a particular dimension `PivotField`. They make it possible to visualize, sort and filter each dimension separately and a Pivot table as a whole.

Results and discussions

An example of the Pivot table is a LLU ITF plan of studies. The plan of studies provides information about groups of students, as well as subjects. Courses are divided into groups, but the flow of students consists of courses. Credit points are given for each subject, whereas all subjects are divided into parts (e.g. A, B and C),

types (e.g. lectures, laboratory works, consultations and seminars) and forms of control (e.g. exams and tests). Lectures are provided to the groups of students. It is better to arrange plan of studies by flows of students as students are split up into flows as well. Then columns can be sorted by courses, terms and subjects. This example of the Pivot table is shown in Figure 4. It is a part of full table plan of studies.

Flow of students	Course	Term	Subject	Part	C	Cr	Hours	Tests	Exams
Programmers	I	I	Mathematics	A	E	2	32		1
			Physics	A	E	3	48		1
			Programming I	A	E	1	16		1
			Software engineering I	A	E	3	48		1

Figure 12. Plan of studies

For example, students can get information from this plan of studies about subjects of the first term, number of the credit points that need to get in first term, number of exams in this term. Each term subjects have to be divided equally, so to have the same number of credit points each term. It is prohibited to divide subjects so in the first term there are 150 credit points and in the second 50. As the Pivot table gives the possibility to calculate the totals, students can easily control the number of credit points per term. Students should get defined number of credit points for each subject part in the learning process. The total values of the Pivot table enables to control number of credit points in each subject part in the process of training plan creation.

Flow of students	Part	Course	Term	Subject	C	Cr	Tests	Exams	
Programmers	A	I	I	Mathematics	I	3	1		
				Programming I	E	2		1	
				Foreign language	I	3	1		
				Software engineering I	E	3		1	
				Total		11	2	2	
	A	II	3	II	Physics	E	3		1
					Mathematics	E	3		1
					Programming I	I	2	1	
					Total		8	1	2
					Total		19	3	4

Figure 5. Other column arrangement in the plan of studies

There is shown a part of the Pivot table ‘Plan of studies’ on the Figure 5. In this example columns are arranged by flows of students and parts of subject. Some students need to choose the subjects themselves. The Pivot table will help to count the credit points’ amount and choose the necessary subject. The columns of the Pivot table can be arranged in any order and the same table will look differently. To change simple table columns order it is necessary to rebuild the table, but the Pivot table can change the look on the fly. It is possible to display data in a new form that can be useful for data analysis, placing the column in the right order. Data can be analyzed relative to column order.

Conclusions

The simplest case of multiplication table is a Pivot table, which can be interpreted as a technological tool, to visualize a simple function with different arguments. Pivot tables are the key feature that represents the functional dependence, and the possibility to calculate the Pivot results of the different dimensions. Pivot tables interactivity allow users, two-dimensional plane of the conditions to manipulate several dimensions, who can arrange horizontally or vertically, as well as to filter and sort every single dimension. There are different possibilities how to create a Pivot table. One of the options is the usage of Microsoft Office Web Components. These components enable users not only to create a Pivot table, but also a variety of charts that could be useful information for analysis. Analysis of the data required the data representing in the correct form - it provides a Pivot table. Placing the columns in the required order, the data are grouped and the totals are counted automatically. Data filtering of Pivot table facilitates the perception and analysis of data by hiding unnecessary information. Data filtering significantly affects to the calculation of totals, which may be useful in some cases, for example in the counting of credit points in learning process. For dynamic data display and analysis should be possibility to arrange columns, filter data and count total values. Pivot table provides all this functions. These tables are an irreplaceable tool for displaying information. Pivot tables can be useful in any scope, especially in business, making the reports more visual.

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PREDICTION OF MECHANICAL PROPERTIES OF RAPID PROTOTYPING COMPOSITE

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Introduction

Nowadays technology is evolving very fast and new products have to be developed in as short cycle as possible to ensure success and competitiveness in industry. In the past, design and development was complex and time consuming process which required numerous iterations before the final shape and functionality of the product was achieved. However, design stage has been significantly shortened with the arrival of computers and computer aided design (CAD) systems. This has been achieved due to various rapid product development methods. One of these methods is rapid prototyping. This refers to a process using 3D CAD design data (as well as 3D scan data) input to directly fabricate geometrically complex objects. The main use of rapid prototyping is to produce models (prototypes) for evaluation and testing directly from CAD data without need for typical manufacturing methods and special tooling. Such “life-like” models radically change design iterations since three-dimensional objects are much easier to comprehend than any 2D drawings or even 3D images and animations. The obvious advantage is considerable saving in cost and time.

If the designed part is of small dimensions, the prototype may be of actual size, although often it is scaled down model. Sometimes size of model is restricted by the dimensions of the prototyping machine but there are cases when prototype must be scaled down due to limitations of the load carrying capabilities of the material it is made from (due to poor mechanical performance of material prototype can not sustain its own weight).

This study is focusing on 3D printing technology with the main goal to develop new modified composite material used for prototyping. The primary objective is to create material with superior mechanical properties (compare to standard 3D printing media) in order to increase size of prototypes. This will allow production of models without need for scaling down dimensions and thus detail level of prototypes will be also increased.

This paper presents first attempt to characterize new composite used in 3D prototyping. Mechanical properties of CaSO₄/epoxy based composite used in rapid prototyping 3D printers were predicted theoretically in this work, results of predictions are compared with experimental data. Comparison between modeling results and experimental data showed that the accuracy of models in large extent is influenced by accuracy of description of material's actual morphology.

Experimental

Materials

For specimen production system zpTM130 powder and zbTM58 binder, both from Z-corporation were used. Chemical analysis of constituents (performed by Riga Technical University Institute of Inorganic Chemistry) revealed that printing media (zpTM130 powder) mainly consists from gypsum (CaSO₄•H₂O). Dry zpTM130 powder were binded together with water based binder (zbTM58) during the printing procedure. After print-out specimens were impregnated with epoxy resin. Mechanical properties of all these constituents are not measured directly in this work. Instead, properties from the literature will be used in the calculations (see Table 1 below).

Table 1.

Properties of composite constituents.

Material/Property	Density [g/cm ³]	Stiffness [GPa]	Poisson's ratio	Strength [MPa]	Strain at failure [%]	Source
Epoxy	1.25	3.5	0.37	35...100	1...6	[1-2]
Gypsum	1.12/2.32*	4.5/46*	0.33	---	---	[3-5]

*crushed (pulverized)/solid gypsum

Specimen preparation

The manufacturing procedure of composite includes two steps: 1) skeleton of specimen consisting of reinforcement and water based binder was produced on 3D printer; 2) obtained pre-form was manually impregnated with epoxy resin by using paintbrush. Specimens for tensile tests had dog-bone shape and strain gage for the measurements of the transverse strains were attached in the middle of the specimen. Test samples for tensile and fracture toughness experiments are shown in Fig. 1.

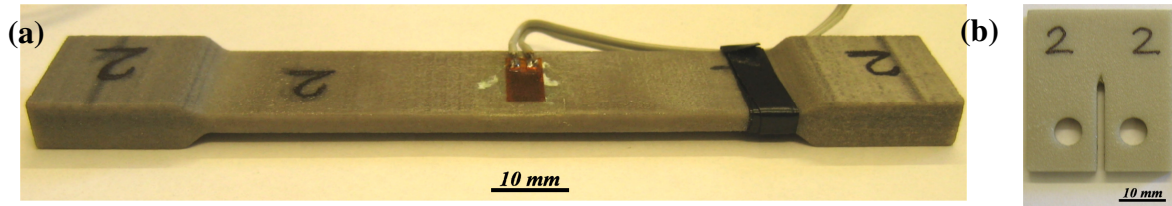


Figure 1. Tensile specimen fitted with strain gage for measurements of transverse strain (a); compact tension specimen with pre-crack (b) for evaluation of fracture toughness.

Mechanical tests

Tensile and fracture toughness tests were carried out on Instron 4411 machine at temperature of 25°C and relative humidity 35-40%.

Tensile test was performed in displacement controlled mode with loading rate of 1.6 mm/min (corresponds to approximately 2%/min). Standard Instron extensometer with base of 50 mm was used to measure longitudinal strain, whereas strain gage with base of approximately 10 mm was employed to register transverse strain. Load, strain and displacement was recorded to PC via acquisition unit with frequency of 10 points/s. Strength and strain at failure were registered from the failure point at the stress-strain curve. Elastic modulus and Poisson's ratio was calculated from stress-strain (modulus) and transverse strain-longitudinal strain (Poisson's ratio) curves within linear interval of 0.05-0.15% by linear fitting.

Fracture toughness test was carried out according to ASTM D5045-95 standard with speed of grip separation 10 mm/min. All calculations and verification of validity were performed according to standard.

Bur-out test and density measurements

Burn-out test was performed in ventilated oven. The following burn-out cycles were used: 1) 2h/400°C; 2) 1.5h/500°C. Two unimpregnated (gypsum + binder) and two impregnated (gypsum + binder + epoxy) were used in these tests. Specimens were weighted on precision scales (accuracy 0.1 mg) before burn-out procedure and after each burn-out cycle. The mass of specimens was measured right after they were taken out from the oven in order to avoid moisture uptake.

In order to estimate density, dimensions of specimens used in burn-out tests were measured (before tests samples were grinded to obtain straight edges which reduce errors of measurements). Density was calculated from volume and mass measurements.

Characterization of microstructure

Length and diameter distribution of gypsum particles have been measured from optical micrographs obtained by using stereo microscope (aigo Digital Microscope – GE5) at 540x magnification. Powder obtained from unimpregnated samples was used for these measurements. Micrographs were stored on PC and measurements made in vector graphics software Corel Draw 11. In total 7 images were used and every distinguishable particle from these images were measured.

Modeling

Although crystal of gypsum has rod-like shape (see Fig. 2), aspect ratio (L/D) of those rods is rather low and it was decided at this stage to employ micro-mechanical models which are specifically developed for particulated composite ($L/D \approx 1$). The crystals of gypsum are assumed to be isotropic.



Figure 2. Fibrous gypsum from Brazil (image by Eurico Zimbres FGEL/UERJ).

Halpin-Tsai-Nielsen (H-T-N) model

The elastic modulus for polymer filled with particles can be predicted by using the following formula [6]:

$$E = \frac{1 + ABV_f}{1 - B\phi V_f} E_m \quad (1)$$

where

$$B = \frac{(E_f / E_m) - 1}{(E_f / E_m) + A} \quad (2)$$

and

$$\varphi \cong 1 + \frac{(1 - V_{f \max}) V_f}{V_{f \max}^2} \quad (3)$$

E_f – tensile modulus of the filler; E_m – tensile modulus of the matrix; $A = k_E - 1$; k_E – Einstein coefficient ($k_E = 2.86$ is obtain for $L/D = 1.97$); V_f – volume fraction of filler; V_{fm} – maximum volume fraction ($V_{fm} = 0.785$ for cubic packing and $V_{fm} = 0.850$ for parallel random packing);

Halpin-Tsai (H-T) model for elastic properties

This model [7] is similar to the one shown above (Eq. 1) but coefficient A is calculated differently and $\varphi = 1$. The equations used to calculate coefficient A is obtained empirically and it depends on type of the filler (either spherical particles $L/D = 1$ or aligned whiskers with $L/D > 1$).

The general representation of Halpin-Tsai equation is the following:

$$P = \frac{1 + ABV_f}{1 - BV_f} P_m \quad (4)$$

where P is property of composite and P_m is corresponding property of matrix material (P can be either elastic modulus E or shear modulus G).

The following equation should be used for polymer filled with spherical particles:

$$\text{to calculate tensile modulus (P} \rightarrow \text{E)} \quad A = 2 + 40V_f^{10} \quad (5)$$

$$\text{to calculate shear modulus (P} \rightarrow \text{G)} \quad A = 1 + 40V_f^{10} \quad (6)$$

It should be noted that in case of spherical particles composite is isotropic.

In case of aligned whiskers composite is anisotropic and the equations are as follows:

$$\text{to calculate longitudinal modulus (P} \rightarrow \text{E}_L) \quad A = 2(L/D) + 40V_f^{10} \quad (7)$$

$$\text{to calculate transverse modulus (P} \rightarrow \text{E}_T) \quad A = 2 + 40V_f^{10} \quad (8)$$

$$\text{to calculate shear modulus (P} \rightarrow \text{G}_{LT}) \quad A = (L/D)^{1.73} + 40V_f^{10} \quad (9)$$

Poisson's ratio ν is calculated from simple rule of mixture (for both types of filler):

$$\nu = \nu_f V_f + (1 - V_f) \nu_m \quad (10)$$

where ν_f is Poisson's ratio of filler and ν_m is Poisson's ratio of matrix.

It is not unusual that there is rather high content of voids in the composite, especially if it is reinforced with such porous material as gypsum. The presence of voids in the material might significantly influence mechanical properties of composite. The influence of the voids on stiffness of the material can be taken into account by the following expression [8]:

$$E_C = E (1 - V_V)^2 \quad (11)$$

where V_V is volume fraction of voids in composite, E_C is modulus of composite with porosity and E is the modulus without porosity (calculated from Eq. 1 or Eq. 4).

Results and Discussion

Measurements of length and diameter of gypsum particles

Length and diameter distribution of gypsum particles have been measured from optical micrograph (see typical image below, Fig. 3). Particles were treated as cylinders with constant cross-section.

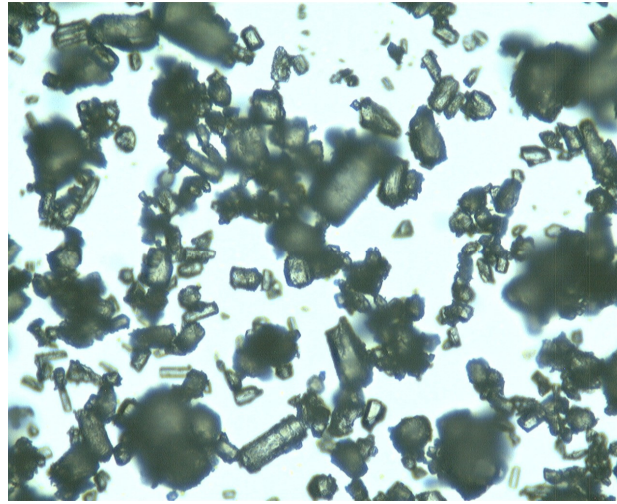


Figure 3. Typical micrograph for measurements of length and diameter of gypsum particles (the area on the image is approximately $0.7 \times 0.7 \text{ mm}^2$).

In total, more than 50 measurements were done and distributions for gypsum particle length, diameter and aspect ratio were constructed (see Fig. 4). However, since micro-mechanical models require only one value rather than distribution, average values were used. The results are as follows: average length $L = 0.390 \text{ mm}$; average diameter $D = 0.198 \text{ mm}$; average aspect ratio $(L/D) = 1.97$. From Fig. 4b it is clear that majority of gypsum particles have very low aspect ratio 1.5...3.5. These results confirm that gypsum in the composite should be treated as rod-like or even spherical particles, rather than fibers.

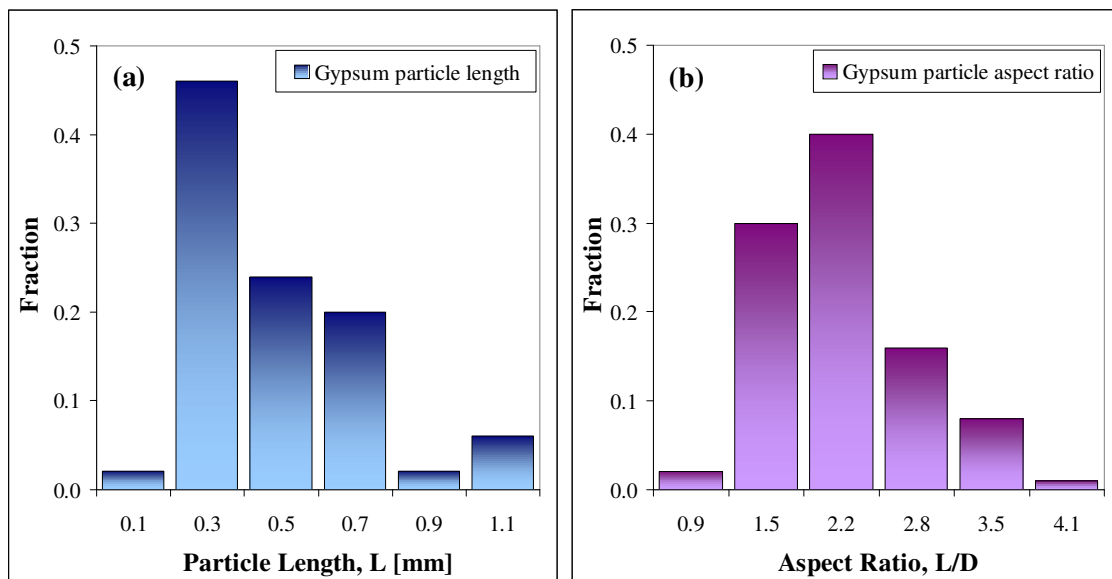


Figure 4. Distribution of gypsum particles length L (a) and aspect ratio L/D (b).

Density measurements

Measurements of the densities were performed on unimpregnated gypsum samples as well as on impregnated specimens left over from tensile tests. While unimpregnated samples were of the same type (no visual differences), composite specimens were obtained from different batches. The results of these measurements are presented in Table 2.

Table 2

. Density measurements				
Specimen	Type	Volume [mm ³]	Weight [mg]	Density kg/m ³
1	Unimpregnated	1645	1958	1190
2	Unimpregnated	2906	3530	1215
3	Impregnated (light)	1845	2723	1476
4	Impregnated (dark)	2132	3436	1611

It is seen that measurements of density for unimpregnated gypsum specimens are rather close to each other with average value of approximately 1.20 g/cm³. This correlates very well with literature results [4] found for pulverized (1.12 g/cm³) gypsum.

Measurements of density for composites slightly differ from each other but they are still within 10% which might be within accuracy of the measurements. On the other hand, these are composites from different batches and it is very likely that their composition (volume fractions of constituents) is a little different.

Burn-out test

In order to measure weight fractions of constituents in the composite, burn-out of polymer from was performed. The same thermal treatment was also used for unimpregnated gypsum to monitor weight loss due to drying. As it was mentioned earlier, bur-out test was done in two steps. After first step it was evident that complete burn-out of the polymer did not occur (specimens were dark due to burning of polymer but it was still present there). After the second step all specimens, impregnated and unimpregnated, looked the same – only gypsum powder was present. The results of these measurements are presented in Table 3.

Table 3.

Results of the burn-out test (absolute weight loss and loss in %).

Specimen	Type	Weight loss 2h/400°C [mg] / %	Weight loss 2h/400°C+1.5h/500°C [mg] / %
1	Unimpregnated	346 / 17.7	350 / 17.9
2	Unimpregnated	637 / 18.0	649 / 18.4
3	Impregnated (light)	807 / 29.6	929 / 34.1
4	Impregnated (dark)	1087 / 31.6	1322 / 38.5

It is interesting to note that both unimpregnated specimens lost almost exactly the same weight in %. Moreover, during the second stage (1.5h at 500°C) the weight loss was negligible (0.2-0.4%). This indicates that both specimens contained the same amount of moisture and that only water was lost during the burn-out procedure. Therefore it was assumed that initial moisture content in unimpregnated gypsum and composite is the same and it is equal to $W_{H_2O}=18.2\%$, which is an average from both unimpregnated specimens.

In the case of composite the weight loss was slightly different for two specimens from different batches. “Dark” composite lost more weight than “light” material (the difference is approximately 13%, not absolute values). This also correlates with measurements of densities were difference between these samples was also close to 10%. This is probably due to different composition (fractions of gypsum and epoxy) of composites from different batches.

It is assumed that impregnated samples (composites) contain the same amount of water as unimpregnated gypsum specimen. Then the weight content of resin is estimated as: $W_m = W_{TOT} - W_{H_2O}$; (were W_{TOT} is total weight loss in %). The average value (from two composite samples) of resin content in the composite is $W_m = 36.3\% - 18.2\% = 18.1\%$. Based on the weight fraction and densities of resin and composite the volume fraction of epoxy in composite can be calculated:

$$V_m = W_m \frac{\rho_c}{\rho_m} \quad (12)$$

where ρ_c and ρ_m are densities of composite and matrix (epoxy resin) respectively. The density of composite is measured (see Table 2) and density of epoxy is also known (see Table 1). By using average values from both batches of composites ($\rho_c = 1.54 \text{ g/cm}^3$) the volume fraction of resin in composite is calculated to be $V_m = 0.22$.

It is rather clear (from optical microscopy and from comparison of densities of solid gypsum and unimpregnated samples) that this material contains a lot of pores. The pore content (or void content V_v^{UN}) can be calculated from the densities of solid gypsum and unimpregnated specimens (density of air is neglected):

$$V_v^{UN} = 1 - \frac{\rho_{UN}}{\rho_{SG}} \quad (13)$$

where ρ_{SG} and ρ_{UN} are densities of solid gypsum and unimpregnated material respectively. By using average density of unimpregnated material (1.20 g/cm^3) and literature data for solid gypsum (see Table 1) the void content (by volume) in the unimpregnated sample is estimated to be $V_{UN}^V = 0.48$, which means that gypsum content is $V_G = 1 - V_{UN}^V = 0.52$. It is assumed that volume of the specimen does not change after the impregnation with epoxy resin because the pores in material are filled with polymer. It is also reasonable to assume that content of gypsum does not change in the specimen after impregnation. Therefore, since the following relation has to be fulfilled $V_G + V_m + V_V = 1$, the final composition of the composite is as follows: $V_G = 0.52$; $V_m = 0.22$; $V_V = 0.26$. These volume fractions of constituents were used in calculations to predict mechanical properties of composite.

Mechanical properties

Tensile properties of composite were obtained from the tests of 7 specimens, the average values from both batches of composites are presented in the Table 4 (note that elastic properties are calculated from unloading curve). The fracture toughness of material was measured from 6 specimens: $K_{IC} = 1.23 \pm 0.08 \text{ MPa}\cdot\text{m}^{1/2}$. Although this indicates that material is rather brittle, it is still more ductile than neat epoxy ($K_{IC} \approx 0.6 \text{ MPa}\cdot\text{m}^{1/2}$).

Table 4.

Average values of experimentally obtained mechanical properties.

Max stress [MPa]	Max Strain [%]	Elastic modulus [GPa]	Poisson's ratio	Shear modulus* [GPa]
17.6 ± 3.0	0.296 ± 0.090	7.66 ± 0.70	0.278 ± 0.013	3.00

* - calculated from the relationship valid for isotropic materials: $G = \frac{1}{2}E/(1+\nu)$.

The results of the theoretical predictions from Eq. 1, Eq. 4, Eq. 10 and Eq. 11 are summarized in the Table 5.

Table 5.

Summary of the modeling results (Eq. 1, Eq. 4, Eq. 10 and Eq. 11).

Model/Property	E_L	E_T	G_{LT}	ν_{LT}
H-T-N (parallel random packing, no voids)	11.7	11.7	4.34*	0.349
H-T-N (parallel cubic packing, no voids)	12.4	12.4	4.60*	0.349
H-T-N (parallel random packing, with voids)	6.4	6.4	2.37	N/A
H-T-N (parallel cubic packing, with voids)	6.8	6.8	2.52	N/A
H-T (spherical particles, no voids)	11.1	11.1	3.40	0.349
H-T (aligned whiskers, no voids)	13.7	11.1	4.70	0.349
H-T (spherical particles, with voids)	6.1	6.1	1.86	N/A
H-T (aligned whiskers, with voids)	7.5	6.1	2.57	N/A

* - calculated from the relationship valid for isotropic materials: $G = \frac{1}{2}E/(1+\nu)$.

First of all it should be noted that all models give rather similar predictions, this is probably because models are very similar and aspect ratio of gypsum crystals is too low to significantly influence results. Secondly, these results show that elastic properties predicted by models without accounting for porosity are significantly higher than experimentally measured values (by 45-79% for elastic modulus; by 13-57% for shear modulus and by 26% for Poisson's ratio). However, predictions in which porosity is accounted for are only slightly lower than experimental results (by 2-20% for elastic modulus; by 14-38% for shear modulus). It can be concluded that porosity definitely must be accounted for. On the other hand the procedure to estimate void contents must be refined, since underestimation of the experimental results by model prediction is most likely due to too high estimate of porosity. One of the possible solutions could be use of some kind of image analysis procedure to measure void content instead of method which is purely based on density comparison.

Summary

Material for 3D printing was studied in this work. Mechanical properties of gypsum/epoxy composite were experimentally characterized and predicted by simple micro-mechanical models developed for particulated composites. Generally speaking these models can predict elastic properties of gypsum/epoxy composite with reasonable accuracy. However, from comparison between experiment and modeling results it is rather clear that in order to get accurate prediction of tensile modulus it is necessary to take into account porosity present in material. Methodology of determination of void content in the composite should be more accurate. This can be achieved by employing image analysis.

Future work concerning modeling of mechanical properties should be based on numerical simulation (finite element method) rather than micro-mechanical modeling since morphology of material is rather complex for accurate prediction of strength and fracture properties. However, numerical approach will require much more comprehensive and accurate characterization of micro-structure of composite.

Development of reliable and accurate models for prediction of mechanical properties of gypsum/epoxy composites will allow better understanding of behavior of these composites which is required in order to create novel material with superior properties for rapid prototyping.

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PROGRAMMABLE MATTER

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Abstract

The report is dedicated to one of the latest trends in technologies – claytronics and technology encouraging application of robotic particles. Programmable matter is the phenomenon the mankind will deal with in the nearest future. Some insight into the philosophy about that how extensible this field can become and true in the future and also how dangerous it can be if it is not dealt with carefully. Current ideas about the programmable particles are offered for discussion. The author of the article draws the readers' attention to physical aspects and challenges of very small programmable cells. Claytronic atoms (catoms) – their application suggest the necessity of bright ideas, bright solutions for problems and so far.

Key words: *programmable matter, claytronics, particles, catoms.*

Introduction

People sometimes are dreaming about science fiction to become true. The question they ask themselves is, what they will be able to do in their new life together with robots. There are many ways to go on with every new technology whether it is good or bad. But anyway there are good ideas and technologies what can be done to manage the things already in next few years. Nowadays humans use robots for different monotone tasks in their every day life already. But every robot has its limitations in shape, color and size, therefore the solution is – programmable matter.

Programmable matter

Programmable matter is some kind of particles which have the ability to change their physical properties, for example shape, color, density and other in a programmable way. Programmable matter actually is small particles – robots.

These robotic particles in higher level can collaborate together to solve different problems for some significant tasks. There are already many robots which can do all this stuff at the moment. They move bypassing different kinds of barriers. For some big barriers they join all together to trespass them, or for some small locations they can split for getting through very narrow places. They are very small nanoscale robots designed to form much larger scale machines or mechanisms.

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INDUSTRIAL APPLICATIONS OF ICT

DEVELOPMENT OF MICROCONTROLLER PERIPHERAL CONFIGURATION SOFTWARE

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Abstract

The paper focuses on evaluation the issues of peripheral configuration of PIC16 mid-range microcontrollers in Assembly language. Basing on the study software has been developed, which automates daily job in PIC16 programming. Such software can allow to faster embedded system development progress by minimizing delays caused by assembly code configurations and eliminating routine and possibly erroneous peripheral configuration by hand. Corresponding Software Requirements Specifications and Software Design Descriptions were created and used in development of tool for automatic Assembly configuration code generation – “PCS PIC16”. The research covered PIC16 microcontroller family architecture study and PIC16 peripheral modules and theirs configurations study. Next close look up was at PIC16 program and generated code structure. “PCS PIC16” was evaluated and compared to the same type of available programs.

Key words: *Microcontroller, Software Development, PIC16*

Introduction

Microcontroller application development however consists not only of programming and a peripheral modules configuration. The layout of external components, electrical and mechanical properties and configuration (external interface chips, motor drivers, etc.) are essential parts of embedded control system development process and should also be considered. Usually software and hardware development are carried out in parallel. These topics are not covered in this paper.

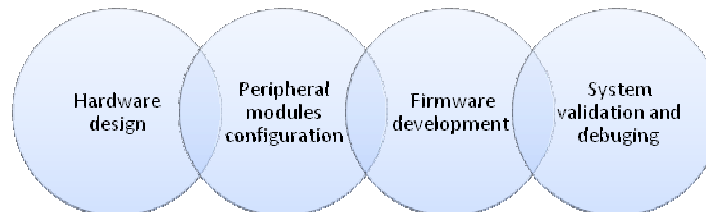


Fig.1. PIC16 solution development challenge areas

Figure 1 shows areas of problems in solution development for microcontroller. This paper presents conception of peripheral configuration task facilitation through automated code generation. Paper consists of two blocks of a theoretical part PIC 16 8-bit microcontroller’s research, its architecture, configuration options, and programming tools. And the second part where we develop Software Requirements Specification and Software Design Description to have a complete picture of the Peripheral Configuration Software (PCS) tool. Then describe practical usage and benefits obtained through PCS implementation.

Materials and Methods

Microchip offers a complete suite of free tools for PIC and dsPIC software development including PIC16 family. It consists of MPLAB integrated development environment, MPASM assembler for executable and object code generation, MPLIB librarian for code library generation and MPLINK for object linking. C compiler is available for PIC16, which can be used with a microcontroller to gain C language advantages, but free version of this compiler is available only for a limited number of microcontroller models. Analysis of these development tools and the PIC16 architecture will define requirements for the peripheral configuration application. The requirements were summarized in SRS. SDD was also composed and used in development of the “PCS PIC16” tool. For programming we use Microsoft Visual Studio 2008 with 3.5 frameworks.

Our PCS PIC16 program conception is to solve peripheral configuration task more effectively and gain advantage of automatic assembly code generation. Each developer's primary objective is to find the best solution for the given problem - whether it is an engine control or temperature control, or manufacturing process control. Accordingly to the requirements of each application the peripheral module configuration should be carried out.

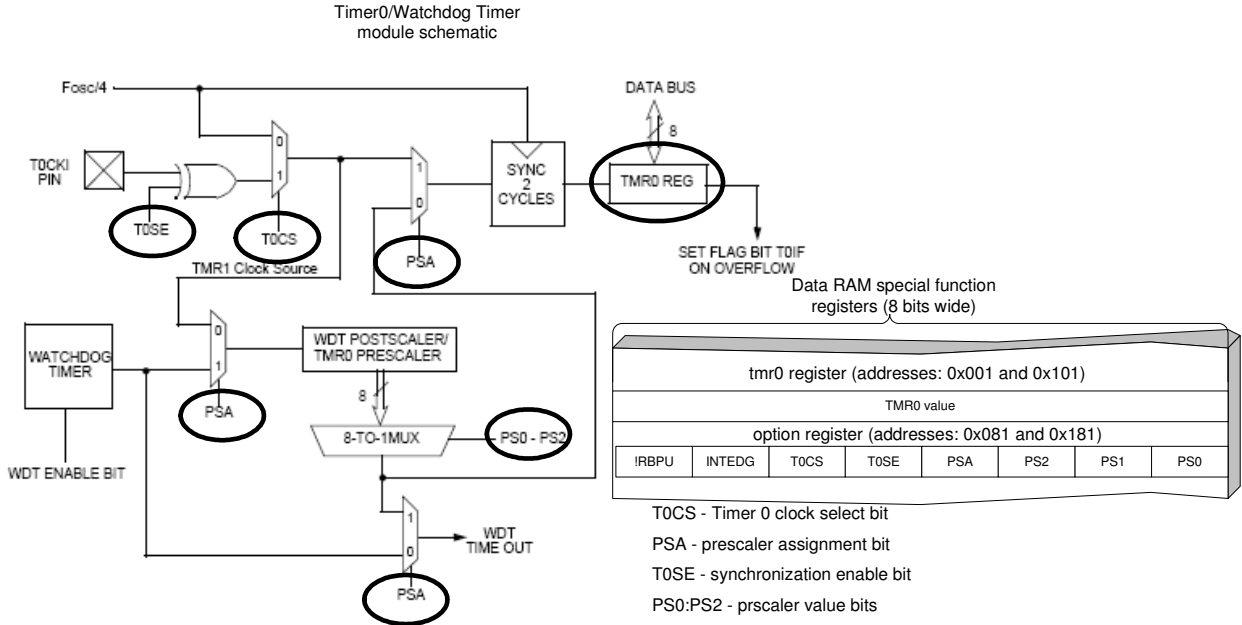


Figure 2 shows the principle of peripheral configuration on the example of a timer module of generic PIC16 microcontroller.

Listing 1

```

Init_TMR0
    bcf          intcon,T0IE          ;disables Timer 0 interrupts
    banksel    option_reg
    movlw      b'11000000'          ;\clears bits in option_reg
    andwf     option_reg,F          ;/affected by TMR0
    movlw     _TMR0_OPTIONS        ;\TMR 0
    iorwf     option_reg,F          ;/setup
    banksel   tmr0
    movlw     _TMR0_VALUE          ;\TMR 0
    movwf    tmr0                  ;/value
    bcf      intcon,T0IF          ;clears IRQ flag
    if      _TMR0_INTERRUPTS == 1 ;interrupts setup
    bcf     intcon,T0IE
    else
    bsf     intcon,T0IE
    endif
    return
    
```

Fig.2. Timer 0 module and its configuration register (schematics form PIC16F628A datasheet)

There are several programs that can speed up microcontroller configuration using automated code generation. First in list is Microchip developed Maestro. Maestro program is designed so that a programmer could develop in the same MPLAB environment and add code modules as *.cls scripts. This program is available for installation with additional modules, which include various interface configurations such as SPI, I2C, USART, LCD and ADC (Serial Peripheral Interface, Inter-Integrated Circuit, universal asynchronous receiver/transmitter, Liquid Crystal Display). This solution is generally for use with PIC18 microcontroller series, although it supports also PIC16 microcontrollers, but does not guarantee support for the standard modules, such as a timer configuration, CCP, IO, Interrupts.

Tab.1.

Comparison of programs

Criteria	Maestro	PIC Timer Calculator	PCS PIC16 Tool	MPLAB Visual Initializer	Simulink Real-Time Workshop
All modules support	NO	NO	x	x	NO
Integration with MPLAB	NO	NO	NO	x	x
Add module	x	NO	NO	NO	x
Project save/load	NO	NO	x	x	x
PIC MCU family support	PIC16/PIC18	PIC16	PIC16	PIC32	PIC24/PIC32
Friendly GUI	NO	x	x	x	x
Additional programming constructs support	NO	NO	NO	x	x

Maestro is the software tool which allows users to customize firmware peripheral modules written specifically for Microchip's PIC16 and PIC18 microcontrollers meeting the specific needs of their applications. The Application Maestro shortens design cycles by enhancing software reusability and allowing the programmer to focus more on a design application and spend less time on the configuration details of the PICmicro microcontroller peripheral modules.

The PIC Timer Calculator will calculate the real time period of the various timers associated with most of the PIC 16F series.

PCS tool has user-friendly interface that allows modules to be quickly navigate configuration options, save and open the project and use developed the user's manual which was attached to the project. Editor section is possible to download, save and edit generated code. Using MPLAB with PCS tool will enable the MCU to create solutions more quickly than it was possible.

Configuring a 16-bit MCU or dsPIC can be a complex and challenging task. MPLAB Visual Device Initializer allows users to configure the entire processor graphically, and when generate code usable in Assembly or C programs. MPLAB Visual Device Initializer does extensive error checking on assignments and conflicts on pins, memories and interrupts as well as selection on operating conditions. The generated code files are seamlessly integrated with the rest of the application code through MPLAB project. The detailed report on resource assignment and configuration simplifies project documentation. MPLAB VDI is a standard plug-in to MPLAB Integrated Development Environment (IDE) and can be invoked from within MPLAB under the Tools menu.

The Real-Time Workshop® and executes stand-alone C code for developing and testing algorithms modeled in Simulink® and Embedded MATLAB™ code. The resulting code can be used for many real-time and non-real-time applications, including simulation acceleration, rapid prototyping, and hardware-in-the-loop testing. You can tune and monitor the generated code using Simulink blocks and built-in analysis capabilities, or run and interact with the code outside the MATLAB® and Simulink environment.

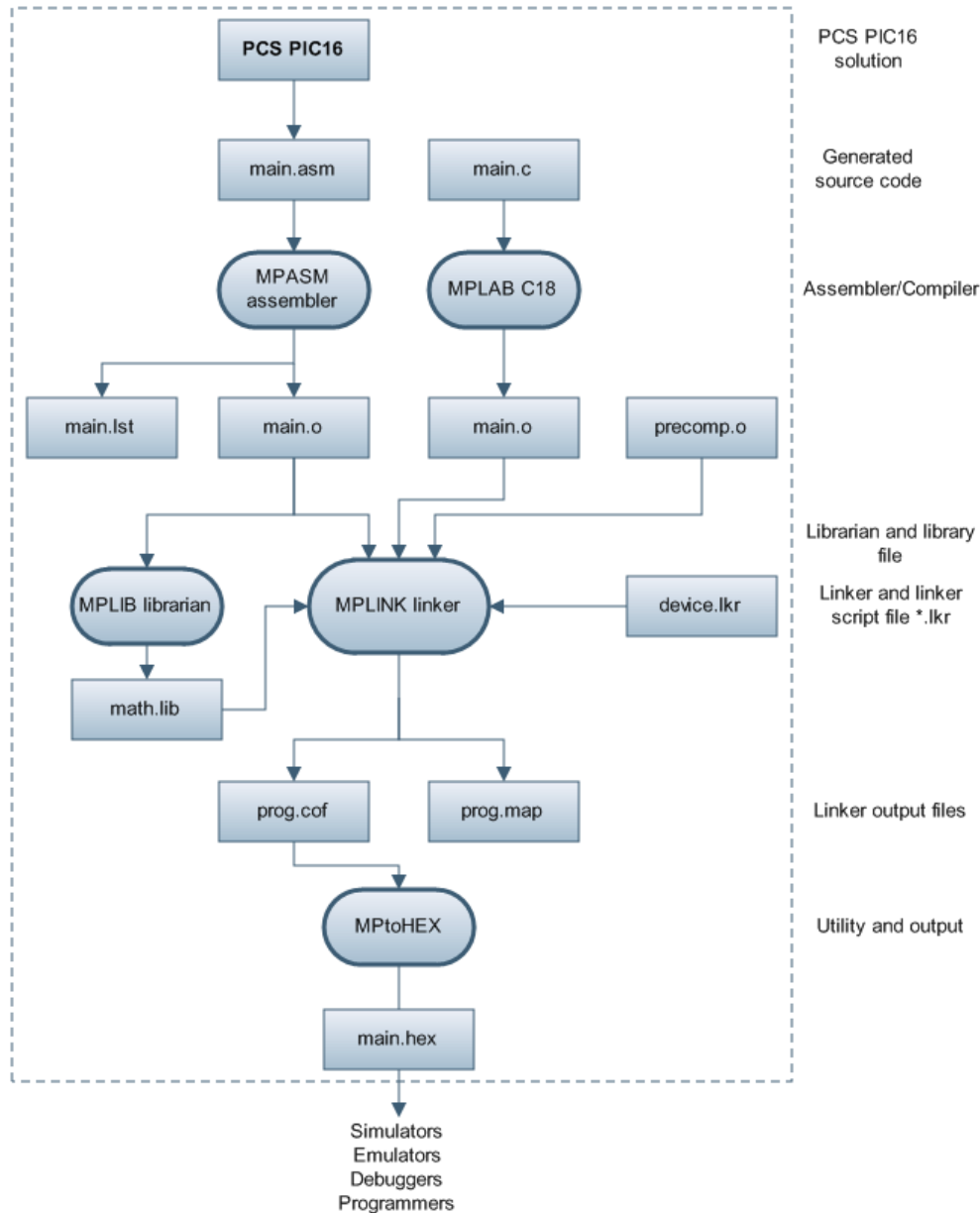


Fig.3. PIC16 solution development routine

Results and Discussion

Result of this work is the program PCS PIC16 for peripheral modules configuration, which allows automating the operation chain. To develop program further it can be automated the application programming, creating a visual low-level algorithm programming environment, enabling automatic configuration of the periphery and programming. Similar functionality offers Math LAB software with have an interface with MPLAB programming tool. It is necessary to develop a *.inc file recognition, which would give more accurate generation of assembler code. PCS PIC16 program was developed in Visual Studio 2008 programming environment. Operating principle of the PCS is taken from Maestro program on witch base was developed program prototype. Consequently, the PCS solution is more flexible than the Maestro solution. PCS program is focused on the relocate able code generation, to produce *.asm files on the output. To develop high quality solutions in assembler environment requires experience, but PCS tool with MPLAB allows fast user-centric software solution development. That solution will help users with lower experience level to end project faster. PCS software is able to maintain project settings as XML data file and load those settings back in the program. To the PCS is attached MPASM program and system calculator, if the program is small, the programming and ongoing assembly works can be done in this tool.

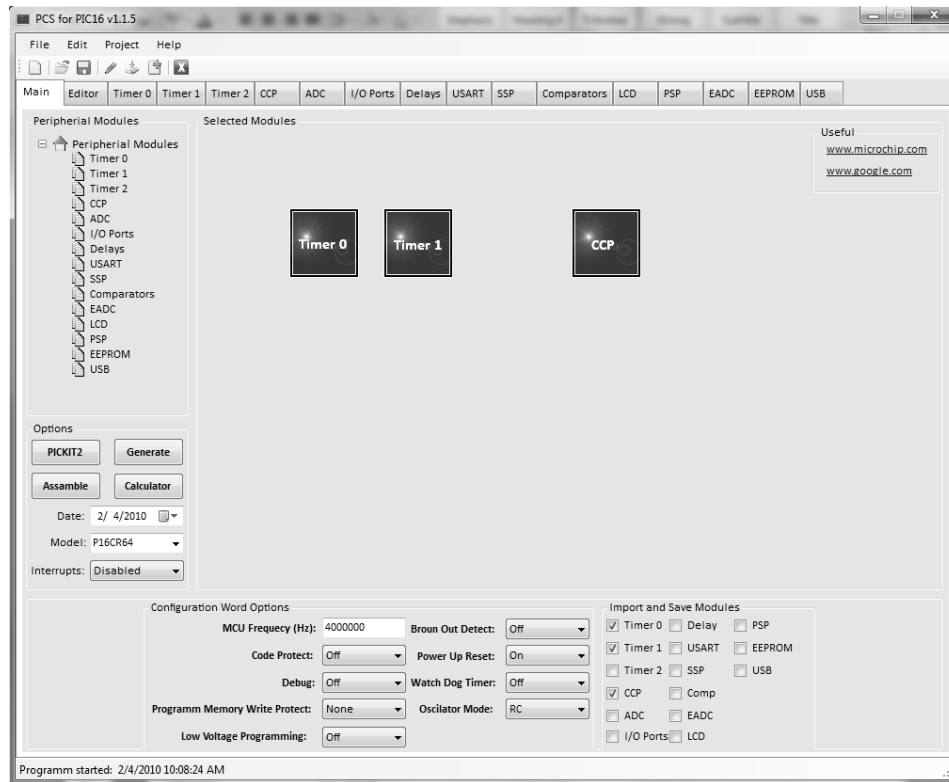


Fig.4. PCS PIC16 graphic user interface

PCS usage guidelines:

1. Choose peripheral module from the list.
2. Click on loaded module.
3. Choose enter data or delete data.
4. Enter all data on required modules.
5. Generate peripheral configuration code.
6. Configure Configuration Word Options.
7. Click on all chosen modules in Import and save modules.
8. Choose PIC16 model.
9. Generate main program.
10. Save all files.
11. Save Project configuration.

Conclusion

Based on the information gathered during the work and experience gained, it can be concluded that the program development process in assembler environment is complex and labor intensive, but higher-level language C use, for a programming is expensive because of the prices available for the start of PIC C version. Therefore, it is advantageous to structure and accelerate the development process by developing the necessary tools for work. The own-made programs are much more flexible than others offered because of required functionality can be developed and revised, if necessary. With other software it will be not so easy. No less important is the research work, which we made in electronics field, which allows creating more efficient solutions. Microchip offers very good line of microcontroller series, which has both performance and good flexibility. From research we learned that program programming principle, can be improved. Such possibility is offered by Math LAB software and Flaw code visual programming tool, only for few microcontrollers, which are supported by those programs. That software provides automatic code generation from user interface. Programming and peripheral modules configuration automation can bring some advantages in program development for PIC16 microcontrollers. In addition to the whole would need to create a database of models available, which are able to read the configuration information or to create *.inc file recognition that stores configuration information of PIC16. MPLAB big advantage is that this software has debug tool which makes programming process more flexible error search process become easier. Compilation process is technologically complex, because of program dependence on architecture. Architecture change will also change the complex method. This approach of programming is difficult. Low-level algorithms are efficiently to implement in assembler. System and the user interface level are beneficial to implement in higher level of programming language because of programming

logic and syntax reasons. It is necessary to structure a program in library *.dll files. It is important to use the software development standards. In program development was a used LVS 68:1996 and 72:1996 standard. According to SRS and SDD documents program was developed. In addition electronic instruction was developed, which is available from the program environment that facilitates the orientation of PCS software.

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DISCRETE INDICATORS AND TOUCH-PANEL BASED HUMAN-MACHINE INTERFACE

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Abstract

The article examines a new HMI (Human-Machine Interface) system. The system is based on statically positioned indicators for data output and a touch screen above them for data input. Indication elements consist of discrete light emitting diodes (LED), LED matrices, segment-type displays and small sized graphical visualization panels. LEDs can be used as point-type indicators for single bit (on/off) data output and also in certain degree as gauge indication (by lightening or darkening the LED). LED matrices in their turn can be used to output single and double dimensional bit array data type, which can also be used as gauges, symbolic indicators and along with segment-type displays to output numerical and textual data. Graphical visualization can be carried out by discrete graphical displays e.g. LED or OLED (organic LED). All the elements can be organized and labeled using passive printed or engraved background panel, which can be replaced to meet changeable application requirements. Background and all active elements are covered with touch panel, which serves as an input device. The main advantages of this approach in comparison to traditional full-sized touch-screens are better visibility of critical visualization elements in low ambient light, lower power consumption and lower cost. Such HMI systems can be used in applications where full-sized screens are not necessary and ergonomic and robust design is required, for example in industrial facilities, agriculture, smart home management, etc.

Key words: Touch-screen, HMI, process visualization

Introduction

A wide variety of different HMI (Human-Machine Interface) devices are available on the market nowadays: starting from the button matrices to the dynamic LCD graphical interfaces with touch screens. Static button arrays or matrices, knobs, switches etc. are combined with data output and indication elements, such as discrete point-type indicators, segment displays or double row LCD thus achieving interactivity and making possible of data flow between user and software of the automatic control application and forming HMI of the simplest type. Control interfaces of this type can be used to implement fixed functionality for a given application, the advantages are low cost and simple and robust construction. The main drawback is fixed placement of buttons and indicators (human-machine interaction elements), which in most cases bounds the HMI to only application for which it was initially designed. The second type of HMI that are widely used are graphical displays with touch panels (touch screens) where input elements are projected on display and the input itself is sensed with touch panel in marked locations, thus the touch screens can be used in almost all industrial, automotive, household or medical applications where human-machine interaction is needed. Unified standard multifunction touch screens for industrial use in various environmental conditions are available, for example VIPA TP600-series or Siemens 'Simatic' TP-series touch panels. These panels can be easily configured to use in almost all application areas mentioned above, but such multifunctionality can also be disadvantageous in economical matter. Automatic control of industrial applications itself is a well defined process, which also defines the look and functionality of HMI. Usually industrial machinery is designed for use in a certain phase of technological process and feedback information (operation parameters, status, raw material consumption etc.) that needs to be displayed remains of the same type. Use of large graphical displays in this way can be economically unreasonable and this is applicable not only for industry, but also for other areas of economics where automatic control of equipment is used. On the other hand simple button arrays and character displays may lack in functionality.

We propose a new intermediate type of interactive HMI, which consists of statically placed indication and mark-up elements and touch panel, but without using a full-screen graphical display: discrete indicators and touch-panel (DITP) human-machine interface.

Materials and methods

The proposed DITP interface, see Fig. 1, can serve both as input and as output device and it can be composed of low-cost components available on the market. The data output is performed using statically placed discrete indication elements, which can be implemented using light emitting diodes (LED), one or two-dimensional

groups of LED, individual numerical or alphanumeric segment displays, segment displays rows, groups of these elements and small-sized (< 3 – 4 ") graphical displays.

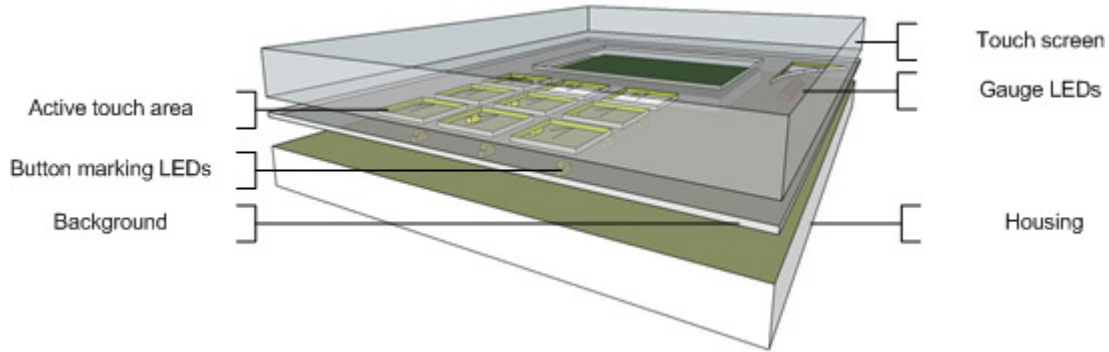


Figure 1. The structure of DITP

Table 1 summarizes the most common indication elements that are considered to use in DITP. It also gives output data type and possible applications for each group of elements in the context of the proposed device.

Table 1

Types of indication elements and their representative data types in DITP

Element	Output data type	Application
On-Off LED single	boolean	On-Off status indication, pushbutton marking, push visual feedback
Adjusted brightness LED single	up to 2-4 bit integer	On-Off status indication, low resolution gauges, pushbutton marking, push visual feedback
On-Off LED 1-D array	boolean array or integer in binary, HEX, BCD (binary coded decimal) or gauge representation	Numerical output, position output, gauges, status indication, slider marking
Adjusted brightness LED 1-D array	boolean array or integer in binary, HEX, BCD or gauge representation	Numerical output, position output, gauges, status indication, slider marking
On-Off and adjusted LED 2-D arrays	1-D integer array or 2-D boolean array	Gauge array (histogram, equalizer), slider marking, slider array marking, pushbutton matrix marking, push visual feedback
7-segment and dot numeric display, single and array	4 bit BCD or HEX integer on each display	Numerical data output (integers and floating points)
Alphanumeric LED dot matrix, single and array, character displays	8 bit integer (character) on each display	Numerical and textual data output
Graphical displays	All	Numerical and textual data output, graphic output and animations

Characteristic functionality for a particular application can be configured with background, which is placed over the indication area. Background should be mainly opaque and transparent, semitransparent or with openings over indication elements. Background can be used both to label input areas of touch-panel placed above and indication elements below and to show various drawings, tables and application instructions. It should be pointed out, that the background does not contain any components and it is not connected to the electronics of the module and it can be easily replaced by the user or developer which is using the panel as OEM product, thus changing the labeling and also the functionality of the DITP elements (indicators and active touch areas). For example

numerical keypad can be replaced with functional keypad or even QWERTY can be added in free area. Gauge diode array can be changed from pressure to temperature display, see Figure 2.

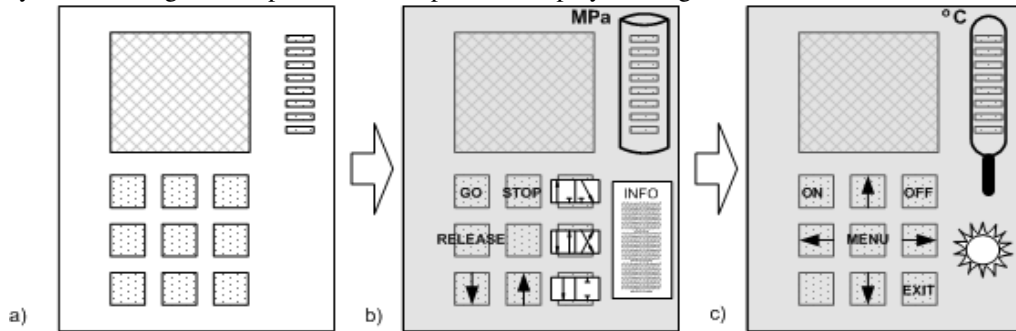


Figure 2. DITP application adoption examples using changeable background (dashed areas show led indication elements and small-sized graphical display): bare panel (a), industrial fluid power application (b) and smart-house thermostat application (c).

User data input is to be carried out using transparent touch-sensing panel, which is positioned over background layer. Note that the surface of the touch-panel is used only partially in so-called active touch areas identified by panel controller and representing buttons, sliders etc., and the usage can be adopted to each application's requirements. For example in figure 2 (b) central button is not used, but in (c) – left bottom button. As the input layer is transparent indication elements can be used not only for data output, but also for marking active areas and for visual pushbutton feedback (flicker on push).

It should be highlighted, that full-sized graphical display is not used in DITP thus it is possible to significantly lower both the costs of control hardware and software (only control program, configuration and several graphical templates for small-sized display can be kept in the memory of device) and also to lower power consumption. The control tasks can thus be implemented on simple hardware such as microcontroller unit (Noergaard, 2006). Interfacing with touch-screen using microcontroller is also task of acceptable complexity (Downs, 2005). Configuration of DITP can be done remotely using serial interface from personal computer using specialized software in the same way as it is in standard industrial HMIs. Configuration consists of defining active touch areas, indication data types, touch area marking and visual feedback scenarios and also communication commands with main application controller. The same or another parallel communication interface is used to send control information and get operational status and sensor readings from the application control equipment, see figure 3.

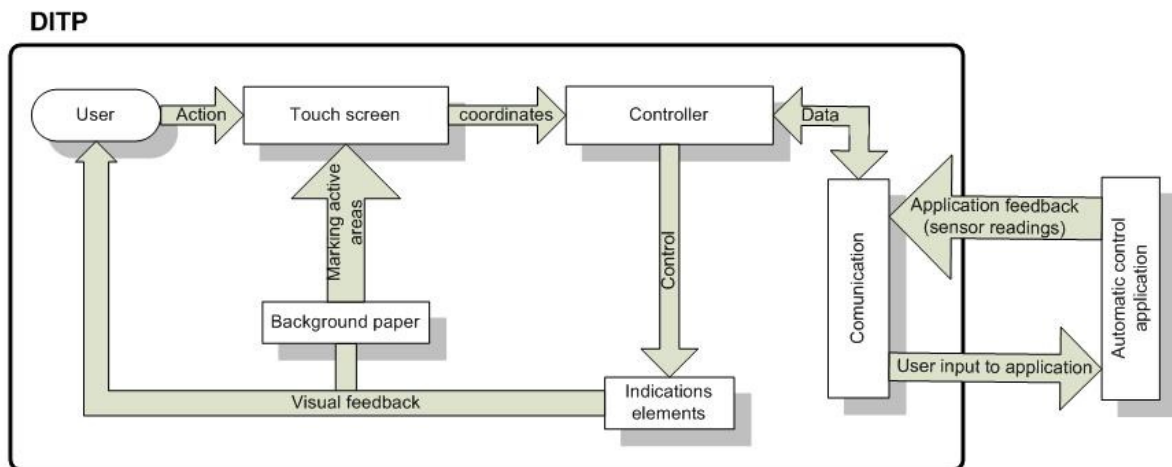


Figure 3. DITP data flow in application control loop

The scenario of exploitation of the proposed HMI panel as OEM device is as follows. Application requirements regarding human-machine interaction should be defined. According to these requirements application engineer configures DITP and performs system setup and puts it into operation. Further application engineer or user himself can change the functionality of panel in accordance to changing application requirements or for use in completely different place. It is an iterative process. Predictable life cycle of DITP is depicted in figure 4.

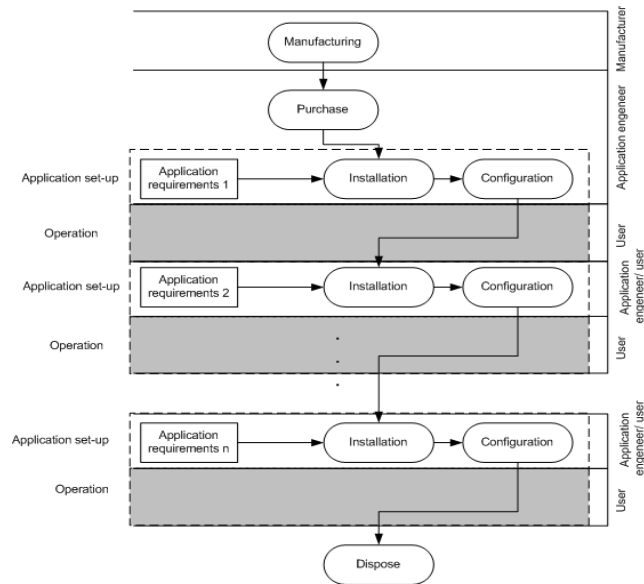


Figure 4. Life cycle of DITP

Results and discussion

As a prototype of DITP we propose a HMI device, which consists of 10" resistive touch-panel, one OLED (DD-160128FC-1A 160x128 pix) graphical display and two surface mounted LED arrays, see figure 5. Table 2 shows guide prices of main materials and components used, 109.28 euros total. For comparison with VIPA price list HMI Touch Panel category “TP605LQE” costs 500 euros and “TD 03” - Text Display category costs 150 euros.

The first LED array in two-dimensional arrangement forms 3x3 keypad and is intended to mark and give visual feedback from active input areas. The second array is positioned vertically and can be used for various gauge or level information output e.g. liquid level in a tank, blind position on window, temperature, pressure etc. For dynamical information output OLED graphical display can be used e.g. complex textual messages, pictures and animations. The prototype DITP is based on Microchip PIC24FJ256GB110 microcontroller unit.

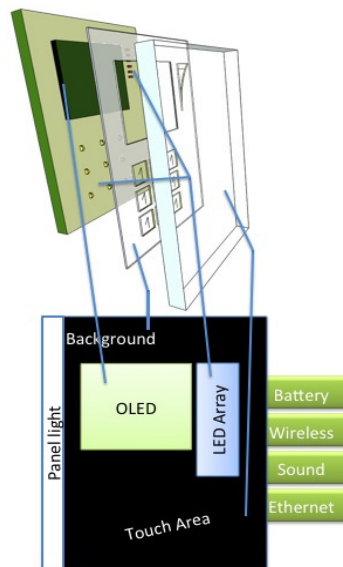


Figure 5. Structure of prototype DITP

Serial interface is used for communication for both in application set-up and operation modes. Data interchange between the HMI and configuration host personal computer or application controller is structured accordingly to OSI reference model (ISO/IEC10731, 1994) using master-slave approach (in software) where DITP is slave. For now three OSI layers are implemented: physical, data link and application. Physical layer is built on RS-485 line with hardware UART module in microcontroller and UART to RS-485 transceiver on the HMI side and RS-232/RS-485 on the master side. Data link layer was implemented partially using IEC 870 (data flow control,

frame formats and checksums). As an alternative Meter-Bus standard for utility meters can be considered (EN13757-2 2004, EN13757-3, 2004). Application layer was implemented using own command system.

Table 2

Guide prices of main materials and components used in prototype DITP

Position	Prices*
TOUCHSCREEN, 10.4"	€ 37.26
DISPLAY, OLED, RGB, 160X128	€ 22.70
LEDs	€ 1.14
MCU PIC24FJ256GB110	€ 7.41
CONTROLLER, TOUCH SCREEN	€ 2.21
TRANSCEIVER RS-485	€ 2.44
ENCLOSURE BOX	€ 6.12
Mainboard	€ 30.00
Total:	€ 109.28

* Prices accordingly to www.farnell.com on-line store pricelist, 12.02.2010.

This type of panel can be used for variety of facility management systems, which are not demanding an abundance of functions and is energy saving. Installation and electrical wiring convenience still join user friendly interface configuration, which does not require extensive knowledge of configuring the panel. If necessary, the control unit can be placed in addition to technological solutions. To be able to remove the access panel may consist of Ethernet networking equipment, or use one of the industrial data exchange standards, or example, KNX smart home European Standard (CENELEC EN 50090 and CEN EN 13321-1), or SCADA industrial network standard (www.aeso.ca/rulesprocedures/8818.html). In this way to the panel can be accessed from all over the world via the World Wide Web. Can also build local management capabilities through voice recognition or to compare libraries. In panel can be integrated wireless solutions as WiFi, Zigbee, Bluetooth and more, in order to ensure a continuous feeding or self-feeding can be integrated into the accumulator battery. In this way, achieving a portable device or remotely controlled.

Working in wet environments, such as livestock facilities, barn or technical facilities, garages, panel may be damaged. Using existing technology for energy transmission and wireless communications dashboard by integrating can be obtained, panel completely sealed, air-tightness. In industry used PLC types HMI. Those categories could be divided into three types. The button located fixed to the screen or diodes indication, some or more of the buttons and built-in LCD touch-screen and the third option, only the touch panel with LCD screen. The first kind is inexpensive, but it is limited to visual comfort and functionality.

Conclusions

Proposed HMI of a new type – DITP, where statically deployed indicators, labeling background and touch panel are combined, is an intermediate solution, which occupies domain between the existing HMI solutions: keyboard blocks and line displays, and touch panels with full-size displays. The main advantage of DITP is a positive cost and functionality reduction ratio, compared with full-size touch screen. It means, that with saving on full-sized display usage and the complex electronics, functional diversity for HMI implementation in various spheres of the automatic control system is kept. This approach can be used not only with discrete HMI development, but also with PLC-integrated interfaces (like Unitronics VisiLogic or Siemens LOGO-type). DITP could be used in systems different types of communication options for connecting the control equipment (PLC, industrial computers) and safety standards.

Acknowledgements

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IMPROVING THE ENERGY EFFICIENCY IN DWELLING BUILDINGS USING MULTI-AGENTS MODULS

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Abstract

This paper is monographic review of energy control in dwelling buildings based on multi – agents interactions. Authors in the paper describe the possibilities of energy use reduction with the help of automated energy control system based on multi-agents interaction. The problem regarding energy saving in dwelling buildings is to reduce energy consumption at the same time to provide user with necessary energy amount. This has not been analyzed and discussed in research papers in Latvia. To solve the problem authors propose to analyze the available energy control systems in the market and to create a scheme of multi-agent in automated energy control system. Automated energy control system with multi-agents interaction is more stable and can track dynamic environment changes in real time. Besides such systems reacts faster to prevent energy loss compared to automatic energy control system without multi-agents interaction. The authors emphasize that such innovative system based on developed principle schema with the interaction of multi-agents is able to respond to events of the environment, analyze the human daily gait and to optimize energy consumption much better that to automatic energy control system without multi-agents interaction. Reviewed literature shows also opportunities for automation of energy control system equipments, back-water radiators, wind generators, solar power in dwelling buildings. Main conclusion of the paper is to make further researches and make practical experiments based on purposed principal multi – agents scheme.

Key words: *Multi – agents, automation, energy control systems, energy efficiency.*

Introduction

To the next few decades, two major problems with regard to energy is the greenhouse effect as well as oil and gas resources decline. Therefore, the use of renewable resources of energy such as wind or solar, building projects are realized, knowing that the building consumes 45% of energy consumption and is responsible for 25% of the greenhouse phenomenon [1]. In addition, no doubt, the user may encounter on a variable tariff on energy, according to the hourly and daily rate of energy producers. From this point of view the production and consumption of energy, where the buildings are equipped with automation systems to control energy consumption, home automation system requires a compromise between the priorities of the user comfort and cost, and at the same time needs to remove technological constraints, and reduce user comfort equipment shortages.

The aim of the article is to develop principles of energy efficient control system (EECS) scheme for dwelling buildings based on the multi - agent operating principle. Multi – agent ability is tackle complex systems, for what in last years has increased attention in building automation research field and is part of ISES (Information/ Society/ Energy/ System) project that aims is to gain energy efficiency and occupants comfort via added services. [12] To achieve the paper aim following tasks were put:

1. analyze available automatic control energy providers and energy consumers;
2. make the multi - agent description;
3. create automatic ECS functions with a multi - agent operating principle schema;

This article is monographic view on automatic control system based on multi – agents interactions. Automatic control system allows the transmission of information objective from sensors to specific processing hardware like personal computer with additional software, microcontrollers or execution equipment. Heat equipments are divided into conditioners type, various fuel systems (solid fuel system, liquid fuel systems, gas fuel system, biomass fuel system), the back – water radiators, heat pump, solar energy. Multi – agent systems are used to solve a complex micro and macro problems in agents interaction environment. Agents can solve problems using acquired environment and agent history action information from data carrier. They uses this information to make own independent decisions which makes multi – agent system work much more better and react faster on changes in environment. Uniting these two technologies in prototype there is many opportunities to create dynamic multi - agents energy control system with data analyzing, which can adapt to dynamically changing environment and to predict human daily gait to effectively use energy.

Materials and methods

Different energy control systems (ECS) for adaptive equipment control have been analyzed. Heat ventilation and air condition (HVAC) type of energy control is divided into home, industrial and semi-industrial equipment. Such classification is based on a ventilated room space and equipment capacity. Central air conditioner is one of the best choices to use in conditioner type ECS. Modern central air conditioner is designed to regulate mixing, heating, cooling, cleaning, draining, moisturizing. Central air conditioner is not an autonomous system. The equipment from the outside must be used to provide cold (cold water or not freezing fluid supply), heat (hot water or steam) and electricity for fans, pumps, regulators and closed fitting connections of air and fluid lines.

Solid fuel type ECS is not fully automated. It is governed by semi-automatic or manual control system. Boilers regularly must be loaded by the fuel material. Their facility is operated by the automatic system, which accompanies the temperature regime to ensure, by changing the heating system operating parameters depending on the outdoor air temperature (weather control mode) and comply with a timer programmed activities (like switching on and off heating) as well as communicate for the deviation of the system, that energy is produced as user requires. Systems can be provided with heat controllers or with thermostats to allow changing temperature.

Liquid fuel type control system is usually chosen when the house is located far away from the gas mains. Liquid fuels require a ground fuel storage tanks. Construction principle is the same as the solid fuel automatic control system but requires specially designed furnaces with liquid fuel spray head.

Gas fuel type control system is often chosen because of simplicity in operation and maintenance. Gas fuel system does not need a storage tanks. It is provided by pipes to stove. To activate the heating process it needs to simple a push of start button. Gas fuel type control system is widely used in living places or heating environment that has been located nears the main gas mains.

Heat pump type control system is one of the best energy efficient ECS. Its heat is generated by the formation of two heat quantities:

- Heat from the cooled material;
- Heat, which is produced by compressor work.

In comparison with boiler heating systems in heat pump solution the chamber is replaced with, for example, the tube circuit, which is a heat source (cooled material) for living environment, and it's warmed up with heat carrier. The heat source can be: the top layer of earth, groundwater, natural reservoir, the ambient air, waste air from the ventilation system, waste water with low temperature industrial processes coolant (if the temperature is too low to use the simple heat exchanger). Heat pump mostly combines with solar panel or solar battery.

Biomass fuel type control system is governed by semi-automatic or manual control system. Similarly like solid fuel ECS these boilers regularly need some human resources for fuel loading. A harmful emission levels are reduced using biomass fuels, as well as it's a renewable resource.

The back – water radiators in central thermal system has special devices - heat charge distributors. They are installed on all back – water radiators in all apartment rooms. A whole month they are recording how much and how long the radiator has been working. A heat charge distributor converts this information to the sections that serve as the basis for the calculation of heating costs. Distributors can be located on different types of heat sources. Furthermore, the radiators should be equipped with vents, because only with them will be able to regulate the temperature and hence the monthly fee for warmth. However, such a system requires people to adjust the flow of heat radiators, so it is not an automated heat system. [5]

Solar energy systems divide in to two categories: solar electric (photovoltaic systems - PV) and solar thermal. PV system converts sun energy in to electric. PV systems mostly consist of solar panels, charge controllers, batteries and inverters. Solar panel converts sun energy in electric current. Solar panels can be united in block to produce greater electric current. Electric energy is stored in different kind of batteries. Batteries can be united to make bigger electric energy storing capacity. Charge controllers are used to prevent to solar panel overcharge the batteries. Inverters converts solar panel produced and in batteries stored DC 12 V electrical energy in to AC 230 V, which use mostly electric consumer in dwelling buildings. Solar thermal energy production is used combining with HVAC, central thermal system, water heating processes to increase energy efficiency in dwelling buildings.

Occupants needs for hot water consumption is unavoidable. All consumed hot water is drained from dwelling building to sewerage and this process isn't energy efficient. Washing process uses water heating process, drained hot water thermal energy transformation to other heating processes, hot water dosing to each occupant individually. To improve energy efficiency in dwelling building washing process should discussed like one of influencing factors.

Cooking process is mostly associated with HVAC systems to drain hot air from environment. Hot air reaches the heating or cooling element of HVAC and mixes with fresh air with different temperature. This process provides much lesser energy consumption and increase energy efficiency. Cooking process to generate a heat uses fuel material or electric current and combined with additional energy efficient automated control system decreases energy consumption.

Wind generator consists of tower or mount, blades, generator, controller, nacelle, anemometer. Tower is place on which turbines are mounted. Blade converts wind power in mechanic power. Generator converts rotation energy in to the AC electric. Controller starts and shuts the generator in given constraints. Nacelle protects all wind generator mechanical and electrical component parts. Anemometer measures the wind power and transfers data to controller. Wind generator can be combined with different electric generators to increase green energy production. [Fig.1]

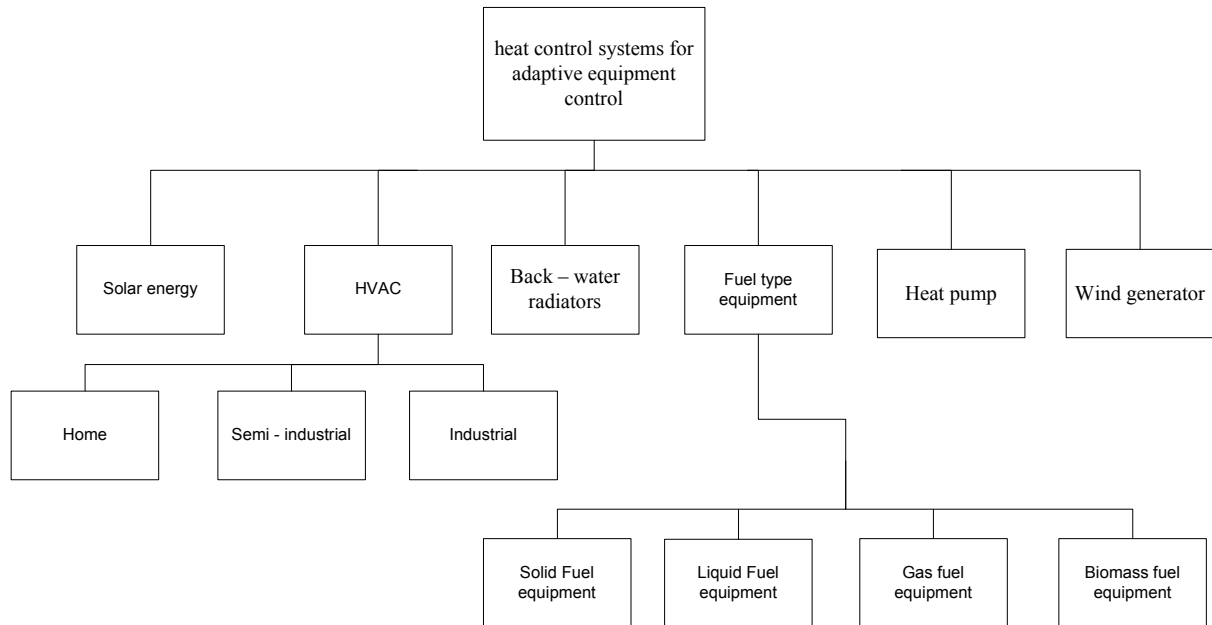


Fig. 1. Different ECS for adaptive equipment control block diagram [authors made]

To understand what kind of methods must be used to create automatic ECS, there is need to make out which type of ECS can be fully automated and which can be only partly automated. Best choice to make fully automated ECS is heat pump, gas fuel type equipment, HVAC, solar power solution, because there is no need to fulfill boilers of fuel material. Biomass fuel type equipment, liquid fuel type equipment, solid fuel type equipment ECS must be fulfilled sometime with fuel material. In order to create automated ECS schema there is an offer to consider system equipment ability to provide heat without fulfilling fuel materials. In this case there is no need of human help to recharge fuel materials and system can be made fully autonomous. Back – door radiators are offered to be equipped by control valve, which provides individual control on back – door radiator. Controlling district heating liquid flux can be administered heat in dwelling rooms.

Energy efficiency

Energy efficiency and user comfort in dwelling buildings is recommended to study how a single joint, rather than as two separate researches. Methods and techniques for optimizing the energy consumption and occupants comfort have been researched and applied long before the emergence of multi – agent technology. Comfort is understood as a function of the occupants selections, requirements information, and can be integrated in multi - agent system as the rules for a decision making and take responsibility for energy optimization as well as controversial and supported processes realization. Some proposals have been put forward to improve energy efficiency and the occupants comfort. One method is to use Fuzzy - logic to determine the classical controller parameters [7]. Another method is use a multi – criteria optimization heating ventilation air condition (HVAC) system uses multi – criteria optimization [11]. Some research aim is to use a constraints predicted percentage of dissatisfied to calculate a population averaged occupant comfort [10]. However [8] there also is purposed to use an index for degree of individual dissatisfaction method to gain improved thermal comfort and gratification for every occupant in the same time minimizing energy consumption. To improve energy efficiency multi – agent system is combined with wireless sensor networks to make economical solution [9]

Multi-agent in ECS

Three main features the multi – agent energy control system (MECS), which consist of different type agents and interaction mechanisms, should reach:

1. Distributed – energy resources and execution equipment are distributed spatially in dwelling buildings and their control systems are self – determined from others control systems.
2. Flexible – energy resources and execution equipment can depending on the needs of MECS services accumulate, devote heat energy or increase, decrease heat production processes.
3. Opened – the count of MECS energy resources and execution equipment can vary over the time and in this case MECS should be easily reorganized without having to completely redefine the control and interaction mechanisms.

Each agent in MECS should have five different modules [Fig. 2] with following functionality:

- Through the sensor module deliberation module updates knowledge about environment on the agent request.
- Through the goals module deliberation module creates agent aims using sensor and behavior library modules cooperation. Goal is the main direction of choosing behaviors.
- Behavior library module realizes the agent goal by adding appropriate behaviors.
- Execution equipment module executes actions based on selected behaviors.
- Deliberation module makes calculation and each other module data processing and consolidating. Resulted action is passed to execution equipment.

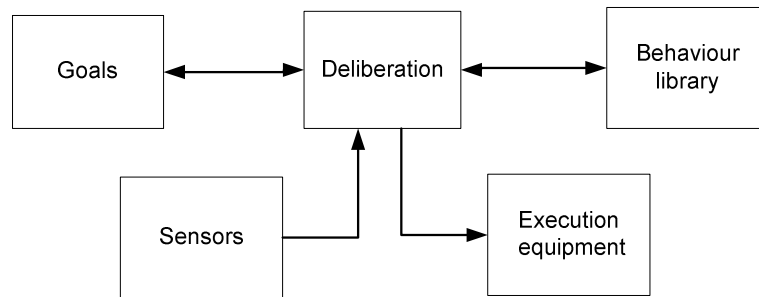


Fig. 2. Agent architecture [authors made]

All these five modules deliberate with each other asking necessary information and choosing best optimal behavior to realize agent created goal. All agents connected in one shared communication network are MECS. This system contains several services like cooking, washing, thermal processes like thermal air, thermal water, renewable energy creation processes like solar energy, wind energy. Each service and process mostly has inconsistent standards and technologies, which must be united in one shared communication network. To create such communication network there is need for mediators in MECS. The mediators role between services and processes realize agent, which can communicate through shared communication network in MECS with other agents. Agent tells to additional controller execute actions on service or process through execution equipment module [fig. 2]. Information about service or environmental agent gets through the sensor module. Sensor module, goal module, behavior library module are interconnected through deliberation module, where agent makes intentions and seeks best behavior in behavior library for execution equipment actions. Agent should compare his chosen behavior with his goal, and don't use behaviors that are in conflict with the goal.

Agents should have an opportunity to communicate, get, request, send information to each other, and make an interaction and deliberation of known information to perform optimum choice of behavior and actions. Also agents should have learning possibility of environment and occupant individual needs and daily gait. MECS architecture should consist of a number of software agents. Every agent is an abstraction that describes software, which acts for occupant or other program in relationship module. There are many definitions of agents, and most of them in MECS should agree on the following common concepts:

- Persistence – agents have at least one or more threads of control. They can exist continuously in MECS, should insist on their positions meanwhile not forgetting the goal of interaction in MECS and at the right time depart from its view, as view confronts with the goal.
- Social ability – agents are able to engage with other agents via communication network, coordination process and even cooperate on the task.
- Activeness – agents don't simply act on environmental changes. They demonstrate goal – directed behavior and take an initiative when it is necessary.
- Reactivity – agents perceive the context, where they have influence, and react on it appropriately.

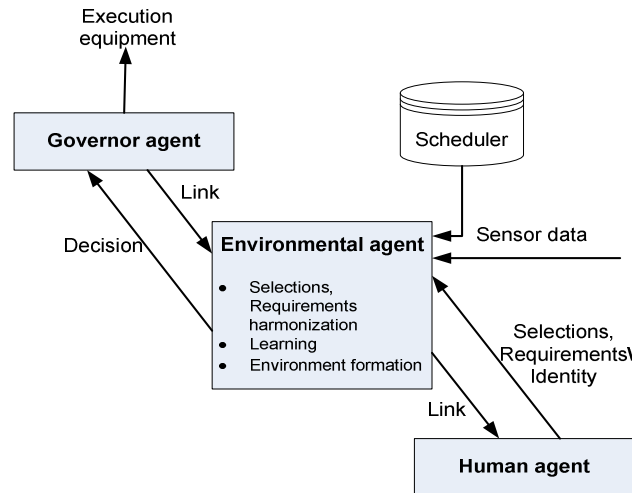


Fig. 3. MECS agents functional architecture [authors made]

MECS should consist of three types of agents with different reactivity and social ability functions: governor agent, environmental agent, human agent. All these three types of agents together make a fully functional MECS with learning, occupant identification, decision making, deliberation and goal – based behavior abilities. MECS also agrees with persistence, social ability, activeness and reactivity concepts.

Governor agent – it should have two main functions in MECS: decision collection from all other environmental agents and providing access to input / output interface of the execution equipment required by the environmental agents. Governor agent should have following concepts: [Fig.3.]

- Persistence – governor agent have its own threads and schedules. It can start and shut down them having no impact on other types of agents.
- Social ability – governor agent interacts with environmental agents collecting decisions and deciding of decision execution. Governor agent provides an interface with internal and external services.
- Activeness – governor agent don't demonstrate activeness behavior.
- Reactivity – governor agent acts like chief to other environmental agents and execution equipment by taking requests and providing services.

Environmental agent - it should have the main role in MECS. It should act like a mediator between human agent and governor agent. Environmental agent might harmonize conflicting preferences from different occupant, establish rules that restrict possible settings for environment parameters, learn occupant behavior, and provide data about environmental agent operating environment formation.

Environmental agent should have following concepts: [Fig.3.]

- Persistence – governor agent has its own threads and schedules. It can start and shut down them having no impact on other types of agents.
- Social ability – environmental agent interacts with human agent to acquire occupants credentials and require information from environment via sensors and acquire information from environment.
- Activeness – environmental agent goal – directed behavior goal is to find a balance between occupants selections, requirements and energy efficiency.
- Reactivity – environmental agent observes environment formation via sensors, human agents and responds to changes that occur in it by informing human agent and sending decisions to governor agent.

Human agent - it should represent occupants selections, requirements and provide with that kind of information proper environmental agent. Human agents should be like Environmental agents assistants that operate with occupants information, observe the ambient environment, and provide link from other environmental agents to the individual occupant selections, requirements.

Human agent should have following concepts: [Fig.3.]

- Persistence – human agent has its own threads and schedules. It can start and shut down them having no impact on other types of agents.
- Social ability – human agent collects dwelling occupants credentials (identity, selections, requirements) and provides them to environment agent. Human agent acquires environment formation form environment agents.
- Activeness – Human agent goal – directed behavior makes negotiation with human agents to choose learning mechanism and reserve place in MECS action schedule.

- Reactivity – human agent perceives current environment via environmental agent and takes a response to environmental change, for example temperature, insisting on environmental agent by alerting occupants influencing their behavior. [12]

Results and Discussions

From analyzing materials of heat equipment control systems, multi - agents and multi - agents modeling languages, has been made a principal schema for agent in automatic ECS with multi - agents interaction [Fig. 5]:

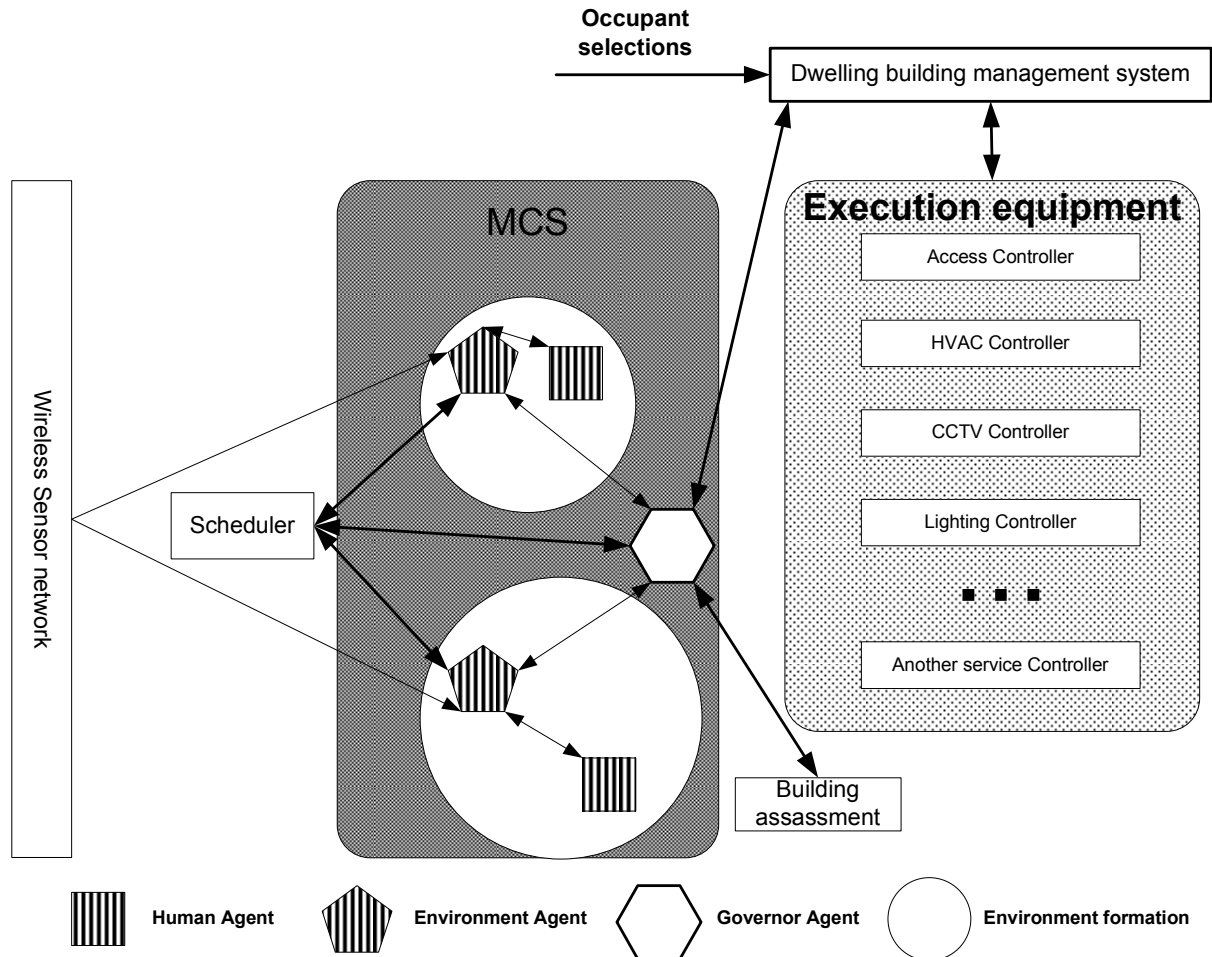


Fig. 4. Purposed schema for Energy Efficient control system with multi - agents interaction [authors made]

Principal schema of Energy Efficient control system (EECS) shows MCS and execution equipment interaction mechanism. In MCS human agents must always keep occupant identity, to know on which environmental formation is user behavior. This can be assured by Windows technology or industrial security made software based on UNIX or Windows platforms.

Human agents keep occupants selections, requirements for all measured data like temperature, identity index, building performances parameters, thermal calculated index and other non - added indices or occupants requirement variables. Human agents cooperate with environment agents responsible for the current environment formation condition and parameters. To influence the user behavior human agents have access to warning processes like sound distress signal and distress light signals. Human agent always verifies occupants identity and interacted environment formation. When environment formation change, human agent shifts interaction to next influencing environment agent, achieves new value of parameters and new environment formation.

Environment agents don't collect information about occupants, but of current environment formation. Environment formation is the basic unit of dwelling building structure populated place and can extend physical room borderlines. Using a scheduler queries, artificial intelligent scheduling environment agents are able to make energy balancing prediction and adopt new balancing plan and modifies rules for the environment formation. Environment agents get occupants selections and requirements, identity and all other specified occupant index from human agent and send environment formation changes, building assessment to human agents. Environment agents keep decision making and learning rules, mechanisms and send them to governor agent. They through the governor agent link get answer about elected action taken upon those decisions. Some

rules for decision making are static and can't be changed others are created for individual occupants and provided based on environment formation parameters. Environment agents collect information about environment formation through wireless sensors network using sensors acquired data.

Governor agent provides some services which allow starting or stopping, deploy or delete agents, provide environment agent with environment formation changes, summarize received decisions from several environment agents before convert them for execution equipment in understandable language. In the case when decision is not approved then corresponding environment agent will be notified through link.

Execution equipment has its own dwelling building management system which unites all of them in a complex execution system. Occupants enter individual constraints, selections, requirements to EECS through dwelling building management system where MAS provides functionality to correctly maintain them providing energy summarization and occupants comfort level.

Building assessment is a data storage place with agents acquired information about each environment formation, users entered data, information acquired from learning mechanisms for dwelling building. Building assessment data uses governor agent to approve environment agents' sent decisions, correctness or decline controversial decisions in EECS. Building assessment data can dynamically change or remain static. Authors suggest that this kind of EECS schema is subject for further research and is needed to test in practical experiment [Fig.4].

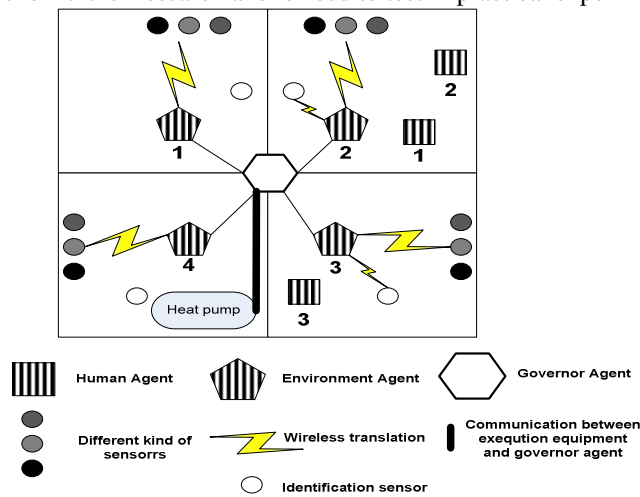


Fig. 5. Agents and sensors layout in environment formation.

Each environment agent is responsible for collecting any information in environment formation about space parameters. Changing parameters are collected via different kinds of sensors, human persistence in environment is collected via identification sensors and dwelling occupant information is acquired from additional human agents in environment. Environment agents send decisions to the governor agent and in affirmative decisions cases the governor agent sends specific converted machine code to execution equipment (Heat pump) for execution. Scheme [fig.5] shows how abstractly sensors placement, agents influencing environment formation and data acquiring from sensors could be visualized in dwelling buildings.

Conclusions

Through automated ECS research it was found out that the existing equipment autonomously regulates only one piece in dwelling buildings installed ECS not all ECS instantly to increase energy efficiency overall in building. There also is necessary to merge each ECS with multi agent system to increase occupants comfort level and use identity, assessment and scheduler processes with purposed MEES.

To create automated ECS schema must be consider system equipment ability to generate energy without fulfilling fuel materials.

Paper research shows that multi – agent advantage is tackle complex systems by agents interactions, decision – making, planning, negotiating with each other to find a best system behavior or action to dispose difficulties.

Offered principle schema is based on three kind agent architecture principles: governor agent, environmental agent, human agent. Purposed EECS schema shows ability to implement occupants identity, building assessment, agents predicted actions scheduler, wireless sensor network and possibilities to easy attach or disconnect execution equipment or process form EECS without major architecture changes.

EECS schema must be used for further research in agents simulation tools, on decision making mechanisms creation, on MCS prototype creation, on learning mechanism creation, on preferences learning and decision making in conflict resolutions, on MCS prototype interaction with real execution equipment, MCS prototype interaction with execution equipments and data translations in wireless sensors network . In each research stage

will acquire necessary information to continue next stage of researches, which will lead to working EECS in dwelling building.

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TEMPERATURE CONTROL SYSTEM FOR RISK MINIMIZATION IN HONEY BEE WINTERING BUILDING

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Abstract

During the winter time honey bees can be placed in a special wintering building to save physiological resources of bees and honey compared with outdoor wintered bees. This building should have stable and convenient microclimate conditions for bees. The most important parameter of microclimate to be controlled is temperature. The ambient temperature of +8°C corresponds to the lowest warmth power produced by bees and therefore it is the desired temperature in the building.

For our bee wintering building we have developed a special temperature control system. The developed control system is based and controlled by the PLC. In our case we are using Siemens S7-200 controller with CPU 224XP. PLC controls other equipment in the building. The controlled equipment consists of air recirculation fan, cooling ventilator system, fresh air fan and electrical duct heater. The main task of the system is to control the temperature changes. Temperature is measured, using the Siemens Sitrans TF2 sensor.

The developed system helps to minimize honey bee wintering risks. The possible risks are the start of intensive brood rearing before early spring and the risk of control system failure. The solution for minimizing system failure risk is realized by applying error notification method. When the temperature reaches the critical limit, it is important to inform the responsible person or persons (beekeepers) about this. The critical temperature limit is defined in the system by a system user. Notification methods that can be realised are SMS or e-mail sending. But SMS sending is a more efficient way of notification, because beekeepers will receive the error message without any significant time delay, but e-mail could be read after some time, when PC will be used. But in our case the reaction from beekeepers is needed immediately, if they want to save their honey bees.

VIRTUAL SERVER INFRASTRUCTURE TO IMPROVE INFORMATION SYSTEMS IMPLEMENTATION PLANNING IN ENTERPRISE

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Abstract

The aim of the paper is to perform the analysis and comparison of the planning and introduction methods of different information systems from the aspect of the necessity of physical and technological resources. This paper show how using virtual server infrastructure can help optimize usage of existing physical infrastructure and minimize expenses for maintaining existing and planning new server rooms and data centres. Also this paper show that consolidation of more information systems in less technical resourced, like servers, do not overload them.

Keywords: *virtual infrastructure, data centre, consolidation*

Introduction

Nowadays, under the austerity circumstances, the Ministry of Regional Development and Local Government (MoRDLG) in its website on 2009.10.01. (<http://www.raplm.gov.lv/pub/index.php?id=25&gid=3&lid=1573&id=25>) has published information that it has aggregated information on the use of IT resources at the state administration institutions, which shows that the significant budgetary funds are spent for this purpose. The MoRDLG also considers it is useful to develop a uniform data centre for all the state administration institutions, where, using the modern technologies such as the server virtualization technology, it would be possible to optimize the maintenance costs of IT infrastructure.

The problem of the optimization of IT infrastructure maintenance costs is not only on the agenda of state and local governmental institutions, but also refers to anyone under whose administration the objects of IT infrastructure are situated. Basically the maintenance of IT infrastructure, of course, is related to the enterprises, whether they are state or municipal, or private. The amount of infrastructure maintenance costs and their optimization possibilities mostly depend on the correct and well-considered planning and introduction of IT infrastructure. The mistakes made within the planning and introduction process of IT infrastructure could negatively influence the future possibilities to introduce the new information systems.

One of the most significant factors to be taken into account by enterprises, when planning and introducing new information systems, is the existing infrastructure of the enterprise. The infrastructure has physical limitations, which are determined, when planning and developing the information technology of the enterprise, the most important element of which is a server room or data centre. The introduction of new Information systems might be impossible due to physical or technical limitations of server rooms or data centers, therefore within this material the problem of the introduction and planning of new information systems was considered from the aspect of limited physical and technical resources, where the basis is already existing server rooms or data centers, whether the limitations of physical and technical resources are related with the financial, material, as well as technical requirements, determined during the stage of the planning of server rooms and data centers.

The planning and introduction of information systems in the server rooms and data centers (hereinafter — SR and DC) is on the agenda of many medium and large enterprises. Since it is unlikely to overestimate the significance of these SR and DC objects for the ensuring of enterprise activities, their important role is obvious. Thus almost every modern enterprise has faced the necessity to develop or maintain, or expand SR or DC. There are enterprises, which themselves try to develop and then to maintain their DC or SR — this report could assist such enterprises in the decision-making regarding planning and introduction of new information systems and development and expansion of SR and DC related to this process. However, the enterprises, which have decided to use for the placement of their information systems the enterprises, the activities of which are directly related to the rendering of services regarding renting of DC and SR, could find this report useful in order they themselves could evaluate the technical aspects of the offer according to the needs of the enterprise.

The aim of the report is to perform the analysis and comparison of the planning and introduction methods of different information systems from the aspect of the necessity of physical and technological resources. In order to achieve the aim, the following objectives set are to:

- Consider the main methods of the planning and introduction of information systems — the method of physical environment and the method of resource virtualization environment.
- Identify the main criteria for choosing the planning and introduction methods of information systems in the following criteria groups:

The main physical resources necessary for ensuring of the operation of information systems.

The main technological resources necessary for ensuring of the operation of information systems.
 The applicability of information systems.
 Financial resources necessary for the information systems.

- On the basis of a particular enterprise case, to perform the comparison of the method of physical environment and the method of resource virtualization environment for the planning and introduction of information systems.

1. Resources and methods

Within the framework of this material there were physical and resource virtualization environment methods viewed, which can be used during the process of planning and introduction of new information systems at the enterprises.

The method of physical environment envisages that the introduction of any new system is related to the determination of such resources as server capacity, place for the server room, energy consumption and climate control system consumption for every particular system. The major disadvantage of this method and thus also all limitations, which determine the amount of information systems, the total amount of used servers, the total electrical power used, the total physical place (room) used, as well as the total maximum acceptable capacity of heating, determine the server room and data centre at the moment of designing and development. These limitations cannot be increased without significant reconstruction of the server room or data centre, which make the server rooms and data centers unsuitable for use during the reconstruction period.

The method of resource virtualization environment envisages the possibility to place in one physical resource (physical resource – used server, occupied room, consumed electrical power, consumed cooling capacity, used communication cables) several independent information systems, preserving for each of them its unique environment and independence from other information systems. The most significant advantage of this method is the possibility, using the existing server room or data centre, to increase the amount of the information systems to be placed, as well as to optimize the efficiency of physical and technological resources, thus avoiding the necessity to reconstruct the server room and data centre. When applying this environmental method, it is also possible to plan considerably smaller server rooms and data centers in order to meet the same technological requirements like applying the method of physical environment. Besides, it is possible to reduce considerably the costs of construction, as well as those of future maintenance of server rooms and data centers.

Table 1

The Groups of Criteria

Group of Criteria	Criterion	Unit of Measurement
Physical resources	- Electrical power	kW
	- Capacity for ensuring climate	BTU
	- Room and number of servers	cm ³ /pcs.
Technological resources	- Load of processors	GHz
	- Amount of main memory	MB
	- Space of disks	GB
Applicability	- Possibility to recover the systems	n/a
	- Comfortableness of server maintenance and repair	n/a
	- Comfortableness of system expansion	n/a
	- Comfortableness of system physical availability	n/a
Finances	- Costs of electrical power	LVL/month
	- Costs of SR or DC maintenance or rent	LVL/m ²

While preparing this material, there were several criteria set, which were considered to be the most important and taken into account, when developing SR and DC and planning further introduction and maintaining of information systems at an enterprise. These criteria will enable to compare the method of physical environment and the method of resource virtualization environment and to emphasize their advantages and disadvantages. The set criteria are structured in a way that there is described the significance of each criterion for the planning and developing SR and DC together with the measures to be taken to ensure them in the case of the method of physical environment. Since in the case of the method of resource virtualization there also exists the physical environment, the criteria for the development of physical environment should be related also to the method of resource virtualization, however, within each criterion it is emphasized how in the case of the application of resource virtualization method, there are the requirements changed, which should be taken into consideration, while planning and introducing new information systems.

For the comparative analysis of each method there had been chosen and used four groups of criteria, see Table 1.

1.1. Physical Resources for Ensuring the Operation of Information Systems

For ensuring the operation of information systems, the main following physical resources are necessary:

- Electrical power.
- Capacity for ensuring climate.
- Room and number of servers.

When developing, as well as planning further development of SR and DC, introducing new information systems, such values as the electrical power to be consumed with sufficient reserve should be taken into account in order to ensure the possibility of further increase of electrical power to be consumed alongside with the increase of necessity to locate more and more new equipment and information systems. In many already established SR it is a major problem, because it might be difficult to increase the electrical power to be supplied to SR and DC with DC and SR already put into operation and working. It is also important for ensuring the electrical power to envisage the system of uninterruptible power supply (UPS), which will enable to operate the equipment placed in SR and DC without breaks in the case of temporary cut of power supply, as well as in the cases, when there are observed disruptions of voltage as voltage maximum increase or voltage drop. UPS have a significant role in the cases, when the supply of power is discontinued for a longer period of time. In this case UPS can initialize the procedure of “correct shutting down” of servers and supply all equipment, located in SR, with electrical power, thus preventing data loss. This procedure usually is applied in SR. But in DC, UPS ensure the possibility for the equipment, located DC, to function independently from the public network of electrical power for a sufficiently long period of time in order all the necessary procedures and measures for the commencement of diesel-based electrical generator operation could be taken. These generators, independently from the public network of electrical power, ensure the further generation of electrical power, necessary for DC. Usually the systems of diesel-based electrical generators are ensured with sufficient reserve of fuel in order they could generate electrical power for several days independently from the public network of electrical power, without necessity to increase the reserve of fuel. The systems of diesel-based electrical generators require a lot of space; therefore they are usually utilized in large DC and are not applied in SR. For the increase of the safety of electrical power systems in DC there are also used two connections of the network of public electrical power, where there are utilized physically separated connections of the electrical power network to the nearest substation or even to two different substations. If one of the electrical connections is damaged or if one of the substations is damaged, such solution enables to switch over to the other connection of public electrical power.

As follows from the above mentioned, if the introduction of new information systems exceeds the physical and technological resources to be attracted in the case of the introduction of a new information system, when applying the method of physical environment, the increasing of resources should increase the capacity of several systems. Namely - supplied electrical power, UPS power, and the power of the diesel-based electrical generators. Alongside with the consumed electrical power at SR and DC, it is possible also to observe the increase of the total amount of heating, which causes the necessity for further increase of power also for the system of climate control. When applying the method of resource virtualization environment, it is possible to consolidate considerably the information systems into one physical resource, thus increasing the technological load of the physical resource and decreasing the total amount of necessary physical resources. The method of resource virtualization environment enables to place considerably more information systems in SR and DC, while using the same resources of physical environment.

For any equipment, which shall be placed in SR and DC, the manufacturer has determined particular climatic conditions. And usually the necessary climate is determined by two factors — the permissible air temperature within particular limits and the permissible air humidity in SR and DC. Like in the case of the electrical power connection, the system of climate control should be planned since the beginning of the establishment of SR or DC, in the calculations there should be included also the possibility to expand SR or DC in future in a way that the installed equipment for climate control could maintain the necessary climate also when the amount of equipment of information systems increases, and alongside with it – also the total heat caused by operating equipment. If the correct capacity of the necessary systems of climate control is not planned in advance, later increase of capacity will make to find considerably more financial investments, as well as it will be difficult to increase the capacity, while operating information systems in DC or SR. Usually in practice there are two independent systems of climate control applied, thus ensuring the maintaining of climate in DC or SR also in the cases, when one of the systems of climate control does not function. Many enterprises make a mistake by not including the system of climate control into a single — reserved supply network of electrical power, which is used by equipment placed in SR and DC. As a result of this mistake, although in the case of interferences of electrical power supply, the equipment and information systems continue to function all the envisaged period of time, the system of climate maintaining has already stopped functioning, which causes the rapid increase of temperature, which, in its turn, can cause physical damage to the equipment located in SR and DC, as well as can become the reason of fire.

Like in the sub criterion ‘electrical power’, if the introduction of new information systems increases the physical and technological resources to be attracted in the case of the introduction of new information systems, in the case of the method of physical environment there should be increased the capacity of the system for climate control in order to increase the resources. By applying the method of resource virtualization environment it is possible to consolidate considerably the information systems into one physical resource, thus increasing the technological load of the physical resource and decreasing the total amount of necessary physical resources. The method of resource virtualization environment enables to locate considerably more information systems in SR and DC, while utilizing the same resources of physical environment.

Any equipment takes up a certain place in SR or DC. When planning and introducing information systems, one must plan, how many pieces of equipment these systems would need. The range of equipment, necessary for any particular system, may vary from very broad to very insignificant one. Within the framework of this material, we will deal with space necessary for the installment of physical servers and the number of servers necessary for the introduction of any new information system. Although, alongside with the increase of the above mentioned subcriteria of electrical power and capacity for ensuring climate, there is also the increase of the room necessary for the location of more powerful UPS and systems of climate control, within the framework of this material, we will pay more attention to the room occupied by physical servers and to the situation, how the amount of the occupied room increases alongside with the increase of the number of servers. As a result system incompatibility, it is necessary to purchase more and more new servers to ensure the independence of systems and allow, for instance, different systems to use different operating systems. Thus, alongside with the increase of information systems, the number of servers increases proportionally, as well as there is an increase of the occupied room, which must be ensured for any of these systems. And then we arrive at a moment, when it is impossible to place new servers and information systems in the built SR or DC.

When applying the method of resource virtualization environment, it is possible to consolidate several information systems into one physical server, thus decreasing the necessary number of servers and alongside with it — the room necessary for the placement of more and more new information systems. This possibility enables to replan the location of information systems in the physical servers in already existing SR and DC, thus freeing the physical resources and enabling to continue planning and introducing new information systems on the basis of existing physical resources. On the other hand, when planning the construction of new SR and DC, the above mentioned possibility enables to decrease the size of SR and DC necessary for the planned-envisaged amount of information systems, which should go in the new SR or DC. Thus it is possible to reduce the amount of financial resources necessary for the construction SR or DC.

1.2. Specific Technological Resources for Ensuring the Operation of Information Systems

For ensuring the operation of information systems the following technological resources are necessary:

- Speed of processor servers.
- Amount of server main memory.
- Space of server disks.

One of the most significant server parameters, which should be taken into account, when purchasing servers, is the computational speed of central processor, which is expressed as the amount of operating cycle of processor per one second, which is measured in Hertzes. The productivity of modern processors has reached the volume, when such parameters should be considered as the average load of processors, and the most significant — the unused potential of processors. The indicator of the unused potential of processors particularly increases in the cases, when it is necessary to place in SR and DC the information systems and servers, performing more and more new functions and their consolidation into one server are not possible. Thus, for example, it is not possible to place on a physical server the simultaneously functioning Windows operating system and Linux operating system. Similarly, taking into account a great many recommendations given by the producers of software and the examples of best practice, the systems functioning on the bases of one operating system are often recommended to place on separate servers. It follows that, on the one hand, for ensuring the necessary functions, it is necessary to purchase and install at SR and DC more and more new servers, which, of course, increases the consumption of electrical power, the total heat caused by the equipment, takes up the limited space; on the other hand, there is an increase of the ineffectively utilized capacity of processors, which would be possible to use for ensuring the new functions, but, when applying the traditional approach, it is impossible due to the above mentioned circumstances.

In this sub criterion we can see the significant advantages of resource virtualization environment, which enable to consolidate several information systems into one physical resource without any concerns about the compatibility problems. Such consolidation enables to reduce to the minimum the unused capacity of processors, thus increasing the total productivity of physical resource and decreasing the amount of necessary physical resources.

Like the above mentioned parameter of the operating speed of processor servers, the amount of server main memory is one of the most significant to be taken into account, when purchasing new servers. Modern

technologies have reached the developmental level, when the server storage and memory in general show the indicators of considerable high-speed operation, besides, the costs for their production and thus also purchase have decreased. When the servers are purchased, they are equipped with main memory, which usually exceeds the initially necessary amount of needed memory, thus the value of the unutilized amount of memory emerges. There are several reasons, why the servers should be purchased with the amount of memory, which exceeds the necessary volume. One of the most significant reasons is to ensure the opportunity of enlargement, when the requirements would increase, and the second significant reason is the price of memory, which, under the circumstances of modern rapid development may be higher than it is today, because the memory placed in the server today might be outdated and taken out of the production after a certain period of time.

The method of resource virtualization environment enables to use fully all memory installed in servers, thus decreasing the amount of ineffectively used memory. One of the negative phenomena of resource virtualization method is the aspect that the virtualization environment of information system requires its amount of memory in addition to the amount necessary for the information system itself. Although this phenomenon exists, nowadays this problem is not so topical, because the costs of memory have decreased considerably during the last years, as well as there had been observed the increase of the possible maximum amount of memory, which can be installed into servers. Also, alongside with the increase of virtual environments in one physical resource, there increases the demand for the high-speed memory, because the total amount of the necessary high-speed memory resource consists of the sum of separate high-speed memory amounts of necessary information systems. This problem also is not so topical nowadays, because the high-speed operation of memory produced today is sufficient to meet the requirements of several virtualized information systems.

The amount of space of server disks like the above mentioned subcriteria – capacity of server processors, amount of the main memory of servers – is one of the most significant parameters to be taken into account, when purchasing new servers. Nowadays it is impossible to purchase a server with disks, the amount of which would be less than 60 GB. It follows that, when introducing a new information system, the requirements of which in relation to the space of a disk are very insignificant, there emerges a lot of spare disk space in the server. When introducing a new information system by applying the method of physical environment, it is necessary to purchase a new server with a new space of disks on it, although in other servers there had emerged the unused disk space.

By applying the method of resource virtualization environment, it is possible through the consolidation of several information systems into one physical server to utilize all available space of disks. By the utilization of the available space of disks in several information systems, the total necessary amount of the space of server disks in SR and DC is reduced.

1.3. The Applicability of Information Systems

Ensuring of information systems is characterized by the following main criteria of applicability:

- Possibility to recover systems.
- Comfortableness of server maintenance and repair.
- Comfortableness of system expansion.
- Comfortableness of system physical availability.

The recovery of all system in the traditional systems, where the recovery process is based on the retrieval of information from the reserve copies or information, which was possible to retrieve from the nonfunctioning system, is possible only in precisely the same physical environment, where the system has functioned before. Of course, it is possible to install all system in the physical environment, which is not precisely like the previous one, but in this case it could be considered to be the introduction of a new system, instead of the system recovery, because the adjustment process consumes considerable amount of resources. In this paper the system recovery means the recovery of such systems as operating system, database management system, monitoring system, instead of the recovery of data usually related to system recovery.

The method of resource virtualization environment is based on the virtualization of all server systems from the aspect of an operating system. It means that any equipment, identified by the operating system, is no equipment of the physical, particular server, but its concept created by the virtual environment. From the view of an operating system, it appears operating with the real physical equipment and also interacts with it on such basis. All virtual equipment, used by the operating system and created by the virtual environment for the operating system, is practically identical and independent from the equipment of physical server. This fact enables the operating system to create the same environment, where it has functioned on any other server, enabling it to recover the system from the non-functioning server to any other available server. This provides new opportunities in the field of system recovery, thus facilitating the recovery of system functioning.

By the comfortableness of maintenance in this subcriterion, the author means the maintenance of physical systems (servers) and work related to the maintenance. Such significant work for the maintenance of system as firmware recovery, preventive measures and other types of work are very problematic in the traditional systems, because it is impossible to carry out such activities without discontinuing the operation of system for a longer

period of time. Besides, the recovery of firmware may result in the impossibility to recover the system at its place of operation or without attracting the authorized service of the equipment producer. In order to maintain SR and DC, the above mentioned subcriterion is on the list of problems of many enterprises and their employees. The method of resource virtualization environment enables to move all the information system, located on a physical server, to another server, thus allowing performing the maintenance of the physical server and work related to it. The method of resource virtualization environment provides two opportunities to move the information systems to another physical server. One of the methods offers to do it manually by switching off every information system and moving it to another physical server, and then restarting it again. The advantage of this method is that there are no necessary special disk arrays, as well as the additional software, which would move the information system from one physical system to another. One of the considerable disadvantages of this method is that during the process of moving the information systems are switch off and therefore they are not available for the users. The second method offers an opportunity to move the information system from one physical server to another without switching off the information system. The advantage of this method is that the information system is not switched off and is fully available for the users also at the moment, when the information system is being moved. As the disadvantage of this method we could mention the necessary expensive disk arrays, as well as the expensive software which controls the process and moves the system.

Like the sub criterion of maintenance comfortableness, the criterion of system expansion comfortableness is very important for the daily activities in SR and DC. When applying the methods of traditional system placement, where one system is installed on one or several physical servers, the expansion of the system is very difficult and connected with both significant risk during expansion and physical impossibility to carry out the expansion without complete instalment of the system as a new one on a different equipment, which, of course, is a resource-consuming process. The frequent expansion of the system, in the process of which it is necessary to increase any of the parameters, whether it would be the increase of processor capacity, or the enlargement of operating memory, or the expansion of disk space, is connected with the preparatory work for several months, the installment of a parallel system on a more powerful equipment and its subsequent move from the old equipment to the new one, besides, trying to decrease inaccessibility of the system up to minimum.

Like in case of the sub criterion ‘the comfortableness of server maintenance’, the advantages of the above mentioned method of resource virtualization environment, when it is possible to move information systems from one physical server to another, it is possible not only to increase the comfortableness of information system expansion, but also to ensure more safety regarding it and to decrease the inaccessibility of the information system.

The sub criterion of physical availability usually is related to the comfortableness of accessibility to the equipment and performance of all necessary maintenance activities, as well as installing of new equipment in SR or DC. This sub criterion is usually directly related to the requirements set during the process of SR and DC planning, but this sub criterion seems important to the author within the framework of the developed material, because this criterion often has a tendency to change for worse within a period of time, which is connected with the necessity to place more and more new equipment in SR and DC.

When we use the possibilities, ensured by the method of environment virtualization, to consolidate several systems of information in one physical resource, we reduce the amount of necessary physical resources, which enables to obtain or not to occupy the room of DC and SR, thus increasing the comfortableness of system physical availability.

1.4. Financial Resources Necessary for Information Systems

This criterion is related to every of the above mentioned criteria and the subcriteria, and any necessity to achieve the higher or lower parameters of above mentioned criteria and subcriteria is related to the increase of financial resources necessary for information systems. When applying the method of environment virtualization, it is possible to decrease the physical and technological resources needed for ensuring the operation of information systems. Thus, the financial resources necessary for maintaining information systems are also decreased.

Thus, for instance, alongside with the increase of information system quantity of information systems, which are not possible to consolidate into one physical server, we face the necessity to purchase new physical servers, which in its turn causes the financial expenditure, related to the purchase of new servers. When using the resource virtualization environment, we do not face the necessity to purchase new physical servers just because it would not be possible to consolidate information systems into one physical server. If the necessity to purchase new physical servers every time, when a new information system is introduced, decreases, the place taken up by the physical servers reduces, as well as the consumed electrical power does not increase and alongside with it the expenses for the electrical power do not increase, and the costs related to the necessity of maintaining a large SR or DC do not increase.

2. The Comparison of the Methods of Physical and Resource Virtualization Environments, when Planning and Introducing Information Systems by “MERKS” LTD

When testing the offered criteria on the basis of a real company “Merks” LTD, there were compared the values of particular criteria in the case of the method of physical environment and in the case of the method of environment virtualization, as well as there were analyzed their values and the explanations given, what benefits might be obtained in a particular case. There was only one physical server used for the purpose of research. In the case of the method of physical environment there was one operating system with one information system installed on it placed on the server, measuring the set criteria. In the case of the method of environment virtualization there was the infrastructure of virtual environment installed into the physical server. On this infrastructure there were seven operating systems installed with the information systems placed on them. There were measured the same criteria as set in the case of the method of physical environment. The most significant emphasis was laid on the increase of physical system usefulness, as well as on the decrease of the number of physical servers alongside with the subsequent decrease of necessary room, electrical power, capacity for ensuring climate.

The quantitative criteria, set for the comparative analysis and to be measured experimentally:

- Room and number of servers (cm³/pcs.).
- Electrical power (kW).
- Capacity for ensuring climate (BTU/h).
- Load of processors (GHz).

Table 2

The Groups of Criteria, Chosen for the Comparative Analysis

Group of Criteria	Criterion	Unit of Measurement
Physical resources	- Room and number of servers.	cm ³ /pcs.
	- Electrical power.	kW
	- Capacity for ensuring climate.	BTU/h
Technological resources	- Load of processors.	GHz
	- Amount of main memory.	MB

- Amount of main memory (MB).

2.1. Room and Number of Servers

The parameters of the physical server HP DL360G5, used for the comparative analysis of the method of physical environment and the method of resource virtualization environment, are as follows: 4.32 cm x 69.22 cm x 42.62 cm. The server, apart from the place necessary for the cables of power and communications, takes up 12,744.68 cm³. In SR and DC there are usually used the server stands of 48.26 cm (19 in), where there are standardized spaces for the placement of servers. The width of servers to be placed in the standard spaces of stands is 48.26 cm (19 in), but their length usually does not exceed 100 cm. The height of servers in the stands is measured in 1U units. The height of 1U server space is 4.43 cm. The number of U units, necessary for different servers, might differ. The height of the server, used for the purpose of this report, is 1U unit. The place of 1U, envisaged for a server, in the stands usually takes up more space than the size of the physical server itself, but, in order not to go for deeper discussions on different types of stands and the issue how much space is envisaged for servers in each of them, for the comparative analysis of the space taken up by the server we will use the physical parameters of the server. This brief introduction on U, the designation attributed to the server space in SR and DC, will be used a little bit later to compare costs one faces, when renting 1U server space in DC.

In Table 3 it is showed that alongside with the increase of the number of systems, the number of necessary servers increases, when the method of physical environment is applied. When applying the method of resource virtualization environment, it is possible to introduce all systems by using one physical server. We can also see in Table 3 how, in the case of the method of physical environment, the costs per month of the place rented in DC increase alongside with the increase of the number of servers. The costs of 1U are based on real numbers from the contracts concluded by a real company. We can see that in the particular case the number of taken space and monthly costs increase seven times, when the method of physical environment is applied.

Table 3

The Comparative Analysis of the Necessary Space and Financial

Number of Systems	Method of Physical Environment			Method of Resource Virtualization Environment		
	Number of Necessary Servers	Occupied Space (cm ³)	DC Costs per Month, LVL (without VAT)	Number of Necessary Servers	Occupied Space (cm ³)	DC Costs per Month, LVL (without VAT)
1	1	12,744.68	26.00	1	12,744.68	26.00
2	2	25,489.36	52.00	1	12,744.68	26.00
3	3	38,234.04	78.00	1	12,744.68	26.00
4	4	50,978.72	104.00	1	12,744.68	26.00
5	5	63,723.40	130.00	1	12,744.68	26.00
6	6	76,468.08	156.00	1	12,744.68	26.00
7	7	89,212.76	182.00	1	12,744.68	26.00

2.2. Electrical Power

The necessary power of the physical server used for the comparison of the method of physical environment and the method of resource virtualization environment is 0.852 kW (The server input power, measured by the server manufacturer.

<http://h20000.www2.hp.com/bizsupport/TechSupport/Document.jsp?lang=en&cc=us&taskId=120&prodSeriesId=1121486&prodTypeId=15351&prodSeriesId=1121486&objectID=c00754630>). In order it would be possible to use the particular calculations and costs for the expenses related to the consumption of electrical power, we will not use, within the framework of this report, the subordinate systems, the costs of which cannot be calculated with unambiguity. The main of these systems would be UPS and the system of diesel based electrical generator. However, it is logical that alongside with the increase of electrical power consumed by the information systems, which, in a particular case, we could reduce for the necessary amount of servers, there is also an increase of costs. These costs, although they are a single financial investment, are disclosed in the balance sheet as the monthly amortization costs in the same section, where the regular maintenance costs are registered. The monthly costs, like a single financial investment, forming a system, have a tendency to increase, when the amount of electrical power, necessary for the information systems, increases.

In Table 4 it is showed how the consumed electrical power increases, when the number of information system increases in the case of physical environment method. We can also see how the monthly costs of electrical power increase, when the number of information systems and servers increases in the case of physical environment method. For the calculation of electrical power costs, the author used the tariff of electrical power determined by JSC "Latvenergo" for legal entities as of October 2009, which is 0.06694 LVL without VAT per 1 kWh. In Table 4 it is also showed, that, while the number of information systems increases seven times, the consumption of electrical power and the monthly payments for the electrical power do not increase, when the method of resource virtualization environment is applied.

Table 4

The Necessary Electrical Power and the Comparison of Necessary Financial

Number of Systems	Method of Physical Environment			Method of Resource Virtualization Environment		
	Number of Necessary Servers	Necessary Electrical Power (kW)	24x7 Costs per Month, LVL (without VAT)	Number of Necessary Servers	Necessary Electrical Power (kW)	24x7 Costs per Month, LVL (without VAT)
1	1	0.852	42.43	1	0.852	42.43
2	2	1.704	84.86	1	0.852	42.43
3	3	2.556	127.30	1	0.852	42.43
4	4	3.408	169.73	1	0.852	42.43
5	5	4.260	212.16	1	0.852	42.43
6	6	5.112	254.59	1	0.852	42.43
7	7	5.964	297.03	1	0.852	42.43

2.3. Capacity for Ensuring Climate

The capacity of the heat energy caused by the physical server used for the comparison of the method of physical environment and the method of resource virtualization environment is measured in BTU (British Thermal Unit – an energy measurement unit. BTU is defined as an amount of heat needed for the increase of one pound of liquid water for one degree — from 60⁰ to 61⁰ Fahrenheit — at the constant pressure of one atmosphere.) and constitutes 2,870 BTU/h (Heat energy, caused by the server and identified by the server manufacturer. http://h18000.www1.hp.com/products/quickspecs/12476_na/12476_na.html).

In Table 5 it is showed how increases the amount of the heat caused by servers and thus also the capacity of the system for maintaining necessary climate, alongside with the increase of the number of information systems and servers, when the method of physical environment is applied. We can also see in Table 5 how, using the advantages of the method of resource virtualization environment, the heat caused by the servers unchanged even if the number of information systems is increased seven times. It is obvious that, when the method of resource virtualization environment is applied, it is possible to use in SR and DC the systems of less capacity for maintaining climate, thus reducing the costs of the system for maintaining climate.

Table 5

The Comparison of Cooling Energy, Necessary for the System for Ensuring Climate

Number of Systems	Method of Physical Environment		Method of Resource Virtualization Environment	
	Number of Necessary Servers	Necessary Cooling Energy (BTU/h)	Number of Necessary Servers	Necessary Cooling Energy (BTU/h)
1	1	2,870	1	2,870
2	2	5,740	1	2,870
3	3	8,610	1	2,870
4	4	11,480	1	2,870
5	5	14,350	1	2,870
6	6	17,220	1	2,870
7	7	20,090	1	2,870

2.4. Load of Processors

The operating speed of processor servers of the physical server HP DL360G5, used for the comparison of the method of physical environment and the method of the resource virtual environment, is $2 \times 4 \times 2333 = 18.664 \text{GHz}$. The operating speed of the server, used for the comparison, cannot be considered at present as something particularly significant. Almost every server purchased today will be equipped with at least one or two processors of four cores. In this report, in order to compare the load of processors in the case of physical environment method and the method of resource virtualization environment, there is used the measurement unit “The load of processor in GHz”. In the report, there is used information on the processor load in Giga Hertzes, which is obtained from the statistical data on the processor load within 36 hours.

2.4.1. The Utilization of Processor Cycles, when Applying the Method of Physical Environment

We will study the processor load, obtained in the case of one information system on one physical server. Then we will generalize the obtained results and calculate the mean load of processors, when the amount of information systems and the number of physical servers increase. We will also calculate the total unutilized load of processors in the case of seven information systems, which are installed each on its own physical server.

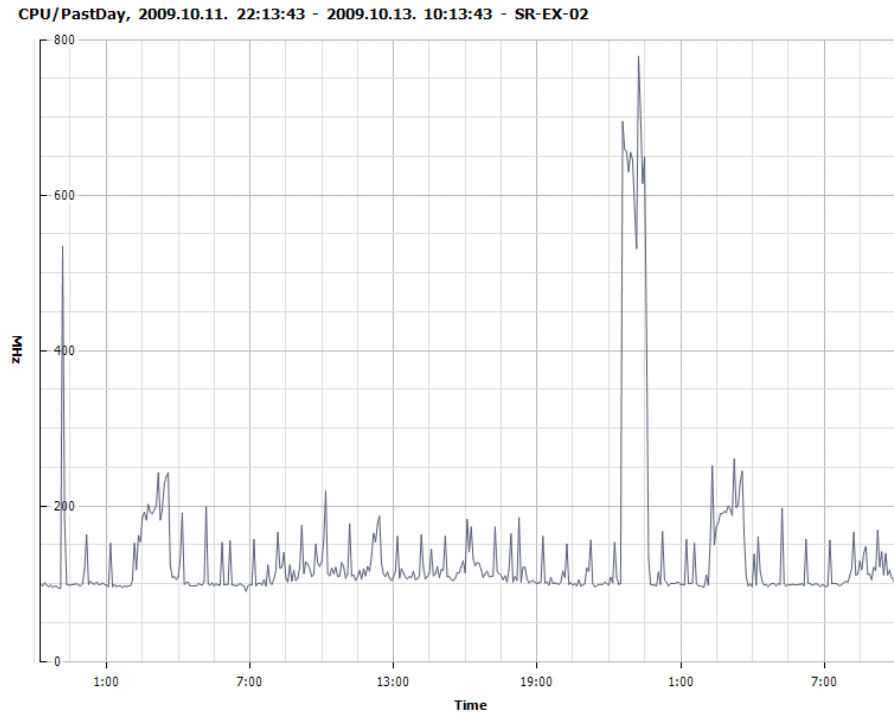


Figure 1. One Information System Processor Load in MHz on One Physical Server.

In Figure 1 we can see that within 36 hours the maximum load of processors does not exceed 0.741 GHz, which constitutes 3.97% of the total operating speed of processor, but the showed mean load is 0.0971 GHz, which constitutes 0.52% of the total operating speed of processor. Since the total operating speed of processors is 18.664 GHz, the unutilized load of processor at the maximum load of information system is 17.92 GHz or 96.3%. When applying the method of physical environment and its necessity for the use of separate physical servers for each information system, the calculated total necessary operating speed of processors for seven information systems is 5.187 GHz, but the unutilized total load of processors is 12.55 GHz.

2.4.2. The Utilization of Processor Cycles, when Applying the Method of Resource Virtualization Environment

We will study the obtained load of processors in the case of seven information systems, which are installed in one physical server. We will also calculate the total unutilized load of processors in this case.

In Figure 2 we can see that within 36 hours the maximum load of processors does not exceed 2.33 GHz, which constitutes 12.44% of the total operating speed of processor, but the mean load is 0.566 GHz, which constitutes 3.03% of the total operating speed of processor. Since the operating speed of processor is 18.66 GHz, the unutilized total load of processors at the maximum load of information system is 16.34 GHz or 87.56%.

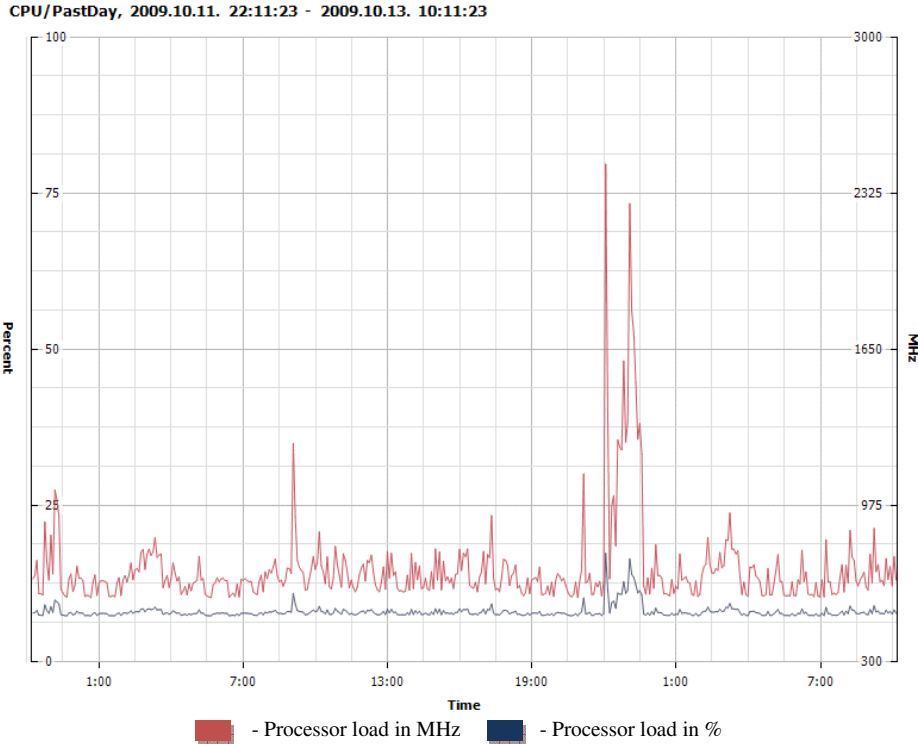


Figure 2. The Load of Processors of Seven Information Systems in one Physical Server, Applying the Method of Resource Virtualization

2.4.3. The Comparison of the Utilization of Processor Cycles, when Applying the Method of Physical Environment and the Method of Resource Virtualization

We will compare the calculated total results of processor load in the case of seven physical servers and the obtained results in the case of seven information systems, which are installed in one physical server.

Table 6

Total, necessary and utilized processor performance

Environment	Total processors performance	Necessary processors performance		Unutilized Processors performance	
	GHz	GHz	%	GHz	%
7 physical servers with 7 IS	130.648	5.187	3.97	125.461	96.03
1 physical server with 7 IS	18.664	2.332	12.49	16.332	87.51

In Table 6 we can see that, when the method of physical environment is applied, seven information systems would need seven physical servers HP DL360G5 with the total high-speed operating of 130.648 GHz. The total high-speed operating of processors, used by each of the information systems, would be 5.187 GHz, which constitutes 3.97% of the total high-speed operating of all seven processors. As we can see in Table 6, when 7 physical servers are used, the unutilized high-speed operating of processors would be 125.461 GHz or 96.03% of the total high-speed operating of processors. When applying the method of resource virtualization environment and using only one physical server for the functioning of seven information systems, we can see in Table 6 that the efficiently utilized high-speed operating of processors in comparison with the case of the application of seven physical servers increases from 3.97% up to 12.49%, as well as the unutilized high-speed operating of processors decreases from 96.03% to 87.51%.

2.5. Amount of Main Memory

The amount of memory, installed on the physical server HP DL360G5, which is used for the comparison of physical environment method and the method of resource virtualization environment, is 8,192 MB. This amount of memory cannot be considered as something particularly large. The maximum possible memory to be installed on server HP DL360G5 is 65,536 MB, which is eight times more than the memory of the physical server used for this comparison. The author uses the information on the amount of active memory, expressed in MB, and the

utilization of memory, expressed in percentage, which is obtained from the statistics for the period of time of 36 hours.

2.5.1. The Amount of Utilized Memory, when applying the Method of Physical Environment

We will consider the amount of active memory obtained in the case of one information system on one physical server. Then we will generalize the obtained results and calculate the total amount of active memory, when the amount of information systems and the number of physical servers increase. We will also calculate the total amount of unutilized memory in the case of seven information systems, which are installed each on its own physical server.

In Figure 3 we can see that in the case of one information system, installed on one physical server, the maximum amount of active memory does not exceed 747.33 MB, which constitutes 9.12% of the total amount of physical server memory. In Figure 3 we can also see that the mean amount of active memory does not exceed 229.01 MB, which constitutes 2.8% of the total amount of physical server memory. Since the total amount of memory is 8 192 MB, the inefficiently utilized amount of memory at the maximum load of information system memory is 744.47 MB or 90.88%. Applying the method of physical environment and its necessity to use separate physical server for each information system, the calculated total amount of the necessary memory of seven information systems at the maximum load of memory is 5,231.33 MB (9.12%), but the total unutilized amount of memory constitutes 52,112.67 MB or 90.88%.

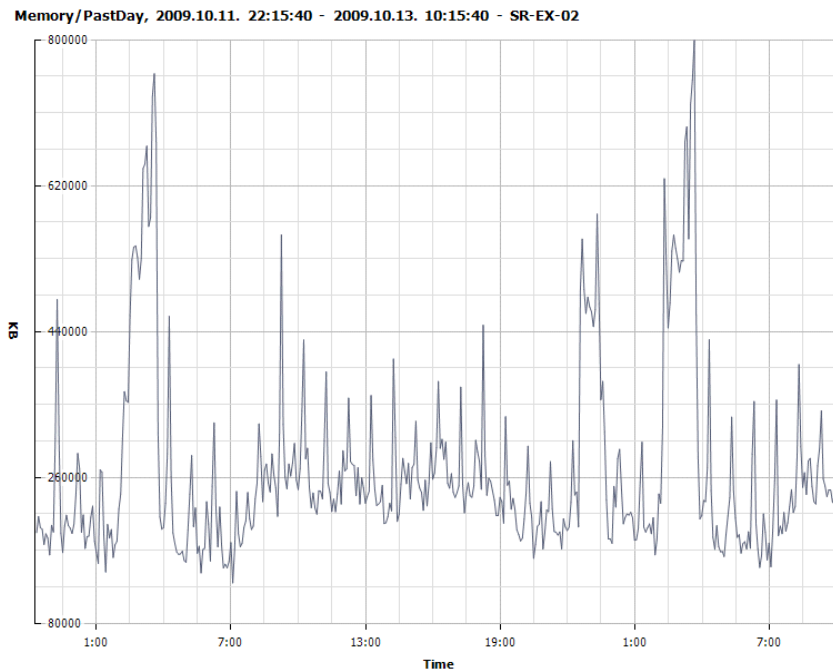


Figure 3. The Amount of One Information System Active Memory in KB on One Physical Server

2.5.2. The Amount of Utilized Memory, when applying the Method of Resource Virtualization Environment

We will consider the amount of obtained active memory and the utilization of memory in the case of seven information systems, installed in one server. We will also calculate the total unutilized amount of memory in this case.

In Figure 4 we can see that within 36 hours the maximum amount of active memory does not exceed 2,148.97 MB, which constitutes 26.23% of the total amount of physical server memory, but the indicated mean amount of active memory is 1,340.40 MB, which constitutes 16.36% of the total amount of installed memory. Since the total amount of installed memory is 8,192 MB, the amount of utilized memory at the maximum load of information system is 6,043.03 MB or 73.77%.

2.5.3. The Comparative Analysis of Utilized Memory Amount, when applying the Method of Physical Environment and the Method of Resource Virtualization Environment

Let us compare the calculated amount of total active memory in the case of seven physical servers and the obtained results in the case of seven information systems, installed on one physical server.

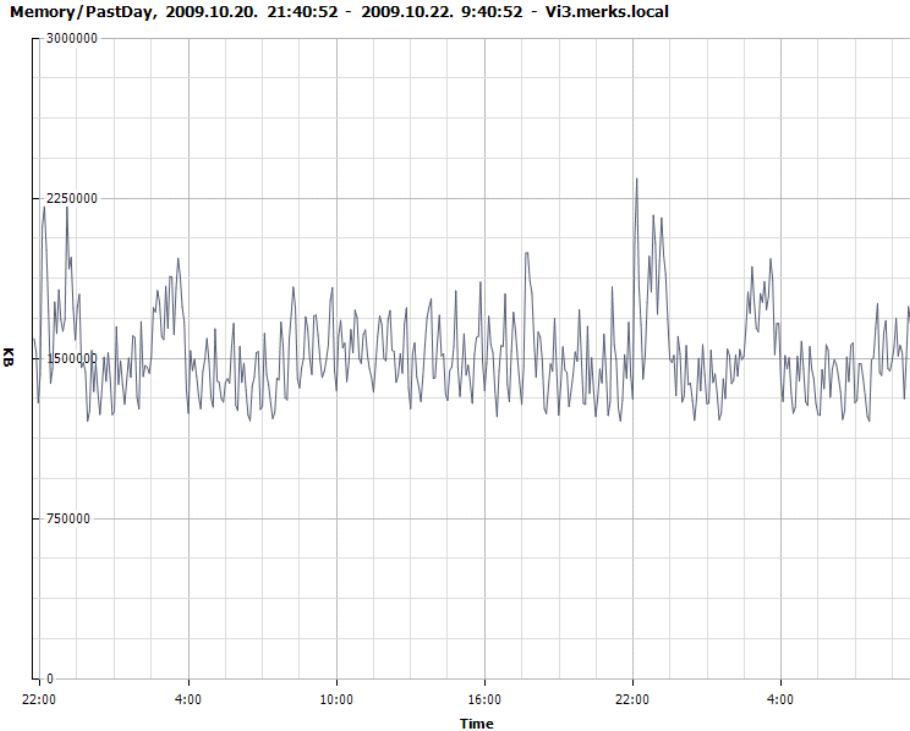


Figure 4. The Active Memory Amount of Seven Information Systems on One Physical Server, applying the Method of Resource Virtualization

Table 7
The Comparison of the Active Memory Amount of Seven Physical Servers and One Physical Server with Seven Information Systems (IS), and the Unutilized Amount of Server Memory

Environment	Total Amount of Memory	Necessary Amount of Memory		Unutilized Amount of Memory	
	MB	MB	%	MB	%
7 physical servers with 7 IS	57,344	5,231.33	9.12	52,112.67	90.88
1 physical server with 7 IS	8,192	2,148.97	26.23	6,043.03	73.77

In Table 7 we can see that, when the method of physical environment is applied, seven information systems would need seven physical servers HP DL360G5 with the total memory amount of 57,344 MB. All total amount of memory, used by each of the information systems, would be 5,231.33 MB, which is 9.12% of the total memory amount of all seven servers. As we can see in Table 7 shows that, when 7 physical servers are used, the amount of unutilized memory is 52,112.67 MB or 90.88%. In table 7 we can see that, when applying the method of resource virtualization environment and using only one physical server for the functioning of seven information systems, the amount of actively utilized memory, in comparison to the case of using seven physical disks, increases from 9.12% up to 26.23%, as well as amount of unutilized memory decreases from 90.88% to 73.77%.

Conclusions

Nowadays there is an increase of demand for information technologies and resources necessary for ensuring their functioning and developing. Therefore new technologies are developed and the old ones are improved to optimize the accessibility of information technologies and to ensure the necessary technological resources. At present, one of the most advanced technologies with the economically calculable benefits, provided by its use, is the resource virtualization. This technology ensures not only the real economy of electrical power and room but also improves the accessibility indicators and utilization comfortableness of infrastructure. The opportunity to apply the virtualization technologies more efficiently has been provided by the industry of information technologies itself through the creation of more and more powerful, high-speed and capacious technological resources, such as processors, memory, disks, disk systems etc. In the report, on the basis of a real company

“MERKS” LTD, there are shown the opportunities provided by this technology and benefits achieved through the introduction of resource virtualization. There are obvious financial and practical benefits provided by this technology to the particular company. There has decreased the consumption of electrical power, the amount of necessary room, as well as there had improved the total accessibility of information systems. As well as we can see that the infrastructure of information technologies of a particular company is not overloaded and can provide services for more information systems than it does at present.

The virtualization of the resources of information technologies ensures good opportunities for the decrease of physical resources, such as electrical power, server stands, safety systems and other systems, and the increase of their efficiency.

In order to obtain fully valid and by practice proved results, we should perform further experimental research, developing the test laboratory for this purpose on the basis of a particular company. All information systems of a particular company with all data arrays in the virtual environment should be moved to the test laboratory, and we should model their real load for the period of time of at least one month.

Having studied available literature and participated in the seminars organized by the developers of the virtualization of the resources of information technologies, we can established that until now the aspects of the application of virtual technologies had been studied a little on the basis of real companies.

I would recommend to all companies the application of resource virtualization. The advantages of accessibility and applicability, provided by resource virtualization, can be seen already since the first introduced system. More financial benefit one can see already from the second system, which in the case of physical environment cannot be consolidated on one server because there is no more necessity to purchase a new server. As a solution of standard virtualization I would recommend the use of two physical servers connected to one SAN (Storage Attached Network – architecture, which enables to connect the distance storage equipment to the servers in a way that from the aspect of servers are indicated as locally connected.) data array with an opportunity to migrate the virtual servers from one physical server to another.

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SEVENTH NORDIC – BALTIC AGROMETRICS CONFERENCE

AGROMETRICS IN THE NORDIC AND BALTIC COUNTRIES RETROSPECTIVE AND PERSPECTIVES

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Abstract

In 1997 arose idea of cooperation among the Nordic and Baltic Agriculture universities in the field of agrometrics (mathematics and statistics in higher agricultural education), with a view to identify the kind of mathematical education is needed as well as enhancing the quality of learning through the exchange of lecturers' experience and the collection of the use in agriculture of learning methods and mathematical modelling techniques. Under this initiative, there have been several international conferences, including in 2001 and 2010, organized by Latvia University of Agriculture (LUA). Since it is established tradition that the organizers of the Agrometrics conference summarize past experience and puts it on, thereby maintaining idea of agrometrics society, this article aims to shed some light on the problems encountered and progress achieved in cooperation among the Baltic and Nordic Agricultural universities in the field of agrometrics for twelve years. In order to find out the views from colleagues in other countries for cooperation and its possible directions, the author outlines the future directions of this cooperation and the possible forms of future cooperation in the final paragraph of this paper.

Key words: Agrometrics conference, agrometrics, mathematics, statistics, study process, cooperation.

Introduction

At present the latest findings determined that the mathematics in the study, experience and practice is applied to develop ways how to economically use the natural resources to facilitate the existence of the mankind (ABET, 2006). Mathematics is not only a fundamental scientific basis for personality scientific development, but it also includes the specific emotional experience in areas characterized by clarity of mind, a fantastic sudden realization and full understanding (Evans, 2000). Language of mathematics in almost all sectors of science is applied in descriptive areas, as well as analytical.

Several international organizations in education (e.g., IEEE, IGIP, SEFI, etc.) to promote the higher education offer according to the human development trends emphasizes the importance of the direct application of mathematics and its role in solving problems. It should be noted that Europe has established several centres of excellence in mathematics, whose mission is to foster support for mathematical study, to consolidate the educational, scientific and intellectual potential of cooperation in the field of mathematics, as well as to coordinate development of study programs, and transfer of knowledge in mathematics. In that way the development of Mathematics education needs international collaboration. The 7th IOSTE Symposium for Central and Eastern Europe marked that added to the greater integration of EU, there is need for the exploration, discussion and exchange of education ideas, analysis of common problems, implementations of European dimension in science education (Nezvalova et al., 2009). Moreover there were stressed that science and technology education should stimulate international cooperation in research and development and promote cooperation with other international organizations (Lyons, 2009).

In 1997 – 1998 arose idea of cooperation among the Nordic and Baltic mathematicians working in national agriculture universities (Raskiniene et al., 2008). The purpose of this cooperation was the necessity to understand what kind of mathematics and what amount of it agriculture specialists need as well as to achieve common standards in higher agriculture education. The other reason of this cooperation was to improve the teaching quality by means of exchanging teachers' experience, to learn about the problems and methods used to solve them in the neighbouring countries.

The original idea was very important, but it has proven to be not quite viable for financial reasons, as well as the lack of organizational structure and strong leadership to coordinate these institutions and to mobilize resources to achieve its goals. In the Sixth Agrometrics conference, held in 2008 in Kaunas, Lithuania, there has been update of development issues of current mathematical and the process of statistical studies in the Baltic and the Swedish Agricultural universities, and began discussions on continuing cooperation in the field of agrometrics in desired shapes and forms. In Jelgava, Latvia, 22 to 23 April 2010, the ongoing seventh Agrometrics conference's main task is the development of the framework for Baltic Agricultural universities for future cooperation in the field of mathematics and statistics, as well as the creation of working group to coordinate this cooperation.

To discuss the necessity for an international cooperation network to support agrometrics development and the original idea of the restoration of cooperation among the Baltic and Nordic Agricultural universities in the field of agrometrics, this article aims to shed some light on the problems encountered and progress achieved in twelve years. Besides, it has been established tradition that the organizers of the Agrometrics conference summarize past experience and puts it on, thereby maintaining idea of Agrometrics society.

Investigation methodology

The problem approached by analyzing and evaluating the scientific literature of a number of information sources and reports for the development of the methodological basis of research.

Results and discussion

The cooperation among the Nordic and Baltic countries in the area of mathematics and statistics in agrometrics has been going on since 1997. At that time Ulf Olsson (Swedish University of Agricultural Sciences) and Jaak Sikk (Estonian Agricultural University) received funding from Swedish Institute for cooperation between Sweden and Estonia in this area. As a part of this project a meeting on teaching of statistics and mathematics in agriculture, forestry and veterinary medicine was held in Sweden in June 1998. Representatives from all Nordic and Baltic countries except Iceland and Latvia attended the meeting. During the meeting the status of mathematics and statistics teaching at the different universities was reviewed. It was found that one major difference between the Nordic and Baltic countries was that statistics had a rather weak position in the Baltic countries (Sikk, 2005). The idea of creation the Baltic and Nordic Agrometrics society rose during that meeting. With increasing number of students who continue training in other European universities in various exchange programs, such cooperation becomes essential. Studies program coherence is an important factor in the common European education area.

Under this initiative, there have been several international Nordic-Baltic Agrometrics conferences: Lithuania (1998), Estonia (1999), Latvia (2001), Sweden (2003), Estonia (2005), Lithuania (2008) and Latvia (2010).

The First Nordic-Baltic Agrometrics conference “The role of mathematical disciplines in higher agricultural education” was held in Kaunas, Lithuania, in September 25-26, 1998 organized by Lithuania University of Agriculture. This conference was as a part of 50th anniversary of Department of Mathematics. The main result from this conference was that the term “Agrometrics” was proposed as a summary for mathematics and statistics in the agriculture sciences. As other result was at least important – formation of a five-person contact group – Poul Einer Hansen, Ulf Olsson (Sweden), Jaak Sikk (Estonia), Petras Rupsys (Lithuania) and Liga Rumana from Latvia. This group was created to maintain contacts for teachers of mathematics, statistics and data processing at the Agriculture universities in the Nordic and Baltic countries.

In the conclusions of this conference were gather information about the topical problems in agrometrics:

- 1) The issue about introduction of information communication technologies (hereinafter ICT) and application of them in all spheres of life has become the topic of the day. The biggest challenge for the education institutions is the integration of ICT in education. Agriculture universities have to meet these challenges and to develop students’ skills for life-long learning. That’s why more than ever the mathematics studies will be as a basis for understanding and mastering these changes;
- 2) The higher agricultural universities in the Nordic-Baltic countries should work towards a common standards as a long-term goals;
- 3) The statistics in The Baltic have a sporadic nature to the contrary of Nordic countries where statistics as an applicable discipline was an obligatory. This could be changed in order to prepare students from Baltic countries for participation in several International programs (Socrates/Erasmus) and to be enable them stay at the Nordic Agricultural universities where statistics is a prerequisite for a competence in their profession (Raskiniene et al., 2008).

The Second Nordic-Baltic Agrometrics conference was held in Karaski, Estonia, in September 23-25, 1999. At that time the cooperation was reaching a practical implementation stage. The main outcome from this conference was idea about common standards in mathematics and statistics in Nordic and Baltic countries as well as decision about using common diagnostic tests for students in several of participating countries. The idea of creation the “Agrometrics journal” rose during that conference. This journal should contain papers on teaching and research issues regarding agrometrics. However, that idea did not materialize because of financial and other reasons. It should be noted that the Latvian University of Agriculture has in mind the idea to renew this initiative and to issue such a journal, which could become a periodic collection of scientific papers.

The Third Nordic-Baltic Agrometrics conference was organized by Latvia University of Agriculture and was held in Jelgava, Latvia, in May 24-26, 2001. In two years since previous Agrometrics conference the diagnostic tests in mathematics had been created by Swedish and Latvian universities. These tests were used for first year students at agriculture universities in Latvia, Sweden, Lithuania and Estonia. During the conference the results of these tests were discussed. The results showed that the Swedish students have some advantages in solving practical and applicable tasks whereas Baltic students were stronger in solving ordinary elementary mathematics

(Raskiniene et al., 2008). Cooperation on textbooks and teaching materials and exchange of course description had been established since previous Agrometrics conference in Estonia. A Swedish course book in statistics has been translated into the Estonian and Lithuanian languages (Olsson, 2001). In the Third Nordic-Baltic Agrometrics conference more than half of the presentations were connected with mathematic and statistic modelling in agriculture, forestry, food, science, entomology, environmental science, engineering (Raskiniene et al., 2008).

The development of the mathematical modelling syllabus at Bachelor's, Master's and Doctoral level in Latvia University of Agriculture was presented. There were stressed that the mathematical study courses should be already included in the Bachelor's study programs. In Master's degree study programs should offer very wide range of mathematical modelling studies courses but cooperation among universities is prerequisite for further advancing and developing mathematical modelling in Doctoral study programs (Rivža, 2001). In this conference for the first time not only academic staff from Agricultural universities but also master's degree students presented their research works.

Very interesting experience in statistical consultancy and its organization at Swedish University of Agricultural Sciences was presented by Ulf Olsson (Olsson, 2001). According to the author of this article the statistical consultancy it is still a problem not only in Latvia University of Agriculture but in other universities of Baltic countries and needs close cooperation for developing it.

The Fourth Nordic-Baltic Agrometrics conference took place in Uppsala, Sweden, in June 15-17, 2003 and was organized by Swedish university of Agricultural Sciences. During the conference the main discussions were about decreasing mathematics level among the students and the necessary changes in mathematics study programs. There were either stressed that the size tends to decrease by the means of time. During this conference the study programme „Biometrics“ was proposed by Latvia University of Agriculture which might be an international study programme for all Baltic countries – Latvia, Lithuania and Estonia (Raskiniene et al., 2008).

The Fifth Nordic-Baltic Agrometrics conference was held in Otepaa, Estonia, in June 15-17, 2005. During the conference the main discussions were about teaching mathematics and statistics as well as about mathematic modelling problems.

The Sixth Nordic-Baltic Agrometrics conference took place in Kaunas, Lithuania, in June 18-20, 2008 organized by Lithuania University of Agriculture. This time was the ten years of cooperation in Agrometrics. Moreover this conference was as a part of 60th anniversary of Department of Mathematics. This conference could be seen as a turning point in evolution of Nordic-Baltic Agrometrics society. It was the first conference, which has no longer as participants the founders Ulf Olsson and Jaak Sikk. In addition also the funding from Swedish Institute for cooperation between Sweden and Estonia in this area was over. The work was over also for the five-person contact group which was created during the first conference to maintain contacts for teachers of mathematics, statistics and data processing at the Agriculture universities in the Nordic and Baltic countries. Therefore, for further Agrometrics society became topical question of its place and role in agricultural education and its leadership, as well as financial issues. During the conference, there was discussion on these issues and yet it was decided to organize the Seventh Nordic-Baltic Agrometrics conference in Latvia, seeking new forms of cooperation.

Based on the previously mentioned The Seventh Nordic-Baltic Agrometrics conference organized by Latvia University of Agriculture will be held in Jelgava, Latvia, April 22-23, 2010. Teachers of mathematics and statistics as well as researchers only from Baltic countries will participate in this conference. The main focus during the conference will be devoted to technology enhanced teaching and learning mathematics and statistics such as e-learning, blended learning, virtual learning environments as well as to problems in management of the mathematics and statistics studies process (lasted changes in education not excepting changes in mathematics and statistics studies process, curriculum development and). In contrast with preceding conferences there are not planed discussions about using the mathematic modelling in solving agricultural problems.

In assessing the available conference materials and other sources of information in this article the author has compiled some statistical data held seven Nordic-Baltic Agrometrics conferences during twelve years of existence Agrometrics Society in table 1.

In summary, within twelve years the cooperation in Agrometrics of the Nordic-Baltic national universities of Agriculture the scholars and scientists in these universities had the opportunity to meet, to discuss current problems and find common solutions and share experiences. As part of the work towards common standards, course description and literature lists have been exchanged among the countries (Olsson, 2001). Common diagnostic tests has been created and used for students in several of participating countries. This cooperation has provided the opportunity for teachers to visit other universities for exchange of experience, for professional development and for training purposes.

For the subsequent implementations of European dimension in mathematical and statistical education it is need for the exploration, discussion and exchange of education ideas, analysis of common problems. In author's opinion the possible directions of the further cooperation in Agrometrics would be work on interdisciplinary

study programs; gathering and promotion of the information about applied software in Agrometrics studies, development a common database for studies, etc.

Based on the latest theoretical knowledge of mathematics and its role in higher education, an important future task would be collection of mathematical and statistical modelling methods for use in agriculture and dissemination among Nordic-Baltic and other European universities of Agriculture. As it was mentioned before the statistical consultancy it is still a problem and needs close cooperation for developing it. No less important is the sharing of teaching and learning experiences, etc.

Table 1.

Data about Nordic-Baltic Agrometrics conferences.

Number of the Agrometrics conference	Conference venue and time	Member countries	Total amount of reports	Report topics
First	Kaunas, Lithuania September 25-26, 1998	Estonia, Lithuania, Latvia, Sweden, Denmark	19	?
Second	Karaski, Estonia September 23-25, 1999	Estonia, Lithuania, Latvia, Sweden	11	?
Third	Jelgava, Latvia May 24-26, 2001	Estonia, Lithuania, Latvia, Sweden	28 (6 of them poster presentations)	<ul style="list-style-type: none"> •Organization of the mathematics and statistics studies process – 12 •Mathematical and statistical modelling – 16
Fourth	Uppsala, Sweden June 15-17, 2003	Estonia, Lithuania, Latvia, Sweden	23	<ul style="list-style-type: none"> •Organization of the mathematics and statistics studies process – 10 •Mathematical and statistical modelling – 13
Fifth	Otepaa, Estonia June 15-17, 2005	Estonia, Lithuania, Latvia, Sweden	22	<ul style="list-style-type: none"> •Organization of the mathematics and statistics studies process – 12 •Mathematical and statistical modelling – 16
Sixth	Kaunas, Lithuania June 18-20, 2008	Estonia, Lithuania, Latvia, Sweden	15	<ul style="list-style-type: none"> •Management of the mathematics and statistics studies process – 5 •Mathematical and statistical modelling – 6 •ICT in teaching and learning mathematics and statistics - 4
Seventh	Jelgava, Latvia April 22-23, 2010	Estonia, Lithuania, Latvia	13	<ul style="list-style-type: none"> •Management of the mathematics and statistics studies process – 5 •ICT in teaching and learning mathematics and statistics – 5 • Reports on latest theoretical ideas in mathematics and statistics - 3

In author's opinion the perspectives include the common research on role of Agrometrics studies in agriculture education and realization of what must be changed in mathematics and statistics studies programs as well as several organizational aspects of Agrometrics studies process e.g. the approaches to develop cognitive development of students, didactic aspects of e-learning, cooperation of participants of agriculture education, promotion the development of the competences necessary for labour market etc.

Conclusions

Taking into the consideration the analysis of scientific literature and other sources the main conclusion as well as the author's opinion is that in the sphere of agrometrics education has been done considerably much but there are still a lot of things to be done. According to the author of this article the aims of the further cooperation among the national agriculture universities in agrometrics are:

- 1) To promote information on mathematics and statistics education;

- 2) To recognize and promote the role of mathematics in the life-long learning;
- 3) To improve communications and exchanges among teachers, researchers and students;
- 4) To develop cooperation among agricultural educational institutions in different countries;
- 5) To provide the forums for the exchange of views and ideas among those interested in agrometrics;
- 6) To promote a fuller understanding of the role of mathematics in the agriculture education and its relevance to labour market needs;
- 7) To promote co-operation in the development of courses and support material etc.

To achieve these objectives, of course, must be made a variety of sustainable structures:

- 1) As a precondition for the success of the development of mathematical and statistical study process is a set up of the team of experts;
- 2) Inter-university teams must be set up to share ideas and strategies for agrometrics development, which also could coordinate cooperation;
- 3) To share experiences and support learning for the staff, the important role have 'good practice communities'. Twelve years of existence Agrometrics society has created the basis for their creation.

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DIFFICULTIES IN LEARNING BASIC CONCEPTS IN STATISTICS

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Abstract:

The aim of this research paper is to describe difficulties in learning statistics and to present recommendations to improve the teaching and learning processes of this subject.

Many research studies have shown that ideas of probability and statistics are very difficult for students to learn. Although students may be able to answer some theoretical questions or perform calculations correctly, they may still misunderstand basic ideas and concepts.

The programs and points of credits change; also the knowledge level of the students differs from year to year. This situation requires preparation of new appropriate methodological materials. The usage of information communication technologies within the process of teaching statistics provides a possibility to solve applied problems without wasting time on routine calculations.

Anyone can learn important ideas of statistics by working hard at it, using appropriate methodological materials and working in practical works.

Key words: *statistics, learning statistics, teaching methods.*

Introduction

Data and information are becoming increasingly important assets. The specialists of agriculture find it particularly urgent to be able to properly find, select, analyse and interpret statistical information. Statistical literacy is the ability to read and interpret data: the ability to use statistics as evidence in arguments. (Schield M., 1999). The aim of the statistics teacher's at university is to involve students into this subject, explain and help to master the main concepts, formulae and methods, to show the importance and opportunities of statistics application.

The changes of society influence students' motivation and skills. Students with various experience, knowledge and possibilities enter the university. Unequal preparation for university studies depends on students' economical, social and cultural status, educational factors, situation in educational system, etc.

This academic year, due to the reform of Lithuania's higher education, the admission procedure has changed. The admission of students who pay their own tuition (not covered by national funding) was not limited. For example, specialities of economics and management are very popular in Lithuania, therefore, the number of such students in comparison with the previous year has increased. As a tradition, students mainly from rural schools with lower learning results enter the university of agriculture. There are quite many students with very low grades in exact sciences.

Nowadays in Lithuania the basic elements of probability theory and statistics are taught at secondary school during the lessons of mathematics and other subjects. While studying at university students should extend their knowledge, be able to not only calculate using formulae, but also interpret the received results, make right statistical conclusions. The learning results depend on a few factors: students' entry competences, interest and willingness to study, attitude towards a particular subject, quality of learning material and teacher's qualifications.

Data and Methods

The research was done in 2009-2010 academic years at Lithuanian University of agriculture. 188 students of Faculty of Economics and Management (FEM) participated in it.

A test created by the lecturers of Swedish and Latvian universities of agriculture was used to establish mathematical preparedness. (Kaminskiene J., Raskiniene D., 2001).

The basic method is The Survey of Attitudes Toward Statistics (SATS). (Gal I. et al., 1997). This questionnaire was used in other research works (such as Suanpang P. et al., 2004; Nasser F. M, 2004; Cashin S. E. et al., 2005), hence, its suitability is well - grounded and tested practically. The questionnaire was used to investigate students' opinion. The questionnaires were filled in before and after the course of statistics. The results of the research performed before the course show students' preliminary opinion about statistics which was formed at secondary school while solving problems with data, also watching TV, reading the press, showing interest in sports results, and etc. The results of the research performed after a short statistics course show how the presented material was accepted and whether the opinion about statistics changed.

The questionnaire is formed of 28 various statements concerning statistics, focusing on both positive and negative attitudes and opinions. For example, 'I like statistics' and 'I feel stress during statistics class'. In the

questionnaire there were 5 possible options of expressing opinion: ‘strongly disagree’, ‘disagree’, ‘neither disagree nor agree’, ‘agree’ and ‘strongly agree’. While processing the data of questionnaires these options of the answers were coded by numbers: -2 (strongly disagree), -1 (disagree), 0 (neither disagree nor agree), 1 (agree) and 2 (strongly agree). The answers with the negative opinion were decoded in a reverse order. Therefore, higher score indicates more positive attitudes toward statistics.

The statements in the questionnaire are presented at random. However, while analysing the data of the research they are grouped into four categories according to the subjects and the aim of the research.

The SATS contains 4 aspects: *affect*, *cognitive competence*, *value* and *difficulty*.

Affect had 6 statements measuring positive and negative feeling concerning statistics. *Cognitive competence* had 6 statements measuring attitudes about intellectual knowledge and skills when applied to statistics. *Value* had 9 statements measuring attitudes about the use, relevance and worth of statistics in personal and professional life. *Difficulty* had 7 statements measuring attitudes about the ease or difficulty of the statistics subject.

In addition, the respondents were asked to evaluate their own skills in mathematics and informatics (IT) in the system of 5 points (from 1- poor, to 5- excellent). To establish students’ motivation a question about a present speciality (what was the number of it in a general admission list) was included.

In order to identify the level of mastering lectures’ material the analysis of tests was carried out.

Research results

The test designed to check mathematical skills and knowledge given to students at the beginning of the academic year has proved that the majority of the first year students are weak at mathematics. Students were offered to take extra fee-paid courses to revise the main secondary school topics. Unfortunately, the courses were attended poorly.

The level of students’ preparation for studies can also be defined while analysing the data of their marks in mathematics and informatics in their certificates of secondary education and also by their personal opinion about their own abilities (Table 1). The mark in the certificate of secondary education has been chosen because a part of students didn’t take a final state or school mathematics examination. Those who took that examination have different types of evaluations (standard, criterion).

Table 1: Students’ objective preparation and students self – assessment

Faculty of Economics and Management (FEM)	Average of marks in certificate	Self - assessment					Average \pm std.error(mode)
		bad	fair	average	good	Very good	
Mathematics	6,4 (mode 7, std.error 0.109)	2,7%	21%	57%	19%	0,5%	2,9 \pm 0.05 (mode 3)
ITC	8,5 (mode 8, std.error 0.106)	2,1%	17%	46%	32%	3,2%	3,2 \pm 0.06 (mode 3)
10 point assessment system		1 – bad, 2 – fair, 3 –average, 4 – good, 5 – very good					

In comparison with the analogous survey carried out in 2007 - 2008 academic years the average mark in the certificate of secondary education has decreased: in mathematics- from 7,5 to 6,4, in informatics- from 9,2 to 8,5; self- assessment: mathematics- from 3,2 to 2,9, informatics- from 3,5 to 3,2. So we can assume that the level of preparation is lower than two years ago. However, students’ motivation is higher: the number of students who succeeded in entering the desired speciality has increased from 42,6 % to 54,3 %.

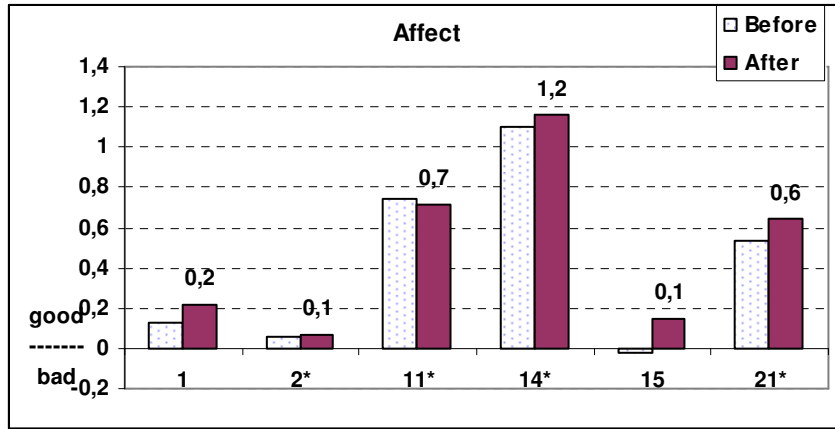
Students rather critically assess their competences. The majority assess their knowledge as average, a quite big part find it fair or weak (more in mathematics) or find it good (more in informatics). After the course the results stayed the same, just a few assessed their informatics knowledge better.

The answers about statistics were analysed separately. An average score of every single statement is calculated and a mode is chosen. If an average score is close to zero, it means that the number of positive and negative scores is the same or the opinion of the majority of students is neutral (it is shown by a mode). The average score ranges from - 2 to 2.

On the horizontal axis of the diagram there are statements numbers. The statements with asterisks in the questionnaire focused on a negative attitude concerning statistics. While analysing the received data the results of these statements were decoded. According to this the higher score shows a positive attitude and vice versa. The diagrams show the average scores of respondents’ answers. The statements in the diagrams are presented in a shortened form.

The average scores of students’ emotional attitude concerning statistics are presented in Figure 1.

Students’ emotions regarding learning statistics are positive and almost didn’t change after its course. The number of students who enjoyed the course of statistics slightly increased. No significant differences.



- 1 – I like statistics,
- 2* – I feel secure when I have to solve statistics problems,
- 11* – I do not frustrated going over statistics tests in class,
- 14* – I feel no stress during

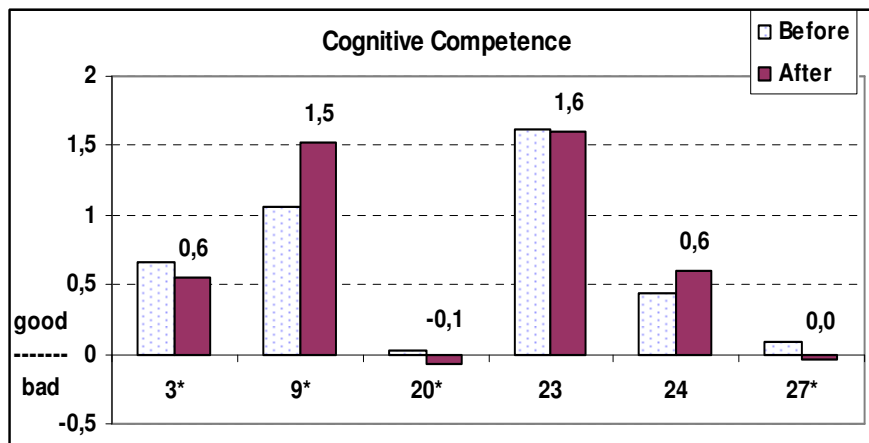
statistics class,

15 – I enjoy taking statistics courses,

21* – I am not scared by statistics

Figure 1: Average scores of statements evaluating students' affects

The diagram of cognitive competence reflects the complexity of the subject of statistics and capability to learn it (Figure 2).

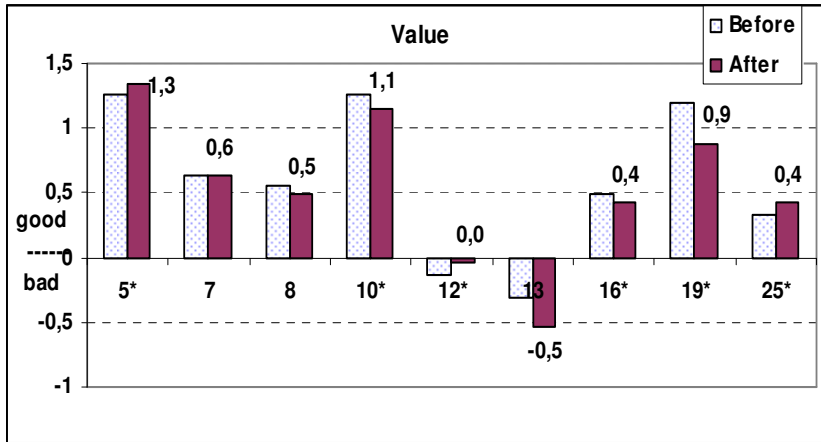


- 3* – understand statistics easily,
- 9* – I am well aware of what's going on in statistics,
- 20* – I don't make a lot of math errors in statistics,
- 27* – I can learn statistics

Figure 2: Average scores of statements evaluating students' cognitive competence

After the course of statistics students better understand what it is about (9* statement) and there is a significant difference between student's evaluations before and after course ($P=0,000187$). They better understand statistics formulae (24 statement) and admit making many mathematical mistakes (20* statement).

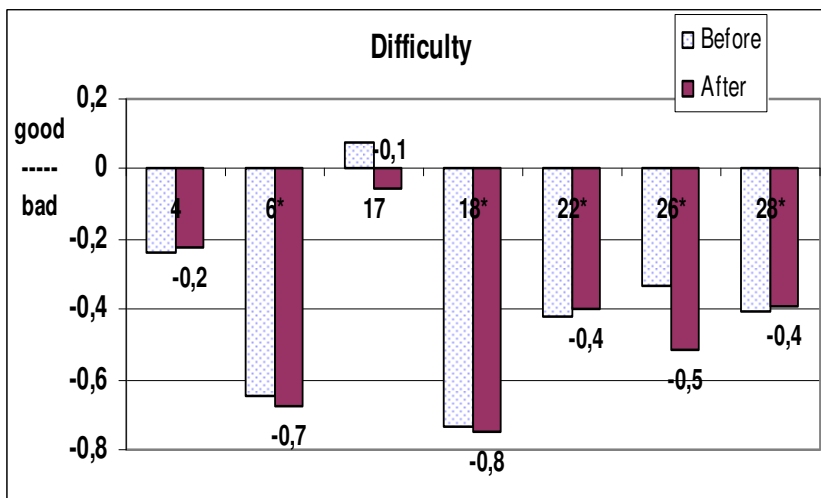
The group of statements about the value was formed to find out students' opinion about the relevance of statistics in the process of studies, in professional and everyday life. The average score of respondents' attitude towards the value of statistics is presented in Figure 3.



5* – statistics is useful,
 7 – statistics should be required part of my professional training,
 8 – statistical skills will make me more employable,
 10* – statistics is necessary in my professional area,
 12* – statistical thinking is applicable in my life outside my job,
 13 – I use statistics in my everyday life,
 16* – statistics conclusions are often presented in everyday life,
 19* – I will have application for statistics in my profession,
 25* – statistics is relevant in my life

Figure 3: Average scores of statements evaluating students' attitude to the value of statistics

Students after the course better understand that statistics will have application in their profession (19* statement) and there is a significant difference between student's evaluations before and after course ($P=0,0062$). Students formulated a negative attitude concerning the usefulness of statistics in everyday life (12* and 13 statements). Average scores of statements evaluating students' opinion about difficulties are presented in Figure 4.



4 – statistics formulas are easy to understand,
 6* – statistics is not a complicated subject,
 17 – statistics is subject quickly learned by most people,
 18* - learning statistics does not require a great deal of discipline,
 22* - statistics does not involve massive computations,
 26* - statistics is not highly technical,
 28* - most people do not have to learn a new way of thinking to do statistics

Figure 4: Average scores of statements evaluating students' opinion about difficulties

Students both before and after the course have the opinion that the difficulties still exist. The majority of students admit that learning statistics requires efforts, concentration, that statistical concepts and formulae are complicated, and the subject of statistics is complex.

In the questionnaires students had a possibility to express their full opinion about statistics in general, about its interesting and difficult aspects. The most frequent answers are presented below:

Statistics, in my opinion, ...

- Is an interesting science; necessary science; complex science; difficult science;
- Is necessary in my profession;
- Is a possible to learn subject, etc.

Students focused not on what we learn, master, but estimated statistics having in mind emotions and complexity.

The most interesting thing in statistics is...

- Work on a computer;
- Calculations;
- Analysis of data; data representation in graphs;
- To get a right answer, etc.

Students get interested when they can link new ideas with the skills they already have, for example, working on a computer, drawing graphs, selecting formulae and possibility to check a received answer. Theoretical comprehension and statistical thinking require a lot of efforts, and is not interesting.

The most difficult thing in statistics...

- Remember concepts, terms, theory;

- Apply formulae; remember formulae;
- Statistical conclusions;
- Analyse results,
- Hypothesis testing, etc.

Prevailing opinions were about the difficulties in solving tasks, but indeed, it was the problem of understanding how to apply statistics itself.

While assessing students' knowledge it was noticed that students perform calculations well (i.e. are able to choose and apply formulae) and answer correctly theoretical questions, however, don't understand the meaning of statistical estimators. Students find descriptive statistics topics to be the easiest ones. The reason for that may be the concepts of descriptive statistics familiar since secondary schools. Nevertheless, while formulating conclusions about sample characteristics we face the problem of not being able to describe results both in subject matter and linguistic aspects. The most difficult problem for students was to grasp the idea of statistical estimators and their necessity. Although it is too difficult to understand the idea of testing hypothesis, the calculations are performed correctly and a proper conclusion is formulated. It is necessary to explain and constantly remind that according to the sample of data the formulated conclusions are about population.

Teaching methods

Since the beginning of this academic year first semester of the first year includes a module Mathematics consisting of 5 credits (instead of 4 mathematics and 2 statistics credits), which contains a part of probability theory and statistics (about 2 credits). The number of hours in comparison with the previous year was reduced, the program had to undergo some changes eliminating some topics of mathematics and of probability theory. The structure of statistics module stayed the same.

Lectures are a primary source of students' knowledge. It has been noticed that weak students are not able to master the material for the first time they encounter with it. Some are not able to concentrate, while the others are not able to memorise all the concepts heard during a two hour lecture. It is necessary to repeat formulae and concepts during practical works or at the start of a new lecture. The knowledge acquired during the lectures should be extended and consolidated while self studying and performing individual tasks.

Teachers are constantly looking for new ways how to help students to learn statistics. A methodological material 'Theory of probability and mathematical statistics' according to the program of FEM is prepared. (Kaminskiene J., 2008). It includes a theoretical background for every topic, problem solving samples, statistics laboratory works performed in computer classes and tasks for self-study. The material is useful to self-study statistics and it is also recommended to extramural students. It is always possible to analyse statistical problems at home. In the questionnaires students don't complain about the lack of methodological books.

Some tasks of statistics and theory of probability are solved in computer classes applying EXCEL program which contains sufficient possibilities of graphical representation, statistical functions and tools for data analysis to learn a basic statistics course. In the questionnaires students expressed that this kind of work is interesting. In lecturers' opinion, during such activities students worked intensively enough, asked questions and analysed the received information.

Every student had to carry out an independent statistical research with real data. It was a graphical data representation, conclusions for sample characteristics, statistical estimators and testing of average hypothesis. Work with real data forms the opinion about the necessity and usefulness of statistics in a professional area.

Conclusions

1. Statistics, according to students, is rather a complex subject, demanding good theoretical background. However, it is possible to master statistics, consuming a lot of work and time. Attendance of lectures, performance of practical tasks, willingness to learn and efforts to self-study always lead to perfect results.
2. After a basic course of statistics students have to realise that statistical analysis is relevant and beneficial in their professional area, it is also necessary to perceive the information presented by mass media. After realising the importance of statistics students should put more efforts and work into the process of learning.
3. Practical work in computer classes, work with real data, formulating conclusions, etc. encourage students to learn and understand the main concepts, apply proper formulae and choose a particular methodology.
4. Students' opinion about statistics almost didn't change before and after the course, because 2 credits (6 weeks) is too short time.

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E-LEARNING VERSUS GIVING LECTURES OF MATHEMATICAL STATISTICS

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Abstract

Nowadays e-learning is quite common. E-learning can widen educational opportunities and enhance the quality of learning. The students can understand the subject better and get higher results as they have flexible access to the material.

This paper examines the pros and cons of e-learning. The article compares the results of previous years students who were given lectures only with the results of last year students who used e-learning only. It would be interesting to clarify whether the good mark in statistics depends on the mark in higher mathematics.

GENERALIZATION OF TOEPLITZ WORDS

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Abstract

Combinatorics on words is research topic in discrete mathematics, which in recent times is also motivated by computer science and biology (including plant biology). We briefly introduce some basic concepts of combinatorics on words and then consider so-called Toeplitz transformation on one way infinite words. The aim of this paper is to generalize definition of Toeplitz words and explore cases when they are generated from non-periodic infinite words.. Special significance is paid to transformation of Thue-Morse word by Toeplitz transformation. We prove that after finite number of iterations Thue-Morse word over alphabet $\{0, ?\}$ is transferred into Thue-Morse word over another alphabet. After infinitely many iterations it is transferred into periodic word 0^ω .

Keywords: Toeplitz words, Thue-Morse word

Introduction

A historical overview of Toeplitz words is given in (Cassaigne and Karhumäki, 1997). Its roots can be found in the beginning of 20th century when german mathematician Otto Toeplitz (short biography can be found in (Toeplitz biography)) introduced an iterative construction to define almost periodic functions on the real line. Later Konrad Jacobs and Michael Kean modified this construction to define infinite words, but nowadays Toeplitz words are considered from combinatorial point of view.

The Toeplitz words are usually defined as follows (Cassaigne and Karhumäki, 1997): ‘take an infinite periodic word w^ω on the alphabet $\Sigma \cup \{?\}$, where ? corresponds to a hole. Fill the holes iteratively by substituting the word itself into the remaining holes. As the limit all holes are filled and an infinite word is defined’.

The aim of this paper is to generalize definition of Toeplitz word and explore cases when they are generated from non-periodic infinite words. In section ‘Preliminaries’ we briefly introduce some basic concepts of combinatorics on words and generalize some definitions for further use. In section ‘Results and Discussins’ we pay special significance to Thue-Morse word – we prove some properties of it before and after applying Toeplitz transformation on it. It is proved that after finite number of iterations Thue-Morse word over alphabet $\{0, ?\}$ is transferred into Thue-Morse word over another alphabet. After infinitely many iterations it is transferred into periodic word 0^ω .

Preliminaries

In this section we give basic notions of Combinatorics on words. Basically we keep to standard terminology (see, (Allouche and Shallit, 2003; Bult and Lorencs, 2006; Lothaire, 2002; Cassaigne and Karhumäki, 1997), only when it is necessary we generalize some definitions.

Let Σ be a finite set of letters, which is called an *alphabet*. We denote by Σ^* the *set of finite words* over alphabet Σ and by λ the *empty word*. By $|w|$ we denote the *length of word* w . The length of λ is 0. We use notation $\Sigma^+ = \Sigma^* \setminus \{\lambda\}$ for the set of finite nonempty words. Every finite word $u \in \Sigma^+$ can be written in the form $u = (u_1, u_2, \dots, u_n)$, where $\forall i = \overline{1, n} u_i \in \Sigma$ and $|u| = n$.

Let $u = (u_1, u_2, \dots, u_n)$ and $v = (v_1, v_2, \dots, v_m)$, $u \in \Sigma^+$, $v \in \Sigma^+$. Let $u\#v$ or simply uv denote the concatenation operation: $u\#v = (u_1, u_2, \dots, u_n, v_1, v_2, \dots, v_m)$. The concatenation of words is obviously associative therefore we will use notation $u = u_1 u_2 \dots u_n$ instead of $u = (u_1, u_2, \dots, u_n)$. The set Σ^* is free monoid over Σ .

The word $w \in \Sigma^*$ is called a *factor* (or *subword*) of word $u \in \Sigma^*$, if there exist $u, v \in \Sigma^*$ such that $w = uwv$. The word u (respectively v) is called a *prefix* (respectively a *suffix*) of w . We denote by $F(w)$ (resp. $\text{Pref}(w)$, resp. $\text{Suff}(w)$) the set of all factors (resp. prefixes, resp. suffixes) of a word $w \in \Sigma^*$.

An (indexed) infinite word x over the alphabet Σ is any total map $x: \mathbb{N} \rightarrow \Sigma$. We set for any $i \geq 0$, $x_i = x(i)$ and write $x = x[i] = x(i) = x_1 x_2 \dots x_n \dots$. The set of all infinite words over alphabet Σ is denoted by Σ^ω .

The word $w \in \Sigma^*$ is a factor of $x \in \Sigma^\omega$ if there exist $u \in \Sigma^*$, $v \in \Sigma^\omega$ such that $w = uwv$. The word u (respectively v) is called a *prefix* (respectively a *suffix*) of x . We denote by $F(x)$ (resp. $\text{Pref}(x)$, resp. $\text{Suff}(x)$) the set of all factors (resp. prefixes, resp. suffixes) of a word $x \in \Sigma^\omega$.

For any $m = \overline{0, n}$ both $x[m, n]$ and $x[m, n + 1)$ denote the factor $x_m x_{m+1} \dots x_n$. The indexed word $x[m, n]$ is called an occurrence of w in x if $w = x[m, n]$. The suffix $x_n x_{n+1} \dots x_{n+i} \dots$ is denoted by $x[n, \infty)$.

We call an infinite word $w \in \Sigma^\omega$ *periodic* or *ultimately periodic*, if it can be written in the form $w = v^\omega$ or $w = uv^\omega$, where $u, v \in \Sigma^+$ and $v^\omega = vv \dots v \dots$. The concatenation of $u = u_1 u_2 \dots u_n \in \Sigma^*$ and $x \in \Sigma^\omega$ is an

infinite word $ux = u_1 u_2 \dots u_n x_1 x_2 \dots x_n \dots \in \Sigma^\omega$. In this case $|u|$ and $|v|$ are called, respectively a *preperiod* and *period*.

Proposition 1. (Lothaire, 2002). Let ϕ be a nonerasing morphism from Σ^* into itself (namely, $\phi(\Sigma^*) \subseteq \Sigma^*$), and $a \in \Sigma$ be a letter such that $\phi(a) = as$ for some nonempty word $s \in \Sigma^+$. Set for $n \geq 0$, $u_n = \phi^n(a)$ and $v_n = \phi^n(s)$, then

- 1) $u_{n+1} = u_n v_n \wedge u_n \in Pref(u_{n+1})$;
- 2) $u_{n+1} = a v_0 v_1 \dots v_n$;
- 3) infinite word $x = as\phi(s)\phi^2(s) \dots \phi^n(s) = \lim_{n \rightarrow \infty} s_n$.

Proof. (1) $u_{n+1} = \phi^{n+1}(a) = \phi^n(\phi(a)) = \phi^n(as) = \phi^n(a)\phi^n(s) = u_n v_n$, so $u_n \in Pref(u_{n+1})$.

(2) holds for $n = 0$, and by induction $u_{n+1} = u_n v_n = a v_0 v_1 \dots v_{n-1} v_n$.

(3) $x = as\phi(s)\phi^2(s) \dots \phi^n(s) \dots = a v_0 v_1 \dots v_n \dots = \lim_{n \rightarrow \infty} u_n$. Moreover,
 $\phi(x) = \phi(a)\phi(s)\phi^2(s) \dots \phi^n(s) \dots = x$. ■

The word x of the proposition is also denoted by $x = \phi^\omega(a)$ and we say that word $\phi^\omega(a)$ is obtained by iterating the morphism ϕ on letter a .

Definition. The *Thue-Morse* infinite word over alphabet $\Sigma = \{0,1\}$ is defined as the limit $\tau^\omega = \lim_{n \rightarrow \infty} \tau_0^n$, where the sequences of words $(\tau_0^n)_{n \geq 0}$, $(\tau_1^n)_{n \geq 0}$ are defined as follows: for all $n \geq 0$

$$\begin{aligned} \tau_0^0 &= 0, \tau_1^0 = 1, \\ \tau_0^{n+1} &= \tau_0^n \tau_1^n, \tau_1^{n+1} = \tau_1^n \tau_0^n. \end{aligned}$$

The word τ^ω is a morphic word since $\tau_0^n = \mu^n(0)$, where μ is the morphism

$$\mu: \begin{matrix} 0 \rightarrow 01 \\ 1 \rightarrow 10 \end{matrix}$$

$\tau^\omega = 01101001100101101001011001101001 \dots$

Now we generalize notion of Thue-Morse word for further use. Let $\tau_{\alpha_k}^\omega = \lim_{n \rightarrow \infty} \tau_{\alpha_k}^n$ be Thue-Morse word over alphabet $\Sigma_k = \{\alpha_k, \beta_k\}$, where

$$\alpha_0 = 0, \beta_0 = ?, \forall k \geq 1 \alpha_k = \underbrace{0 \dots 0}_{2^k}, \beta_k = ? \underbrace{0 \dots 0}_{2^k - 1}$$

and

$$\forall k \geq 0 \tau_{\alpha_k}^0 = \alpha_k, \tau_{\beta_k}^0 = \beta_k, \forall i \geq 1 \tau_{\alpha_k}^i = \tau_{\alpha_k}^{i-1} \tau_{\beta_k}^{i-1} \wedge \tau_{\beta_k}^i = \tau_{\beta_k}^{i-1} \tau_{\alpha_k}^{i-1}$$

Example. By Thue-Morse word over alphabet $\Sigma_2 = \{\alpha_2, \beta_2\}$ we mean the limit $\tau_{\alpha_2}^\omega = \lim_{n \rightarrow \infty} \tau_{\alpha_2}^n$, where the sequences $(\tau_{\alpha_2}^n)_{n \geq 0}$, $(\tau_{\beta_2}^n)_{n \geq 0}$ are defined as follows: $\forall n \geq 0 \tau_{\alpha_2}^0 = \alpha_2 = 0000$, $\tau_{\beta_2}^0 = \beta_2 = ? 000$, and

$$\tau_{\alpha_2}^{n+1} = \tau_{\alpha_2}^n \tau_{\beta_2}^n, \tau_{\beta_2}^{n+1} = \tau_{\beta_2}^n \tau_{\alpha_2}^n$$

Or alternatively, $\tau_{\alpha_2}^n = \mu^n(\alpha_2)$, where

$$\mu: \begin{matrix} \alpha_2 \rightarrow \alpha_2 \beta_2 & \text{or} & \mu: 0000 \rightarrow 0000 ? 000 \\ \beta_2 \rightarrow \beta_2 \alpha_2 & & ? 000 \rightarrow ? 0000000 \end{matrix}$$

When we consider Thue-Morse word over alphabet $\{0, ?\}$ we usually write τ_0^n instead of $\tau_{\alpha_0}^n$ (resp. τ_1^n instead of $\tau_{\beta_0}^n$).

Obviously $|\alpha_k| = |\beta_k| = 2^k$, $|\alpha_k|_? = 0$, $|\beta_k|_? = 1$.

Definition. Let $x \in \Sigma^\omega$, then $u = x[m, n]$ is the $(k+1)^{\text{st}}$ occurrence of u in x , if there exist directly k occurrences of $u = x[m_i, n_i]$ in x with $m_i < m$.

Example. Let $x = (0123)^2(01)^2 2^\omega = 01230123012222 \dots$. If $u = 012$, then $x[0,2]$ is the first occurrence of u in x , then $x[4,6]$ is the second occurrence of u in x and $x[10,12]$ is the third occurrence of u in x .

Now we are ready to give traditional definition of Toeplitz word (Cassaigne and Karhumäki, 1997).

Let $?$ be the special letter or hole such that $? \in \Sigma$. For a word $u \in (\Sigma \cup \{?\})^+$, let $T^0(u) = u^\omega$, and for all $i \geq 0$ $T^{i+1}(u)$ is obtained from $T^i(u)$ by replacing sequentially all the occurrences of letter $?$ in word $T^i(u)$ with letters of u^ω (each $?$ is replaced with one letter). Or alternatively, by filling the holes of $T^i(u)$ with letters of u^ω (one letter in each of the holes, some holes will stay empty). The limit of sequence $T^\omega(u) = \lim_{i \rightarrow \infty} T^i(u)$ is called *Toeplitz word*.

Example. Let $u = 123???$, then $T^0(u) = u^\omega = (123???)^\omega = 123????123????123????123????123???? \dots$, $T^1(u) = 123\underline{123}123????123\underline{123}123????123\underline{123}123????123\underline{123}123???? \dots = (123123123????)^\omega$, etc.

We generalize notion of Toeplitz words and consider this iterative transformation on infinite non-periodic words.

Definition. For a words $x \in (\Sigma \cup \{?\})^\omega$ let $T^0(x) = x$ and $\forall i \geq 0$ $T^{i+1}(x)$ is obtained from $T^i(x)$ by replacing sequentially all the occurrences of letter $?$ by letters of a word $x \in (\Sigma \cup \{?\})^\omega$. The limit of sequence $T^\omega(x) = \lim_{i \rightarrow \infty} T^i(x)$ is called *Toeplitz word*.

If $i = 1$ then instead of $T^1(x)$ we usually write $T(x)$.

Results and Discussion

First we will prove some properties of Thue-Morse word and then we will apply Toeplitz transformation on it. Let τ^ω be a Thue-Morse word over alphabet $\{0, ?\}$.

Lemma 1. $\forall n \geq 1 \ |\tau_0^n| = |\tau_1^n| = 2^n$.

Proof. The proof is by induction. If $n = 0$ then by definition of Thue-Morse word $\tau_0^0 = 0$, $\tau_1^0 = ?$, therefore $|\tau_0^0| = |\tau_1^0| = 1 = 2^0$. Suppose that $|\tau_0^k| = |\tau_1^k| = 2^k$.

Then by definition $\tau_0^{k+1} = \tau_0^k \tau_1^k$, thus $|\tau_0^{k+1}| = |\tau_0^k \tau_1^k| = |\tau_0^k| + |\tau_1^k| = 2^k + 2^k = 2^{k+1}$. Similarly, from $\tau_1^{k+1} = \tau_1^k \tau_0^k$ follows that $|\tau_1^{k+1}| = |\tau_1^k \tau_0^k| = |\tau_1^k| + |\tau_0^k| = 2^k + 2^k = 2^{k+1}$. ■

Lemma 2. $\forall k \geq 0 \ |\tau_0^k|_? = |\tau_1^k|_? = \frac{1}{2} |\tau_0^k| = \frac{1}{2} |\tau_1^k| = 2^{k-1}$.

Proof. The proof is by induction. By definition of Thue-Morse word $\tau_0^0 = \tau_0^0 \tau_1^0 = 0?$ and $\tau_1^0 = \tau_1^0 \tau_0^0 = ?0$, thus $|\tau_0^0|_? = |0?|_? = 1 = 2^0 = \frac{1}{2} |\tau_0^0| = \frac{1}{2} |\tau_1^0|$ and $|\tau_1^0|_? = |?0|_? = 1 = 2^0 = \frac{1}{2} |\tau_0^0| = \frac{1}{2} |\tau_1^0|$.

Suppose that $\forall i \in \overline{1, k} \ |\tau_0^i|_? = |\tau_1^i|_? = \frac{1}{2} |\tau_0^i| = \frac{1}{2} |\tau_1^i| = 2^{i-1}$. By definition $\tau_0^{k+1} = \tau_0^k \tau_1^k$, therefore

$$|\tau_0^{k+1}|_? = |\tau_0^k \tau_1^k|_? = |\tau_0^k|_? + |\tau_1^k|_? = 2^{k-1} + 2^{k-1} = 2^k = \frac{1}{2} |\tau_0^{k+1}| = \frac{1}{2} |\tau_1^{k+1}|.$$

Similarly, from $\tau_1^{k+1} = \tau_1^k \tau_0^k$ follows that $|\tau_1^{k+1}|_? = |\tau_1^k|_? + |\tau_0^k|_? = 2^{k-1} + 2^{k-1} = 2^k = \frac{1}{2} |\tau_0^{k+1}| = \frac{1}{2} |\tau_1^{k+1}|$. ■

Now we apply Toeplitz transformation on Thue-Morse word over alphabet $\{0, ?\}$ and consider properties of obtained words.

Lemma 3. $\forall k \geq 1 \ T(\tau_0^{k+1}) = T(\tau_0^k)T(\tau_1^k) \wedge T(\tau_1^{k+1}) = T(\tau_1^k)T(\tau_0^k)$.

Proof. B definition of Thue-Morse word that $\tau_0^{k+1} = \tau_0^k \tau_1^k$ and $\tau_1^{k+1} = \tau_1^k \tau_0^k$, thus we have to prove that $T(\tau_0^k \tau_1^k) = T(\tau_0^k)T(\tau_1^k)$ and $T(\tau_1^k \tau_0^k) = T(\tau_1^k)T(\tau_0^k)$.

The proof is by induction. At first we consider $T(\tau_0^0) = T(0?) = 00$, $T(\tau_1^0) = T(?0) = ?0$. Then we notice that $T(\tau_0^0) = T(0??0) = 00?0 = T(\tau_0^0)T(\tau_1^0)$ and $T(\tau_1^0) = T(?00?) = ?000 = T(\tau_1^0)T(\tau_0^0)$. Suppose that for $\forall i \in \overline{1, k} \ T(\tau_0^i \tau_1^i) = T(\tau_0^i)T(\tau_1^i) \wedge T(\tau_1^i \tau_0^i) = T(\tau_1^i)T(\tau_0^i)$ and consider words $T(\tau_0^{k+1} \tau_1^{k+1}) = T(\tau_0^{k+1})$, $T(\tau_0^{k+1})T(\tau_1^{k+1})$ and $T(\tau_1^{k+1} \tau_0^{k+1}) = T(\tau_1^{k+1})$, $T(\tau_1^{k+1})T(\tau_0^{k+1})$.

It follows from lemma 2 that $|\tau_0^{k+1}|_? = \frac{1}{2} |\tau_0^{k+1}| = |\tau_0^{k+1}|$. It means that after one iteration of Toeplitz transformation on τ_0^{k+1} all occurrences of letter ? (or all holes) are sequentially replaced (resp., filled) with letters of word τ_0^{k+1} . Moreover, we know that $\tau_0^{k+1} = \tau_0^{k+1} \tau_1^{k+1}$ and $\tau_0^{k+1} = \tau_0^k \tau_1^k$. It follows from lemma 2 that $|\tau_0^{k+1}|_? = |\tau_0^{k+1}|_? = \frac{1}{2} |\tau_0^{k+1}| = |\tau_0^k| = |\tau_1^k|$. Hence we obtain such result: after one iteration of Toeplitz transformation on $\tau_0^{k+1} = \tau_0^k \tau_1^k$ all the letters ? of the word τ_0^{k+1} are sequentially replaced with the letters of the word τ_0^k and, respectively, letters ? of the word τ_1^{k+1} with the letters of τ_1^k .

Now we consider the word $T(\tau_0^{k+1})T(\tau_1^{k+1})$. By Thue-Morse word definition $\tau_0^{k+1} = \tau_0^k \tau_1^k$ and by lemma 2 $|\tau_0^{k+1}|_? = |\tau_0^k|$, thus from these identities and from above mentioned we notice that $T(\tau_0^{k+1})[0, 2^{k+1}] = T(\tau_0^{k+1})$.

On the other hand, by definition of Thue-Morse word $\tau_1^{k+1} = \tau_1^k \tau_0^k$ and by lemma 2 $|\tau_1^{k+1}|_? = |\tau_1^k|$, therefore $T(\tau_1^{k+1})$ is obtained if we sequentially replace all occurrences of letter ? in word τ_1^{k+1} by the letters of τ_1^k . Hence we obtain that $T(\tau_1^{k+1})[2^{k+1}, 2^{k+2}] = T(\tau_1^{k+1})$, thus $T(\tau_0^{k+1}) = T(\tau_0^k \tau_1^k) = T(\tau_0^k)T(\tau_1^k)$.

The second part of the lemma (that $T(\tau_1^{k+1}) = T(\tau_1^k \tau_0^k) = T(\tau_1^k)T(\tau_0^k)$) can be proven similarly. ■

We can now consider Thue-Morse word over alphabets $\Sigma_0 = \{0, ?\}$ and $\Sigma_1 = \{\alpha_1, \beta_1\} = \{00, ?0\}$ and prove the following theorem:

Theorem 1. $\forall n \geq 1 \ T(\tau_{\alpha_0}^n) = \tau_{\alpha_1}^{n-2} \wedge T(\tau_{\beta_0}^n) = \tau_{\beta_1}^{n-1}$.

Proof. The proof is by induction. We check the first elements of the sequence:

$$\begin{aligned} T(\tau_{\alpha_0}^1) &= T(\tau_0^1) = 00 = \alpha_1 = \tau_{\alpha_1}^0, \quad T(\tau_{\beta_0}^1) = T(\tau_1^1) = ?0 = \beta_1 = \tau_{\beta_1}^0; \\ T(\tau_{\alpha_0}^2) &= T(\tau_0^2) = T(0??0) = 00?0 = \alpha_1 \beta_1 = \tau_{\alpha_1}^1, \\ T(\tau_{\beta_0}^2) &= T(\tau_1^2) = T(?00?) = ?00? = \beta_1 \alpha_1 = \tau_{\beta_1}^1. \end{aligned}$$

Suppose that $\forall i \in \overline{1, n} \ T(\tau_{\alpha_0}^i) = \tau_{\alpha_1}^{i-2} \wedge T(\tau_{\beta_0}^i) = \tau_{\beta_1}^{i-1}$ and check for $n + 1$. By definition of Thue-Morse word and lemma 3 it follows that:

$$\begin{aligned} T(\tau_{\alpha_0}^{n+1}) &= T(\tau_0^n \tau_1^n) = T(\tau_0^n)T(\tau_1^n) = T(\tau_0^n)T(\tau_1^n) = T(\tau_0^n)T(\tau_1^n) = \tau_{\alpha_0}^{n-1} \tau_{\beta_0}^{n-1} = \tau_{\alpha_0}^n, \\ T(\tau_{\beta_0}^{n+1}) &= T(\tau_1^n \tau_0^n) = T(\tau_1^n)T(\tau_0^n) = T(\tau_1^n)T(\tau_0^n) = \tau_{\beta_0}^{n-1} \tau_{\alpha_0}^{n-1} = \tau_{\beta_0}^n. \quad \blacksquare \end{aligned}$$

Corollary 1.1. $T(\tau_{\alpha_0}^\omega) = \tau_{\alpha_1}^\omega \wedge T(\tau_{\beta_0}^\omega) = \tau_{\beta_1}^\omega$

We have proved that after one iteration of Toeplitz transformation Thue-Morse word over alphabet $\{0, 1\}$ is transferred into Thue-Morse word over alphabet $\{00, ?0\}$. Intuitively it seems that after finite number of iteration it is transferred into Thue-Morse word over another alphabet. To prove it, we consider Thue-Morse word over alphabet $\Sigma_k = \{\alpha_k, \beta_k\}$ and prove some properties of such words.

Lemma 4. $\forall n \geq 1 \ \forall k \geq 0 \ |\tau_{\alpha_k}^n|_? = |\tau_{\beta_k}^n|_? = 2^{n-1}$.

Proof. We already proved it for $\alpha_0 = 0$ and $\beta_0 = ?$ (see lemma 2). By Definition of Thue-Morse word $\tau_{\alpha_k}^0 = \alpha_k$ and $\tau_{\beta_k}^0 = \beta_k$, thus $|\tau_{\alpha_k}^0|_? = |\alpha_k|_? = 0$ and $|\tau_{\beta_k}^0|_? = |\beta_k|_? = 1$.

Further we notice that $|\tau_{\alpha_k}^1|_? = |\tau_{\alpha_k}^0 \tau_{\beta_k}^0|_? = |\tau_{\alpha_k}^0|_? + |\tau_{\beta_k}^0|_? = 1 = 2^0$. Similarly, $|\tau_{\beta_k}^1|_? = |\tau_{\beta_k}^0 \tau_{\alpha_k}^0|_? = 1 = 2^0$. Suppose that $\forall i \in \overline{1, n} \quad |\tau_{\alpha_k}^i|_? = |\tau_{\beta_k}^i|_? = 2^{i-1}$ and consider $\tau_{\alpha_k}^{n+1}, \tau_{\beta_k}^{n+1}$.

Hence $|\tau_{\alpha_k}^{n+1}|_? = |\tau_{\alpha_k}^n \tau_{\beta_k}^n|_? = 2 \cdot 2^{n-1} = 2^n$, $|\tau_{\beta_k}^{n+1}|_? = |\tau_{\beta_k}^n \tau_{\alpha_k}^n|_? = 2 \cdot 2^{n-1} = 2^n$. ■

Lemma 5. $\forall n \geq 0 \quad |\tau_{\alpha_k}^n| = |\tau_{\beta_k}^n| = 2^n \cdot |\alpha_k| = 2^n \cdot |\beta_k| = 2^{n+k}$.

Proof. Suppose $n = 0$. Then by definition of Thue-Morse word $\forall k \geq 0 \quad |\tau_{\alpha_k}^0| = |\alpha_k| = 2^k$, $|\tau_{\beta_k}^0| = |\beta_k| = 2^k$.

Let $n = 1$, then $|\tau_{\alpha_k}^1| = |\tau_{\alpha_k}^0 \tau_{\beta_k}^0| = |\alpha_k \beta_k| = 2^1 |\alpha_k| = 2^{k+1}$. Similarly, $|\tau_{\beta_k}^1| = |\tau_{\beta_k}^0 \tau_{\alpha_k}^0| = 2^1 |\beta_k| = 2^{k+1}$.

Suppose that for all $i \in \overline{1, n} \quad |\tau_{\alpha_k}^i| = |\tau_{\beta_k}^i| = 2^i \cdot |\alpha_k| = 2^i \cdot |\beta_k| = 2^{i+k}$, then

$$|\tau_{\alpha_k}^{n+1}| = |\tau_{\alpha_k}^n \tau_{\beta_k}^n| = 2^{n+1} \cdot |\alpha_k| = 2^{n+1+k} \text{ and, similarly, } |\tau_{\beta_k}^{n+1}| = |\tau_{\beta_k}^n \tau_{\alpha_k}^n| = 2^{n+1} \cdot |\beta_k| = 2^{n+1+k}. \quad \blacksquare$$

Lemma 6. $\forall k \geq 1 \quad \alpha_k = T(\tau_{\alpha_{k-1}}^1) \wedge \beta_k = T(\tau_{\beta_{k-1}}^1)$.

Proof. Let $k = 1$, then $T(\tau_{\alpha_0}^1) = T(0?) = 00 = \alpha_1$, $T(\tau_{\beta_0}^1) = T(?0) = ?0 = \beta_1$. Suppose that

$$\forall i \in \overline{1, k} \quad \alpha_i = T(\tau_{\alpha_{i-1}}^1) \wedge \beta_i = T(\tau_{\beta_{i-1}}^1)$$

and consider $T(\tau_{\alpha_k}^1)$ and $T(\tau_{\beta_k}^1)$. It follows from lemma 4 that $|\tau_{\alpha_k}^1|_? = |\tau_{\beta_k}^1|_? = 2^{1-1} = 1$. We notice that $\alpha_0 = 0$. From here it follows that, by applying Toeplitz transformation, the only one letter ? in word $\tau_{\alpha_k}^1$ is replaced with $\alpha_0 = 0$, thus all letters $T(\tau_{\alpha_k}^1)$ are 0. Similarly, the only one letter ? in $\tau_{\beta_k}^1$ is replaced with $\beta_0 = ?$, thus the first letter of $T(\tau_{\beta_k}^1)$ is ?, but all the rest letters are 0, e.g., $T(\tau_{\beta_k}^1) = \beta_{k+1}$. ■

Lemma 7. $\forall n \geq 1, k \geq 0 \quad T(\tau_{\alpha_k}^{n+1}) = T(\tau_{\alpha_k}^n \tau_{\beta_k}^n) = T(\tau_{\alpha_k}^n) T(\tau_{\beta_k}^n) \wedge T(\tau_{\beta_k}^{n+1}) = T(\tau_{\beta_k}^n \tau_{\alpha_k}^n) = T(\tau_{\beta_k}^n) T(\tau_{\alpha_k}^n)$.

Proof. By lemma 4 $|\tau_{\alpha_k}^n|_? = |\tau_{\beta_k}^n|_? = 2^{n-1} = |\tau_{\alpha_k}^{n-1}| = |\tau_{\beta_k}^{n-1}|$. From here it follows that $T(\tau_{\alpha_k}^n)$ is obtained if we sequentially replace all occurrences of letter ? in $\tau_{\alpha_k}^n$ with letters of $\tau_{\alpha_k}^{n-1}$. Similarly, $T(\tau_{\beta_k}^n)$ is obtained by replacing all occurrences of letter ? in $\tau_{\beta_k}^n$ by letters of $\tau_{\beta_k}^{n-1}$. By lemma 4: $|\tau_{\alpha_k}^{n+1}|_? = 2^n = |\tau_{\alpha_k}^n| = |\tau_{\alpha_k}^{n-1} \tau_{\beta_k}^{n-1}|$.

Moreover, we notice that $(\tau_{\alpha_k}^{n+1})[0, 2^{n-1}] = T(\tau_{\alpha_k}^n)$ and $(\tau_{\alpha_k}^{n+1})[2^{n-1}, 2^n] = T(\tau_{\beta_k}^n)$, therefore

$$T(\tau_{\alpha_k}^{n+1}) = T(\tau_{\alpha_k}^n) T(\tau_{\beta_k}^n).$$

The second part of the lemma can be proven similarly, therefore the proof is left to the reader. ■

Now we can proceed with proof of proposition that after one iteration of Toeplitz transformation $(n+1)$ st element of Thue-Morse word over alphabet $\Sigma_k = \{\alpha_k, \beta_k\}$ is transferred into n -th element of Thue-Morse word over alphabet $\Sigma_{k+1} = \{\alpha_{k+1}, \beta_{k+1}\}$, or more precisely:

Theorem 2. $\forall k, n \geq 0 \quad T(\tau_{\alpha_k}^{n+1}) = \tau_{\alpha_{k+1}}^n \wedge T(\tau_{\beta_k}^{n+1}) = \tau_{\beta_{k+1}}^n$.

Proof. The proof is by induction. We use the theorem 1 as the base of induction. Suppose that

$$\forall i \in \overline{0, k-1}, \forall n \geq 0 \quad T(\tau_{\alpha_i}^{n+1}) = \tau_{\alpha_{i+1}}^n \wedge T(\tau_{\beta_i}^n) = \tau_{\beta_{i+1}}^n$$

and consider for $i = k$:

Let $n = 0$, then by lemma 6: $\tau_{\alpha_{k+1}}^0 = \alpha_{k+1} = T(\tau_{\alpha_k}^1)$ and $\tau_{\beta_{k+1}}^0 = \beta_{k+1} = T(\tau_{\beta_k}^1)$. Let $n = 1$, then by lemma 6 and lemma 7: $\tau_{\alpha_{k+1}}^1 = \alpha_{k+1} \beta_{k+1} = T(\tau_{\alpha_k}^1) T(\tau_{\beta_k}^1) = T(\tau_{\alpha_k}^1 \tau_{\beta_k}^1) = T(\tau_{\alpha_k}^2)$ and, similarly, we obtain that $\tau_{\beta_{k+1}}^1 = T(\tau_{\beta_k}^2)$.

Suppose that for all $j \in \overline{0, n} \quad T(\tau_{\alpha_k}^{j+1}) = \tau_{\alpha_{k+1}}^j \wedge T(\tau_{\beta_k}^{j+1}) = \tau_{\beta_{k+1}}^j$ and consider for $n+1$: $\tau_{\alpha_{k+1}}^{n+1} = \tau_{\alpha_{k+1}}^n \tau_{\beta_{k+1}}^n$.

By presumption $\tau_{\alpha_{k+1}}^n = T(\tau_{\alpha_k}^{n+1})$ and $\tau_{\beta_{k+1}}^n = T(\tau_{\beta_k}^{n+1})$, therefore by lemma 7:

$$\tau_{\alpha_{k+1}}^{n+1} = T(\tau_{\alpha_k}^{n+1}) T(\tau_{\beta_k}^{n+1}) = T(\tau_{\alpha_k}^{n+1} \tau_{\beta_k}^{n+1}) = T(\tau_{\alpha_k}^{n+2}).$$

Similarly,

$$\tau_{\beta_{k+1}}^{n+1} = \tau_{\beta_{k+1}}^n \tau_{\alpha_{k+1}}^n = T(\tau_{\beta_k}^{n+1}) T(\tau_{\alpha_k}^{n+1}) = T(\tau_{\beta_k}^{n+1} \tau_{\alpha_k}^{n+1}) = T(\tau_{\beta_k}^{n+2}). \quad \blacksquare$$

Corollary 2.1. $\tau_{\alpha_{k+1}}^\omega = T(\tau_{\alpha_k}^\omega) \wedge \tau_{\beta_{k+1}}^\omega = T(\tau_{\beta_k}^\omega)$.

Corollary 2.2. $\forall k \geq 0 \quad T^k(\tau_0^\omega) = \tau_{\alpha_k}^\omega \wedge T^k(\tau_1^\omega) = \tau_{\beta_k}^\omega$.

Proof. If $k = 0$ then obviously $T^0(\tau_0^\omega) = \tau_0^\omega \wedge T^0(\tau_1^\omega) = \tau_1^\omega$. If $k = 1$ then from Corollary 1.1 we obtain the result.

Suppose that $\forall 0 \leq i \leq k \quad T^i(\tau_0^\omega) = \tau_{\alpha_i}^\omega \wedge T^i(\tau_1^\omega) = \tau_{\beta_i}^\omega$ and consider for $k+1$: by presumption and Corollary 2.1.: $T^{k+1}(\tau_0^\omega) = T(T^k(\tau_0^\omega)) = T(\tau_{\alpha_k}^\omega) = \tau_{\alpha_{k+1}}^\omega$, $T^{k+1}(\tau_1^\omega) = T(T^k(\tau_1^\omega)) = T(\tau_{\beta_k}^\omega) = \tau_{\beta_{k+1}}^\omega$. ■

Corollary 2.3. $T_0^\omega = \lim_{n \rightarrow \infty} T^n(\tau_0^\omega) = 0^\omega$ - because we can consider that all letters ? are replaced with 0. $T_1^\omega = \lim_{n \rightarrow \infty} T^n(\tau_1^\omega) = 10^\omega$ - because we can consider that all, except the first, occurrence of ? are replaced with 0.

Conclusion

The aim of this work is to generalize notion of Toeplitz words and explore cases when they are generated from infinite non-periodic words. Thue-Morse word was chosen because of its specific properties – it is morphic word, for all $n \geq 0, k \geq 0$ we can easily calculate the numbers $|T_k^n|, |T_k^n|_b$ and find connection between these numbers and other elements of the sequence. We proved that after k iterations of Toeplitz transformation Thue-Morse word over alphabet $\{0, 1\}$ is transferred into Thue-Morse word over alphabet $\Sigma_k = \{\alpha_k, \beta_k\}$, and after infinite number of iterations it is transferred into periodic word 0^ω .

Acknowledgements

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KNOWLEDGE MANAGEMENT FOR SUSTAINABLE RURAL DEVELOPMENT

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Annotation

Today sustainable rural development programmes have become more complex. The consultants and managers of rural development projects need specific knowledge. The benevolent environment that expands the capabilities for the successful collaboration of rural inhabitants should be created for the favourable rural development knowledge management that identifies and closes knowledge gaps. The integration of the rural development strategies together with the knowledge management strategies help the rural production, business and public organizations and the groups of village inhabitants to straightly adapt to the changing environment and increase their intellectual capital. This paper deals with the role of the knowledge management for the improvement of the sustainable rural development. It presents the framework of rural development knowledge management which can help to utilize the knowledge management concepts for the rural development. It also shows how the alignment of the knowledge management strategy with the rural development strategies can bring to the more effective management of the sustainable rural development.

Keywords: *sustainable rural development, knowledge management, knowledge community.*

Introduction

Sustainable rural development is an evolving process that accepts changes and leads to the improvement and harmonization of economic, social and environmental conditions. Solutions of managers in programmes and projects of sustainable development have become more complicated. It is important to balance between different short-term and long-term aims in economic, social, and environmental dimensions. Sometimes managers may be stunned by everyday problems. In other situations the actions taken may seem to be fully controlled from the first sight but their long-term benefit remains vague. And often the complexity, related with a very vast scope of activities, becomes a heavy burden. The overload of the complexity needs to be avoided as it leads to irresolution and ineffectiveness. The usage of mathematical modelling and information systems helps to conduct a more professional systematic analysis of the current situation, to predict possible future risks and urgently form adequate solutions, eliminating risks (Pranevicius and Kurlavicius, 2003; Pranevicius et al., 2006).

The majority of managers in the sphere of sustainable agricultural and rural development still apply hierarchical models and methods. However, such models do not ensure the complete understanding of development processes and are insufficient for the investigation of complex systems as well as inappropriate for the integration of interests in various dimensions of different subjects. It is rather difficult to recognize the entire picture, plan and implement general actions in network type structures with widely distributed data. Many managers of agricultural and rural development have already started applying the elements of systematic approach; however, they frequently do not conform to mandatory procedures. There is a need to systematize the principles of the management for sustainable agricultural and rural development, to formalize them and to employ all the possibilities of modern information and communication technologies for the increase of the effectiveness of sustainable agricultural and rural development management. It has been noticed that the knowledge-based management could help strategists of agricultural and rural development to forecast and estimate unfavourable factors and to reduce the impact of unfavourable events. According to Sami AlBana, a bigger threat to sustainable development is caused not by a lack of technologies or capital, but by existing barriers that disturb a rapid creation, dissemination of knowledge and learning, based on it (Sami AlBana, 2000). The programmes of agricultural and rural development should include the implementation of advanced technologies and knowledge transfer. Contemporary managers and consultants of programmes and projects for agricultural and rural development should possess wide knowledge and instruments enabling them to transfer from solutions of separate rural development problems to the effective management of sustainable agricultural and rural development.

This paper deals with the role of the knowledge management for the improvement of the sustainable rural development. The aim of the article seeks to investigate the management of sustainable agricultural and rural development applying systematic approach, to provide means for the solution of complicated managerial problems and, thus, help politicians and managers of sustainable agricultural development to deal more efficiently with complex development projects under the circumstances of constantly changing environment. The article presents how the arrangement of organizational cybernetics and knowledge management with the management of agricultural and rural development could make the agricultural and rural development more sustainable and viable.

Knowledge based integration of rural development dimensions

The management of basic processes and feedbacks within the study of sustainable agricultural and rural development are analyzed using available literary sources as well as detailed interviews and evidence of the main participants of the study. The majority of authors identify the need for a systematic rather than a traditional hierarchical approach while dealing with issues of sustainable development (Sanders, 2006; Espinosa et al., 2006). The systematic approach incorporates different perceptions and methodologies, integrated into a set of tools, required for the investigation and analysis of complex systems (Schwaninger and Koerner, 2000). A viable system model, created and developed by Stafford Beer (Beer, 1984) and expanded by other authors (Schwaninger, 2001; Schwaninger, 2006) (Espinosa and Walker, 2006; Stangu, 2005) provides a set of guidelines for the holistic approach to sustainable development. According to Stafford Beer, an organization or another system is regarded to be viable as long as it retains its identity. Possibilities of using the model of the viable system for the solution of agricultural business were discussed as well (Kurlavicius, 2009).

Sustainable agricultural and rural development indicates the viability of economic activities (economic dimension); the sustainable usage of resources as well as ecological measures (ecological dimension); the willingness and ability of individuals and organizations to collaborate and be responsible for activity results (socio-cultural dimension) (Fig. 1).

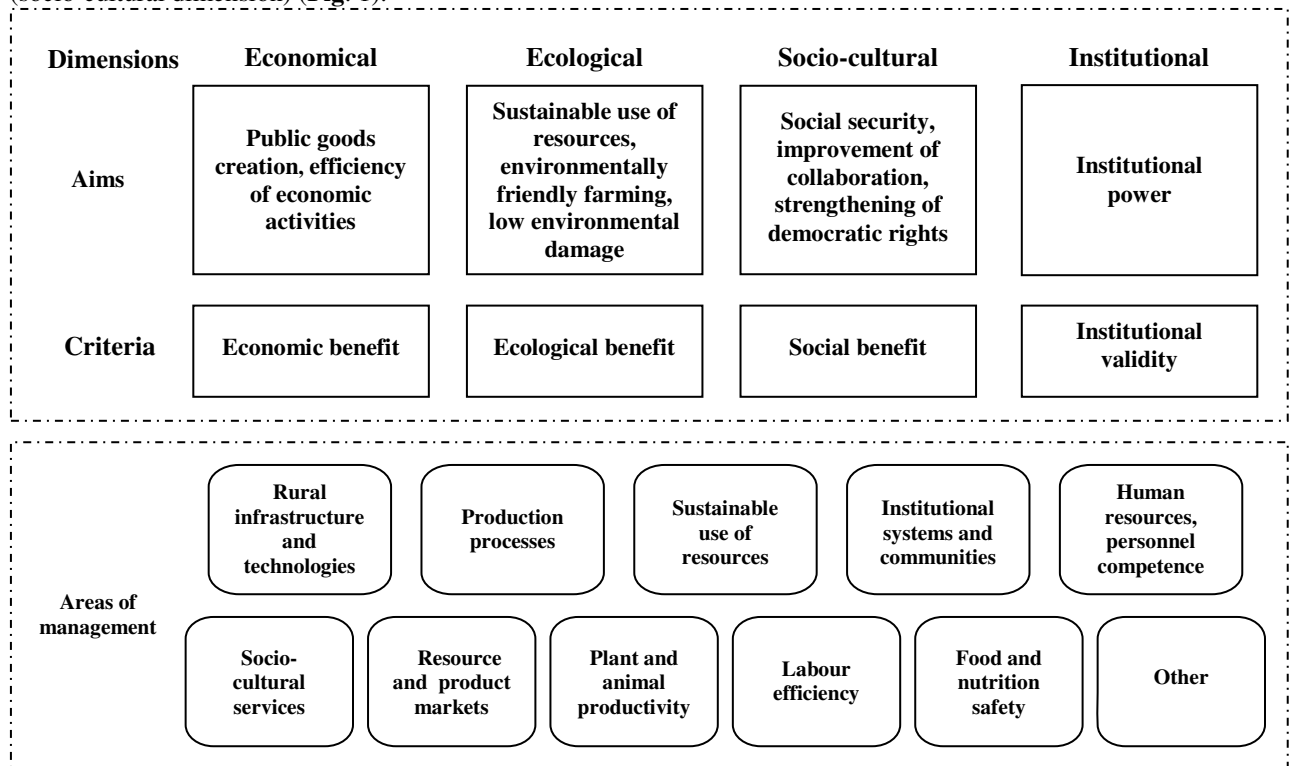


Fig. 1. The dimensions, aims and management areas of sustainable rural development

Within the development of agriculture and rural areas, institutions and their abilities to cope with changing requirements are necessary to be strengthened (institutional dimension), and the awareness of people and community organizations as well as the provision of support for solving problems have to be improved.

The economic dimension of development strategically focuses on the strengthening of economic skills, the creation of new opportunities, the reduction of economic risks and the improvement of life quality. Agricultural and rural business is regarded to be a source of living. The promotion of local economic development, the support for agriculture and alternative activities, the improvement of relationships between rural areas and towns, the creation of honest access to limited resources, the assistance in specific cases and, lately, the creation and preservation of rural public goods are all attributed to the economic dimension of agricultural rural and development (Huylenbroeck, 2003). Seeking to ensure suitable and coordinated effects, the economic approach should be mutually related with other approaches through specific processes of agricultural and rural development.

The ecological dimension is related with the sustainable use of natural resources, the reduction of environmental damage and environmentally-friendly farming. Ecological components of the development include the selection of suitable control methods of natural resources, the development of ecological farming systems, the design and implementation of subsidy systems for sustainable production, and the certification of sustainable production and products. The management of natural resources applies means that stop resource degradation processes and solve the problems of resources utilization conflicts.

The socio-cultural dimension of the development is more directed to the promotion of social changes, the assurance of social welfare, the improvement of communication of people, state agencies and service suppliers, the integration of public goods into the entire socio-cultural space. A particular attention is paid to specific disadvantaged groups of people and communities, the expansion of the access to basic socio-cultural services, multicultural considerations, and the strengthening of democratic rights.

Within the development of agriculture and rural areas, institutions and their abilities to cope with changing requirements are necessary to be strengthened (institutional dimension), and the awareness of people and community organizations as well as the provision of support for solving problems have to be improved. The institutional dimension of the development is connected with the improvement of mechanisms of democratic administrative institutions and decentralization while exhausting resources better. Institutional development should help to unite sectoral and national, regional and local programmes, facilitate the formation of public property and autonomy, create environment, appropriate for collaboration, and promote partnership based on common activities as well as the development of information and communication technologies. The effectiveness of services and support could be increased in such a way, as well as less hierarchical, more flexible multi-sectoral coordination ensured with higher competition, public participation, transparency and responsibility.

Information and knowledge become the central components of innovation, growth and sustainable development. Informative support for decision making increases the effectiveness of solutions. Information and communication technologies could be employed as a powerful tool to bridge the digital divide of rural districts (Kurlavicius, 2006).

Politicians of agricultural and rural development influence the subjects of the basic subsystem through long-term development programmes, strategic plans and regulations. The efficiency of the influence depends on the reconciliation of activities of national, regional and municipal institutions and nongovernmental sector. Good policy of agricultural and rural development and its effective implementation could reduce damage to the nature and promote investment.

Agricultural and rural development of the European Union (EU) member states is influenced by an external environment and the interventions of the European Union, national, regional and local levels. A recursive structure, proposed by Stafford Beer (Beer, 1985), could be used to reduce the complexity of the system. Applying the principle of the recursive structure it is possible to single out four management levels of sustainable agricultural and rural development system (Fig. 2).

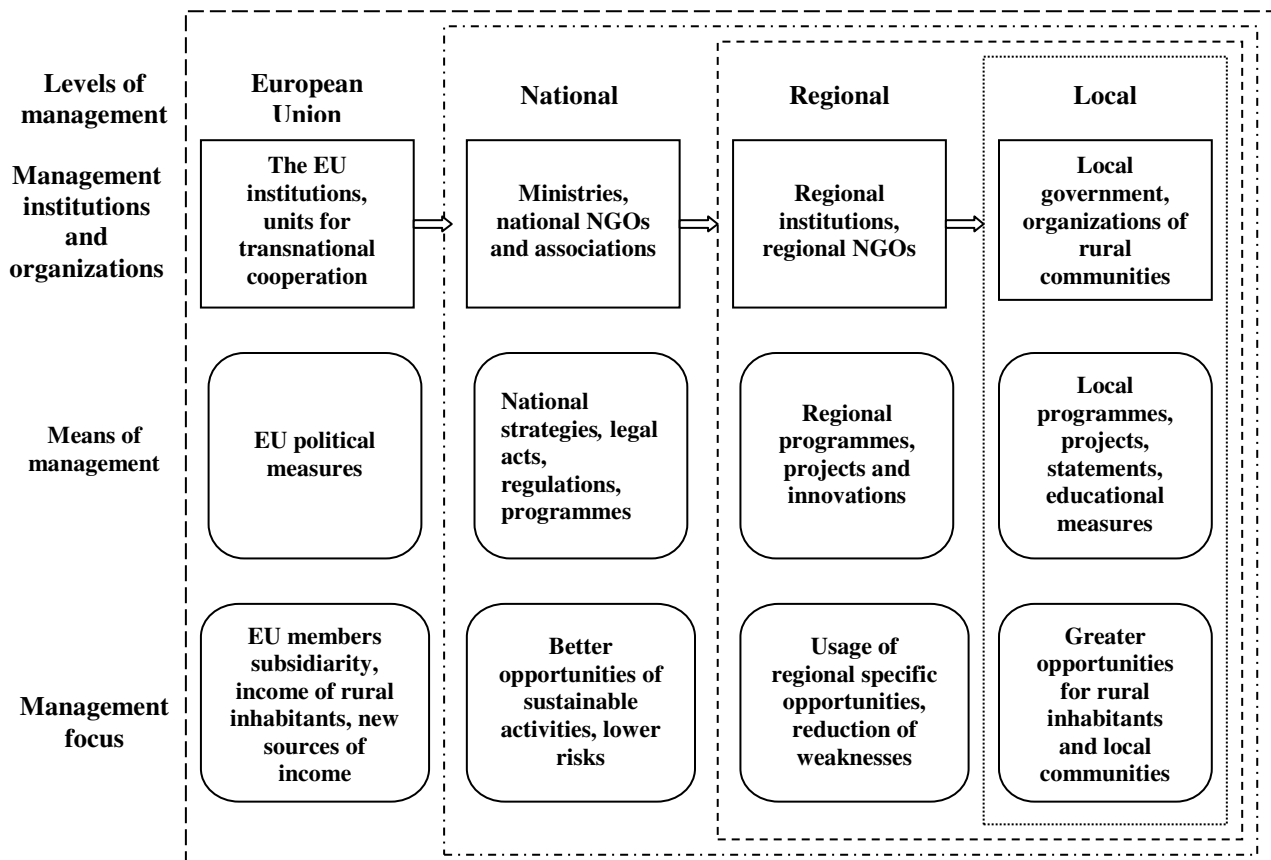


Fig. 2. Management levels of the sustainable agricultural and rural development in the EU.

The background of sustainable rural development is a combination of environmental and agricultural policy as well as initiatives of rural community organizations (EEC, 1992). The overall measures for the implementation of rural development objectives are defined in Council Regulation No.1257/99 and in Council Regulation No. 1698/2005 (EC, 1999; EC, 2005).

The national system of sustainable agricultural and rural development management with its organizational structures is formed in the national level. The national policy of agricultural and rural development influences subjects of the development through laws, programmes in accordance with general political regulations of the EU.

The strategy of regional development determines concrete plans for regional development, directs organizations, leaders and specialists of agriculture and other sectors, indicating guidelines for implement various programmes and projects of development. Regional level interventions are used to strengthen possibilities of regional rural districts.

The interventions of the local level condition the implementation of local programmes and projects, training of rural population, land and animals productivity, labour efficiency, food and forage safety increase and the development of community organizations and their activity.

To describe the problematic situation of the local level, two main subsystems of sustainable agricultural and rural development could be identified. The basic (controlled) subsystem is comprised of individuals, families, organizations, associations, communities and other non-governmental organizations that carry out the main functions of agricultural and rural development. The functioning and the sustainability of this subsystem are determined not only by its internal components, but by the second subsystem, defined as the control subsystem. The main mission of the control subsystem is to predict the changes of global and local environment, the problems disproportions of development, to propose and implement strategic decisions, necessary to solve problems. This subsystem consists of institutions and organizations of agricultural and rural development management that include organs of governments and legislators of different levels, international organizations, universities, research centres and nongovernmental organizations. The control subsystem strives to help the subjects to fulfil the main functions of sustainable development, to reconcile contradictory aims, to detect dangers, to reduce the negative impact on nature and to adapt to constantly changing environment. The position of decentralization and coordination significantly increases when the principle of public administration „from bottom to top“ is realized in agriculture and rural development.

The efficiency of the control subsystem is determined by its interaction with the basic subsystem. This interaction is provided via feedbacks. Four basic feedback loops identified as economic, ecological, socio-cultural and institutional could be distinguished in the model of the management for sustainable agricultural and rural development (Fig. 3).

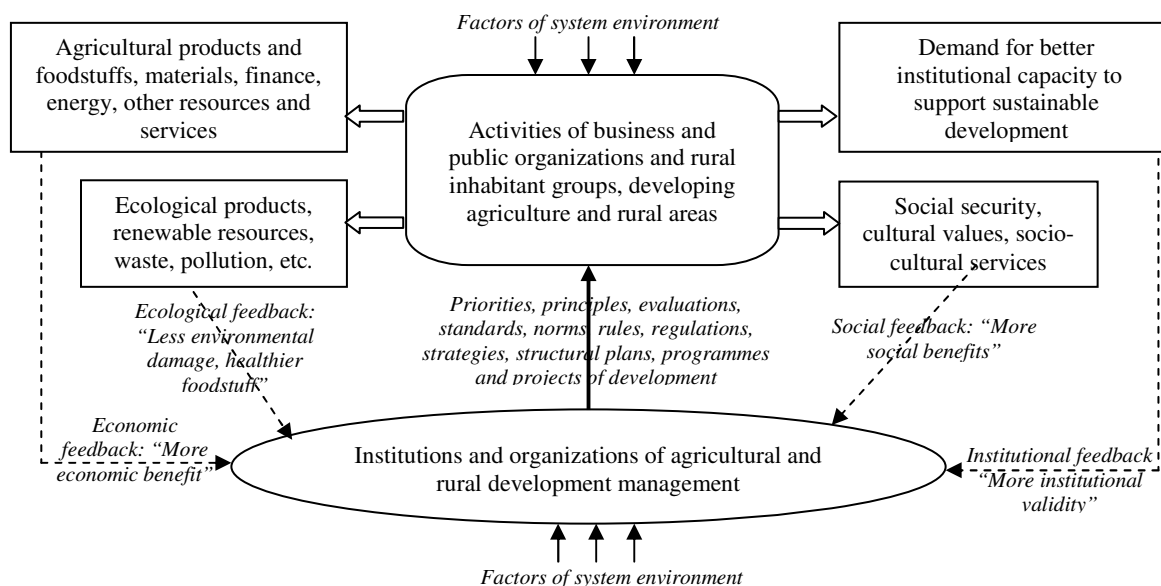


Fig. 3. Basic feedbacks of sustainable agricultural and rural development management.

The centre of optimization is present in all four components and their interrelations. The identification of the main agricultural and rural development processes in the range of causal loops makes it possible to understand the dynamics of the sustainable development better and focus on processes, representing the impact, critical to the sustainability of the system.

While managing agricultural and rural development, the system components and their relationships have to be developed as well. The model of the viable rural development system consists of five subsystems that include: 1)

the main activities and services, 2) coordination 3) control and monitoring 4) adaptation and 5) policy (Kurlavicius, 2009). The model of the viable system is a recursive model, which means that a model contains other models and is contained within other models. Thus, it is important to distinguish national, regional and local systems of sustainable agricultural and rural development management and to analyze their constituent parts and interactions within them.

The model of the viable system illustrates components and requirements, obligatory for the management system of sustainable development. The model of the viable system provides possibilities to specify flows of strategic information in the agricultural and rural development system, helps form strategies for the development of information systems and support management decisions.

The effective knowledge management anticipates the need to balance between the short and long lasting objectives in various sustainable rural development dimensions and different technological domains. It is expedient to integrate the strategies of rural development with the knowledge management strategies in order to help the rural production, business and public organizations, and groups of villagers to constantly adapt to the changing environment. The degree of the aim achievement of the sustainable rural development reflects the effectiveness of the rural development knowledge management.

Knowledge environment of sustainable rural development

The aim of the knowledge management is to guarantee the organized collaboration level, to transfer the appropriate knowledge for the most useful people in due time and enable them to make the best solutions, to exploit knowledge as the intellectual wealth that creates some profit.

The knowledge management chain includes the knowledge identification, the knowledge acquisition, analysis, storage, dissemination, sharing and evaluation. The system of rural development knowledge management must relate the knowledge of rural development institutions and individuals and convert them into electronic files and employ them in a system in the form of the knowledge pool that can be used online at any time.

The benevolent environment should be created for the successful rural development knowledge management. The environment has to ensure the possibilities of the villagers to conveniently collaborate, helping to identify and minimize the knowledge gaps. The infrastructure of knowledge management must ensure the management of the communication, content and document.

The organizational components of knowledge environment are the knowledge management and sharing system, the knowledge management technologies, the knowledge societies and the knowledge users. The knowledge management and sharing system consists of the data bases and knowledge pool with their operational mechanisms, the reasoning machine, and the subsystem of communication and real time knowledge sharing. In the rural development knowledge pool the knowledge of all forms (highly-structured, semi-structured and unstructured) should be accumulated and stored as well as that which is rarely updated or, on the contrary, very dynamic. The knowledge pool covers databases, directory files, web sites, book collections, indices, maps, videos, audio resources, picture resources, films, art collections, discussion trails, transcripts, research results, e-mail sets, expertise locators, directory resources, etc. The knowledge pool may store laws, regulations, the assets of agriculture and rural business knowledge, statistical data, experience data, samples, tools, templates, methodologies, etc.

The system of rural development knowledge management and sharing may have the functions of distant input, modification and removal, as well as the services of the common usage via the Internet. The good knowledge environment enhances the ability of the rural development institutions and organizations to reach the goal and create and strengthen their intellectual capital.

In order to join the knowledge owners for the common knowledge sharing or pooling, the organizational structures or inter-organizational networks, and knowledge societies can be created.

The knowledge community is focused on the knowledge sharing, creating, distributing and expanding and joins the separate individuals with a shared interest. The membership should stretch and overstep the geographical and organization margin limits. The topics may include processes, methods, competences, technologies, markets or products. The members learn more quickly and with the use of methods and lessons they learn to improve their work.

We can distinguish three basic forms of the rural area knowledge communities. The communities of interest are formed according to the need to analyze, discuss or study new topics. A practitioner's network joins the practitioners working in the same topic area. An expert network joins the established and accredited topic specialists. These community networks may overlap with each other.

Managers of agricultural and rural development must effectively manage their information and knowledge. Information support of decision is demanded in every level (local, regional and national) of sustainable development management. Information systems of management should be based on the reality of agricultural and rural development and ensure the provision of suitable information for all the subsystems and elements of the viable system. It is important to transfer the proper knowledge to the most appropriate people in the right time and enable them to make the best decisions (Li Sijing, 2002). Web-based information systems which

provide a convenient access to e-services, information and knowledge are necessary for this purpose. There is a sufficient number of general literature on knowledge management; therefore, it was proposed to combine knowledge management with sustainable development (*Sami Albana, 2000*); however, the management of sustainable agricultural and rural development has been insufficiently investigated applying knowledge basis.

Horizontal and vertical communication channels are used in the system of sustainable agricultural and rural development. Horizontal communications present relationship of actors of the main activity with their internal environment and direct management units. General aims of sustainable development are achieved and the viability of the system is ensured if every component takes its way that leads to the same direction. The channels of vertical link connect the units of the primary activity subsystem with institutions and organizations of operative management that form development strategies and policy. Vertical communications help to implement general policies of sustainable development but reduce the autonomy of the main activity actors and the viability of the system at the same time.

Knowledge management of agricultural and rural development includes organized attempts to create, implement and exploit knowledge environment of sustainable agricultural and rural development. The functions of knowledge management and common usage system include knowledge identification, acquisition, analysis and evaluation, storage, reasoning, dissemination and sharing. The system may possess possibilities for distant information entering, modification, deletion and could disseminate information services via the Internet. The strategy of knowledge management indicates the need for learning and feedback. Learning from the previous experience should help to minimize uncertainty in complex situations and help managers to get acquainted with rural development difficulties they could face.

In order knowledge management of agricultural and rural development was successful a suitable environment that expands the capabilities for participants of sustainable development to comfortably collaborate, identify and fill knowledge gaps should be created. Knowledge environment should ensure the availability and accessibility of knowledge. The infrastructure of knowledge management must ensure the management of content, documents and communications. The components of knowledge environment organizations are knowledge pools, knowledge management technologies, knowledge societies and knowledge users. A suitable knowledge environment enhances the capability of agricultural and rural institutions and organizations to reach indicated aims as well as create and enrich intellectual capital.

Agricultural and rural development knowledge management system should integrate knowledge of separate organizations and actors and convert it into electronic files, store it in a knowledge pool that could be used on-line at any time. General knowledge pool integrates information from different sources of agricultural and rural development including explicit knowledge, stored in data bases and implicit knowledge (practical experience, skills, expert thoughts and other) stored in general knowledge pool. Laws, regulations, agricultural and rural trade knowledge, statistical and experience data are also stored in the knowledge pool of agricultural and rural development. It is convenient to store the explicit knowledge in such a pool that has a search engine and online information supply. The strategic resource is a network map of employees' contacts and results of analysis that depicts central nodes, specialists and mediators of the network. Organizational knowledge could be collected and designed into directories of knowledge owners. When people need special knowledge they look for it in the directories, seeking to find out what organizations and who owns this knowledge, and how this type of knowledge could be obtained. It is rather important to store the implicit knowledge in such a way that it could be used after the retirement of an employee. In order to save such knowledge, this kind of knowledge should be transformed into the explicit knowledge by registering knowledge about formal and informal personal contact network and the knowledge about procedures and work processes stored in document systems of institutions.

It is purposeful to integrate the strategies of sustainable agricultural and rural development with the strategies of knowledge management. The arrangement of the strategies could bring positive effects if information and knowledge technologies are analyzed as a strategic component of sustainable development but not as a simple tool for support of operations. The model of the viable system provides an effective tool that helps politicians, managers and specialists of agricultural and rural development to define all the aspects of knowledge necessary to support the management of sustainable development.

Conclusions

Modern sustainable agricultural and rural development increasingly focuses on the implementation of new ideas and high technologies that create conditions for people and organizations to use their opportunities better. Traditional approaches and hierarchical models applied by managers and designers of development programmes for rural areas do not provide the holistic perception of sustainable development processes and do not arrange the integration of interests in various dimensions of different subjects appropriately.

In the management model of sustainable agricultural and rural development three basic feedback loops such as economic, ecological, socio-cultural and institutional could be identified. Sustainable development combines a harmonious reconciliation of the components, mentioned above. A recursive framework that includes four levels such as the European Union, national, regional and local is convenient for the study of management of

sustainable agricultural and rural development in the EU member states. Having granted appropriate authority for communities and organizations, developed mechanisms of self-regulation and coordination in all management levels, the cohesion and viability could be ensured without power and authority but with a benevolent agreement of the subjects. The concerted normative, strategic and operative management of sustainable agricultural and rural development enables to solve complex and controversial problems of sustainable development with a focus on the essential criteria of success.

The programmes of sustainable agricultural and rural development should include the implementation of knowledge management and high communication technologies as well as knowledge based learning.

The programmes of sustainable agricultural and rural development should include the implementation of knowledge management and high communication technologies as well as knowledge based learning. The knowledge management and sharing system, containing databases and knowledge pools with the mechanisms of communication, make up a suitable knowledge environment for sustainable development management. The model of the viable system provides a framework that helps politicians, managers and specialists of agricultural and rural development to integrate and sharing various types of knowledge, necessary for making decisions. The integration of strategies for sustainable agricultural and rural development with the strategies of knowledge management enables rural communities, business and public organizations to adapt to changing environment and retain viability.

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ON TRADITIONAL AND MODERN ORGANIZATIONS OF STUDIES

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My aim is to compare a modern organization of studies, especially the possibilities opened by e-studies, with the traditional ones, both as regards prerequisites and also results. I will highlight the advantages and disadvantages of both alternatives. Traditional organization of studies means auditorium sessions such as lectures, tutorials, and laboratory work conducted by a teacher, to be followed by accounting in the form of assignments and examinations. Modern organization of studies, on the other hand, presupposes that the students have free access to internet in terms of technical equipment as well as skill of use. It is then possible to require of students that they should independently work through the study materials available on internet and submit the required assessment forms.

Based on long-term experience it is possible to assert that the **traditional organization of studies** is suitable, and at times the only feasible, for students with low motivation and insufficient experience of independent work. Through the effort of the teacher they can acquire the essential basic knowledge of the course and skills for subsequent independent work. So we may list the following **advantages** of the old organization of studies:

- direct human contact between the teacher and the student
- rapid communication and feedback
- continuous cooperation during presentation and interpretation of materials

The **disadvantages** of this form of studies may be listed as:

- fixed and limited work time
- requirement of rooms and elementary equipment
- possibility of only passive participation if the teacher lacks in forcefulness in case of large classes or skill to activate the student

A modern **e-study** is well suited to a motivated student with experience in independent work. At the same time it places an increased demand on the material prepared by the teacher. The material must be technically accessible to every student. The **advantages** of this form of study may be listed as:

- free choice of study time and location
- possibility of use of diverse materials
- continuous chance of self-assessment
- individual active communication with the teacher

The **disadvantages** in this case are:

- lack of activating impact by the teacher
- chance of misunderstandings of the material which may not become apparent through the tests
- dishonesty in assignment work

While either way should lead to the primary **result** of mastering the essential truths of a course, the traditional alternative needs to be supplemented with learning to independently interpret study materials. This would later allow the use of opportunities of e-study and, in turn, a recognition of one's abilities and a skill to use one's study time sensibly. For the adequate assessment of results, it is imperative to maintain continuous communication and feedback between the teacher and the student in both study forms.

SOME ASPECTS OF EXPERIMENTAL DESIGN

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Abstract

Latvia University of Agriculture Faculty of Information Technologies realizes statistics courses for the Bsc, Msc and PhD students of the agricultural science. The basic topic for the Bsc level statistics course is real data analysis, when the previous steps in representative data collection were already made. In Msc level statistic course students define themselves the problem, collect data and analyze it. For the PhD course in statistics the main purpose is not only the previous defined tasks but also the experimental design of agricultural data.

The Faculty of Information Technologies provides the statistical courses, based on theoretical and ICT components. The courses consist of statistical theory and practical parts using different statistical programs for data analysis.

For the PhD students the main subject is general liner model (GLM) The major statistical question is to develop model for experimental data analysis. The model constructions depend of experimental design methods and factors which will be include in the experiment.

Key words: GLM, agriculture, experimental designs.

Introduction

For scientific hypotheses testing in the biological, agriculture, as well in social science is using the experiment (al design). A starting point of the experiment is design of experimental study; we shall concentrate on those elements of experimental design where statistical methods have made the greatest contributions.

The design of experiment includes the following questions:

- To set of treatments included in the study;
- The set of experimental units included in the study;
- The rules and procedures by which the treatments are assigned to the experimental unit;
- The measurements that are made on the experimental unit after the treatments have been applied. (J. Neter et al., 1985)

Three principal problems in experimental design pertaining to treatments (factor level or a combination of factor levels) are: choice of treatments to be studied, definition of each treatment, and need for a control treatment. In factor study is important include not only one factor, but include the effect of several factors simultaneously.

An important two questions in definition of experimental units are: sizes of experimental unit and representativeness of experimental unit.

One of the rules of experiment is in beginning of experiment the treatment groups should be similar. If groups were not similar it's called selection bias, selection bias can be minimized by randomization. The use of randomization tends to balance the experimental units in each treatment group with regard to factors other than the treatment that affect the outcome.

The measurement process ideally should produce measurements that are unbiased and precise. The source of measurement bias can be minimized by concealing the treatment assignment to both the experimental subject and the evaluator.

The major methods of experimental design are:

- Completely randomized designs (CRD)

	\underline{A}_1		\underline{A}_2	
	B ₁	B ₂	B ₁	B ₂
C ₁	Y ₁₁₁ .	Y ₁₁₂ .	Y ₁₂₁ .	Y ₁₂₂ .
	Y ₁₁₁ .	Y ₁₁₂ .	Y ₁₂₁ .	Y ₁₂₂ .
C ₂	Y ₁₁₁ .	Y ₁₁₂ .	Y ₁₂₁ .	Y ₁₂₂ .
	Y ₁₁₁ .	Y ₁₁₂ .	Y ₁₂₁ .	Y ₁₂₂ .
C ₃	Y ₁₁₁ .	Y ₁₁₂ .	Y ₁₂₁ .	Y ₁₂₂ .
	Y ₁₁₁ .	Y ₁₁₂ .	Y ₁₂₁ .	Y ₁₂₂ .

- Randomized block designs (RBD)

Block	A_1		A_2	
	B_1	B_2	B_1	B_2
1	Y_{111}	Y_{112}	Y_{121}	Y_{122}
2	Y_{211}	Y_{212}	Y_{221}	Y_{222}
3	Y_{311}	Y_{321}	Y_{321}	Y_{322}

- Nested designs (ND)

	A_1		A_2	
	C_1	C_2	C_3	C_4
B_1	$Y_{111.}$	$Y_{112.}$	$Y_{123.}$	$Y_{124.}$
	$Y_{111.}$	$Y_{112.}$	$Y_{123.}$	$Y_{124.}$
B_2	$Y_{111.}$	$Y_{112.}$	$Y_{123.}$	$Y_{124.}$
	$Y_{111.}$	$Y_{112.}$	$Y_{123.}$	$Y_{124.}$
B_3	$Y_{111.}$	$Y_{112.}$	$Y_{123.}$	$Y_{124.}$
	$Y_{111.}$	$Y_{112.}$	$Y_{123.}$	$Y_{124.}$

- Latin square and related designs use in small scale experiment in preliminary or plot studies

	C	B_1	B_2	B_3
A_1	1	A	B	C
	2	B	C	A
	3	C	A	B
A_2	4	A	C	B
	5	B	A	C
	6	C	B	A

The structure of experiment depends on number of factors and the interaction between them. Not only one factor affected the investigation treatment and it is in interest of experiment, as well the classical factorial experiment provides information on interaction effects between two and more factors (Table 1). In CRD and RBD every level of one factor appears with each level of every other factor and it's named crossed design. A different situation occurs when factors are nested; it is no interaction between factors and levels of nested factor are different in each level of other factor.

Table 1.

Linear model structure by different experimental design

<i>Model / design</i>	<i>CRD</i>
One factor	$Y_{ij} = \mu_{..} + \alpha_i + \varepsilon_{ij}$ $i=1...a; j=1...n$
Two factors	$Y_{ijk} = \mu_{..} + \alpha_i + \beta_j + \alpha\beta_{ij} + \varepsilon_{ijk}$ $i=1...a; j=1...b; k=1...n$
Three factors	$Y_{ijkl} = \mu_{...} + \alpha_i + \beta_j + \gamma_k + \alpha\beta_{ij} + \alpha\gamma_{ik} + \beta\gamma_{jk} + \alpha\beta\gamma_{ijk} + \varepsilon_{ijkl}$ $i=1...a; j=1...b; k=1...c; l=1...n$
<i>Model / design</i>	<i>RBD</i>
Two factors	$Y_{ij} = \mu_{..} + \rho_i + \alpha_j + \varepsilon_{ij}$ $i=1...n; j=1...r; n$ -block number ρ_i - random effect
Three factors	$Y_{ijk} = \mu_{...} + \rho_i + \alpha_j + \beta_k + \alpha\beta_{jk} + \varepsilon_{ijk}$ $i=1...n; n$ -block number $j=1...a; k=1...b$ ρ_i - random effect
<i>Model / design</i>	<i>ND</i>
Two factors	$Y_{ijk} = \mu_{..} + \alpha_i + \beta_{j(i)} + \varepsilon_{k(ij)}$ $i=1...a; j=1...b; k=1...n_{ji}$ $\beta_{j(i)}$ - nested effect
Three factors	$Y_{ijk} = \mu_{...} + \alpha_i + \beta_j + \gamma_{k(i)} + \alpha\beta_{ij} + \beta\gamma_{jk(i)} + \varepsilon_{m(ijk)}$ $i=1...a; j=1...b; k=1...c; m=1...n$ $\gamma_{k(i)}$ - nested effect

Methodology and methods

In the article the experimental study of lysozyme (Ly) concentration in cow's milk is considered. A nested design is used for experiments in which there is an interest in a set of treatments and experimental unit are sub sampled. This type of design is very common in genetic and animal breeding, where statistical linear model is used for traits heritability and genetic parameters estimation.

The aims of the study were:

- Estimation genetic variability of antimicrobial activities (lysozyme, concentration) in milk.
- Estimation the heritability of Ly concentration in milk.
- Improving mastitis resistance by identifying bulls that can sire daughters with superior milk antimicrobial activities.

During experiment we get large number of data and as a next step in experimental design is analysis of investigation data and hypotheses testing.

In lysozyme concentration in cows' milk study were included 30 cows from four genetic groups. Milking 1st lactation cows were included in trial (Table 2). The milk samples were analyzed 3 times during lactation (1st, 2nd and 3rd lactation phase) for milk component lysozyme concentration, somatic cells count and milk yield:

- in November, 2004, the cows were in 1st stage of lactation;
- in March, 2005, the cows were in 2nd stage of lactation;
- in June, 2005, the cows were in 3rd stage of lactation.

Table 2.

Structure of experimental design

Bulls - A (i=1...a)	1 (i=1)				2 (i=2)				3 (i=3)				4 (i=4)			
Cows - C (k=1...c)	1 2 3 4 (c ₁ =4)				5 6...13 14 (c ₂ =10)				15 16...19 20 (c ₃ =6)				21 22...29 30 (c ₄ =10)			
LP - B (j=1...b)																
1 st (j=1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
2 nd (j=2)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
3 rd (j=3)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

The lysozym concentration in milk can be affected by genetic group, which we can identify as bulls and cows and change during lactation (time), as well the lysozyme concentrations increase with somatic cells count in milk.

Ly concentration in milk is dependent on the day of lactation – lactation phase (LP). Higher Ly concentration (0.12 to 0.84 mg/ml) has been found in colostrum (Pakkanen R., Aalto J., 1997) compare to milk produced in further lactation period (0.23 to 0.29 mg/ml). Götze (1977) has reported an increase in Ly concentration till the 13th week of lactation reaching the highest level in the 2nd to 4th months of lactation.

Results

As we can see from the table 2 there are three factors in experimental design, one of which is nested inside the other. Bulls are factor A and Cows factor C, factor C is nested within factor A and Lactation phase is factor B. There are three replications in each instance. Also note that factors A and B are crossed since each level of factor A appears with every level of factor B, factors B and C are crossed to.

First for model develops we include an overall constant and a main effect term for each factor, taking into account when one factor is nested within another. As well in the model include all interaction terms and the error term, which is nested within all factors.

$$Y_{ijk} = \mu_{...} + \alpha_i + \beta_j + \gamma_{k(i)} + \alpha\beta_{ij} + \beta\gamma_{jk(i)} + \varepsilon_{m(ijk)}$$

where:

$\mu_{...}$ - overall mean

α_i - the fixed bull effects

β_j - the fixed lactation phase effects

$\gamma_{k(i)}$ - the random cow (within bull) effects

$\alpha\beta_{ij}$ - the fixed bull * lactation phase interaction effects

$\beta\gamma_{jk(i)}$ - the fixed lactation phase * cow interaction effects (within bull)

$\varepsilon_{m(ijk)}$ - the error terms

$i=1...4; j=1...3; k=1...30; m=1...259$

Analysis of factors by forward methods shows the different influence of factors to traits by using different trial number (Table 3).

Table 3.

Mixed model analysis (forward methods)					
Source	Sig.	Sig.	Sig.	Sig.	Sig.
Genetic group [A]	0,000	0,728	0,683	0,289	0,091
Lactation phase [B]		0,000	0,000	0,000	0,000
Cows (Genetic group) [C(A)]			0,000	0,000	0,000
A*B				0,013	0,000
B* C(A)					0,000
Residual estimate	0,015 ±0,0014	0,014 ±0,0013	0,009 ±0,0009	0,009 ±0,0008	0,004 ±0,0004

Dependent Variable: lizocyme concentration.

Genetic group was the main factor which influence we will estimation during investigation. As we can see from the table 3 if lysozyme concentration in milk was analysed by full model $Y_{ijk} = \mu_{...} + \alpha_i + \beta_j + \gamma_{k(i)} + \alpha\beta_{ij} + \beta\gamma_{jk(i)} + \varepsilon_{m(ijk)}$, the genetic group effect is significant.

Usually, the treatments are in primary interest, and the other treatments are chiefly means for reducing experimental error variability.

Phase of lactation ($p < 0.001$) is the factor, which significantly affected changes in bovine milk Ly concentration. Data obtained in studies of the German researchers (Götze, 1977) give evidence that high Ly concentration is found in colostrum and its maximum is reached from the 2nd to the 4th month of lactation.

Conclusions

The development of experimental design for real data is the most important task in research. The PhD students should analyze the problem before data collection, because this process depends on the experimental design model. The correct model allows evaluating factors significance as well using appropriate statistical programs for data analysis.

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TEACHING MATHEMATICS USING TI-89

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Abstract

The development of computers has increased the importance of mathematics in applications. On the same time, the teaching of mathematics in University has become more difficult and students are losing motivation to learn mathematics. Since mathematics exam is no longer compulsory, many students incline toward the easy option and concentrate more on the study of humanities. Maths studies are kept to the bare minimum. Learning mathematics requires a lot of calculations and other technical work. This could be done with help of calculators, and therefore, enabling to concentrate on the problem solving. For this purpose, we have used the graphing calculator TI-89 by Texas Instrument. Essentially, TI-89 is a special purpose programmable microcomputer for mathematical tasks. Compared with other graphing calculators (including other versions of TI), TI-89 has several features which make it more suitable in the mathematics teaching context. The main difference from most other graphing calculators is its computer algebra system, which allows symbolic manipulation of algebraic expressions. For example, equations can be solved in terms of variables, it has support for symbolic differentiation and integration, etc. Secondly, the programming language of TI-89 is simpler and much easier to learn than that of TI-92. Finally, TI-89 is supported by the simulation software Virtual TI, which allows to prepare and show presentations using PC and data projector. This makes possible to make classroom demonstrations about practical usage of the calculator. In this paper we consider several kinds of mathematics exercises which can be solved using TI-89 calculator.

Key words System of linear equations. Matrix. Vector. Differentiation. Integration.

TEACHING MATHEMATICS WITH WEB 2.0

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During presentation we would like to share our experience of using Web 2.0 to teach mathematics. Special attention has to be played to the fact that with the use of web 2.0 technologies students can work together on assignments online. In our experience we can say that this way, organised student work enhances the interest in the subject and achievement respectively. Working together online, students also acquire the skills of collaborative group work and learn to correctly formulate the questions in the event of problematic situations. In this paper we will share our experience of using a blog to teach mathematics and explain why we decided to create one. We will also give examples of additional web tools and services which were used to increase interactivity of the educational blog (DabbleBoard, WebAsyst, Google Docs, Gadgets, Widgets, Forums and so on).

Web 2.0, Blog, Google Docs, Interactive Whiteboard

Nowadays a large number of people are using Internet: reading news, searching for useful information from different websites and so on. Teachers also have their own personal websites, where students can find set of materials, but in this case students are mostly passive readers/users (so commonly teachers' website is Web 1.0 instrument). But for the teacher there is very important students' feedback and collaborative work between students and teacher. That is why many teachers are moving from personal websites to blogs (which is Web 2.0 instrument). Most of us have, at least to some extent, had experienced with a weblog or blog. In principle a weblog is a website where an individual can add entries. Entries are commonly presented in a reverse-chronological order and they may contain presentations, drawings or for example, videos. A weblog can also be maintained by several individuals and it is also possible to comment on the posts. A weblog can either be available for the general public or a certain community. Millions of people have created their own blogs and blogging has gradually arrived at Estonian schools where weblogs are used for several purposes.

As for us the first idea to create a weblog sprang up after a conference "E-study is already here, where are you?" held at Estonian IT College. As Marina works as an information manager in Tallinn High School of Technology she decided to create a weblog, a purpose of which would be the information exchange within the school. At the same time we have often experienced that communicating with our students at lessons only is not sufficient. Therefore we have used the Internet as an additional means of communication. We have uploaded various tasks, worksheets and materials for revision, whereas feedback has taken place via e-mail. We felt that we were able to offer our students a lot more than we managed to do merely at the lesson or during our consulting hours.

While talking to our students we realised that very few of them have a chance to turn to anyone for help in the case of troubles relating to maths. This situation often results in homework not done as soon as the first problems crop up. This is the main reason why we decided to create a fully interactive maths teaching weblog with an active participation by the students. As a great help to do so we acquired a lot of positive emotion and exciting ideas at a conference "From Teacher to Teacher" held at the end of October 2008 at Tallinn Secondary Science School. This is how the weblog titled "All Maths Fans Unite!" came into being (Figure 1, Figure 2.).

As due to the students' wish the particular weblog is not available for the general public we would like to give an overview of its structure. The left-hand area contains posts on different matters including the information about homework, tips for tests, various presentations, problems solved by ourselves, training videos, etc. The right-hand area comprises various study materials, useful links, chat widget, links to online whiteboards (Dabbleboard), online documents (Google Documents) and online file storages (WebAsyst), two calculators the graphic calculator of which enables to draw graphs of functions directly on the weblog.

In the section above one can find the archives of the blog and the form for posing questions (Figure 1.). Somewhat later we also added a feedback form via which the students have expressed their opinion about our blog and proposed ideas for its improvement. As soon as a student via the designated feedback form has expressed that he or she has trouble with some problem, the teacher involved gets a corresponding message to his or her personal e-mail. As our personal mailbox is almost constantly open we are able to react to our students' queries in no time. But from our experience we can say that a lot of students tend to be active at very late hours when the teacher is going/has gone to bed.



Figure 1.

On Figure 1 we can see navigation list and forum widget (made with cbox, <http://www.cbox.ws/>). We added it, because often students want to discuss something which is not related to topics in posts.

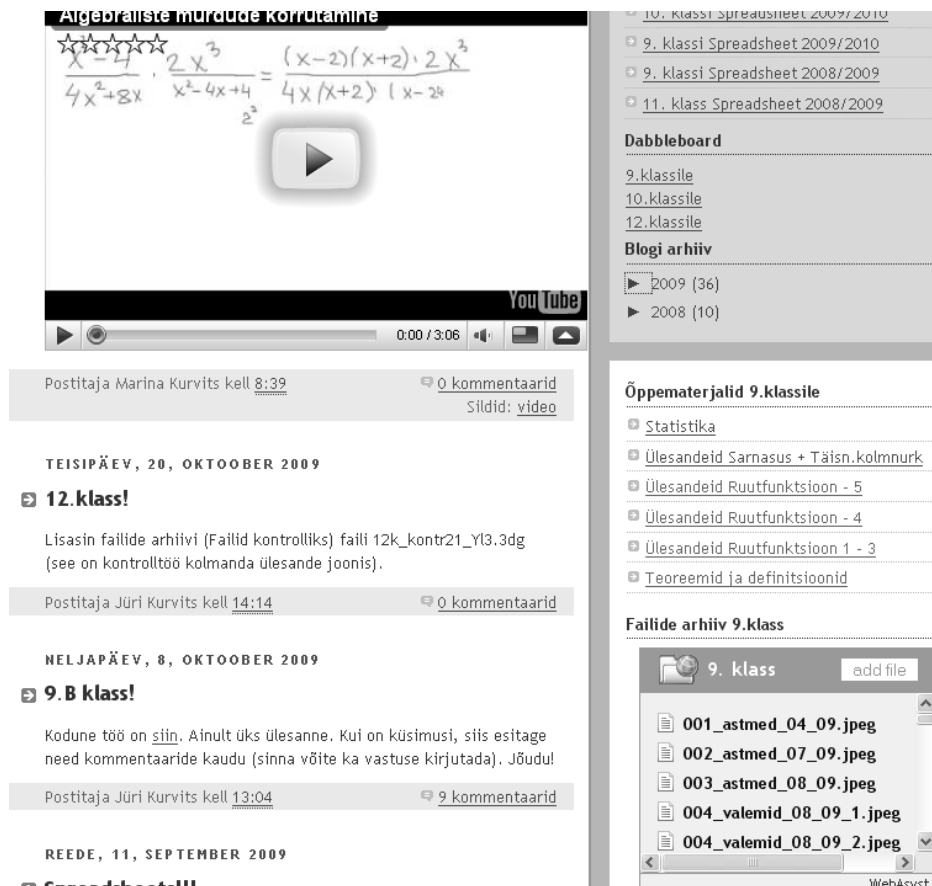


Figure 2.

Figure 2 shows that there are three links to online whiteboards (made with Dabbleboard, <http://dabbleboard.com/>). Teacher and student can write there at the same time and use it to communicate ideas. Also we made personal whiteboards to students who have a bad situation in mathematics and we are working with them individually (Figure 3), at the moment there are four students with personal link to the whiteboard.

Ütl. 6

$$\left(\frac{m}{m-n} - \frac{m}{m+n} + \frac{m^2+n^2}{m^2-n^2} \right) \cdot \frac{m-n}{m^2+2mn+n^2} =$$

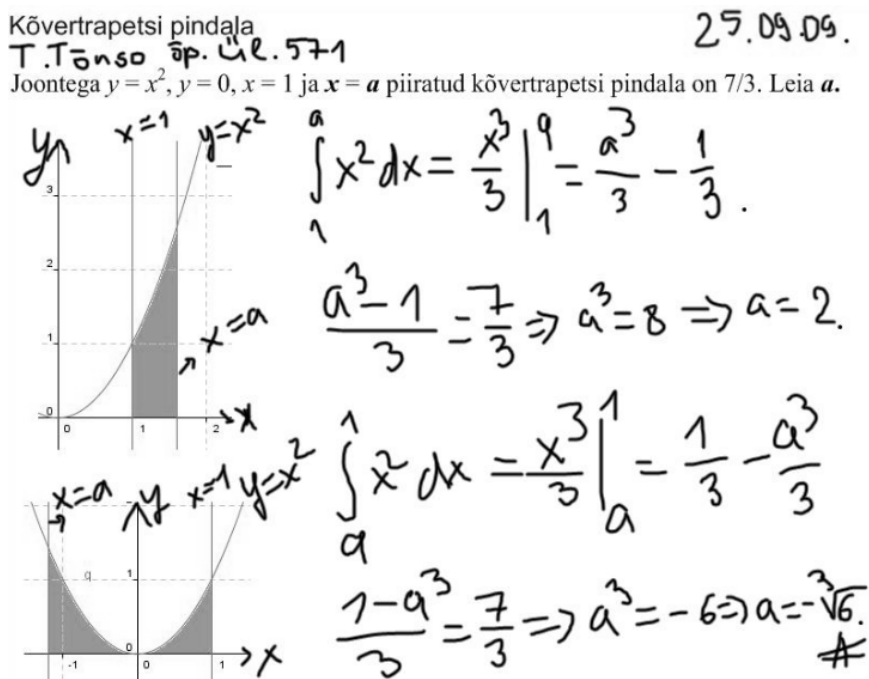
$$1. \left(\frac{m}{m-n} - \frac{m}{m+n} + \frac{(m+n)(m-n)}{(m+n)(m-n)} \right) = \frac{mn+mn}{(m+n)(m-n)}$$

$$= \frac{m^2+mn-m+mn+(m+n)(m-n)}{(m+n)(m-n)} = \frac{mn+mn+m^2+n^2}{(m+n)(m-n)}$$

Figure 3.

Also Figure 2 shows that the right-hand section includes the archive of files (on current figure there is File Archive: Grade 9, in Estonian Failide arhiiv 9. klass). At present there are five of them: Practical Mathematics, Files with Problems from Students, File Archive: Grade 10, File Archive: Grade 12 and File Archive: Grade 9 (all archives are made with WebAsyst, <http://www.webasyst.net/>).

As our classrooms is equipped with an interactive SMART-board which enables to save all the texts and drawings in the form of images, we have after each lesson added a file to the archive to record all the tasks performed (so, all math lessons were recorded, for example see Figure 4). This has been appreciated by the students who, for some reason or other have missed a class and who, thanks to this opportunity are able to familiarise themselves with the jobs done.



Students have also an opportunity to make their own entries into the files (archive of files: Files with Problems from Students). Should a problem arise with solving a problem a student can always add an image of the page of

their notebook containing the troublesome problem as a separate file to the archive, which contains an alternative solution to the particular problem. When we open the file we can provide the students with useful tips or add another file containing an alternative solution to the problem.

Using these archives of files we have conducted tests which the students can take from home. The arrangement is as follows: at a fixed time the tasks appear in the weblog and by the next morning a corresponding file with solutions by the student is expected for the teacher to appear.

Any student has an opportunity to comment on the posts and sometimes vivid discussion can arise (up to 30 – 40 comments to a single post). A positive aspect of such exchange of comments is that through the discussion the students may find a solution to the tough problem on their own, without the teacher interfering them. The teacher, though, instantly receives an e-mail about a post by a student.

The school-leavers thus should presumably have a substantial experience of team-work and they are expected to have skills in both oral and written expression of their ideas. We have been trying to provoke our students to express themselves and their ideas at the lessons designed for such response. We often introduce a new topic avoiding to provide the students with already existing solutions or reading theorems to them. Instead we try to create a situation where students can reach the solution “on their own”. In this the materials added to the weblog have proved to be useful as these are easy to demonstrate by using the projector. While explaining new material we try to avoid any “pre-digested” solutions. A maths teacher cannot be just a lecturer and let the students be passive scribes. Maths does mean active brainwork. This consequently means an active dialogue between the student and the teacher. We as the teachers felt an urge to continue this dialogue after the formal lesson had finished.

We have always found it of ultimate importance that questions are asked at a lesson as, in our opinion, studying any subject without asking any questions seems impossible to us. But students are very different and some of them never ask questions in the class. In this situation our weblog offers help as it is possible for a student to turn to us individually or discuss problems with peers. From our own experience we can say that these students who seldom utter a word in the class during the whole week may be quite active commentators on-line. A reason may be the fact the web-based environment is natural and familiar to present-day students. It is easier for a student to open the weblog than to find a textbook on the bookshelf. It is also worth mentioning that not a single student has doubted whether to join the weblog. In fact we did not bother ourselves too much about what they had to do in order to join in, we just sent an invitation on each student's e-mail and they did the rest independently.

Having noticed the students' interest we decided to create one more option for interactive communication: files in Google documents environment, one for ninth-graders, one for tenth-graders and the other for twelfth-graders. These files are called Spreadsheet and they are very similar in shape to the Microsoft Excel files (Figure 5).

The screenshot shows a Google Spreadsheet with a math problem in Estonian. The problem asks for the area of a trapezoid given its perimeter and height. The spreadsheet contains the problem text, a table for calculations, and a chat window on the right with several messages.

A	B	C	D
NB!!!	Siia kirjutame ka vastuseid, küsimusi jne	Kui kirjutate siia midagi, siis see salvestatakse automaatselt!	Arge u saab "!
Ülesanne 1.	Leia koonuse täispindala kümnenäki täpsusega, kui telglike pindala on 168cm ² ja põhja ümbermõõt 44 cm.		
	Vastus:	Nimi:	Küsimus:
	Täispindala on 703,0 ruutsentimeetrit. St=703,7 cm ²	K	
		S, K	
		R, P	kas r or
	St=703,4 cm ²	M S	
	St=703,4cm ²	L P	
	St=703,4 cm ²	G O	
	St=703,5 cm ²	S S.	
	St=703,4cm ²		

Chat window messages:

- kristinlehtlaan: kindel?
- Gerbera14: aga kui ma 1.5ga labi korutasin mis siis tegema pean?
- kivikoll: akki arutad välja?
- 750 / 3 * pii = gramm?
- silu_101: 500/3*1.5*pii
- võ
- kivikoll: sama asi
- anette.arula: aga kuidas selle 5ga sii ikkagi jääb?
- kivikoll: mitu korda seletanud juba ju

Figure 5.

These files are on-line documents and they include tasks added by us. It is possible to write questions, answers, solutions to the tasks, etc. in the same file. Especially noteworthy is the possibility of chatting (in Figure 5 on the right-hand strip it can be seen that on the moment of taking this photo there were ten people working on this file). In fact we could not believe that the student would be able to collect that much material during a chat one night.

We have used the previously mentioned files for weekend tasks and some colleagues are surprised that students have starting to ask for additional homework.

In fact we have also used the Google documents environment also for tests (Figure 6), quizzes/polls, presentations, preparation of study materials. All study materials on our weblog are in Google documents environment. Google documents are constantly on-line and using them noticeably simplifies interactive group work. Users who have been given access to these documents by their authors can read or change them. Any changes can be seen immediately. This feature makes the use of these documents convenient for organising work in groups at the school's computer class.

Test - Trigonomeetrilised funktsioonid

Nimi *

Leia funktsiooni $y = \tan 0,1x$ periood. *

Leia funktsiooni $y = 2\sin 2x$ lokaalsed miinimumkohad, kui $0 < x < 2\pi$. *

Kas funktsioon $y = 2 + \cos 5x$ on paaris- või paaritu funktsioon? *

Paaritu funktsioon
 Paarisfunktsioon
 Kumbki

Kirjuta allolevasse kasti, kuidas visandaksid funktsiooni $y = -\sin(x - \pi) - 1$ graafiku? *

Joonisel 1. on kujutatud funktsiooni $y = 3\cos(x - 0,25\pi)$ graafik. Leia parameetrite a, b, c ja d väärtused. (joonist vaata siit: http://docs.google.com/Doc?id=d3gj9pw_209rrzq54fb) *

Figure 6

We have received a lot of positive comments as feedback. Students are satisfied and they hope that other teachers also start creating their own weblogs. Students were especially impressed by the fact that the only prerequisite to make use of the materials was connection to the Internet. Our students have pointed out that Google documents are ideal media for transmitting homework, as during the process of solving the problems they can discuss matters with other students or turn to the teacher. This has proved to be useful while preparing for tests. We should certainly say thank you to our students for their active and enthusiastic attitude towards the new study environment.

MATHEMATICS CURRICULUM DEVELOPMENT AT TECHNOLOGICAL UNIVERSITY

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Abstract

The purpose of teaching calculus at a technological university is concerned with the transmission of basic ideas of existing traditional 'mathematical culture', considered by mathematicians as crucial. The values of such traditional mathematics teaching approach are more social-cultural than practical. The rapid technological development had started to change society and its attitudes towards education. This process is causing urgent needs to change the education environment, both at school and university. The mathematics is very much touched by this process. There exist a gap between mathematics offered by mathematics departments of technical universities and mathematics needed to educate a modern engineer. Shift of the teaching-learning paradigm is a necessity.

Our challenge is to find synthesis of different attitudes towards mathematics teaching. The purpose is to move away from mathematics as an isolated subject. Mathematics must be integrated into the study. For that purpose the dialogue between mathematicians and engineers is needed. In order to save all rational in current attitudes we must investigate mathematical culture of engineering. The other important issue: We know that in increasingly more countries the descent in the mathematical ability of new entrants to the university degree programmes is a major problem of organizing adequate teaching process. Consequently, a productive dialogue between mathematics teachers at school and university would be needed. The study of educational innovations has become increasingly important. It must lead to new didactics, with its own characteristics and teaching possibilities, different from the traditional way of teaching offered by mathematicians now.

Classifications: MESC D35; AMS2000 97D30

THE PROBLEM OF FINITE GENERATED BI-IDEAL EQUALITY AND PERIODICITY

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Abstract

This thesis analyses finite, generated bi-ideals from given generating systems $\langle u_0, \dots, u_{n-1} \rangle$ and $\langle u'_0, \dots, u'_{m-1} \rangle$, investigating the case when all words u_i are of equal length, whereas all words u'_j are also of equal, but different length than u_i . A relation between such different bi-ideals is found as follows:

$$a/2 * |v_i| = b/3 * |v_i| + b/3 * |v_{i-1}| + a * b/6.$$

*This relation for two different bi-ideals compares respective letters of these bi-ideals and thus the problem concerning such bi-ideal equality is investigated. The solutions of this problem's special cases are given in this paper and it substantially not only uses relation $a/2 * |v_i| = b/3 * |v_i| + b/3 * |v_{i-1}| + a * b/6$, but also some verities from number theory.*

Keywords: *bi-ideals, periodicity, word input.*

Introduction

Combinatorics on word is a discrete mathematics discipline, which investigates finite or infinite symbol strings that are generated from a particular alphabet A . The basic principles and definitions of this theory are given in [1], [2] un [3]. Some of definitions are taken from unpublished material by A.Lorencs. One of the fundamental problems in this field is the following: let's assume that 2 generating word systems $\langle u_0, \dots, u_{m-1} \rangle$ and $\langle u'_0, \dots, u'_{n-1} \rangle$, which generate bi-ideals x and y , are given. If both of these systems generate the same word, is the word periodical? Solution of this problem might be useful in such fields as biology, medicine and cryptography. This article examines a specific case of the above mentioned problem, when words generated by the first system are all of equal length, but those generated by the second system – also of equal, but different length than that of the words generated by the first system. Several word and bi-ideal properties, as well as verities from number theory are used to find the solution. Solution of the problem in a general case remains to be found.

Basic definitions

Let $A = \{a_0, \dots, a_k\}$ be a finite set usually called the *alphabet*. Element cortege (u_0, u_1, \dots, u_n) of a set A is called *finite word* and is denoted $u = u_0u_1\dots u_n$. A set of finite nonempty words will be denoted A^+ .

Definition 1. Number $n+1$ is called the *length* of finite word $u = u_0u_1\dots u_n$ and is denoted $|u| = n + 1$.

Word u can be *empty* and it is denoted as ε . The length of an empty word by definition is equal 0 or $|\varepsilon| = 0$.

Definition 2. Everywhere defined representation $x : N \rightarrow A$ is called *infinite word*. A set of all infinite words is denoted A^ω .

Definition 3. Infinite word $x \in A^\omega$ is called *periodic* if it is of the form $x = z^\omega$ for some $z \in A^+$. A word $x \in A^\omega$ is *eventually periodic* if it is of the form $x = yz^\omega$ for some $y, z \in A^+$. The length of y is called *pre-period*, but the length of z is called *period*.

Example 1. Suppose $x = abcdecde\dots = ab(cde)^\omega$ is infinite word. Then it has pre-period 2 and period 3.

Suppose we have infinite sequence of finite words $\{u_i\}_{i \in N}$, and u_0 is not empty. Let defined sequence of words $\{v_i\}_{i \in N}$ inductive in this way:

$$v_0 = u_0,$$

$$v_{i+1} = v_i u_{i+1} v_i.$$

Definition 4. The limit of this sequence $x = \lim_{i \rightarrow \infty} v_i$ is called *bi-ideal*.

Definition 5. Bi-ideal x is called *finite generated bi-ideal*, if sequence $\{u_i\}_{i \in \mathbb{N}}$ is periodic. It means, there exists such natural number m , that $u_{i+m} = u_i$. In this case, it is said that cortege $\langle u_0, \dots, u_{m-1} \rangle$ generated this bi-ideal x .

Definition 6. Suppose bi-ideal x is finite generated by cortege $\langle u_0, \dots, u_{m-1} \rangle$ and bi-ideal y is finite generated by cortege $\langle u'_0, \dots, u'_{n-1} \rangle$. If $|u_i| = a, \forall i \in 0..m-1$ and $|u'_j| = b, \forall j \in 0..n-1$ then this pair of bi-ideals (x, y) is called an $(a-b)$ *bi-ideal pair*.

Results and discussion

For all results it is assumed that every word from generating system $\langle u_0, \dots, u_{n-1} \rangle$ is of equal length a , whereas every word from generating system $\langle u'_0, \dots, u'_{m-1} \rangle$ is also of equal, but different length than u_i , denoted b .

Lemma 1. $\frac{a}{2}|v'_i| = \frac{b}{3}|v_i| + \frac{b}{3}|v_{i-1}| + \frac{ab}{6}$.

Proof. \Leftrightarrow . To prove this equality mathematical induction will be used. The base for induction $i=2$ is used. Then $|v_2| = 7b$, but $|v'_2| = 7a$ and $|v'_1| = 3a$. Substituting in equality, we get $\frac{a}{2}7b = \frac{b}{3}7a + \frac{b}{3}3a + \frac{ab}{6}$ and this holds true. The inductive step is done next. Suppose that equality is true for $i=n$. It is known that $|v'_{i+1}| = 2|v'_i| + b$. Therefore $\frac{a}{2}|v'_{i+1}| = \frac{a}{2}(2|v'_i| + b) = 2(\frac{b}{3}|v_i| + \frac{b}{3}|v_{i-1}| + \frac{ab}{6}) + \frac{ab}{2} = \frac{b}{3}(2|v_i| + 2|v_{i-1}| + a + a + \frac{a}{2})$.

Since $|v_{i+1}| = 2|v_i| + a$ and $|v_i| = 2|v_{i-1}| + a$, it follows $\frac{a}{2}|v'_i| = \frac{b}{3}|v_i| + \frac{b}{3}|v_{i-1}| + \frac{ab}{6}$. The inductive step has been made and Lemma has been proven. Δ

For further results some assumptions from number theory are used.

Theorem 1. If $x_1, x_2 \dots x_m$ is complete residue system by divider m and $\gcd(u, m) = 1$, then ux_1, ux_2, \dots, ux_m is complete residue system by divider m too.

Theorem 2. Suppose cortege $\langle u_0, \dots, u_{n-1} \rangle$ generates bi-ideal $x = \lim_{i \rightarrow \infty} v_i$ and cortege $\langle u'_0, \dots, u'_{m-1} \rangle$ generates bi-ideal $y = \lim_{i \rightarrow \infty} v'_i$. If (x, y) is $(5-3)$ bi-ideal pair, $\lim_{i \rightarrow \infty} v_i = \lim_{i \rightarrow \infty} v'_i$ and $\gcd(m, n) = 1$, then x is periodic word.

Proof. At first generating system $\langle u_0, \dots, u_{n-1} \rangle$ is denoted as:

$$\begin{aligned} u_0 &= d_0 e_0 f_0 g_0 h_0 \\ u_1 &= d_1 e_1 f_1 g_1 h_1 \\ &\dots \\ u_{n-1} &= d_{n-1} e_{n-1} f_{n-1} g_{n-1} h_{n-1} \end{aligned}$$

But generating system $\langle u'_0, \dots, u'_{m-1} \rangle$ is denoted as follows:

$$\begin{aligned} u'_0 &= a_0 b_0 c_0 \\ &\dots \\ u'_{m-1} &= a_{m-1} b_{m-1} c_{m-1} \end{aligned}$$

Now let's see how length of u'_i and u_i change:

$$\begin{array}{ll}
 |v_0| = 5 & |v'_0| = 3 \\
 |v_1| = 15 & |v'_1| = 9 \\
 |v_2| = 35 & |v'_2| = 21 \\
 \dots & \dots \\
 |v_i| = 2 * |v_{i-1}| + 5 & |v'_i| = 2 * |v'_{i-1}| + 3 \\
 \dots & \dots
 \end{array}
 \tag{1} \qquad \tag{2}$$

If we look at sequences (1) and (2), it is noticed that $|v'_i| = |v_i| - |v_{i-1}| + |v_{i-4}| + |v'_{i-4}| + 5$.

Lemma 2. $|v'_i| = |v_i| - |v_{i-1}| + |v_{i-4}| + |v'_{i-4}| + 5$.

Proof. From Lemma 1 it is known that $|v'_i| = \frac{2}{5}|v_i| + \frac{2}{5}|v_{i-1}| + 1$. If we substitute into $|v'_i|$ and $|v'_{i-4}|$, then $\frac{2}{5}|v_i| + \frac{2}{5}|v_{i-1}| + 1 = |v_i| - |v_{i-1}| + |v_{i-4}| + \frac{2}{5}|v_{i-4}| + \frac{2}{5}|v_{i-5}| + 1 + 5$. As $|v_k| = 2|v_{k-1}| + 5$, and we can reduce this equation until length of words v_{i-5} , i.e. $|v_{i-5}|$. Thus we get $\frac{96}{5}|v_{i-5}| + 93 = 16|v_{i-5}| + \frac{16}{5}|v_{i-5}| + 93$ and both sides of this equation are equal so Lemma has been proven. Δ

Finally, five very important conclusions:

Conclusion 1. $|v'_i| - |v'_{i-4}| - 2 = |v_i| - |v_{i-1}| + |v_{i-4}| + 3$.

Conclusion 2. $|v'_i| - |v'_{i-4}| - 1 = |v_i| - |v_{i-1}| + |v_{i-4}| + 4$.

Conclusion 3. $|v'_i| - |v'_{i-4}| = |v_i| - |v_{i-1}| + |v_{i-4}| + 5$.

Conclusion 4. $|v'_i| - |v'_{i-4}| - 3 = |v_i| - |v_{i-1}| + |v_{i-4}| + 2$.

Conclusion 5. $|v'_i| - |v'_{i-4}| - 4 = |v_i| - |v_{i-1}| + |v_{i-4}| + 1$.

Let's compare inputs $v'_i [|v'_i| - |v'_{i-4}| - 2]$ and $v_i [|v_i| - |v_{i-1}| + |v_{i-4}| + 3]$ by variable index. It can be done easier, if we look at words v'_i and v_i graphically in Figure 1:

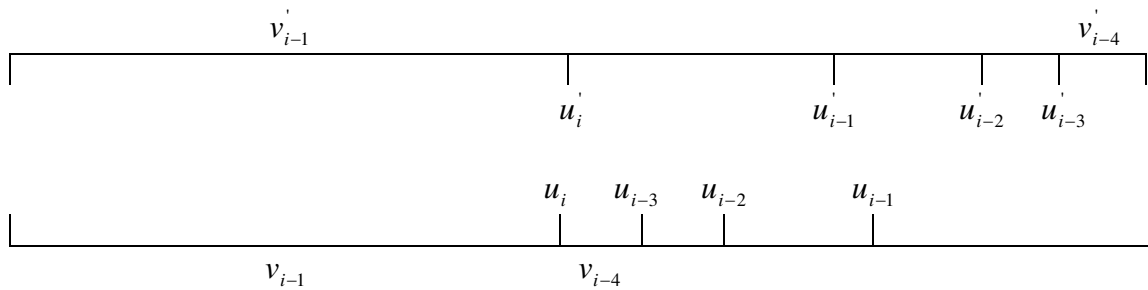


Figure 1

From Conclusion 1 we know that these inputs have to be equal. It is easy to see that for word v'_i in this input always will be character $u'_{i-3}[1]$, but for word v_i respectively - character $u_{i-3}[3]$. Let's view 2 sequences:

$$u_0[3], u_1[3], \dots, u_{n-1}[3], u_0[3], u_1[3], \dots \tag{3}$$

$$u'_0[1], u'_1[1], \dots, u'_{n-1}[1], u'_n[1], u'_{n+1}[1], \dots \tag{4}$$

These sequences will be denoted as follows:

$$W_0, W_1, \dots, W_{n-1}, W_n, W_{n+1}, \dots, W_{2n}, \dots, W_{(m-1)n}, \dots$$

$$W'_0, W'_1, \dots, W'_{n-1}, W'_n, W'_{n+1}, \dots, W'_{2n}, \dots, W'_{(m-1)n}, \dots$$

Now we will compare both sequences at $0, n, 2n, \dots, (m-1)n$ positions. Obviously in all those positions for sequence (3) there will be the same element $u_0[3]$. But for sequence (4) in all those positions elements will be with different index. It known that $0, 1, \dots, m-1$ is a complete residue system by divider m . As $\gcd(m, n) = 1$ from given, then from Theorem 1 it follows that $0, n, 2n, \dots, (m-1)n$ is also a complete residue system by divider m . It means that all indexes for $u^i[1]$ will be different in corresponding positions $0, n, 2n, \dots, (m-1)n$. To explain more precisely, let's look at residues $i = j(\text{mod } m)$, where for j we take all positions of $0, n, 2n, \dots, (m-1)n$. From each of those equalities we get that $u_0[3] = u_i^i[1]$. As $0, n, \dots, (m-1)n$ is a complete residue system by divider m , then in each of these positions index i will be different. Therefore $u_0[3]$ will be equalent with all $u_i^i[1]$. Now we got that $u_0[3] = u_0^i[1] = \dots = u_{m-1}^i[1]$ but from this follows that $u_0[3] = \dots = u_{n-1}[3] = u_0^i[1] = \dots = u_{m-1}^i[1]$. Similarly from conclusion 2, it follows that $u_0[4] = u_1[4] = \dots = u_{n-1}[4] = u_0^i[2] = u_1^i[2] = \dots = u_{m-1}^i[2]$ and from conclusion 3 it follows that $u_0[5] = u_1[5] = \dots = u_{n-1}[5] = u_0^i[3] = u_1^i[3] = \dots = u_{m-1}^i[3]$. Thus words from generating systems $\langle u_0, \dots, u_{n-1} \rangle$ and $\langle u_0^i, \dots, u_{m-1}^i \rangle$ are in the following forms:

$$\begin{array}{ll} u_0^i = abc & u_0 = d_0 e_0 abc \\ u_1^i = abc & u_1 = d_1 e_1 abc \\ \dots & \dots \\ u_{m-1}^i = abc & u_{n-1} = d_{n-1} e_{n-1} abc \end{array}$$

Now v and v^i inputs $v_i^i[|v_i^i| - |v_{i-4}^i| - 3]$ and $v_i[|v_i| - |v_{i-1}| + |v_{i-4}| + 2]$ for variable index are compared. From conclusion 4 it can be seen that these inputs have to be equal. Obviously for word v_i^i in this input always will be character $v_{i-4}^i[|v_{i-4}^i|] = u_0^i[3] = c$, but for word v_i respectively – character $u_{i-3}[2]$. It follows that $u_0[2] = u_1[2] = \dots = u_{n-1}[2] = c$. At last v and v^i inputs $v_i^i[|v_i^i| - |v_{i-4}^i| - 4]$ and $v_i[|v_i| - |v_{i-1}| + |v_{i-4}| + 1]$ for variable index are compared. From Conclusion 5 it can be seen that these inputs must be equal. Obviously for word v_i^i in this input always will be character $v_{i-4}^i[|v_{i-4}^i| - 1] = u_0^i[3] = b$, but for word v_i respectively character $u_{i-3}[1]$. It follows that $u_0[1] = u_1[1] = \dots = u_{n-1}[1] = b$. Therefore words from generating systems $\langle u_0, \dots, u_{n-1} \rangle$ and $\langle u_0^i, \dots, u_{m-1}^i \rangle$ are in following forms:

$$\begin{array}{ll} u_0^i = abc & u_0 = bcabc \\ u_1^i = abc & u_1 = bcabc \\ \dots & \dots \\ u_{m-1}^i = abc & u_{n-1} = bcabc \end{array}$$

As $u_0^i[1] = u_0[1]$ and $u_0^i[2] = u_0[2]$, then $a = b = c$ and all words of generating systems $\langle u_0, \dots, u_{n-1} \rangle$ and $\langle u_0^i, \dots, u_{m-1}^i \rangle$ must consist of one and only one character a . It means that all characters of bi-ideal x are the same and this bi-ideal is periodic with period 1. Δ

Conclusions

Although solution of the problem in a general case remains to be found, the formula that is found and proven in the article could serve as key for further analysis, as it links the relation for general finite, generated word lengths

a and b . We can prove with help of formula $a/2 * |v_i| = b/3 * |v_i| + b/3 * |v_{i-1}| + a * b/6$ special cases which are not mentioned in this article like for $(2-3)$ bi-ideal pair, $(3-8)$ bi-ideal pair, $(5-7)$ bi-ideal pair and others. Intuitive it seems that this problem has positive solution in general case and that could be the next task to get it.

Acknowledgements

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THE USAGE OF ORTUS WEB SITE IN THE RTU STUDIES OF MATHEMATICS

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Introduction

Nowadays, with the increasing amount of technologies, the demand for qualified specialists which could act rapidly with the latest scientific developments, modern technologies and materials, as well as create qualitative global business – has increased too. Thus universities nowadays have to be ready to provide its students with such an education which could be competitive in the present environment and would develop the level of competences.

Reacting to these rapid changes the higher educational establishments of Latvia are improving their study programs, improve the quality of studies by updating the system of education, thus significantly improving the basis for the acquirement of modern knowledge and qualifications.

The draft law of the higher education paragraph 3 of Article 1 states:

The higher education – the level of education after the secondary level and the process in which students obtain intellectual maturity level in their chosen fields, which provides with the opportunity to think independently, to be aware of the limited characteristics of knowledge and to obtain the skill to use the knowledge in practical spheres accordingly to their qualifications, knowledge, skills and competences certified in the degree.

In order to raise the student's accountability for the study process and facilitate the ability for independent learning it is of a paramount importance to create intrinsic environment for self-motivated studies. Meaning, the students themselves are involved in setting their enabling objectives, plan the study process, presentations, as well as evaluate their work and together with course mates and lecturers agree on the final assessment. (Lamb, T.E., 2008)

Consequently, the self-motivated studies are defined as the student's active participation in the creation of the study plan, as well as in the acquirement of knowledge and skill and the assessment of their own results. (Gibbon, M, 2009).

It takes more understanding from the student of the study process, expected results, self-evaluation skills, determination, intrinsic motivation and responsibility. Everyone has to be able to analyze his/her own input in the creation of the process and determine his/her own stumbling blocks which blocked the way for the development.

Materials and Methods

A great assistance for the student's self-motivated studies is e-learning.

E-learning is an essential stream in transformation of society to so-called „information society“. Nowadays it becomes an easily available and effective education tool. In engineers education it is widely spread, at least as a progressive support of traditional education. Many authors have been interested in its efficiency and in its particularities distinguishing it from traditional education. They say less about the teachers' readiness for their working in e-learning.

The e-learning started through conversion of study texts into electronic form that brought their easy transfer and simplified retrieval of their content. This form, however, wasn't fully achieving the potential of e-learning. These days, it is far more dynamic and interactive, provides greater flexibility, modularity and many other advantages. Newer e-learning study materials use the multimedia content more extensively bringing a whole range of advantages. It makes the receiving of new information more simple, easy and comfortable and prolongs its storage in our memory. E-learning could be understood as a way of teaching, acquiring information, knowledge and skills using modern information and communication technologies.

The introduction of e-studies in the higher educational establishments does not mean only the creation of data basis which provides access to materials (Kellner, D., 2001) It also requires the organization of new teaching forms as well as a new way of assessing the acquired level of knowledge. (see Figure 1) The most important changes are regarding the reorganization of administration. It requires a new approach in task performance monitoring, as well as a new approach to final assessments and the issuing of certificates.

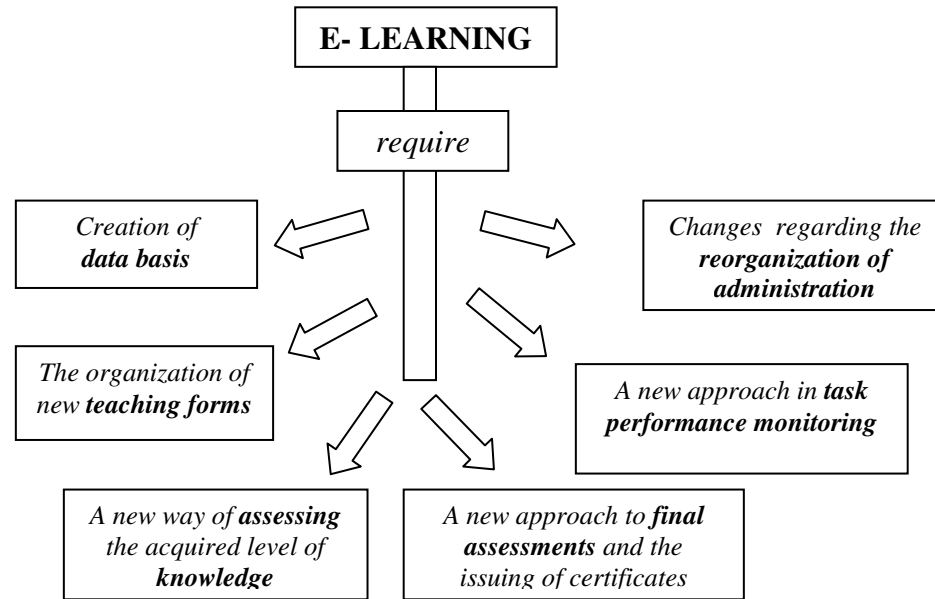


Figure 1. The introduction of e-learning in the study process of the higher educational establishments.

Well-structured e-learning system has 8 key functions (Rosenberg, M. J., 2001):

- e-learning community in the digital world, where computers are used as everyday tools for creative production;
- e-Centre for smart functions:
Extensive and accessible advanced collection of resources;
- enrichment:
For excellence in education to develop personality and to improve productive thinking skills (creative thinking; critical thinking, Creative Problem Solving (CPS), and Future Problem Solving). Research studies revealed that: children who employ the Internet spend 37% less time watching television and 16% more time with friends and family .
- e-Mentoring (*also known as: telementoring; virtual mentoring; iMentoring*):
E-mentoring is: a caring and structured relationship focuses on the needs of the mentored participants. It adds values to the lives of those involved, and uses advanced technology to connect people across time and/ or distance. It is seeking to help the gifted and talented to communicate with other individuals who are experts within a specific field.
- e-Guidance & Counseling:
How could we channel learners' curiosity and employ e-learning to help them grow intellectually, socially, and emotionally
- evaluation of the organizational components & structure:
We must answer to two important questions: „Why schools were not producing more creative persons?“ and “ Is there any correlation between traditional education and creative productiveness?“
- expertise & competences:
As well as talented to build the required competencies for: lifelong careers; e-businesses; e-buy; and e-pay; ...etc. It's“means:
 - * Ability to search, collect, and process (create, organize, distinguish relevant from irrelevant, subjective from objective, real from virtual) electronic information , data and concepts and to use them in a systematic way” (Geser, 2007).
 - * “Ability to use appropriate aids (presentations, graphs, charts, maps) to produce, present or understand complex information” (Geser, 2007).
 - *Ability to employ e-learning (including Virtual Learning Environments (VLEs) to develop, support and facilitate productive thinking skills (creative thinking, critical thinking, creative problem solving, and future problem solving) and attitudes.

- evolutions in content, strategies, teaching methods, evaluation, ...

SUGGESTIONS FOR TRANSITION TO SELF-MOTIVATED STUDIES (Gibbons, M., 2002)

- The introduction to the self-motivated process in **several study tasks**
- Self-planned study guidelines, **united creation of plan**
- Stimulate and teach for **self-reflection** and how to assess the process and the results
- The stimulation of independent thinking:
 - ✓ Formulate one's own judgments
 - ✓ Suggest one's own solutions for problems
 - ✓ Altering the content to question form

E-learning is learning (self-education, study) through electronic teaching tool, books, textbooks, that can be distributed in various ways and the educated can obtain study materials and information also by means of new information and communication technologies. At the same time, it is based on voluntary approach, consciousness, responsibility and ambitions of an individual student who is self-responsible for the selection of his study materials, the way he studies, his specialisation as well as the search for possibilities of obtaining a certificate for his knowledge. He himself states (programmes) the goals of his education and adapts them to his own needs, conditions, life rhythm and lifestyle. This shows how the centre of education and responsibility for results is being transferred to the student even more. This form of education plays an important role in life-long education process, E-learning can be also a part of an organized form of study (education, learning), for example distance learning as well as attendance form of study.

The advantages of e-learning

- The documents are accessible at all times and in all places where the internet access is available
- It is possible to use heterogeneous data forms in the creation of global information blocks
- Technologies are a motivator for learning because it provides with different tools for the acquirement of academical knowledge
- If a person is working it is possible to solve the conflict of time and place
- Individual pace of studying

The disadvantages of e-learning

- The role of individual differences in the acquisition of special skills using online environment study materials
- How to provide with qualitative distance education in e-learning environment, effectively develop the collaboration on the internet, develop new forms of guidelines.
- Students are not aware of the requirements in e-environment. Are not aware how to study, how to discuss, how to work with study plan and collaborate with lecturers.

Results and Discussion

During the period when in Latvia there is a discussion on the higher educational establishment's quality and its development Riga Technical university (RTU) commencing with 2007/2008 academical year has transitioned to RTU united e-learning system using RTU website ORTUS which is based on e-learning program MOODLE (Modular Object-Oriented Dynamic Learning Environment).

The main task of ORTUS (www.ortus.lv), web site is to provide support for the scientific and administrative processes by facilitating effective communication. The establishment of ORTUS web site is advantageous to the students, the administration as well as improves the inner communication of the university by providing the administration with the necessary feedback from the students.

ORTUS at the moment is the most modern, widest and the most multifunctional higher educational establishment website in Latvia. At the moment there are integrated several subsystems which provide with united access to RTU e-services, giving advantages to the students, the lecturers and the administration by improving the university's inner communication, as well as providing with the opportunity for the administration to receive feedback from the students. The lecturer of each subject provides his/her students with various ways of self-preparation for tests and examinations. On the website there are posted the home tasks, the solutions of tasks, lectures and tests and by comparing the completed tasks the students can assess their level of readiness in each particular subject and its final examinations. (see Fig.2)

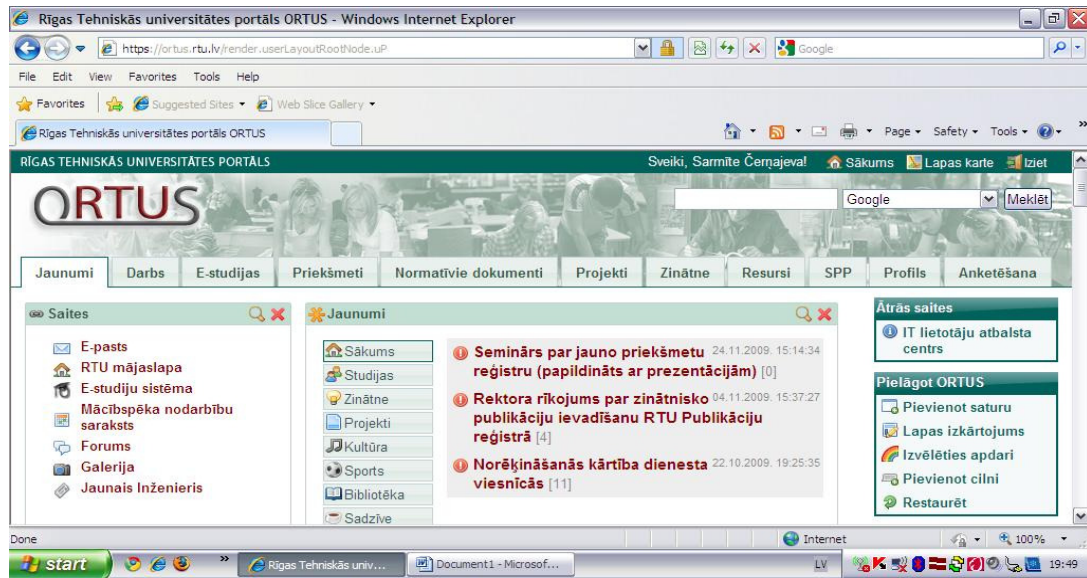


Figure 2. Riga Technical University ORTUS website

In the usage of the web site for the studies of mathematics it is essential to pay attention to the didactical aspects of the studies. Very important is the creation of the notes of the lectures and the suitable self-control tests. In the creation of the tasks, examples as well as the home tasks it is essential to set the difficulty level for each task and accordingly create the tasks by slowly increasing the difficulty level. It is also very important to create suitable marking scale system where would be included the motivation to attend the lectures and students could independently improve the knowledge of mathematics by using the given e-course. Thus it is of a paramount importance to create suitable 'blended learning' system where e-learning would rationally supplement the actual lectures

In order to clarify the student's opinion on the study work, the university has created a questionnaire system for the students in which the students evaluate each RTU subject's quality and the lecturer's work in the auditorium. This information allows objective assessment study methods, study materials, the work of lecturers and to initiate the necessary improvements. The forum of the website simultaneously provides the students with the answers to their questions and allows expressing their views on the topical questions in the study process, university administrative work, and politics and so on. Each day there are tens of new commentaries and in six month of its work there have been published and discussed a wide selection of topics and themes and now it has more than 5 thousand commentaries. At the moment ORTUS website provides the students with notice board and newspaper functions, giving information on topical events and activities in RTU. ORTUS provides the students with access to e-mails and RTU normative documentation. The students can find their study information (basic data, personal data, the history of orders, notices on payments) ORTUS website has got an integrated e-learning system (courses with the lecturer's study materials, current events, home tasks and a discussion space) ORTUS website is an integral part of RTU which is proven by a great number of visitors and with each year it is increasing. (see Fig. 3)

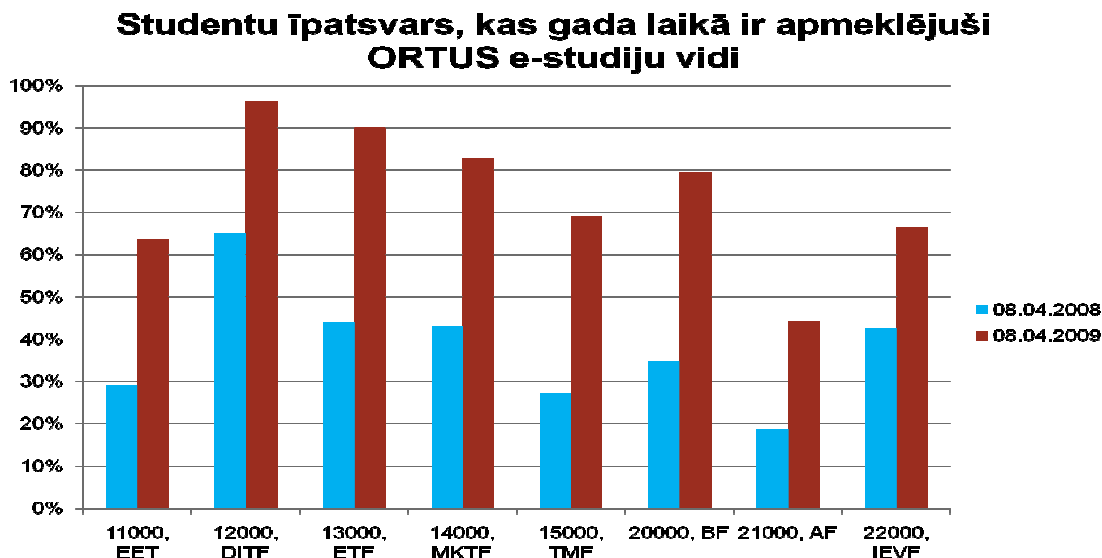


Figure 3. Student’s density of the yearly visits of ORTUS e-study environment. (Zitmanis Z., 2009).

The ORTUS environment is also widely used in the study process of Mathematics in RTU. Students have a chance to read the materials once again and to study separate tasks in their own way. In order to control the self-motivated studies there have been created theory self-control tests (found after each lecture) and task self-control tests (found after the examples of task performances). In ORTUS students also get the possibility for individual home tasks. Carrying out RTU student questionnaire it was discovered that the most popular areas are lectures (37%) and the examples of task performances (38%). (see Fig. 4). Only 14 % of students use the possibility of self-testing which shows on a rather low level of self-motivation.

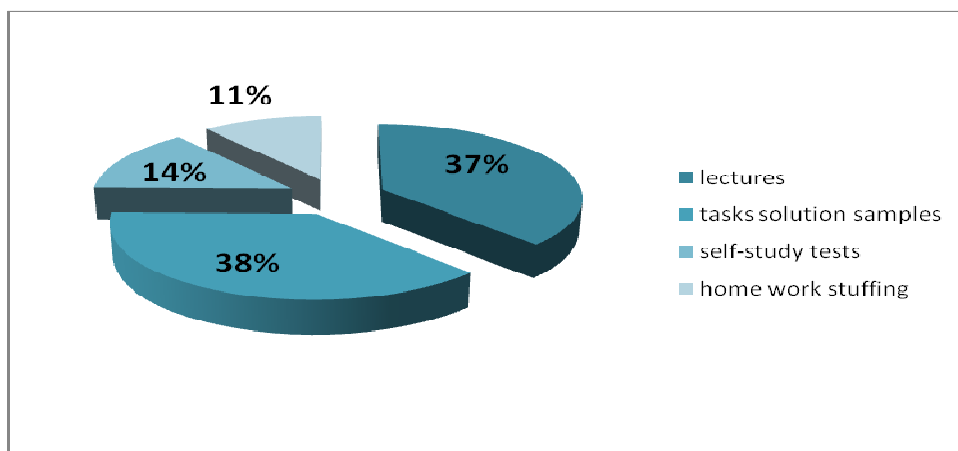


Figure 4. Types of ORTUS teaching materials used in the learning process

It’s evident also from the results of the questionnaire on student’s readiness of studying mathematics in e-environment. Only 11% are ready to study Mathematics in e-environment, 85% of students are not ready and 4% said that they would be ready to do so if it was the only way how to do it. (see Fig. 5).

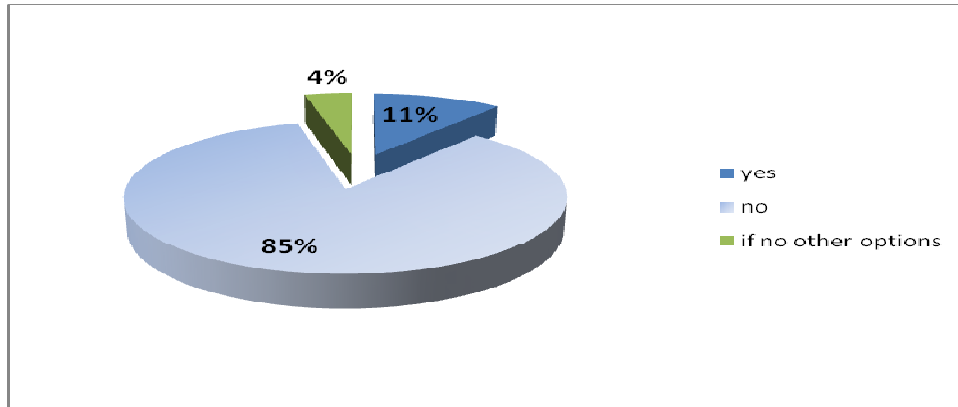


Figure 5. Students' willingness to study mathematics independently in the e-environment

The ORTUS environment is a good assistant in the study process of Mathematics – 92% of students gave a positive response (see Fig. 6) only 4% of students said that ORTUS materials do not help in the study process and 4% said that they do not use them at all.

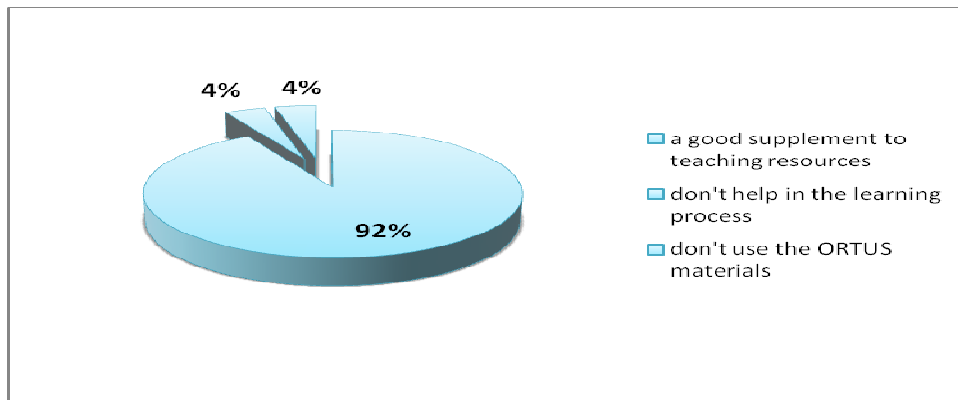


Figure 6. Students' views on the use of ORTUS material in Mathematics learning process at Riga Technical University

The fact that the ORTUS materials are used rather actively in the study process could be proven by the frequent visits of the website. (see Fig. 7) 9% of the students visit the website more than once a week and 70% of the respondents said that they visit the site at least once a week.

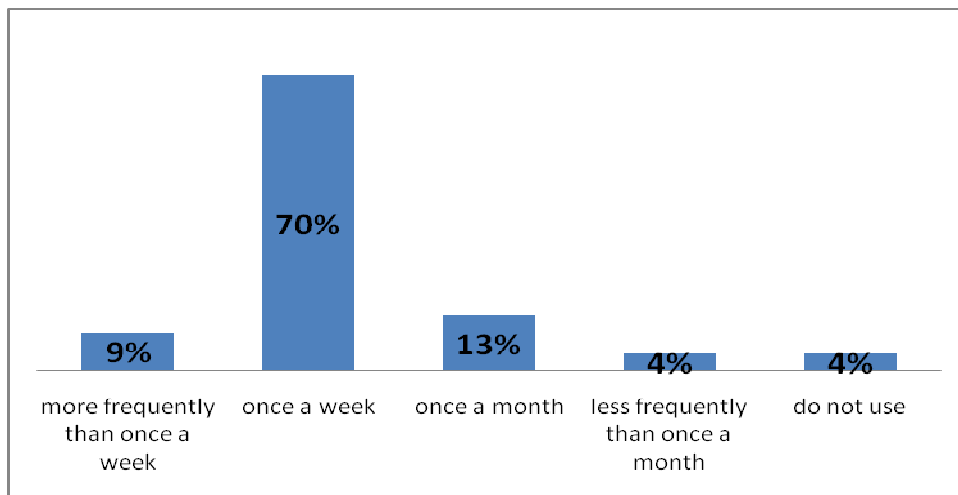


Figure 7. Frequency of use the ORTUS material in Mathematics learning process at Riga Technical University

Conclusion

ORTUS is an environment where the student has the access to all information of studies – schedule, the description of all subjects, the requirements for successful passing of examinations, study materials, access to

international data bases and so on. At the moment ORTUS website has 10 000 RTU visitors per week. It has to be mentioned that RTU IT office has received Latvian IT association prize 'Platina pele 2009' as well as pattern recognition for outstanding achievements in the development of RTU website ORTUS

In 8 January 2010 RTU presented a new website ORTUS for the students of the secondary level with the aim to develop a yet-to-be student's community group and allow them beforehand step into shoes of real students, to choose the right program where they could continue their studies after finishing high school. The website will support all the potential students no matter where they live – it will be a possibility to find out all the necessary information on RTU without going to the capital. In the website the students will receive free of charge the preparatory materials for their final examinations in Chemistry, Physics, Mathematics and the English language, as well as all the information on RTU study programs, preparatory courses, the entry requirements, the feedback from the present students and all the information which could be useful for the potential students. The secondary level students can also ask questions to students, lecturers and the staff of RTU.

The website will not be static. It is constantly going to be improved reacting to the needs and wants of the secondary level students: it will be updated with materials, tests, topical information and with time there will also be lecturers feedback on studies at RTU. It is also planned to organize mini-competitions with prizes (even a computer). At the moment there are 6000 users of the website.

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THE USE OF VIRTUAK ENVIRONMENT FOR LEARNING MATHEMATICS AND STATISTICS IN THE LITHUANIAN UNIVERSITY OF AGRICULTURE

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Abstract

E-learning has become an important part of the education agenda in the last decade. Virtual learning environments are more often applied in distance education when a teacher and a student meet seldom. However, such an environment could become a rather convenient means, supplementing and providing more variety to traditional learning environments.

The Blackboard Learning System Vista was applied for the teaching of the course Mathematics and Statistics for the first year students in the Faculty of Agronomy of Lithuanian University of Agriculture for several years. The students can find the material of lectures, practical tasks that have to be completed and self-control tests that check knowledge and skills acquired with the help of computer based tests.

The survey, carried out at the end of the course, indicated the fact that students evaluated such teaching method rather favorably; some of them had several difficulties caused due to malfunctioning of the internet connection sometimes. Still the majority of the respondents enumerated the possibility to study in one's convenient time as the greatest advantage.

Keywords: *e-learning, teaching, mathematics and statistics, virtual learning environment.*

Introduction

Both students' professional and general abilities are being developed and perfected in academic studies. The significance of mathematics and information technologies in public life and accessibility of higher education for a wide part of society require changes in purposes of mathematics teaching and implementation of new methods. The first year students while listening to teaching material do not dare ask during a lecture or notice their weak sides. It is relevant to help the first year students to develop their abilities to seek for information and analyze it, assess their achievements and teach how to learn. The proposition that teaching means to help students to learn can be accepted. Information technologies are being used more and more: specialized software, all-purpose spreadsheet, testing systems and virtual teaching environment. The benefits of e-learning have been discussed in many articles (Wang Z., Wang Y., Haggerty N., 2008, Lee B. Ch., Yoon J., Lee I., 2009, Paechter M., Maier B., Macher D., 2010) .

The development of e-learning is influenced by the progress of technical support, possibilities to teach and learn applying Internet technologies. In a period of perfecting virtual teaching systems such as Blackboard, WebCT, Moodle, etc., (Foster B., 2003, Gavalcova T., 2008, Dinov I., Sanchez J., Christou N., 2008) e-learning is becoming handy for a larger circle of lecturers and students. The following benefits are commonly emphasized:

- possibility to study teaching material and fulfil self-control tests at a desirable rate and in a good time;
- well-timed and flexible receiving of information;
- presenting and finding information from any place having Internet;
- operative presenting and receiving information about the results of studies.

However, larger possibilities of learning are related to certain inconveniences such as the lack of learning atmosphere, the necessity of self-discipline, poor contact with lecturers and school fellows. According to the opinion of Bouhnik and Marcus (2006), e-learning is less effective because it takes more time to decide what kind of teaching material to choose. Several studies indicated that students taking online learning courses have similar test scores as students in traditional classrooms. Abilities of first year students to learn independently are not strong and sometimes changed living and educational surroundings lessen the motivation of learning.

Virtual environment for learning Mathematics and Statistics in the Faculty of Agronomy of Lithuanian University of Agriculture has already been used for several years. The assessment of teaching course preparing and administrative experience as well as the investigation about students' needs and the pointview on applied teaching methods are significant in developing the process of teaching.

Discussion

Peculiarities in applying of virtual learning environment

Virtual learning environment (VLE) can be applied not only in remote teaching when a lecturer and a student meet only in virtual environment but also as aids helping to extend the possibilities of traditional teaching and learning.

Virtual environment for learning is comfortable for a lecturer because of:

- teaching materials can be easily corrected and administered;

- timetables and calendars can be managed presenting various reports about events, dates of reports and reminders;
- observing function enables to view students' interest in presented material and observe individual advancement;
- sufficient variety of control and computer-assisted assessment of knowledge;
- additional access to information can be pointed (possible internet reference to various e-literature);
- synchronous and asynchronous communication using chat rooms, forums and e-mail is possible.

Besides, the benefits of virtual environment for learning give support for students:

- learning material is accessible at any period of time;
- assessment for work is being received immediately;
- there is a possibility to ask a lecturer questions using internal e-mail or initiating a discussion on a problem.

Speaking about the disadvantages of the environment it is observed that structuring of a learning module; schoolwork and preparation of tests require lots of lecturer's time, suitable properties and experience. Moreover, some students have insufficient learning motivation and information how to work with information technologies. Sometimes interruption and technical problems of internet connection can interfere with effective practice.

Blackboard Learning System Vista is being used in learning mathematics and statistics course in the Lithuanian University of Agriculture. In Lithuania this learning system is used centrally among higher schools. The coordination centre of the Lithuanian Distance Education Network (LieDM) updates and manages the licenses.

Virtual learning environment for the course of Mathematics and Statistics has been applied in the Faculty of Agronomy since 2007/2008 school year. Therefore, having certain experience it is relevant to analyze the problems of applying Blackboard Learning System in students' learning and to discuss if such mode of learning is convenient and comfortable. Applying virtual learning system there is a possibility to carry out exhaustive analysis of students' activities, besides, a questionnaire form was practiced at the end of a school-year.

Analysis of learning mathematics and statistics applying VLE

Three course credits are appointed to learning mathematics and statistics in the Faculty of Agronomy of the Lithuanian University of Agriculture. Usually the students of agronomy speciality are not excellent at mathematics. In our opinion, such small amount of teaching hours is insufficient, because considerably many of them need additional consultations. Besides, the students of the first course have no experience to work self-independently; they do not dare ask during a lecture and do not know how to evaluate their lacunas in knowledge (activities). Virtual learning environment is not only a convenient mean of independent learning, but is also known as a measure to solidify students' knowledge. Consequently, Blackboard Learning System as additional teaching measure has been tried to implement.

During the first year of environment applying the students were given theoretical material, individual tasks, several tests of self-control and tests (definitions of linear algebra and statistics) and they were assessed by accumulative marks. The experience of the first year of learning has showed that such environment can be successfully used. During the second year of learning theoretical material was adjusted and supplemented as well as new tests (differential and integral calculation) were created.

124 students of the Faculty of Agriculture studied the subject 'Mathematics and Statistics' during spring semester in 2008-2009 school-year. They were connecting to virtual environment 3938 times during the semester. The most industrious student was connecting 209 times. Four students connected once. The average number of consumers was 31 a day. The duration of one session was 8 minutes. The students had 566 interlocutions. The messages in a discussion board were viewed 486 times though only 3 students participated actively. The records in a calendar were viewed 475 times and a bulletin board was reviewed 1133 times. Various tests were attempted to fulfil 2000 times.

Summarized data on the activeness of students' activities is presented in Table 1. Data show that students are mostly active during June – it means before an examination – they networked 50 times a day on the average, while the number of connections during other months was twice less.

Table 1. Activeness of students' activities

User sessions	February	March	April	May	June
Total	691	884	646	871	846
Average user sessions per day	28	29	22	27	50
Average user sessions per day on weekdays	31	32	23	33	59
Average user sessions per day on weekends	19	19	17	14	21

There were several self-tests presented in the Blackboard system, and students dealing with them could see correct answers. For example, the test in arithmetic was designed to repeat simple rules of sums. However, they used the possibility of self-control insufficiently (Figure 1). For example, the test on integral calculus was carried out only 8 times, though this subject was the most difficult for them.

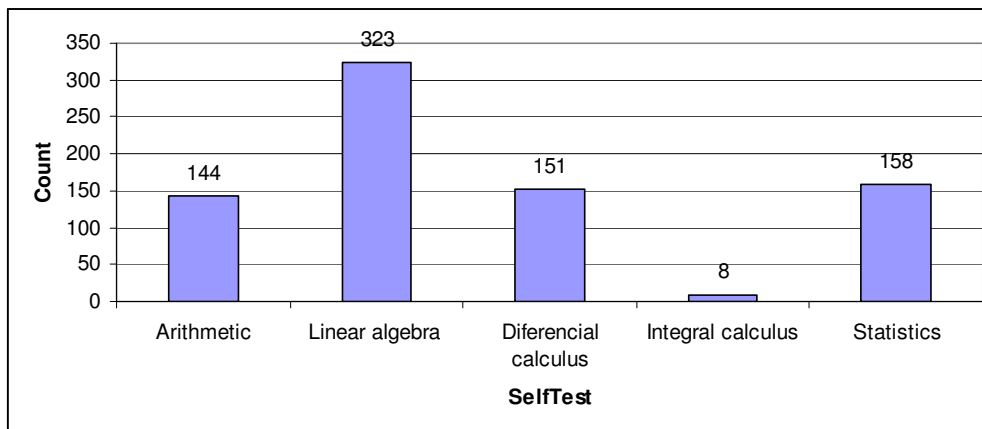


Figure 1. The number of self-tests fulfillment in a semester

Figure 2 represents the frequency of self-test fulfillment. The self-test could be fulfilled a desirable number of times. More than 100 students tried to do it at least once; however, there were students who tried more than 10 times. Unfortunately, a student who tried to do the test more than 20 times, was under-achieved (failed the examination). As more detailed analysis has shown, he tried to do the test 71 times but finished only 4 times.

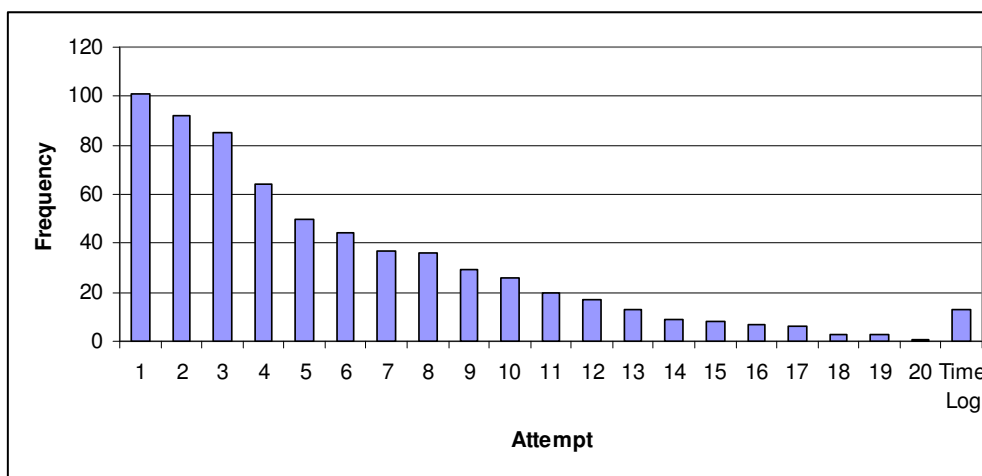


Figure 3. Frequency of statistics self-test fulfillment

There were 3 quizzes given during a semester: calculation of fluxion (3 attempts were possible, the term of fulfillment was 4 weeks), integral calculus (the number of attempts was unlimited; the term of fulfillment was 3 weeks), probability theory (the number of attempts was unlimited; the term of fulfillment was 4 weeks). The best result has been chosen as a final assessment. As it can be seen, the students fulfilled all the quizzes for analogous number of times, only the attempts to do a probability theory test were slightly greater.

The students were sufficiently interested in learning material; however, their participation in discussions was heavy and dull. The students used to explain the problems among their own, although, in the year 2007/2008 they communicated in virtual environment using e-mail rather actively.

Sadly, not all the students could carry out tests on time; they used to lost terms, complained that they had no approach to the internet.

At the end of a school-year 84 students answered the questionnaire. The survey has shown that students were satisfied with such methods of teaching. The majority of answers were positive. 42 students did not indicate any drawbacks.

The following benefits were indicated:

- necessary information in one place;
- information is always accessible;
- comfortable to find the assessment for work; confidential presenting of results;
- asking and getting answers being at home;
- convenient possibility to use a calendar and find information in boards;
- possibility to use self-tests;
- possibility to correspond (cooperate) with school fellows carrying out the same subject.

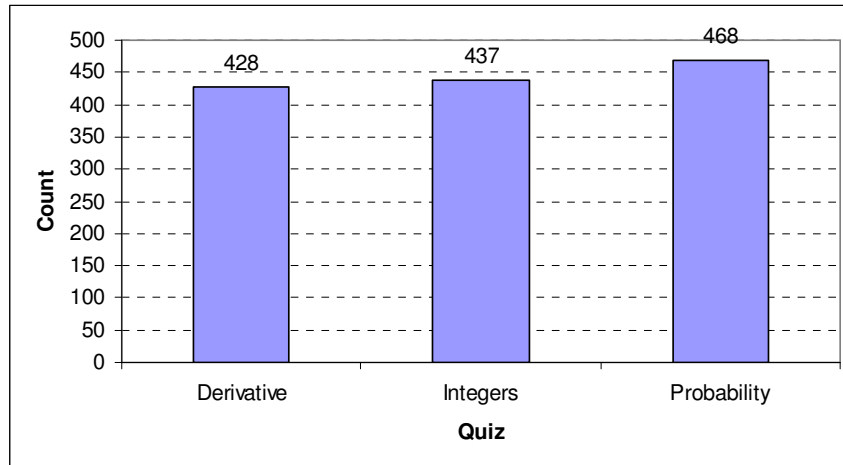


Figure 2. The number of quiz fulfillment during a semester

Main drawbacks consisted of technical problems (unstable internet connection) and the problems of computer illiteracy. Several students indicated possible dishonesty cases fulfilling individual tasks. One respondent requested more contact sessions, because it was difficult to learn independently.

Respondents presented the following wishes:

- it was difficult to orient in the environment; additional teaching is required;
- there would be more discussions and they have to be obligatory;
- perfect the format of information presenting;
- more tasks with answers for individual learning;
- more theoretical materials and explanations;
- easier tasks.

To use virtual environment was new experience for the first course students; it caused certain troubles for a part of them due to the lack of computer literacy. Some students had difficulties in applying Blackboard possibilities according to their needs. Nevertheless, it was useful practice for most of them.

Conclusions

The usage of Blackboard System as additional measure in teaching mathematics and statistics has answered the purpose, because most students have been satisfied using virtual environment. They have used the possibilities of the environment rather positively.

The usage of virtual environment needs abilities to orient in it and adapt it to individual requirements as well as to take advantages of its possibilities. Consequently, it is necessary to educate students' computer literacy explaining about virtual environment during the lectures of informatics in greater detail.

It is necessary to develop and perfect teaching material of "Mathematics and Statistics" subject presenting more self-tests and tasks of various levels of difficulty.

It is purposeful to develop students' abilities to communicate, cooperate and analyze tasks organizing obligatory discussions.

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