FUZZY LOGIC BASED QUALITY OF SERVICE MODELS

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Abstract: The continuous monitoring of information systems' quality of service increases importance as business becomes more and more dependent of those systems. In order to obtain that view, quality models need to be defined for those systems. Because of its complexity and today modelling frameworks, quality models tend to result in a poor representation of reality, mainly because of their lack of ability to represent uncertainty. In this work, we investigate the use of fuzzy logic's properties to create a new kind of quality of service models, which handles uncertainty and imprecision naturally. The objective is to obtain models that are a better representation of reality and easier to create and understand. This article presents the investigation on related topics to support the identified problem and motivations, followed by a solution proposal and a validation scenario.

1 INTRODUCTION

Along the years, several quality models have already been proposed, both for the implementation of the information systems as for the evaluation of its general performance (S.O. et al., 2010). Their main goal is to find the answer to the question "What is quality?". This answer is commonly built by defining what characteristics are considered important to exist in a service (ISO, 2001).

In the case of evaluation of information systems' performance, there are multiple dimensions that can be quantified, and from those the definition for quality's characteristics can be created. By performance we mean how well a system, already assumed correct, works (Khaddaj et al., 2004).

As systems increase in complexity, so do the rules that reason about its state, or in other words, the quality of service model becomes more complex and harder to understand. In addition, the quantitative values, obtain from monitoring specific system's dimensions, are usually modeled using boolean like logics where, for instance, abrupt variations in quality level can occur, consequence of strict thresholds have to be defined (Zadeh, 1973).

In such complex information systems, concluding on the quality level carries much uncertainty and by forcing fixed thresholds to separate different levels, the model will no longer represent the reality, where for some range of values the conclusion about the correspondent level of quality can be fuzzy (Campbell et al., 1996).

So, the challenge presented in this scenario is to create models that give a more accurate view of reality and at the same time require less effort to create and understand.

1.1 Motivation

Human reasoning is known for its ability to process incomplete and vague information in order to infer results or make decisions. As said in the previous section, that property presents serious challenges when creating a model to represent it. That is especially true if logics that work with scales measured by discrete values are used. A alternative to such logics is Fuzzy logic (Zadeh, 1973).

By combining the paradigm of the *if-then* rules with the descriptive capacity of the *linguistic variables*, more comprehensive models can arise, while at the same time reducing the effort of their development and improving its final quality.

1.2 Objectives

The main goal of this investigation is then to evaluate how fuzzy logic's concepts can improve the construction of an answer to the question "what is quality?". Our objective is also to improve that process, so a more natural transition from human reasoning real-

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ity to a quality of service model, can be achieved.

In order to build such models we'll need some framework to provide us with a common set of concepts to describe all the parts and their relations. Being this investigation under the scope of the Center for Organizational Design and Engineering (CODE) the preferred framework for this task will be the CEO (Vasconcelos et al., 2007). Because CEO framework does not consider fuzzy logic and some quality of service related concepts, an extension proposal will be presented in order to enable the creation of the models required to this investigation.

2 RELATED WORK

To have models, we perform modeling. According to (Silva and Videira, 2001) modeling is both an art and a science, and a model is the interpretation of a subset from the real world. Through the simplification of the reality down to a set of concepts and relations, different languages can be used to describe the model according to the audience expectations, knowledge and/or objectives.

2.1 Quality of Service

Quality is generally defined as a multidimensional concept (Khaddaj et al., 2004). These dimensions are used to construct a quality model, as also described in the International Standard ISO 9126. As for service, in the domain of enterprise architectures, (Open, 2006) defines it as a mechanism that provides access to capabilities. In the field of networking, the notion of quality of service is associated with the guarantees of performance transporting a flow of information, measured mostly through specific metrics.

A broad review of quality of service investigation is presented in (Campbell et al., 1996), which defends that investigation is mostly focused on individual layers, instead of addressing the overall *QoS Architecture*. Also, a generalized QoS framework is described, to include principles about its construction, specification and mechanism to handle the system's behaviour. QoS specification is described as the capturing of quality level requirements and management policies, which will be different for each architectural layer. As for QoS Mechanisms, it will vary according to the specification and can be separated in three groups: provision, control and management mechanisms.

On the topic of QoS specification, (S.O. et al., 2010) presents a survey of models, according to a classification set. The authors conclude that performance is itself subjective and open to different interpretations. Also, most models were found to be limited by their inability of handle uncertainty and imprecision. Some approaches, like the probabilistic models, which can handle vagueness, is however not adequate to handle information expressed in natural language.

2.2 Enterprise Architectures

Based on (Lankhorst, 2005) to manage the complexity of large systems it's necessary to have an architecture, which captures all the components, their relationships with each other and their surrounding environment. An architecture also provides a common language to describe the system, it's components and their relations, improving overall communication between the stakeholders.

This notion was extended to the field of enterprise engineering and from that originated the term of Enterprise Architecture (EA). An enterprise is seen as a complex system where through a *"whole of principles, methods and models"* it can be decomposed in individual functional parts with respective relations.

2.2.1 Framework CEO

CEO framework (Vasconcelos et al., 2007) originated in CODE investigation group, and its goal was set to describe organizational knowledge as its various levels and the dependency between them. CEO decomposes an organization on three separate levels: organizational goals, business processes and resources, each with adequate forms of representation according to the concepts in question.

CEO uses the Unified Modeling Language (UML) for implementation, with the help of developed stereotypes. In order to represent information systems' concepts, the framework extended its meta model with the necessary concepts, which will be the starting point for our own extension proposal.

3 SOLUTION PROPOSAL

Our solution is targeted at reducing some of the complexity in models by creating models that don't force the removal of uncertainty. That will be achieved through the use of fuzzy logic's concepts, using the method described in the following section.

3.1 Fuzzy Models

The fuzzy controller, as the most successful application of fuzzy logic, will be used to guide the development of the new quality of service models. So, the main focus for the new models will be in the creation of the knowledge database. In order to do so, the necessary variables need to be defined, that in this case correspond to all system's measurable dimensions and quality factors.

Regarding the *if-then* rules, we'll consider as input variables those corresponding to measurable dimensions, and as output variables the quality factors. In order to obtain the final and crisp results for the evaluated rules, its also important that the chosen method to the *defuzzification* is not too complex to avoid making the models hard to understand and/or create (e.g. Centre of Gravity).

As for the all necessary fuzzy reasoning knowledge, we'll follow the original work done in (Zadeh, 1973).

3.2 Metamodel Extension

Regarding the extension to CEO framework, after describing the main characteristics of the new QoS models, the concepts to be proposed are the following:

- **Measurable Dimension.** Any system dimension that can be observed and quantified. This concept is connected with "IT Block", from CEO Framework.
- **Quality Factor.** Relevant characteristic for the definition of quality in a system. This concept is connected with "IT Service".
- **Linguistic Value.** Represents a value of a linguistic variable. Each measurable dimension and quality factor will be composed by these values. By connecting two different values, from a measurable dimension and a quality factor, we'll be defining a *if-then* rule.
- **Fuzzy Operator.** This represents an operator to compose more complex rules.

Using the concepts present previously, the new models can be represented in order to document or share between stakeholders. A visual representation of the extension proposed to the meta model can be seen in figure 1. As different stakeholders may have different perspectives over a model, we also propose a set of views, each with unique objectives:

- **System Quality View.** The first view is an high level view of the model, where for a specific system and services, only the measured dimensions and considered quality factors are present.

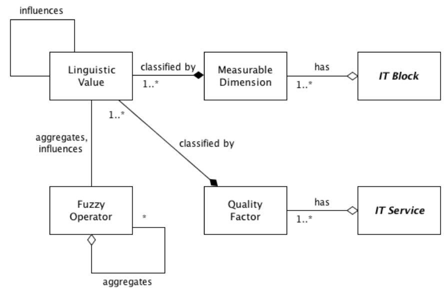

Figure 1: Proposed extension to CEO meta model.

- **Quality Factor View.** This view focus on a specific service's quality factor, relating it to all dimensions that cause some impact, and also the values involved.
- **Measured Dimension View.** In this view the focus is on a system's dimension, showing all quality factors that are influenced by it, as for respective values.

4 SOLUTION VALIDATION

In order to validate the proposed solution, we'll use it to develop a quality of service model for an actual information system, inside a real company, Portugal Telecom Comunicaões (PT-C). This model will be used in the continuous and real-time monitoring of such system, which is performed by the Pulso Platform.

PT-C created the Pulso platform (Alegria et al., 2005) because of a growing concern on its information systems' conditions. One of its goals was to monitor performance, availability and errors of their IT assets with near real-time precision, to determine the quality of service being provided to users. To achieve that a network of agents, attached to relevant system's components, provides basic metrics that correlate and aggregate into indicators.

The solution presented previously will be applied to obtain the necessary quality of services indicators. The current version of Pulso platform, specifically the models used today, will serve as basis for comparison with the developed fuzzy models, in order to determine the gains and/or limitations imposed by this solution.

4.1 Preliminary Test

As a preliminary test for the creation of the new quality of service model, this extension of CEO's meta model was applied to a fictional example. In this example we considered an "IT Block" representing a server, named "Server X". As for the service it provides we consider it as "Infrastructure Support". As for measurable dimensions from the server, "CPU Usage" and "Memory Usage" are available, and for the service's quality factors, "Availability" is to be evaluated. All those variables are composed by two values, "Low" and "High". So, the knowledge base for this example will be the following:

- IF CPU Usage IS Low AND Memory Usage IS Low THEN Availability IS High
- IF CPU Usage IS High OR Memory Usage IS High THEN Availability IS Low

This model can be viewed in figure 2 which uses the new concepts proposed in the meta model extension.

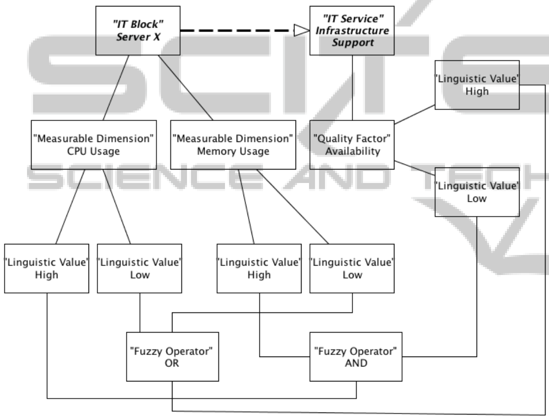

Figure 2: Preliminary test with meta model extension.

5 CONCLUSIONS

From research done so far, we are confident to say that including the tools to handle imprecision and uncertainty is a vital step to achieve better quality of service models. By having models that better represent the reality, we also expect to see great improvement in at least two properties: the effort required to develop models and there complexity should decrease by consequence. In companies where many complex information systems exist, these improvements can have significant impact. In this article we proposed a solution based on fuzzy concepts, which provide us with a formal method to handle uncertainty. From a set of quantified dimensions, quality factors can now be defined by correlation rules, even enabling the modeling of very specific cases. Also it enables an easier extension of the knowledge that defines the quality of service. An extension for the CEO Framework's meta model also is part of the proposed solution. This extension permits a visual representation of the defined rules, and also to establish the link between the previous concepts in the framework. Three new views, related to quality of service, are also proposed to address different perspectives. Finally, the application of the solution to a fictional system, gives an idea of future application to validate this investigation.

REFERENCES

Alegria, J., Carvalho, T., and Ramalho, R. (2005). Uma experiência open source para "tomar o pulso" e "ter pulso" sobre a função sistemas e tecnologias de informação. Technical report, Portugal Telecom.

Campbell, A., Campbell, A., Aurrecoechea, C., and Hauw, L. (1996). A review of qos architectures. *multimedia systems*, 6:138–151.

ISO (2001). ISO/IEC 9126-1:2001, Software engineering – Product quality – Part 1: Quality model.

Khaddaj, S., Khaddaj, S., and Horgan, G. (2004). The evaluation of software quality factors in very large information systems. *Electronic Journal of Information Systems Evaluation*, pages 43–48.

Lankhorst, M. (2005). *Enterprise Architecture at Work: Modelling, Communication and Analysis*. Springer.

Open, O. (2006). Reference model for service oriented architecture 1.0. Technical report, OASIS Open.

Silva, A. and Videira, C. (2001). *UML - Metodologias e Ferramentas Case*. Centro Atlântico.

S. O., O., E. O, O., F. M. E, U., Mbarika, V., and B. A, A. (2010). A survey of performance evaluation models for distributed software system architecture. *Proceedings of the World Congress on Engineering and Computer Science 2010*, 1:35–43.

Vasconcelos, A., Sousa, P., and Tribolet, J. (2007). Information system architecture metrics: An enterprise engineering evaluation approach. *Electronic Journal of Information Systems Evaluation*, 10(1):91–122.

Zadeh, L. (1973). Outline of a new approach to the analysis of complex systems and decision processes. *IEEE Trans. on Systems, Man, and Cybernetics*, SMC-3:28–44.