MODELLING AND SIMULATION OF CLOUD COMPUTING SOLUTIONS

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Abstract: Nowadays, the designing of cloud computing systems is actual approach which is developing very quickly. The cloud computing platform can be useful in any economy domain. Using of cloud computing can increase effectiveness of rural sector through cost savings of monitoring, practically unlimited data capacity for calculating of statistic values and industry values used by domain managers and decision makers. Usually cloud computing requires reengineering of legacy software systems. It means reengineering of currently operated information systems and applications used by domain enterprises and adapting these systems for cloud platform. Solving this problem causes necessity for architecture and functionality modelling of current systems or modelling newly designed systems. Domain owners expect clearly defined vision of system deployment and operation in cloud. An architectural solution of Cloud Computing systems has its own technical peculiarities and it is necessary to precisely describe and gauge them. Behaviour of Cloud systems depends on large number of stochastic factors. For estimation of operational behaviour of such systems determined mathematical expressions usually are insufficient. This kind of systems research tasks could be effectively implemented by stochastic simulation. This paper focuses on design of UML based Domain specific language for modelling and simulation of Cloud Computing systems. Initial Design of Unified Modelling Language (UML) based Domain Specific language (DSL) described in this paper achieves synergy from in IT industry widely used UML modelling technique and the domain specific Cloud Computing extensions. As a novelty for UML modelling, especially for simulation purposes, the presented DSL is enriched by a set of stochastic attributes of modelled activities. Such stochastic attributes are usable for further implementation of discrete-event system simulators.

Keywords: cloud computing, dsl, uml, simulation.

Introduction

This paper is devoted to modelling of Cloud Computing Solution. The authors have developed UML based domain specific modelling language for modelling structure and behaviour of Cloud solution. The structural model is made of three kinds of diagrams. High level cloud diagram, service diagram and service deployment diagrams. In the proposed solution to the cloud behaviour modelling there is offered to add to UML based diagrams with system describing stochastic service attributes. As the final step for modelling the system behaviour would be use of simulation that would allow estimating performance of the system.

The cloud computing technology is a modern IT domain, where the provider of the cloud solution is occupied with the updating of hardware and software. The end-user takes advantage of the provided resources without requiring cloud users to know the location and other details of the computing infrastructure. The technology of the cloud solution consists of two logical parts - back-end and front-end. Back-end part consists of a hypervisor, hardware and software, which drives front-end virtual solutions. Front-end part is powered by the cloud service, used by the ultimate end-user. End users access cloud applications through a web browser or a light weight desktop or mobile app. The provider carries out of the Hypervisor, hardware and software. Cloud computing is the delivery of computing as a service rather than a product as a metered service over a network.

Cloud classification

By working out the model of the cloud the authors use the following cloud classification: public cloud; private cloud; cloud of an organisation; hybrid cloud. Depending on the class, in the modelling of the system, each model has its own set of attributes. Each cloud provides its own kinds of services. Cloud solution serves such kinds of services: software as a service; platform as a service; infrastructure as a service.

Public cloud - Applications, storage, and other resources are made available to the general public by a service provider.
Community cloud - shares infrastructure between several organizations from a specific community with common concerns (security, compliance, jurisdiction, etc.), whether managed internally or by a third-party and hosted internally or externally.
Private cloud - Private cloud is infrastructure operated solely for a single organization, whether managed internally or by a third-party and hosted internally or externally.
Hybrid cloud - Hybrid cloud is a composition of two or more clouds (private, community or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models.

Hybrid cloud, in point of fact, can involve all the above mentioned kinds of Cloud Computing. In its structure it is necessary to define security perimeters which determine whether the cloud is private, of an organisation or public (Buecker et al., 2011).

Application reengineering for operating in cloud

Reengineering occurs when it is necessary to transfer classic software to cloud solution.

Before starting transferring a solution to a cloud solution, it is necessary to analyse the business function. It has to be determined whether the software meets, partly meets or does not meet the requirements of the technology of Cloud Solution. Operation of the cloud depends on a lot of factors. To be possible to project the structure, the measurements and performance of Cloud Solution the authors worked out domain specific language (DSL) for cloud modelling.

Domain specific language for modelling of cloud solutions

A Domain specific language (DSL) is language for programming, specification or modelling suitable for particular problem domain specialists to solve their specific technical tasks (Achim et al. 2007, Lenz and Wienands 2006). This chapter describes domain specific language for modelling and simulation of cloud computing solutions. Proposed DSL language is based on the UML language. Currently, using UML is one of the most commonly used approaches in IT system modelling. UML belongs to the group of graphical modelling languages. Initially UML was built for information systems modelling to facilitate the development and maintenance processes. As regards system modelling, UML modelling is widely used at system development or enhancement phases (Teilans et al., 2011; Teilans et al., 2008). In this research, the UML language will be supplemented by stochastic attributes, that can be used to simulate cloud solution services.

When creating a model with the modelling language based on UML, cloud solution was divided into business logic from the service and service physical topology. In the proposed DSL language cloud solution can be represented by three types of diagrams: Cloud diagram, Service diagram and Service deployment diagram.

Cloud diagram is composed of clouds. Clouds have two attributes - name and description. Clouds are connected with cloud connectors, see Fig.1.

![Cloud diagram](image)

**Fig. 1. Cloud diagram**

For each cloud connector one or more service diagrams should be created. Service diagram depict cross-service use. Service diagram consists of services. Services are connected with the service connectors. Service connector can be unidirectional or bidirectional. This means that the services can use each other. The following diagram is used for modelling business solution functionality. For example, the service diagram Fig.2. shows a cloud of workshops designed for HR system functionality.
In next step, for each service connector, the third kind of diagram - service deployment diagram - should be created Fig.3. Service deployment diagram represents the service sites. In Service deployment diagram services are connected with site connector. Site connector can be unidirectional or bidirectional. This means that service sites can use each other.

The overall DSL cloud model hierarchy diagram is shown in Fig.4.
Simulation of Cloud computing model

To enable model simulation several stochastic attributes were introduced for service entities. See Table 1. For these stochastic attributes it is possible to gather statistics during simulation. Each stochastic attribute is described with probability distribution function. Specific distribution function could be determined by statistical analysis of existing cloud system usage (for example - from event logs). Attributes used in simulation are described in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Service stochastic attributes</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service operation time</td>
<td>effective duration of service operation</td>
<td>ms</td>
</tr>
<tr>
<td>Breakdown interval</td>
<td>Time between service breakdowns</td>
<td>ms</td>
</tr>
<tr>
<td>Service restoration time</td>
<td>Time required to restore service after breakdown</td>
<td>ms</td>
</tr>
<tr>
<td>Number of requests</td>
<td>Requests count per time</td>
<td>Requests per second</td>
</tr>
<tr>
<td>Traffic per request</td>
<td>Number of transferred Kb</td>
<td>Kb</td>
</tr>
<tr>
<td>Traffic per response</td>
<td>Number of transferred Kb</td>
<td>Kb</td>
</tr>
</tbody>
</table>
In Model services are connected using service connectors. Cloud connectors have stochastic attributes as well. Service connectors correspond to internal network connections in real-life Cloud implementation.

Service stochastic attributes are described in Table 1 and Network stochastic attributes are described in Table 2. Attribute **service operation time** describes time which service consumes to handle received service request and returning data to requestor. **Breakdown interval** attribute describes interval between unexpected service breakdowns. **Service restoration time** – time spent to restore service back to functional state. **Number of requests** - request count per time unit which is used for external requests simulation.

**Traffic per request and traffic per response** together with network bandwidth are used for simulation of network utilization. All attribute values could be defined as a probability distribution functions.

### Table 2

<table>
<thead>
<tr>
<th>Network stochastic attributes</th>
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</tr>
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<tbody>
<tr>
<td>Connection breakdowns interval</td>
<td>Time between network breakdowns</td>
</tr>
<tr>
<td>Connection restoration time</td>
<td>Time required to restore network after breakdown</td>
</tr>
<tr>
<td>Network bandwidth</td>
<td>Network throughput</td>
</tr>
</tbody>
</table>

Fragment of Cloud system **service diagram** in proposed DSL language Fig. 5.

![Fragment of Cloud system service diagram](image)

**Fig.5. Services with stochastic attributes**

### Conclusion

The current situation within business indicates the necessity for more complicated and more effective cloud computing systems development. In the presented paper the given approach allows to perform Cloud solutions analysis which is based on the system model specification and simulation. In this way the one window approach is realized for both system developers and maintainers and for those responsible for the operation and deployment policy of a system. The presented DSL are still in the early stages. Further work will be performed to improve the Domain specific language. The second group of further activities will be devoted to implementation of an appropriate simulation engine. Model repository and tools for storing and processing simulation results will be developed for domain specific decision support. This approach will be approved on several enterprise systems decided for cloud migration.

### References


