Architecture of SLA Adaptation Manager using MAPE-K Framework.

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Abstract. The key to the proposed architecture is the utilization of self-* capabilities designed to have self-management over uncertainties and the provision of self-adaptive interactions. Thus, the Monitor, Analyse, Plan, Execute and Knowledge Base (MAPE-K) approach can deal with this problem together with the integration of Fuzzy and Q-Learning algorithms. The proposed architecture is in the context of autonomic computing. An adaptation manager is the main proposed component to update admission control on the ISP current resources and the ability to manage SLAs. A general methodology type-2 fuzzy logic is applied to ensure the uncertainties and precise decision-making are well addressed in this research.

Keywords. Service Level Agreements, Quality of Service, Internet Service Provider, MAPE-K and Fuzzy

1. Introduction

The adaptation control can be classified into three core areas, such as approach, adaptation decision criteria and the degree of decentralisation. The key central question related to the adaptation time is how long it can adapt to the situation. It is related to the input from the user perspective, to evaluate and justify the adaptation with regards to all of the arguments that are connected to the situation. This approach can be realistic with the usage of MAPE-K. Research will extend the focus on the establishing autonomic elements that will be contained within the adaptive management architecture. The elements will be the policy exchanges between the local and global autonomic managers, whereby the overall management will be controlled by the enterprise adaptive architecture.

2. Background

SLA is to be appraised by the Local Autonomic Manager within the same tier on the cost saving, effective routing that concludes the latency issue. It will further be accessed by the enterprise autonomic manager for the results and governance of the autonomic computing within high level architecture as in Figure 2.1. Autonomic element interacts autonomously among them to exchange information, negotiations and perform agreed executions. It works similarly like an autonomous agent in the autonomic computing environment. Local autonomic manager is the handler for each autonomic element under their environment.
Further connection between the local autonomic manager and the enterprise autonomic manager over the autonomic computing main architecture is addressed in Figure 2.2.

The enterprise autonomic manager and the local autonomic manager consist of the same MAPE-K model design for autonomic computing. With abilities to minimise human intervention by providing suitable managed elements via touch point, it will then develop betterment of the knowledge base which runs recursively in the iteration procedure.

Within this architecture, MAPE-K will evaluate the exchanging elements either from the local and enterprise process and to provide the accepted system response. The system will have four core functions, which are monitor, analyse, plan and execute to ensure that the environments are running smoothly and are intelligently updated with every new alert. In the Self-Adaptive literature, research conducted by [11] focused on adaptive pricing strategies with the assumption of healthy competition between domain operators to get as much inter-domain traffic profit as possible. The competition was
based on the available route connections, prices, agents and the network load. The later research by
[18] expressed the adaptation framework with the integration of Fuzzy Q-Learning to handle the
varied workload performance from cloud providers.

Besides Fuzzy Q-learning, Finite Action Learning Automata (FALa) and Continuous
Reinforcement Learning Automata (CARLA) have been applied by [11] in his research. The
objectives were to demonstrate that Interdomain model routing, as an eternal flow on a certain link,
has a cost for the ISP owner. Interdomain links are shared among domains and their prices are equal to
the routing costs. They provide virtual link prices to generate income. The pricing model with the
appropriate costs and utilities has been introduced as the outcome of his work. In the fuzzy system,
the research made by [12-13] demonstrates the benefit of the adaptation of the available services
powered by cloud providers. The adaptation also helps to maximise profits in service level management [14],
deals with the negotiation [12] and lastly, the adaptation is based on QoS requirements [15].

The following fact sheet in Table 2.1 will conclude and highlight some of the other research that is
generally relevant to research areas. The detailed comparison on the closest research available is in
Table 2.2.

Table 2.1. Comparison of Closest Research Reviews – Autonomic Management (Excerpt)

| Ref | ISPs Architectures | Autonomic Management Properties (Self-Configuration, Self-Optimisation, Self-Healing and Self-Protection) | Human Intervention in the framework |
|-----|-------------------|-------------------------------------------------------------------------------------------------|-----------------------------------|
| [2] | Using Web Server Environment | Carrying out of an autonomic manager in predicting the next sequence or actions based on previous behaviour. The autonomic manager will choose one or more appropriate actions of anticipation. | Each element will deliver its own associated policies that will help the autonomic manager to decide on the following course of action. Human Intervention = Unsupervised. |
| [3] | No | Using autonomic elements called SelfLet. It can communicate from one component to another to work within the complex infrastructure. The model can understand the specifying behaviour, abilities and goals of each component. It will direct them to the autonomic manager that is able to understand the entirety of the components. | It works on the Model called SelfLet. Human Intervention = Unsupervised. |
| [4] | No | Autonomic Management approaches to identify the preferred uses of existing policies or learn new policies. | Applying a Reinforcement Learning Model to accommodate the alterations. Human Intervention: Unsupervised. |
| [5] | Future Internet Networks, such as wireless network issues | Using a cognition cycle to adapt the adaptive network management. Cognitive network managers can interpret the previous events in the circle and this works for betterment in the hereafter. | Using a Cognitive Cycle Process Human Intervention: Unsupervised. |

This System will fully utilise the autonomic To present robust
Research solution for ISPs Architecture. management features to ensure that it is able to adapt to the changes and available resources. With that approach, SLAs will be the mainstream contract or template that is transparent between the providers and their partners, which will have been back to the subcarriers and subscribers.

autonomic management with the ability to be semi-supervised from the initial start. The system will further mitigate the process with an unsupervised approach using the MAPE-K framework.

Table 2.2. Comparison of Closest Research Reviews – SLA

| Reference | Research Problems | Contributions | What they do not do | How Can I Improve | My Contributions |
|-----------|-------------------|---------------|--------------------|-------------------|------------------|
| [11]      | There is no tool to the ISPs to gain the optimal link prices. | a) Introduce a selective exploration rule, Learning Automata (LA) for stationary and non-stationary environment for ISPs. b) Using a formal method to calculate the inter-domain routing within ISPs with two scenario. c) Two pricing models available; utility model and cost model. | Full MAPE-K Framework and an evaluation of the agreement between ISPs. It is very crucial to identify any metrics which cannot be fulfilled throughout the SLA. | Incorporate the inter-domain services between ISPs and bind them with SLA. A further framework should be exhibited to ensure the signed SLA will be actively monitored on the agreed terms. Any violations will be subject to the agreement for both parties. | An inter-domain architecture with the present of MAPE-K framework to ensure that the SLA terms actively monitor for any violations. |
| [16]      | To have a renegotiation approach within a cloud based system to ensure the | Using two approaches; a) Bargaining-based negotiation b) Offer generation-based negotiation Ability to generate multiple offer SLA parameters within one round during | The solution is for one cycle and not through the MAPE-K framework, whereby | To have a dynamic Service Level Objective (SLO) that is adaptive to the agreement | To ensure that the renegotiation will have all of the possible inputs from other providers and the enhancement of |
3. Proposed Architecture

3.1 MAPE-K Framework

According to [19], a framework is a basic structure that is underlying a system concept text. Therefore, in this research, the MAPE-K is established with self-properties and it is able to interact with the assigned components iteratively within the loops. The framework is illustrated in Figure 3.1.
The architecture is based on the MAPE-K approach, and it has two layers. Goal management and adaptation model. On top of the layers is the abstract model. The policy approach is the main connector for the two layers. In this research, each ISP has MAPE-K and must play their own role to ensure that the relevant actions will be applied to any violation of the signed agreement.

ILLUSTRATION OF THE FRAMEWORK AND THE THREE LEVELS OF SELF * FEATURES HAVE BEEN PRESENTED IN FIGURE 3.1 AND FIGURE 3.2. AS PER THE INFORMATION, IT IS CLEARLY TABULATED THAT SELF-ADAPTING IS THE HIGHEST COMPONENT SUPPORTED BY THE OTHER SELF-FEATURES.

THREE SIMPLE ADAPTATION RULES HAVE BEEN APPLIED AS BELOW:

- Suitable adaptation rules have been learned
- The environment has changed, there is another approach to the goal
- Another rule is applicable
The adaptation controller applied in MAPE-K comes with the following sequences.

- Monitor the QoS inputs (Latency, Workload and Response Time)
- Analyse the input from the data file and distinguish the rule base violations. This is like a SLA document.
- Plan the possible corrective action to react, such as update in the state to reach the possible learn rate, rewards and explorations.
- Execute the rule base.
- Update the recent executions and use possible actions. The contributions of knowledge at this point enhance the knowledge base of the main framework.

Figure 3.3 Framework of SLA between ISPs

Figure 3.3 contains two more sub-elements, which are vital to this operation. The User Profile model solver inherits three main databases such as the user profile metadata, SLA commitments and ISP Metadata. The first one is the trailing of the user profile from one broker to another and lastly, the negotiation of terms and services with another ISP. All the information related to ISPs performance stored in the Internet Service Providers Metadata and comparison of the SLA commitments. Subscribers able to review the performance of ISP and how they commit in the produced SLA. Having this information, it helps subscribers to evaluate SLA given by ISP and understand the current assessment of ISP. This framework able to list numbers of ISPs according to the selection criteria.
Figure 3.4 Proposed Fuzzy Q-Learning Architecture

The information portrays in Figure 3.4 are the setup of fuzzy q-learning environment. It contains two main layers. Fuzzy and Knowledge Learning. Knowledge learning is where the fuzzy q-learning interacts with input from fuzzy and translated that to system state. System goal is where the learning completed for one episode and later return the value through adaptive policy to knowledge base within fuzzy layer.

In a nutshell, Figure 3.4 explains the executions of MAPE-K framework with the utilization of Fuzzy and Q-Learning.

The proposed architecture in Figure 3.4 is the extension from Figure 3.5.
4. Conclusion
Adaptation manages resides in each ISP and it connected with admission control. In the normal routines, admission control give feedback to SLA manager either to accept or reject SLA request. Accepting SLA will consume more ISP resources and rejecting SLA affects the daily business operation. It reduces the amount of money coming from customer. With the introduction of adaptation manager, it contains the MAPE-K framework to perform four major activities. Monitoring, analysing, planning and executing. This is iteration process and every result stored in the database and it helps adaptation manager to refine better executions and information accordingly.

In the final architecture, the autonomic controller, which is part of the autonomic elements, compliments the overall autonomic computing environment. The proposed enhanced architecture able to provide feedback system during the iterations. It reacts on the given SLA and updated the affected rules accordingly. The adaptation and learning abilities of defined policies demonstrated accordingly with the combination of QoS and Fuzzy Q-Learning parameters.

This autonomic element can either placed as local or global depending on the requirements. In this research, there are other connected elements such as Admission Control, SLA Manager and Broker to automate the ISPs architectures. The solution helps admission control to update the status to SLA Manager either accept or reject on any SLAs offered. The correct justification benefits the entire ISP architecture to prevent any unwanted situations such as penalties, poor performance and in excess of utilization on the resources.
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