IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 4, No 2, July 2011
ISSN (Online): 1694-0814
www.IJCSI.org

Towards an Autonomous System for QoS management of IMS networks

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Abstract

The QoS management in IP Multimedia subsystem Networks (IMS) is a cornerstone for developing real-time services, and facility the acquisition of multitude access technologies. The 3GPP specifications proposes set of scenarios for IMS networks, which focus primarily on providing service, but without internal and external monitoring mechanisms help to correct QoS and resolve network failure. Indeed, this paper proposes a new approach for IMS networks . monitoring, which handles policing and monitoring of media-plane traffic by implementing eTOM-based business processes.
The approach aims to implement a self-configurable system enable adequate monitoring and configuring depending on the business level as customer SLA, the monitoring architecture include a composite services by using web service techniques to implement a new generation of service management operations in IMS networks.
Keywords: *IMS, eTOM, QoS Management, SOA.*

1. Introduction

The 3GPP specifications for IMS [1] networks offers a dynamic approach for resource reservation and configuration related to classes of service with real-time constraints such as video or voice. The approach [2] focuses only on providing service and does not offer monitoring mechanisms of QoS after delivery.
Beyond, the eTOM [3] framework, as business model can be thought of as a set of business processes that are combined for several scenarios service-based, like SLA execution for service monitoring and restoration. However, these specifications are considered standard and generic, which makes their integration in the IMS context a difficult operation.
The architecture result for QoS monitoring and managements (QM&M) include a set of Web Services, each WS represent a business process devotes to a particular operation for QoS.

2. IMS and eTOM operations

2.1 Service Provision in IMS Networks

The Resources reservation is initiated by an AAR [4] message (Diameter) request sent to the PCRF [5] by the PCSCF (Figure 1). The service demand includes the QoS constraints; the IMS use two main protocols: SIP [6] for sessions request and negotiation, and Diameter [4] for resource reservation and service charging.

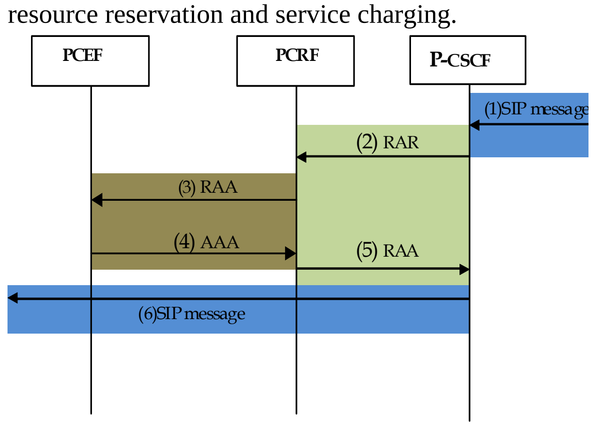

Fig. 1 Resource Reservation

The PCRF proposes an optimal solution as policy set, before sending this solution by a RAR [4] (Diameter) request to the PCEF [7], and these entities must install the policy, and once the configuration is activated the PCEF notifies the PCRF via a RAR request.

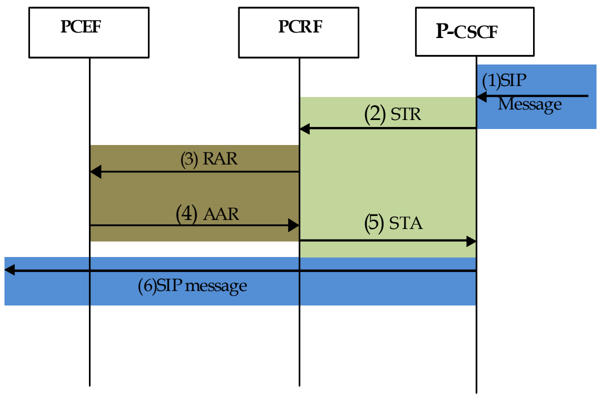

Fig. 2 Resource Release

The resources release is through the STA [4] (Diameter) request (Figure 2) sent the P-CSCF to PCRF at session end. Afterward, The PCRF sends a RAA [4] request to the PCEF for eliminating the PCC rules related to session.
The 3GPP standards propose a flexible QoS provisioning system [2], but without monitoring mechanism after services delivery. The 3GPP specifications focus on providing services such as resources reservation, but without worrying about the behavior-level of flux. Consequently, the IMS as network control layer would be unable to detect QoS deteriorates and resolve the problem, also support neither class of services nor customer importance, and without SLA definition and respect terms.

2.2 eTOM Framework Presentation

The eTOM Framework represent the whole of a service provider's enterprise, and positions this within its overall business context. The eTOM Architecture divides the relationship customer/operator in two main areas:

- Horizontal processes used to manage customer contact or manage the supply chain; it defined the constitutional architecture as well as TMN (Telecommunication Management Network), layers (Costumer, Service, and Resource).
- Vertical processes represent processes end-to-end groupings, which includes all operations management especially the 'Operations' party or FAB (Fulfillment, Assurance, Billing).

An operation between customer and enterprise (operator) will be translated in eTOM processes grouping, which operates the both layers to define the functional components, and End-to-End processes witch perform and fulfil the operation.

2.3. Ordering process flow

The eTOM develop and manage the supply chain as shown in ordering operation [8] (Figure 3), all implemented processes interact sequentially in the scenario and exchanging information between layered processes (Customer, Service, and Resource).
The ordering operation as Fulfillment process is only one scenario out of many possible ways of delivering. The interface 'CRM' (Customer Relationship management) accepts the request and attempt to verify the customer credibility and ensure service availability, before sending the process to 'SC&A' (Service Configuration & Activation) which tries to determine the class of customer (Platinum, Glod, Bronze, Silver), and propose a delivery conception in terms of logical and physical resources. Finally the process 'RP' (Resource Provisioning) will reserve resources for a service and client specific and must notify all supply chain as described below (Figure 4).

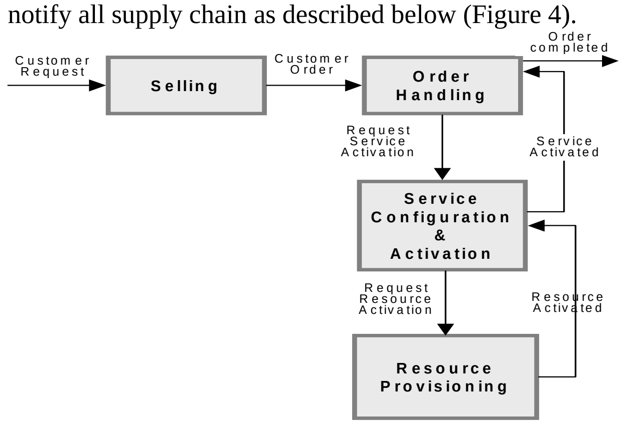

Figure 3.Ordering Processes as described by eTOM specification (Dynamic Ordering process)

In the fact, the IMS entities guarantee the operation of service delivery or fulfillment array perfectly, and can integrate the business as network policies. As well, the eTOM gives an operator the ability to monitor all business operations (Selling, Delivery, Assurance, and Billing) for detecting any problems that appear (SLA violation, anomalies, security).

2.3. SLA Verification process flow

The scenario of SLA verification [9] as defined in the eTOM framework identifies the user satisfaction as well as the QoS provided in real time. And enable QoS correction, entities restoration in the shortest time, and customer communications.
The execution normal of SLA or SLA verification requires the cooperation of several eTOM processes (Figure 4) belonging to the interface "CSR". Initially, the resource process collects the key performance indicators (KPI) [10],

and applies a first analysis; the performance data are filtered and structured to be forwarded to the next higher processes. Depending on the type of service, the process SQM choose the appropriate quality indicators [10] and makes a corresponding with KPI before being transmitted to processes in Customer layer. Finally, the customer process load the user profile to identify the thresholds in the SLA specific to service requested. These thresholds are applied to quality indicators calculated and provide a report. This verification report provides results for the verification.

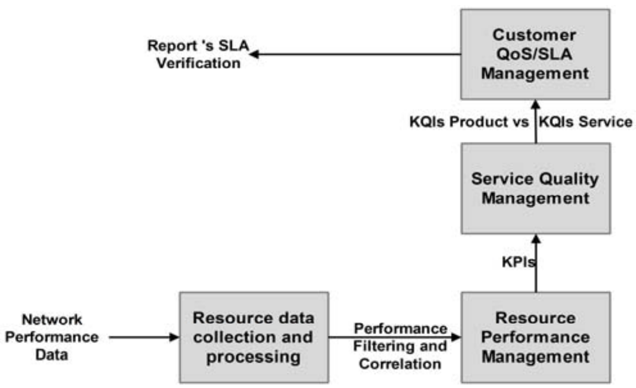

Fig. 4 SLA Verfication Processes as described by eTOM specification

3. Monitoring the IMS networks based on eTOM processes

The approach of IMS networks monitoring based eTOM framework [11] aims to integrate the tools needed to monitor services in real time to identify any QoS deterioration. The QM&M is based primarily on eTOM processes dedicated to monitoring and supervision services. The QM&M conception is performed following steps:

- Good understanding of IMS scenario for service delivery and QoS management.
- Data representation as an information model useful for IMS entities and eTOM processes and their interaction.
- Selection a set of technologies necessary for the implementation and deployment.

3.1 eTOM and IMS interaction scenarios:

The interaction is intended to define the relationship between the IMS network and eTOM Framework, and specify how the business processes are complementary in several operations made by the IMS network. For example, the ordering process is done completely by IMS, but in eTOM the scenario must be run to collect only the configurations and setting data; for other Assurance scenarios there are far from being applied separately by IMS that requires the intervention of eTOM processses.

The SLA verification scenario identifies the QoS deterioration in real time, based the performance indicators collected directly from the network entities and from the ordering operation (Figure 5).

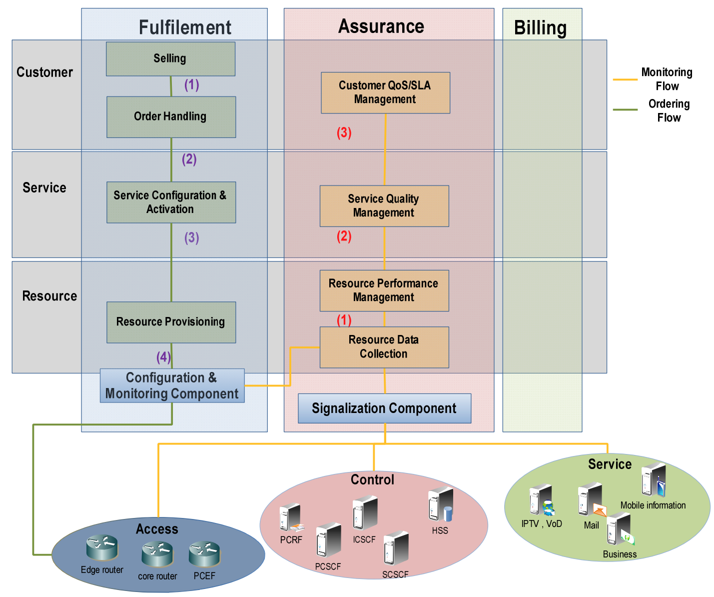

Fig. 5 Projection de l'eTOM dans le contexte de l'IMS

The QM&M ensure the integration of eTOM process involved in both scenarios (Fulfillment and Assurance) in with IMS entities responsible for providing service. The Communication inside QM&M between the two components must use a getaway for translate all information from log files to WS language.
In fact the diversity of entities and their various communication protocols require a set of components, which can interpret all data form and implement it for all QM&M operations. An additional constraint is that the performance data collection and detection of service delivery should be executed in real time or near real.
The QM&M define two component related to operation type:

– **Signalization Component:** The eTOM processes must be linked with the various components of the IMS network, this component is responsible for detect the services launch and their type. This is performed via the S-CSCF as well as the Application Server. For identify the clients and their parameters (IP address, ports, Access technology, etc...).
– **Monitoring & Configuration Component:** The component responsible for the configuration and activation of resources and identification of

network performance based on parameters retrieved from signalization Component.

3.2 Data presentation

The information structuring and deployment is the most critical step in the modelling phase, by aggregate a set of data arriving from multitude components and technologies. So, different solutions are necessary as follows:

- **SID (Shared Information Data)** [12]: for representing information model dedicated to network entities (routers, application server), protocols and configuration activated.
- **Business information**: for structuring the information related to customers as SLA, user profile or other data; all information will integrate as XMLDB.
- **Log files**: for all traces of performance indicators collected in each entity.

3.2 System Architecture

The QM&M implementation requires two main parties; the first party must granitite a flexible presentation of eTOM processes and reliable communication between; and the other party ensures the communication, monitoring and configuration of IMS entities.
The WSOA [13] technology is the adequate solution for representing eTOM processes, since it allows deploying Web services that communicate via fast protocol (SOAP/XML/HTTP) [14].
The multitude of components and the variety of functionalities necessary for monitoring requires referral to distributed system architecture. The components are grouped into three levels (Figure 6), each one focuses on a particular aspect as follows:

- **Resource Layer:** It focuses on the collection of key performance indicators as well as activation and configuration of resources. It brings together different modules dedicated to identifying the parameters of services provided by IMS entities and network status (WS-Resource, IMS agent, AS agent).
- **Synchronization Layer:** allows synchronization between different modules and Web Services.
- **Monitoring Layer:** This layer is the top level of the architecture system that allows processing of performance information collected to identify the state of service and the proposed solution for QoS.

Before defining the SOA modules (Fig 6), it is useful to introduce a set of agents deployed to ensure interaction with IMS entities. Indeed, the interaction by agents, each one focuses on a specific aspect:

– **Application Server (AS) Agent:** responsible for the recovery of service parameters such as ports, address, and the constraints specific to the service provided (codec, compression, bit rate).
– **IMS Agent**: allow the identification of network events, such as the service provisioning signaling and user profile.

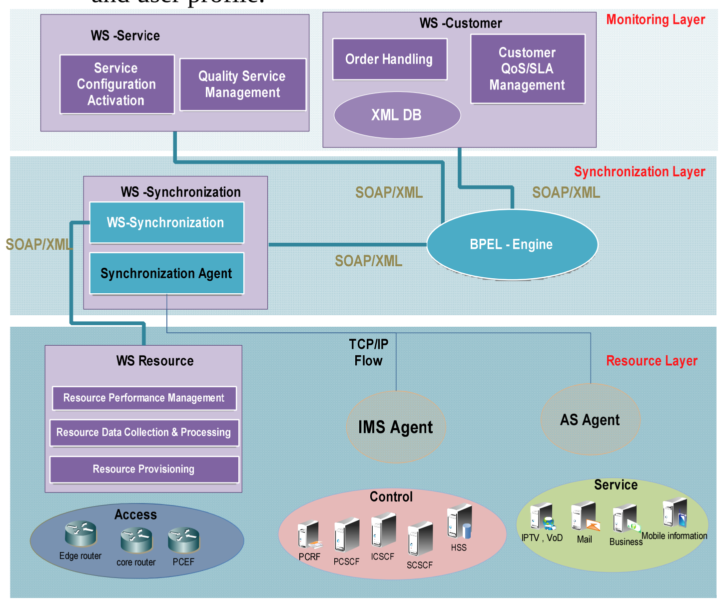

Fig. 6 System Architecture

The eTOM processes are translate into three EJB [15] modules according to horizontal layer from the eTOM framework Resource, Customer and Service, and they are exposed as WS (Web Services) using SOA [15] architecture. The orchestration between different web services is performed by a BPEL [16] process deployed in the synchronization layer. However, it is useful to introduce the agents implemented to represent the components of interaction between eTOM and the IMS (Figure 6).
The main components of the system architecture are as follows:

- **WS-Resource**: This WS is composed of classes implementing operations defined in the Resource layer of eTOM. It implements three main eTOM processes already discussed in the functional architecture: *Resource Data Collection &Processing*, *Resource Performance Management* and *Resource Provisioning*. Both of them are exposed as web services. The resource module is deployed on the routers.
- **WS-Service**: The module implements the operations defined in the Service layer of eTOM. It exposes the main process *Service Configuration & activation.*
- WS-Customer: This module implements the functionality defined in the Customer layer of the

eTOM. It exposes the *Customer QoS/SLA Management, Order handling* & *Selling Process*.

- **WS-Synchronization**: The module responsible for the synchronization, a party of the module synch IMS agent and Application Server agent, and another party is responsible for resources modules management deployed on routers. Indeed, this module exposes a Web service called "Synchronization" which includes reports of eTOM process of resource layer before transmitting to the BPEL-Engine.
- **BPEL-Engine**: implements a BPEL process that invokes the web services described, and synchronization and process mapping.

3.3 Monitoring Scenarios

The IMS agent detects the service request via SIP signalling exchanged between the control entities of the IMS. The agent notifies the synchronization module which makes the recovery of service settings. Once the parameters of services and the IP address of the client are identified, the synchronization module transmits a report to BPEL-Engine for start monitoring.

The BPEL-Engine invokes the eTOM processes involved in the Ordering operation with order (Figure 7). The report of the operation is forwarded by the BPEL-Engine to synchronization module.

The synchronization module transmitted the report of ordering to the resources modules to undertake the collection of key performance indicators (KPI). These indicators are recorded in real time in a log file identified by a session number. The Indicators are also analyzed based on the thresholds identified in the customer's SLA (report of ordering).

At session end or detection of KPIs critical values , the operation of SLA verification is launched. The resource module transmitted the report drawn up to the synchronization module. This last includes the reports of all resources before transmitting them to the BPEL-Engine. The BPEL-Engine invokes sequentially the eTOM process involved in the SLA verification, the operation finally examine the overall QoS and reports SLA verification result.

3.4 Issue

The approach of monitoring allows the identification of any deterioration in QoS during service provision [11]. So the new approach incorporates the specific mechanisms following the constraints required in the SLA of customer, what completes the 3GPP specifications in this direction. However, the information collection and monitoring of services is not sufficient for QoS managing in IMS networks.

Indeed, the integration of the correction mechanisms in real time becomes a necessity to achieve an autonomous system capable of tracking the services evolution, QoS assurance to guaranty a customer satisfaction as described in SLA.

4. The correction Scenario

4.1 The correction scenario defined in the eTOM

The correction scenario defined by the eTOM framework [9] (Figure 7) aims to introduce mechanisms for real-time correction for QoS deterioration or SLA violation. The solutions are established according to the nature of flows but also the quality of the customer. The proposed solutions take into consideration the class of service and the importance of clients' enterprise, to act correctly for restoring the product.

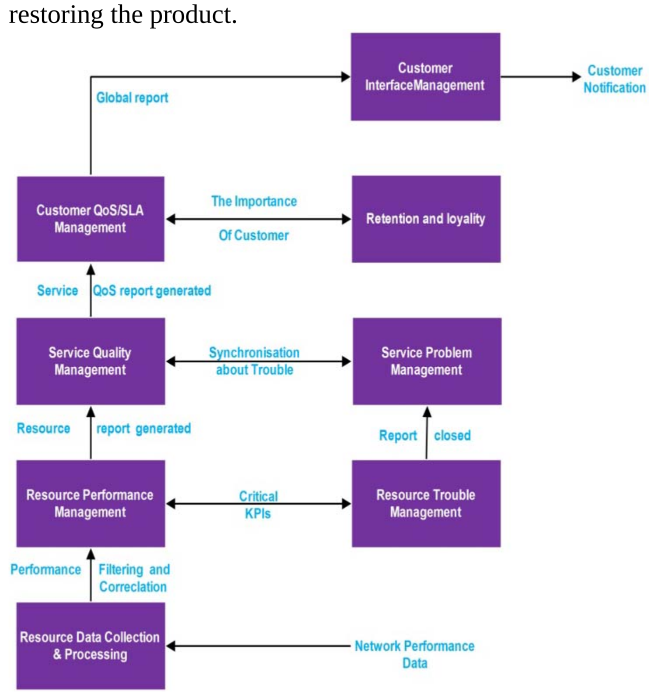

Fig. 7 Correction Processes as described by eTOM specification

The correction scenario is initiated by the *Resource Performance Management* (RPM) process which analyzes the KPIs to identify deterioration and root causes. The RPM transmitted the report which includes the critical values to the *Service Quality Management* (SQM) and the *Resource Trouble Management* process. This process provides an adequate solution according the values of KPIs and the current configuration of the resource. Simultaneously, the SQM process transmits the report to *Problem Service Management* (SPM) process which open a correction report and waits RTM process notification.

The RTM process communicates with the RDC&P process for recovery the KPIs to identify if the problem persist. Whatever, the RTM notify the SPM process of the proposed solution and the deterioration trouble or state. The SQM process communicates with the *Customer QoS/ SLA Management*, which according to the importance of the client, decides whether it is useful to notify the customer of the service state.

1.2 The implementation scenarios for IMS network

The integration of the correction eTOM processes in the IMS context requires a modelling several additional components for configuration and activation protocols in the resources. Also the correction phase must be based on reports made during monitoring involving the status and related resources configuration. The first phase involves the identification of key processes involved in the scenario of correction (Figure 9), as well as entities interfacing between eTOM processes and components of the IMS.

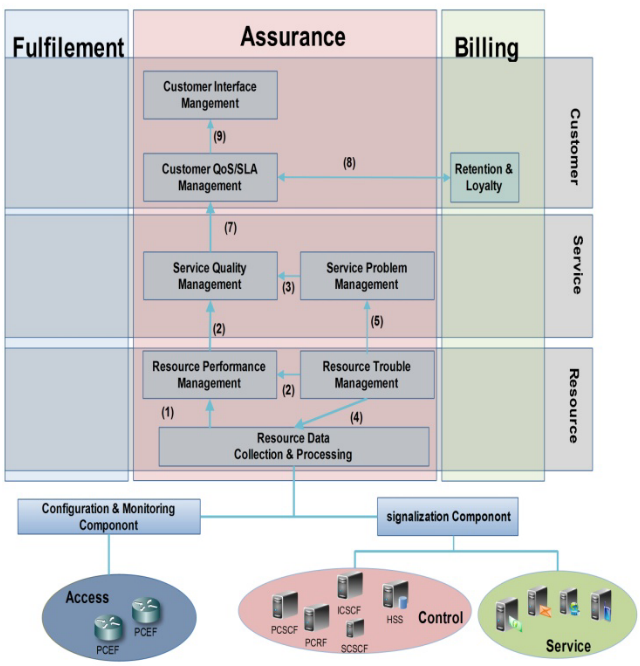

Fig. 8 The projection of eTOM correction process in IMS context.

The complexity of the operation to correct the deterioration is reflected in the variety of information collected and the multitude of entities involved. In effect, the decisions taken by the QoS management entities of the IMS in particular by the PCRF have a direct impact on the solutions to be applied when the correction and more of the state of resources and the client types. In this context the three IMS areas (Service, Control, and Access) are connected to the eTOM processes via the component interaction described in section (3 -1).

4.2 Architecture System

The choice of technological tools and how to deploy eTOM processes have a significant impact on system performance. Indeed, a distributed architecture will minimize the necessary communications between the resource layer and upper layers (Figure 7).
The architecture system [17] proposed (Figure 9) introduces the corrections entities, while minimizing the cost in terms of resources but also in execution time by opting for innovative solutions in deployment.
The SOA [18] technology remains the best solution for the implementation and deployment the eTOM processes, view it was this evidence during the phase of monitoring. Such technology also allows support of the reliable communications means by allowing high reliability of the platform. However it is useful to vary the modes of communications in order to optimize the time needed for message exchange between components.

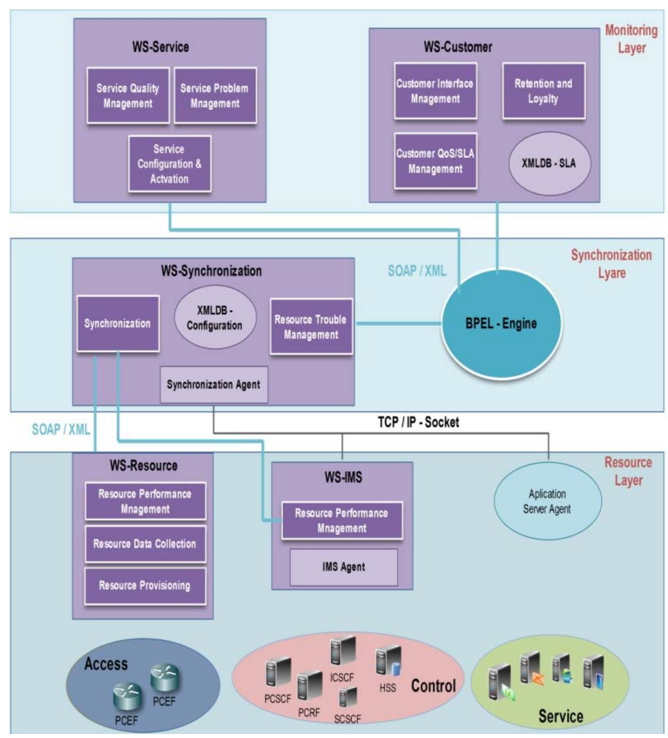

Fig. 9 System Architecture

The new architecture of QM&M (figure 9) includes all those components of the monitoring phase and more the correction entities. This is explained by the necessity of services monitoring to achieve a self-correction in real time.

a) SOA module

Before presenting the different SOA modules of the platform, it is worth noting that the modules WS-Resource, BPEL-Engine and AS agent have the same features as those defined in Section 2-C.

- **WS-IMS**: the WS analysis and structure the information recovery from IMS entities, in particular the configuration proposed by the PCRF in the service provisioning. The operation is done by the RDC&P process before transmitting the report prepared via SOAP [18].
- **WS-Synchronization**: expose two main functions, first is the synchronization between modules deployed in the network resources and the grouping of reports during the SLA verification and the ordering operation. The second functionality is the deployment of the RTM process which intervenes during the correction operation. This module includes an XML [19] database (XMLDB - Configuration) that identifies for each session and proposed solution by the PCRF. An information that will be useful for RTM to identify necessary actions for problems resolution.
- **WS-Service**: These processes or function in WS allow the calculation of specific indicators and identification of the appropriate configuration for each service, and selection for the adequate conception for best service delivery plus the alternatives solutions.
- **WS-Customer**: This module includes the eTOM processes dedicated to Customer. The Processes that allows communication with clients to ensure theirs satisfactions, and also identify the type and the importance of each customer.

The correction operation is initialized by the resource module, particularly by the RPM process that identifies the critical values of KPIs.

Indeed, the action performed by the QM&M is defined by the nature of thresholds exceeded by KPIs values. In this context two types of thresholds are defined:

- **Alert thresholds**: In case of the key performance indicators exceed these thresholds; the SLA verification operation is launched.
- **Critical thresholds**: Once critical thresholds exceeded, the correction mechanisms are activated without SLA verification.

5. Experience and results

The test bed (figure 10) is composed of:

- A core router and two edge routers (Linux boxes) defining a DiffServ [20] enabled network on which are connected an IMS terminal ad an Application Server;
- This network is controlled by the OpenIMS [21] system which is deployed in the core router Linux box;
- Management Server which includes the SOA modules Customer, Service and the web interface.
- Synchronization server that includes the Synchronization module and BPEL-Engine.

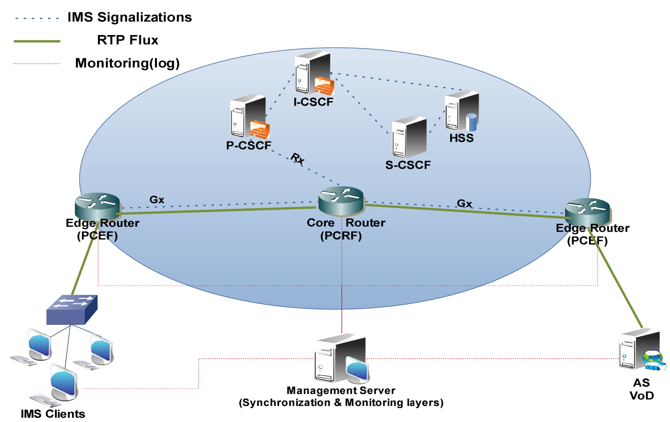

Fig. 10 test band

Initially, 'Alice' requests a video streaming service VoD. Then, for overloading network or create congestion multiple streams are sent in via the IPERF [22] tool. In all cases, the evolution of QoS and the behaviour of the platform are analyzed and discussed.

5.1 Result

The video quality (Figure 11) in the first case is considered good, reflecting the reduced number of service and users in the network. Also, the values of KPIs collected matching the requirements defined in the SLA.

Fig. 11 the image shows screen capture in case 1

In the second case the video quality (Figure 12) has become critical, reflecting the presence of several competing flows. Thus, more static pixels appear with worst audio quality.

Fig. 12 the image shows screen capture in case 2

The Network overload caused the deterioration of the values of KPIs collected, causing the launch of correction mechanisms. The Improving quality video after the launch of correction mechanisms is significant (Figure 12). The correction firstly applied to Real-Time Services.

Fig. 13 the image shows screen after correction

However, the QoS is optimal but worse compared with first case, which is explained by the limitations eTOM correction process in Resource layer [9]. Hence, adequate solution must integrate other processes belonging to the upper eTOM layers as Customer and Service.

5.2 Discussion

The platform detects the deterioration of QoS before correcting successfully. However, it is necessary to evaluate performance in terms of cost in verification time and resources (CPU). We use routers are Linux machines (512MB in RAM and CPU 3.40 GHZ).

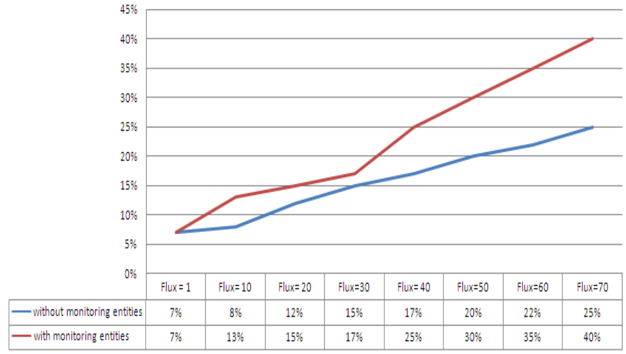

Fig. 14 History of CPU Utilization

The Figure 13 describes the CPU utilization according to the number of flows in the router. The deployment of resource module directly in the routers causes the increased consumption of CPU. However the difference in the recorded use in the event of activation of correction entities does not exceed a certain threshold (15%). What explains the choice of limiting processes deployed in routers; in particular RTM which is exposed by the synchronization module.

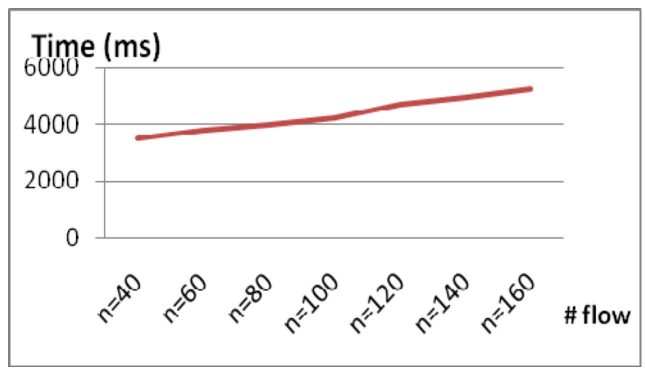

Fig. 15 the correction time

The Figure 14 describes the execution time of correction operation according the number of flows generated in the network. The correction time mainly depends on the flows numbers in progress, reflecting the need to collect performance indicators after cessation of each stream. However, the time required for the correction is acceptable for the type of services deployed.
The cost of the correction in terms of resource and execution time depends mainly on numbers of parallel services in the network, but also the technology deployment eTOM processes and the tools of communication between the components of the platform.

6. Conclusion

The new approach QM&M for monitoring and correction in real-time proposed in this paper ensures high reliability and availability of services in IMS networks. The mechanisms of monitoring enable complement the 3GPP specifications for supervision of service, taking into account the constraints defined in the SLA of the client. This provides a specific behaviour for each customer according type less in terms of QoS management.

The integration of correction mechanisms in real time enable to migrate to a standalone system capable of maintaining acceptable QoS from beginning to end of service. This will enable operators to these customers a wide range of services with an optimal service quality. The solution proposed by QM&M is insufficient and the actions are low-level and do not take several constraints into count, for that it's necessary to integrate other processes for high layers of Customer and Service.

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