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AUTONOMOUS SYSTEM FOR NETWORK MONITORING AND SERVICE CORRECTION, IN IMS ARCHITECTURE

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The IMS networks offer several advantages to telecom operators in terms of connectivity and deployment of new services. However, the multitude of supported access technologies poses significant challenges for QoS management. To this effect, The INQA approach (IMS Network QoS Architecture) provides innovative solutions for services supervision and monitoring, in real time. This allows identification of any QoS degradation, based in resource status. In this work we propose the integration of correction mechanisms and QoS restoration, based on eTOM processes and reports monitoring outcome of supervision operation. The work aims to set up an autonomous system for QoS correction, in IMS context

Keywords: IMS (IP Multimedia Subsystem); eTOM (enhanced telecom operation management); QoS Management. SOA (Service-Oriented Architecture)

1. Introduction

The INQA approach [ERRAIS et al, 2011] (IMS Networks QoS Architecture) for IMS network's [Poikselka et al, 2006] monitoring allows the identification of any QoS degradation in real time. This approach is eTOM-based (enhanced telecom operation management) specification [GB921, 2004] is for the integration of QoS management entities to estimate customer satisfaction [RAOUYANE et al, 2011], according to the defined requirements in the SLA. Thus, the operators enable to enjoy of IMS networks benefits, as multiple connectivity and new services, while guaranteeing a high reliability.

The INQA approach enable to detect QoS degradation in real time, but does not allow a network self correction or purpose solutions. To this end, we propose in this work the integration of QoS correction mechanisms. This approach aims to monitor and correct degradation depending on client importance.

The QoS correction is a critical and difficult operation, which has to take into account the diversity of concerned entities in service provisioning, multitude of access technologies and service type. This requires an innovative and adaptive methodology for autonomous system.

Beside, the eTOM specifications propose standard scenarios for QoS assurance. Those scenarios are generic and have no real solutions for degradation situations. We propose in this work to integrate a new approach for QoS correction in IMS networks, based on eTOM specifications and reports resulting from monitoring phase.

This paper is organized as follows: we start by presenting and discussing related works, especially monitoring of IMS networks. Section II presents our new approach for QoS correction. The results of testing and experimentation stage are presented in section III. The correction costs are discussed and analyzed at the end of the paper in order to review the various aspects of the new approach.

2. Related Works

The architecture convergence (IMS) includes a variety of components and communication technologies. Such organization causes several issues including security, mobility and QoS management.

To this effect several research works have focused on the QoS management, the most important are as follows:

2.1. *The 3GPP specification*

The 3GPP approaches [3GPP TS 29.207 Release 6] [3GPP TS.23.207 Release 9] present the basis for management mechanisms of the service quality in the IMS. They focus on the phase of service provision, offering stable and dynamic solutions for the resources configuration according to specific constraints to the type of service. The idea is to identify the needs of each service in terms of QoS requirements. Although these specifications focus on the phase of supply and do not take into consideration the customer type. This poses challenges in the case of network overload, given the absence of mechanisms for monitoring and real-time monitoring [BELLAFKIH et al, 2010].

2.2. *The self-fault-based technique of causal map*

A second approach was proposed by Jingxian LU [Jingxian Lu et al, 2011], which is monitoring the resources to identify the fault cause via the technique of map causal [Jingxian Lu et al, 2011]. This solution has resulted in the deployment of autonomous manager to detect any failure by identifying the probable cause. This allows change in network performance and minimizes the cost of maintenance. However, the approach aims to monitor resources (routers), and does not give importance to services’ flows while the objective of the IMS is the deployment of value-added services [Poikselka et al, 2006].

2.3. *The SLM&M approach*

The SLM&M (Service Level Management & Monitoring) [RAOUYANE et al, 2012] is a platform for monitoring and supervision of services on the basis of indicators collected directly over the network. These indicators are then processed and analyzed using thresholds defined in (Service Level Agreement) SLA [BELLAFKIH et al, 2012] of each client, before deducting the requirements in the provision of service. However, the SLM& M solution focuses only on the degradations detection but does not include the corrective actions in real time.

Thus we propose in this paper the implementation of an autonomous system able to detect any degradation of QoS, before correcting in real time without human interference. Such solution will improve the reliability of services deployed in the IMS, and so encourage operators to migrate to convergence architecture.

3. INQA Approach for IMS Networks Monitoring

The INQA approach aims to supervise and monitor a service [3GPP TS 29.207 Release 6] permanently based on both key performance (KPI) [RAOUYANE et al , 2010] and quality indicators [RAOUYANE et al , 2010] (KQI). This approach enables the integration of monitoring entities in a multi-technologies context transparently and efficiently.

The eTOM assurance scenarios projection in the IMS context is performed based on fast and reliable communication technologies, particularly SOA (Service oriented Architecture) [Woo and Hong, 2006]. This latter exposes the eTOM process as independent and atomic web services. The communication inter-processes integrate SOAP (Simple Object Access Protocol) [W3C Recommendation, 2007] protocols which provide acceptable performance by avoiding any network overhead.

The INQA approach is presented as the SLM&M platform [RAOUYANE et al,2012] (Figure 1), the platform has several modules deployed to ensure the real-time monitoring. Those modules are as follows:

- *Resource Module:* The resource module includes both eTOM processes of resource layer "Resource Performance Management" (RPM) and "Resource Data Collection & Processing" (RDC&P). Those latter are responsible of collecting performance indicators (KPI) via resources. The inductors analysis is performed by an integrated control system which is based on fuzzy logic to have an effective estimate in real time.
- *IMS Module:* The IMS module detect event in the control layer of the IMS architecture, such as service delivery and customer registration. This module includes the RDC&P process which enables the collection of essential parameters in monitoring service, particularly service type, customer's identity and established configuration at PCRF (Policy charging and rules function) [3GPP TS.23.207 Release 9].

- *Application Server Module:* This module is responsible of service parameters collection. The processes recover service parameters which are necessary parameters for KPIs collection.
- *Synchronization module:* This module has two missions. The first, the model sync between the various deployed resources modules, upon detection of service, to initialize the operation of monitoring. The second is the concatenation of reports obtained from Resource modules deployed on network nodes. The synchronization module contains the database Resource Inventory, which includes logical and physical resources available.
- *Service Module:* This module is responsible of the service quality indicators mapping. This task is made by the "Service Quality Management" (SQM) process, which according to service type identifies adequate KQI before calculating them.
- *Customer Module:* this module performs the SLA comparison by the "Customer QoS / SLA Management" (CSQM) that loads the SLA client, before applying the specific service thresholds on calculated KQIs.

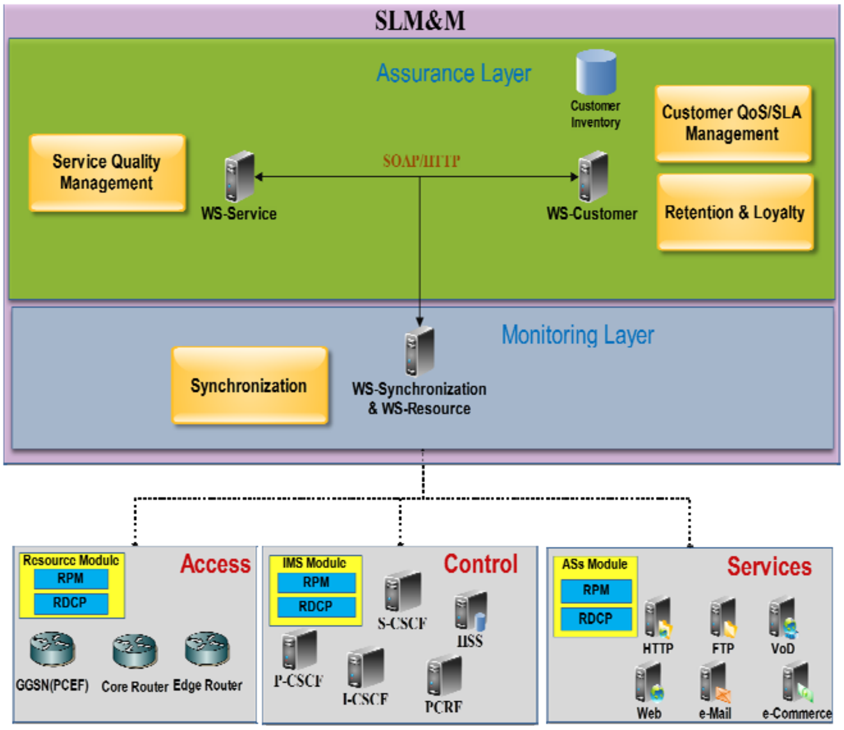

Fig 1. System Architecture for SLM&M Platform [9]

The nominal performance of services supervision and monitoring generates a global monitoring report. The latter includes reports of various involved processes. And it contains all the essential information during the correction phase.

4. QoS Correction

4.1. *Work Description*

The integration of correction mechanisms in real time requires a precise and complete methodology to achieve a standalone system. This methodology aims to study the needs, formulating solutions and integration new processes in the eTOM monitoring platform. We proceed by following stages:

(1) The correction process in eTOM

ETOM specifications include a correction scenario which involves several processes. The latter describe actions to be executed in a form of generalities which require specific formalization in IMS context.

(2) The data structures

The second step is to identify data sources, and adequate structures to each type. This step is necessary for the correction time optimization and proposed solutions effectiveness. There are several types of data structure, which we list as follow:

- *Network data:* Dynamic data which describe service state such as performance indicators and competing flow number in progress.
- *SID Entity:* SID [B922 Release 3, 2003] entities - described in TMFORUM [GB921 Release 4.5, 2004] as UML class diagram- include a description of various network components and available resources. These diagrams also include configurations and protocols supported for each resource.
- *Clients SLA:* Data describing specific quality of service requirements for each customer type. Requirements are expressed in terms of different thresholds for quality indicators

(3) The solutions formalization

The next step is to describe nominal solutions for every situation of QoS degradation. The solutions consist in the queues configuration at routers based on DiffServ [RAOUYANE et al, 2009] protocol.

The idea is to make the current flow priority over competing flows of customers considered less important. The traffic scheduling and packet marking are performed by scripts using the command "tc" (traffic control) and "iptables".

(4) Integration of the correction process to the platform

The final step consists on the correction process integration in the platform. This integration must be done in a transparent manner to allow the costs optimization, while having acceptable performance.

4.2. *QoS correction in eTOM Framework*

The correction scenario in the eTOM requires the cooperation of several business processes belonging to the three horizontal layers Resource, Customer and Service

(Figure 2). The correction is initiated after detection of an anomaly by analyzing indicators or following a negative SLA verification.

The first step of correction is metric and indicators analysis for the identification of breakdown nature via PSDN and RPM processes. This information is then transmitted to the "Resource Trouble Management" (RTM), which applies standard solutions due to the breakdown nature, before opening the report correction. The latter is sent to the "Service Problem Management" (SPM) of the service layer and to the PSDN for collecting KPI after application of proposed solutions. The SPM receives the report correction and communicates with the SQM to retrieve the required quality for current service in terms of IQ. In parallel correction report is sent to CQSL process to notify the client if he is deemed as important. Identifying customer importance is performed by "Retention & Loyalty" (RL) process based on its profile and history of services consumption. In cases where indicators are considered critical, the second level of correction is initiated.

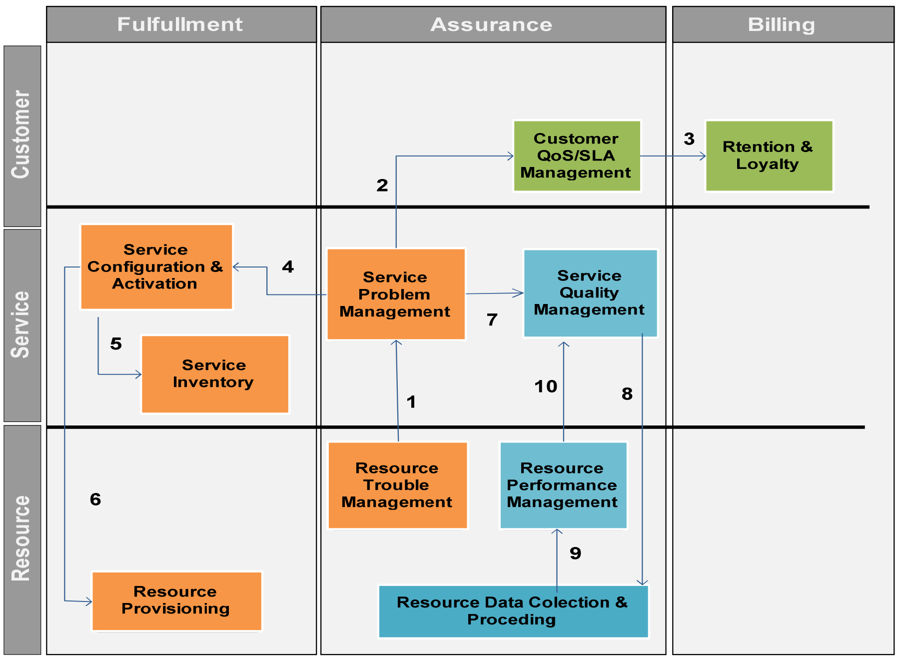

Fig. 2. The correction scenario sequence in the eTOM.

The second level of correction aims to find more complex solutions, which take into consideration customer type, service nature and the various competing flows in the network. This level is initiated by the SPM, which transmitted the correction report to “Service Configuration & Activation (SCA)” process. The latter identifies the optimal solution according to state resources, customer importance and service type. The proposed solution is transmitted to the "Resource Provisioning" which translates it to executable scripts. After reconfiguration, the KPIs are collected and analyzed for closure correction report.

4.3. *Data structuring*

Corrective actions running require a large amount of data, which has to be organized in such a way to allow fast access and an acceptable safety level. Indeed, the deployment and organization of data structures has a significant impact on system performance in terms of self efficacy and cost optimization. For this purpose several entities are defined to meet this need.

- *Customer Inventory:* This entity contains the SLA customers as an XML file which includes the requirements in terms of QoS for each customer type. The entity includes also the history of consumer credit and service.
- *Service Inventory:* This entity includes required configurations for acceptable QoS levels specific to each service type of. The entity also includes the different competing flows in the network and the customers identity for each port
- *Resource Inventory:* This entity contains the logical and physical resources available in the network. It is organized as XML files for static data such as the supported protocols for interfaces network configuration. And SID entities for dynamic data such as resource status, performance indicators and configuration queues.

4.4. *Formalization of solutions*

Corrective actions defined in the eTOM process do not describe explicit solutions for each degradation type. Thus, it is important to identify opportunities for the QoS correction in real time and in a transparent manner. For this purpose there are two correction levels, standard solutions in resource level and complex ones which require the intervention of process belonging to Customer and Service layers.

Resource level solution:

At this stage, the proposed solutions are standard and do not take into consideration the customer importance. The first action is to check whether the configuration set by the PCEF [3GPP TS Release 6] is executed before to reset it based on the monitoring report. The KPIs are then analyzed to identify the performed actions impact on the degradation. In a second step the traffic deemed les important is blocked based on "iptables". Only the control and signalling flows as well as customers one can go through the resource. The solutions in resource level are identified and implemented locally through the “RTM” process.

(1) Higher level Solution

The solutions of the second level include specific actions to the client type. The first step consists on sorting the stream according to customers’ importance. The latter is calculated by type, solvency and consumer services. The idea is to make the flow of priority customer over other flows of less important ones. This difficult operation requires several configurations before identifying the most appropriate one. Configurations are made based on "tc" and "iptables" (Figure 2).

(2) System Architecture

The proposed system architecture (Figure 3) aims to introduce correction mechanisms transparently and efficiently. The deployment of the entities has a considerable impact on system performance, in terms of effectiveness but also implementation costs. To this end the deployment of the correction process is done in two levels. The first is the resource level which comprises the eTOM resource layer process. While the second is assurance level which includes the processes of eTOM upper layers.

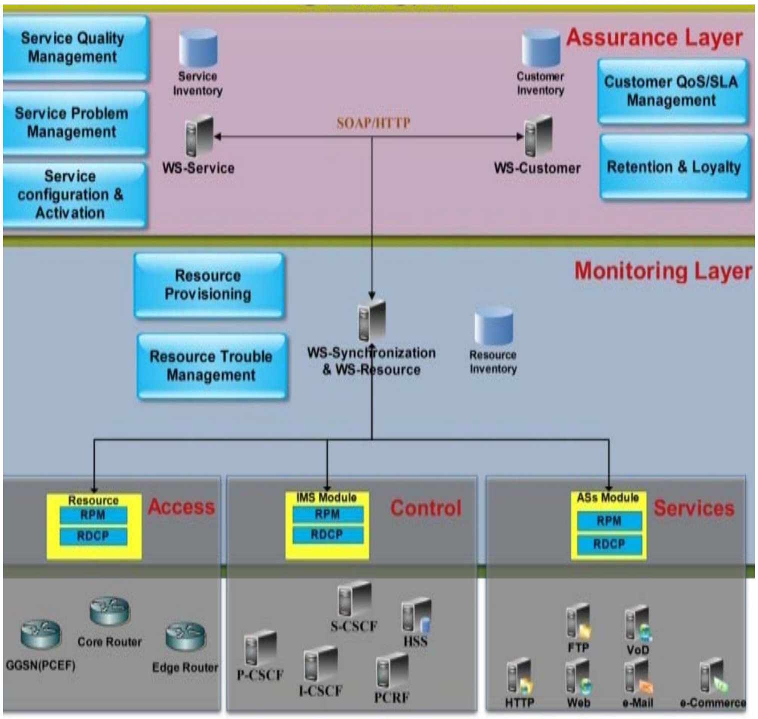

Fig .3. System Architecture

To balance load on resources, the number of deployed processes directly on nodes is two, the RPM and the PSDN. The RTM process and the "Resource Provisioning" (RP) are deployed in the synchronization module as a web service. The platform includes the same correction modules described in Section II of this paper. The module content has evolved to incorporate the correction process (Figure 3) and the data structure entities specific to correction.

5. Tests and experimentation

The tests and experimentation stage aims to evaluate the performance of the new approach in cases of actual service delivery in the IMS. This evaluation puts the item on effectiveness of proposed solutions for the correction, and also on the platform running costs.

5.1. *Bench tests and scenarios*

The bench tests (Figure 4) enables the deployment of all components of an IMS network as defined in 3GPP specifications [2][5][6], in addition the SLM&M platform follow and implement the INQA approach.

The bench tests components are as follow:

- *Core Router :* A Linux machine which has IMS entities deployed by the OpenIMSCore [IMS Core Network, www.openimscore.org] solution and Resource Module Platform
- *Edges Routers:* Two Linux machines that include Resource Module Platform.
- *Application Server:* A server of VoD (Video on demand) application that includes the AS module of SLM&M system.
- *IMS Clients*: Two machines - connected to the network via a switch - which contain SIP [IETF RFC 3261] clients.
- *Management server:* It includes three modules which are service, Customer, and synchronization.

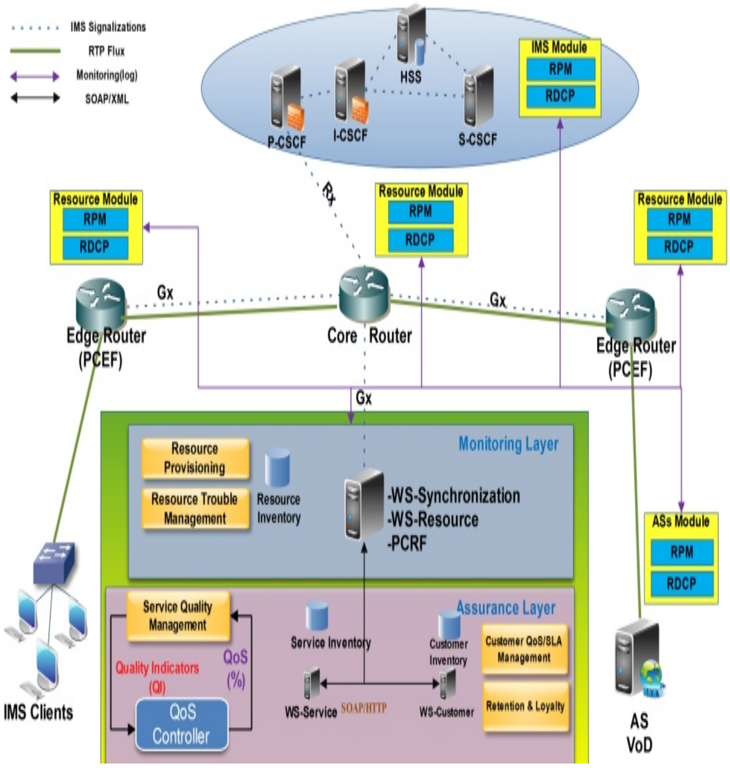

Fig .4. Bench tests

Initially Alice a Platinum client is registered in the network and asks for VoD application. Subsequently, several RTP (Real Time Protocol) flows -belonging to UDP (User Dtagram Protocol) type and simulating IMS flows- are transmitted on different ports, in addition to TCP (Transmission Control Protocol) streams for traffic diversification. The quality of service variation and platform behaviour are discussed and analyzed throughout the experiments.

5.2. *Result and discussion*

The user satisfaction estimation, and thus the quality of service variation, is performed based on quality indicators specific to the requested service. The quality indicators used for multimedia services, particularly IPTV (IP Television) and VoD are the MOS-A (Mean Opinion Score audio) [RAOUYANE et al, 2010] to estimate the voice quality, and MOS-V (Mean Opinion Score video) [RAOUYANE et al, 2010] for estimating video one. These Indicators take values in the interval [0, 5]. A value close to 5 provides a good service quality.

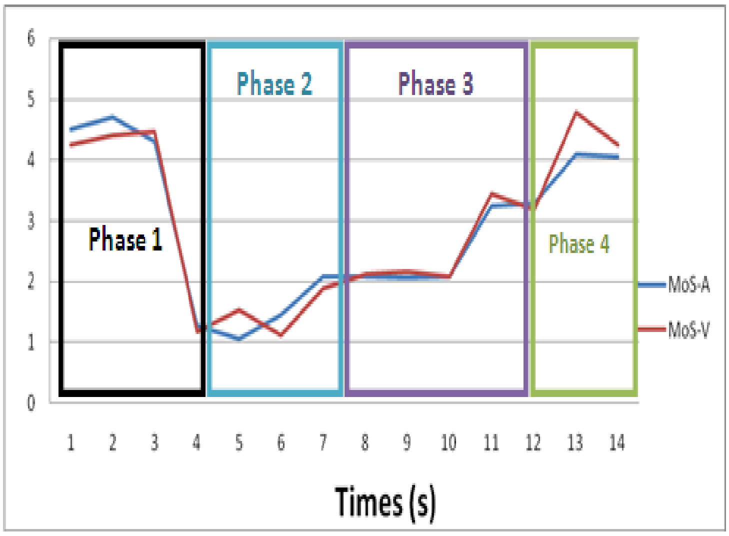

Fig .5. Variation of two quality indicators MOS and MOS-A-V.

Figure 5 shows quality indicators variation in the various stages of supply and correction service. This variation can be studied in four phases:

- *Phase 1:* The first phase represents quality indicators degradation after networks saturation by concurrent flow.
- *Phase 2:* In the second phase, the monitoring platform starts the resource correction level. This phase that takes place in an acceptable time (3.5 seconds). However, the indicator values calculated after the first level of correction does not satisfy the constraints defined in the SLA for customer Alice.
- *Phase 3:* This stage consists on initialization of the second level correction. This task took considerable time (10 seconds), which is explained by the proposed solutions

nature, and the need to run multiple configurations before identifying the most appropriate one.

- *Phase 4:* The last phase describes the evolution of both indicators after the correction. Both indicators have moved beyond critical stage (3.5), which proves the effectiveness of the platform in terms of insurance and correction.

The experiments show platform performance for the proposed solutions effectiveness. However, it is important to assess the costs in terms of time and necessary resources to carry out correction entities for validate our approach.

The first criterion consists on the activation effect of the control entities and resources monitoring. Figure 6 shows the evolution of CPU consumption in a router according to the number of streams monitored simultaneously in the network.

Activation of entities monitoring greatly increases the cost in terms of resource (40% for 70 streams). A difference that is acceptable (20% for 70 streams), to the transactions nature included in the monitoring. The degradation cost depends on the flows number, which can be explained by changes in CPU load by 29% to 40% flow for 70 to 61 streams. Activation of correction entities requires the deployment of significant resources, but is still acceptable to the reliability offered by the new approach.

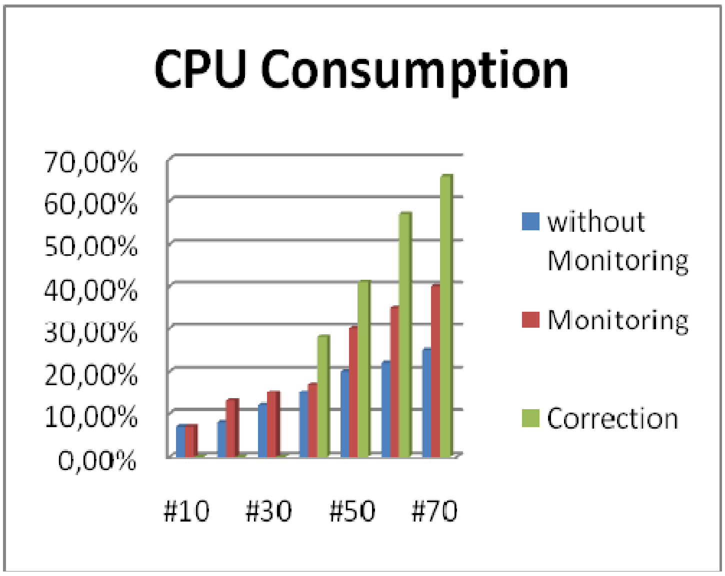

Fig .6. Evolution of the load on resources.

The execution time is a key criterion for evaluating the new approach, for its impact on the service degradation time felt by the customer.

Figure 7 shows the execution time evolution of two correction levels (resource and assurance layers) according to the number of competing flows in the network. The correction time of the first level does not vary significantly after changing the flows number. This is explained by the nature of the transactions included. These operations are standards and generic for all degradation types regardless to the type and nature of customer service.

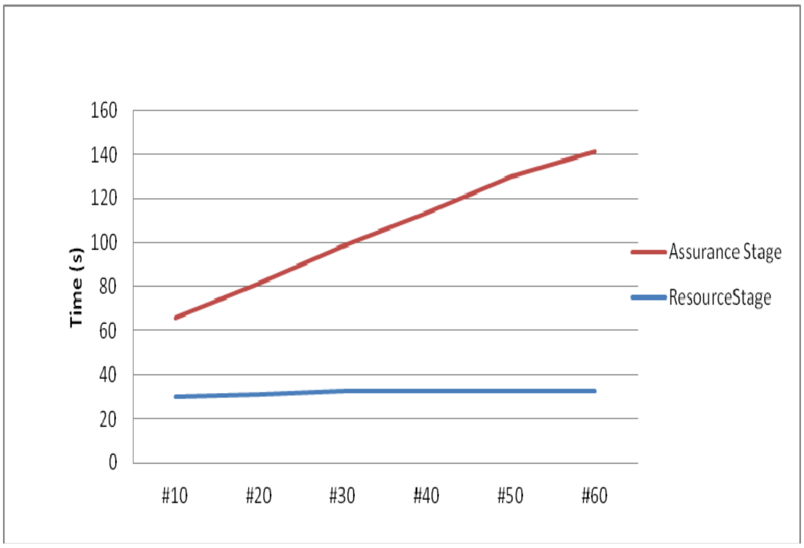

Fig .7. The execution time of correction task

The variation in the concurrent flows number has a considerable impact on the correction time in assurance layer. This is explained by the exchange of information between the different modules of the platform, before identifying the appropriate solution. The Tests stage has identified the platform performance in terms of efficiency. This performance will ensure high reliability of services deployed in the IMS. However the correction cost, in particular the execution time proves significant, which requires the integration of mechanisms that can harness these solutions proposed for similar cases of degradation.

6. Conclusion

The INQA approach for monitoring and correction services in the IMS presents an innovative advanced in terms of quality of service management in the context of NGN. This approach ensures high reliability of services deployed in a complex context which includes a multitude of entity and type of access technology.

The choice of technology and entities deployment allowed optimizing the execution cost of two operations: monitoring and correction. The introduction of synchronisation modules was able to minimize the load on resources and avoid overloading resources. Similarly the integration of SOA technology reduces significantly resulted charges from the data exchange between modules deployed on several organization levels.

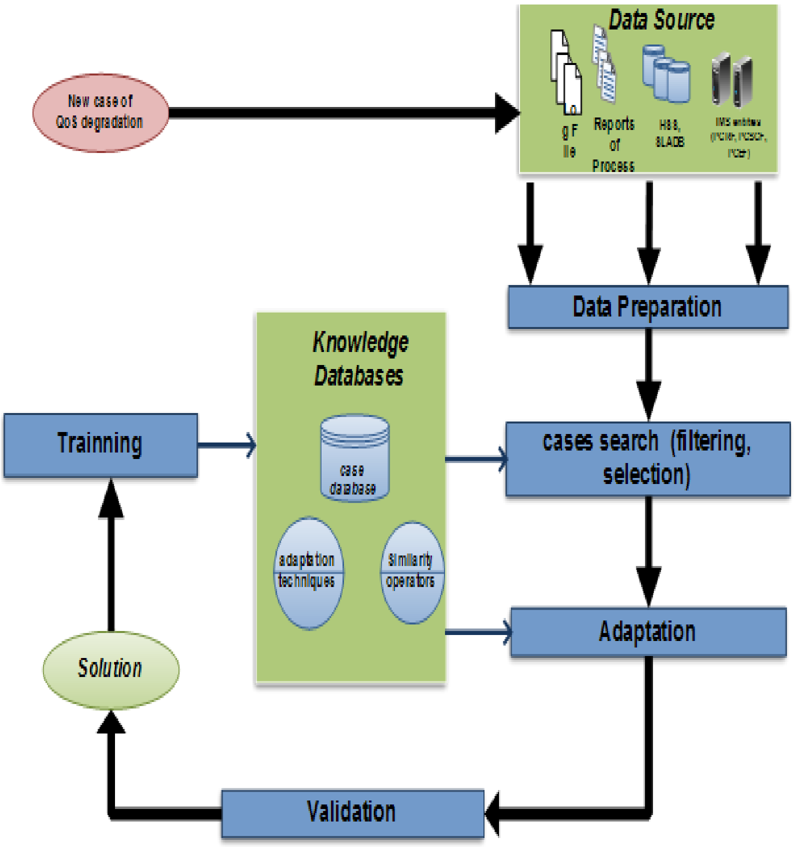

Fig .8. The case-based reasoning execution

The correction operation requires the deployment of considerable resources and a large execution time. Hence the need to migrate to an intelligent system able to exploit the solutions for similar degradation cases, in a transparent and efficient way. To this end, we propose in our future work to use the case-based reasoning [Watson, 2009] to build a new solution for new case-based solutions identified for similar cases.
This migration requires lifting more functional and technological challenges, including the choice of similarity operators [Weinberger and Saul , 2009] used in the research phase of the event target, and the organization of memory to target effectively similar cases.

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