WS-Composite for Management & Monitoring IMS Network

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The 3GPP standards for IMS (IP Multimedia System) provide access to multimedia services with robust procedures for QoS management. However its scope is limited to session initialization only, thus lacking follow-up or monitoring functionality; neither does it tackle SLA (Service Level Agreement) differentiation. A tempting approach would be to leverage the standard architecture by assurance processes based on TMForum's eTOM framework. This scenario would however necessitate a set of general business processes and would require a projection of IMS processes towards the eTOM. The work presented here follows this strategy, providing IMS services monitoring functionality based on eTOM processes able to provide SLA assessment and Service Assurance. It uses the BPEL language for orchestration and SOA elements to implement the distributed architecture.

Keywords: Quality of Service, Video On demand

1. INTRODUCTION

QoS management mechanisms as defined by 3GPP [3GPP TR 23.803 V7.0.0, 2005-09] can be viewed as a network-centric approach to QoS, providing a signalling chain able to automatically configure the network to provision determined QoS to services on demand and in real time, for instance on top of a DiffServ-enabled network [Raouyane et al., 2009]. However, to envision a deployment of such technology in a carrier-grade context would mean significant further effort.

In particular, premium paid-for services with SLA (Service Level Agreement) [TeleManagement Forum GB921 D, 2010] contracts such as targeted by IMS [Poikselka and Georg, 2009] networks would require additional mechanisms able to provide some degree of monitoring in order to asset the SLAs, while IMS by itself does not provide such mechanisms. The eTOM (enhanced Telecom Operations Map) [ITU-T Recommendation M.3050.3, 2004] functional framework is a widespread reference used to model and analyze networks and services activity. From an eTOM point of view, one could argue that IMS does indeed cover the Fulfilment part of service management, but lacks any means to carry out service Assurance. The eTOM framework proposes a complete set of hierarchically layered processes describing all operator activities in a standard way. It is furthermore sustained by a parallel specification of a standard information model, the SID (Shared Information Data) [TMF GB926 Release 4, 2004]. It has to be noted however that both tools, the eTOM and the SID, are generic. Also, the eTOM has been designed at times when Services were viewed as centrally controlled and managed, whereas the IMS is really a distributed layer network. The work presented in this contribution is an attempt to achieve Assurance functionality for QoS-enhanced IMS services following strictly the eTOM specification, thus filling the functional gap as analyzed earlier. The first part of this paper will briefly describe QoS management as defined by 3GPP standards, as well as the eTOM Assurance functional counterpart. The approach followed for monitoring the services is described in the second part; whereas the third part tackles the functional analysis and technical architecture of the proposed system. Experimental results obtained on the trial infrastructure will lead to the conclusion.

This research was supported by INSTITUT NATIONAL DES POSTES ET TÉLÉCOMMUNICATIONS and MédiTelecom operator.
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2. IMS AND SERVICE MONITORING

2.1 Service provisioning in the IMS and its QoS limitations

The management of QoS in the 3GPP specifications is as follows (Figure 1): The client sends a SIP [Rosenberg et al., 2002] request that includes SDP (Session Description Protocol) specifications [Handley and Jacobson, 1998] to the P-CSCF (Proxy-Call Session Control Function), which describe the desired QoS requirements. The P-CSCF identifies the customer and the service before sending a request to the PCRF (Policy and Charging Rules Function) [3GPP TS 29.210, 2006] via the Diameter Protocol [Korhonen et al., 2010]. The PCRF collates subscriber and application data, authorizes QoS resources, and instructs the transport plane on how to proceed with the underlying data traffic by sending a request to PCEF (Policy and Charging Enforcement Function) [3GPP TR 23.803, 2005] for reserving resources in the form of PCC (Policy and Charging Control) rules to classify traffic by service data flows. Upon transaction completion the PCRF acknowledges the P-CSCF. The client negotiates with the application server to agree on the media codec and other requirements, in order to launch the multimedia session with appropriate parameters. After delivery, when the P-CSCF receives a release message (BYE, CANCEL), it requests the PCRF to release resources for others applications.

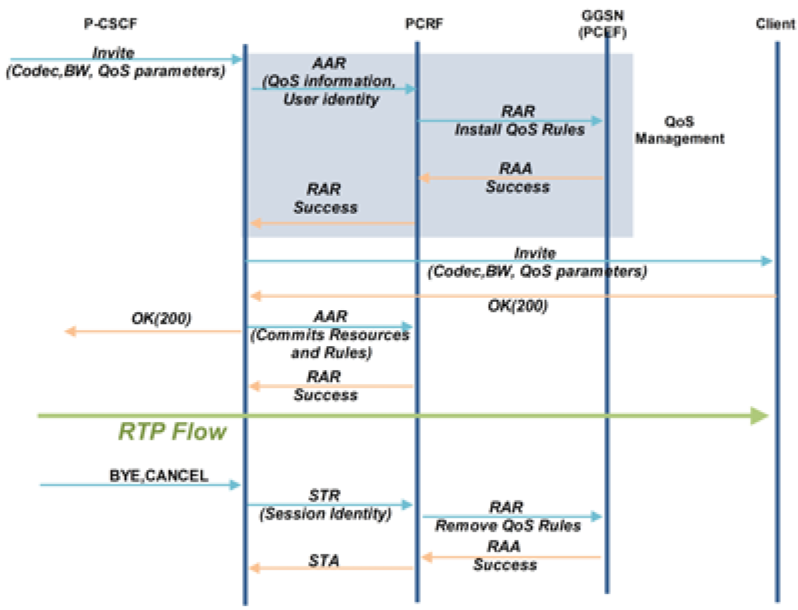

Figure. 1. IMS QoS management in a session

This procedure is agnostic of the actual QoS technology in the network, such as DiffServ [Blake S., 1998] or IntServ [Wroclawski J. 1997]. It is the responsibility of the PCEF to implement the QoS policy in the routers with respect to the actual QoS model supported by the network and its infrastructure. As mentioned earlier, the 3GPP layout and procedure for QoS control is targeted at resource configuration and reservation and does not provide any means to monitor service QoS during delivery.

2.2 eTOM functionality and SLA verification

The eTOM is the functional analysis viewpoint of the NGOSS (Next Generation Operations Systems and Software) [Creaner and Reilly, 2005] framework. As such, it provides a common language to describe business processes carried out in telecom activities. The eTOM has three major business process areas: the Strategy, Infrastructure & Product area, the Enterprise area and the Operations area, of which only the latter is relevant to our discussion. The Operations area is furthermore organized in vertical process groupings (Fulfilment, Assurance and Billing) and in horizontal layers (Customer Relationship, Service Management, Resource Management and Supplier/Partner Relationship). The eTOM model is structured into four abstraction levels allowing viewing processes and tasks in various detail.

2.3 SLA Verification in the eTOM

The eTOM proposes the SLA (Service Level Agreement) Verification [ITU-T Recommendation M.3050.3, 2004] as the suitable procedure for monitoring services. It identifies whether the provided QoS meets the requirements specified in the SLA contract from the information collected through the network entities. The verification process is structured into four stages:

—Performance Indicators Collection: Key Performance Indicators (KPIs) are a relevant means of monitoring the status of delivered services. There are three classes of performance indicators each of which focuses on a particular aspect of media streaming services: Network (Jitter (ms), Delay (ms), Bandwidth (kb/s)), Configuration and Service indicators.

—Mapping of quality indicators: Unlike indicators of performance, quality indicators are correlated to the service, so they can identify the quality of service more concretely than the performance indicators. The KQI (Key Quality Indicator) are calculated after combination or using an algorithm for calculating various performance indicators, which have an impact on this service (Mapping) to identify the quality perceived by the customer The quality indicators most used for multimedia streaming are: MOS-V (Mean Opinion Scores-Video) and MOS-A (Mean Opinion Scores-Audio) [Bellafkih et al., 2010].

—Comparison between quality indicators and SLA: SLA contracts negotiated between a supplier and a user define the conditions of supply, the targets of the QoS, and actions to take if the delivered service does not comply. The SLA must be designed so that it allows easily comparing with quality indicators.

—Report overall service and resources: It is necessary to provide a report on the resource during the provision of service and its status. Likewise for service availability, response times and indicators that measure specific levels of transport infrastructure performance (packet loss, network transit time and transit time variations).

The technical part of SLS (Service Level Specification) defines SLA violation [ITU-T Recommendation M.3050.3, 2004] thresholds; depend on the class of service (CoS) for the client. During service delivery KQIs are continuously calculated and compared to the thresholds.

2.4 Issues

3GPP standards propose a QoS management system lacking any provision for a monitoring mechanism after delivery of services. Indeed, the 3GPP specifications focus on providing services such as reservation of resources, but without worrying about the behaviour that follows. If the QoS deteriorates over time the system would be unable to detect and resolve the problem. Moreover, as the entities responsible for QoS management in IMS, in particular PCEF and PCRF, do support neither class of services nor customer categories, no provision can be made with respect to class-related SLAs. The eTOM functional model together with the NGOSS QoS management framework proposes a working procedure for the Assurance functionality missing in the IMS. A new design is suggested, combining IMS QoS management with eTOM Assurance functionality. The remaining of this paper will give more details how this goal has been achieved.

3. FUNCTIONAL ARCHITECTURE

A first step in this undertaking is to match IMS functionality with eTOM processes. The resulting set has furthermore to be enriched by eTOM processes relevant to Assurance. This broader set forms the basis to select the different SID entities necessary to carry out these processes. The SLA verification procedure as defined in the eTOM model requires the cooperation of several processes belonging to the Assurance column of the 'FAB' area, and spanning the three business layers: Customer, Resource, and Service. These eTOM processes will be activated sequentially (Figure 2). The four processes belonging to the Assurance layer correspond to the monitoring aspect of this operation. In order to link the eTOM processes to the IMS network, a new component entitled Monitoring, Configuration, Data Collection is required, which clusters the core modules to communicate with these entities.

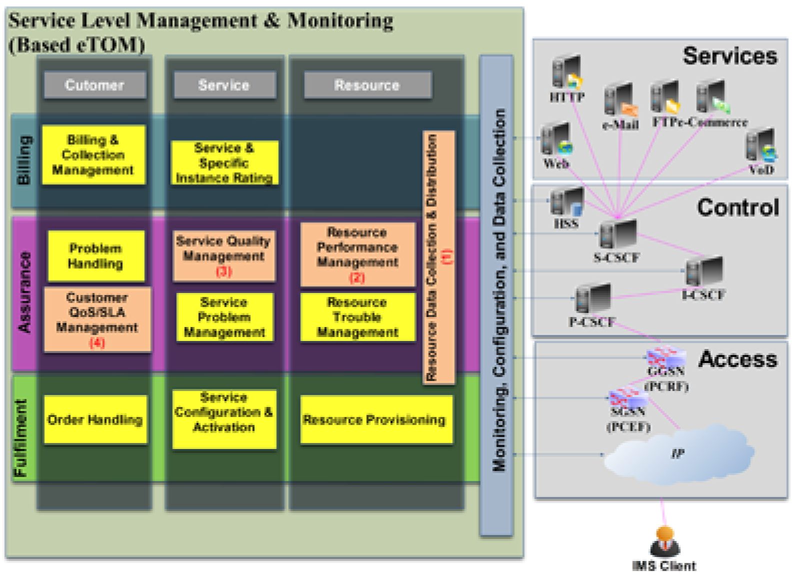

Figure. 2. Processes operating in the SLA verification: (1) aggregation of information, (2) Extraction of KPIs related to service, (3) Mapping and calculating KQIs, (4) Comparison, estimation of QoS and SLA verification.

The diversity of entities and their various communication protocols require multi-protocol components which can implement all the necessary monitoring operations. An additional constraint is that the performance data collection and detection of services should be executed in real time or near real.

3.1 SLA verification components:

Monitoring, Configuration, and Data Collection components: The eTOM processes that are linked with the various components of the IMS network are responsible for the detection of the launch of services and their types. This is performed via the S-CSCF as well as the Application Server to identify the clients and their locations (IP address, access technology). After this operation the components produce performance indicators of physical and logical resources in log form along the flow path of the service.

—Resource Data Collection component: This component is responsible for collecting performance indicators in communicating with the Monitoring, Configuration, and Data Collection module. The Process contains several secondary processes according to level 4 in eTOM decomposition, which are responsible for collecting performance indicators and metrics for all service running in the network.

—Resource Performance Management component: it processes collected performance indicators; it provides XML (Extensible Markup Language) reports featuring a structured view of the KQIs as well as threshold detection.

—Service Quality Management component: this component performs a mapping of performance indicators; it identifies for each service its quality indicators before determining appropriate operations to be performed to calculate them. It is also used to identify causes of QoS failures such as resources failure or missing capacity.

—Customer QoS/SLA Management component: it is responsible for the SLA verification. After the retrieval of quality indicators from the Service Quality Management component and receiving its preliminary report, it imports the client profile as well as SLA parameters to identify threshold levels for comparison purposes. It handles also reporting to the management systems and provisions a comprehensive report on the service (Metric, KQIs, KPIs, Resource, etc. ...).

3.2 Service delivery scenarios

The workflow of SLA verification follows these steps:

—When an IMS customer registers and requests a media service (Video Streaming), the Monitoring, Configuration & Data Collection component detects the service and activates all agents in the network in order to monitor performance indicators and retrieves their information in log form.

—The Resource Data Collection component retrieves KPIs from different entities in the network collected by the previous component. It communicates with the Resource Performance Management component to detect critical values and generate performance reports.

—Collected KPIs are sent to the Service Quality Management component which will identify indicators of suitability for mapping and comparing them to those specific of the requested service.

—The Customer QoS/SLA Management component will load the customer profile to identify the thresholds to be applied to collected data before writing the audit report.

4. SYSTEM ARCHITECTURE

The WSOA (Web Service Oriented Architecture) appears as a valid choice for such a distributed system. The SOA [Mark and Hansen, 2007] concepts will allow to implement EJB [Rima, Gerald, and Micah, 2006] based SOA modules supporting the processes of each component, exposing web services communications via XML/SOAP (Simple Object Access Protocol) /HTTP [Newcomer E., 2002]. Three SOA modules have been designed, each of which supporting a part of the targeted eTOM business processes and their associated SID entities. In addition, a BPEL (Business Process Execution Language) [Poornachandra, Matjaz, and Benny, 2006] component has been designed to orchestrate the various processes and to organize the desired operations (Figure 3).

The three modules of the monitoring system are: Resource Management, Service Quality, and Customer Management; each one exposes a set of web services specified using WSDL (Web Services Description Language) [W3C Recommendation, 2007]. These web services are invoked and synchronized by the central BPEL component that provides moreover tools such as a web interface that tracks the performance of the SLA verification processes and the monitoring of physical and logical network resources (Figure 4).

In order to simplify the platform the number of exposed web services has been limited to eTOM level 3 business processes. Naturally the processes of level 4 are implemented via appropriate methods within the web services. Before analyzing the different SOA modules, it is useful to introduce the interfaces between the SOA modules and the network. These interface agents take (Figure 5) in charge low-level detections and calculations and transmit their results to the SOA modules via dedicated socket interfaces:

—The IMS agent scans S-CSCF activity and detects service launching ;

—The Application Server agent scans Application Server activity in order to identify the customer parameters ;

—The Router and the Customer agents perform network analysis tasks in order to calculate KPIs that will be transmitted to SOA modules.

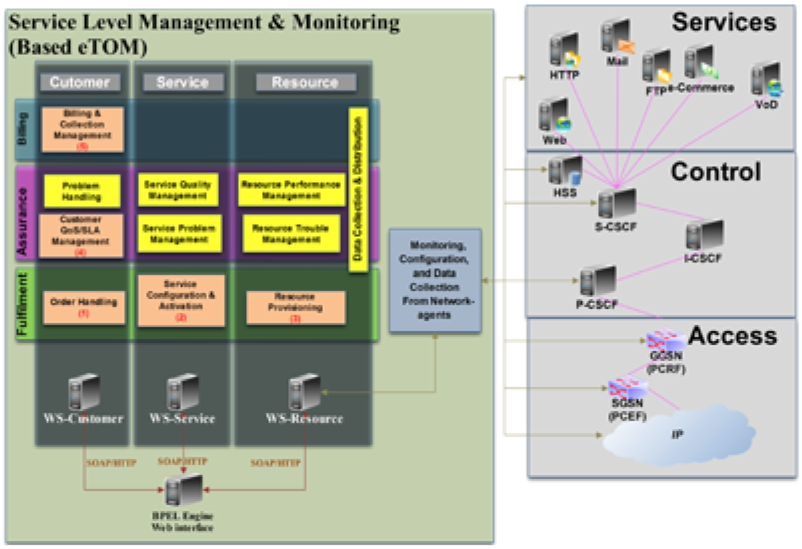

Figure. 3. Implementation Architecture

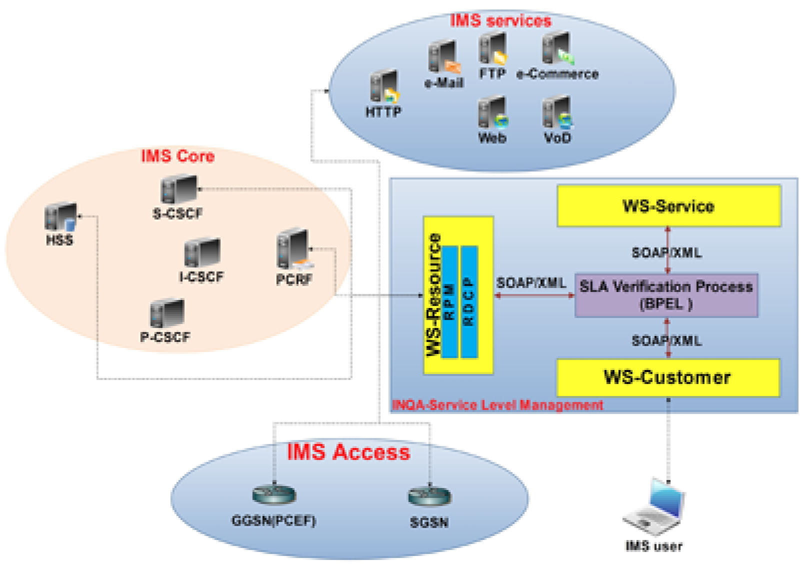

Figure. 4. Implementation architecture

4.1 SOA Modules

—Resource Management: This SOA module is composed of classes implementing operations defined in the Resource layer of eTOM, as well as the corresponding SID entities. It implements two main eTOM processes already discussed in the functional architecture: Resource Data Collection & Processing, and Resource Performance Management. Both of them are exposed as web services.

—Service Quality: This module implements the various SID entities and operations defined in the Service layer of eTOM. The module exposes the Customer QoS/SLA Management web service responsible for the quality indicator mapping discussed in section 3.1

—Customer Management: This module implements the functionality defined in the Customer

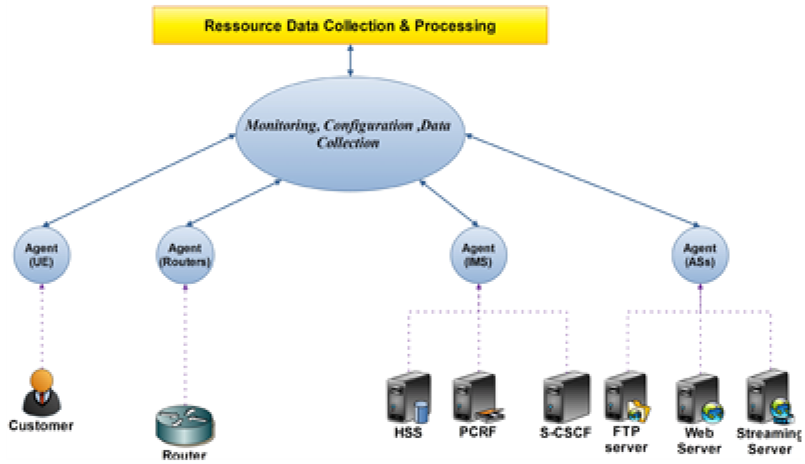

Figure. 5. Collection of metrics in various network entities

layer of the eTOM and its SID model. It exposes the Customer QoS/SLA Management web service responsible for SLA verification. It retrieves the KQIs of the currently delivered service, loads the customer profile and subsequently detects any SLA violation.

—BPEL Engine: The BPEL Engine module implements a BPEL process that invokes the web services described above and synchronize their interaction.

—Web interface : To monitor the SLA verification process, the BPEL engine features a web interface that allows to:
  —Show messages exchanged between web services (XML/SOAP) and modules.
  —List performance indicators collected from the network layer entity
  —Monitor the activity and performance of physical resources such as network routers and logical entities such as CSCFs and the HSS (Home Subscribe Server).
  —Check the provisioning chain of QoS management: PCRF, PCEF.
  —View the results of the audit and SLA verification, the customer class, and values of KQIs.

4.2 Monitoring scenario:

The monitoring activity is triggered by the IMS agent detecting the launch of a service: the Assurance phase begins. Communication with the Application Server agent allows identification of customer parameters. The Router and the Customer agents are started in order to retrieve performance indicators. Meanwhile, the BPEL engine starts the web services; in particular the Resource Data Collection Processing that will retrieve the KQIs via sockets from the Customer and Router agents. These values are forwarded to the Resource Performance Management web service via SOAP. This service generates a XML report that is transmitted to the Service Quality Management web service. The latter performs the first step of stage 2 of eTOM's SLA verification procedure: KQI mapping. The results are forwarded to the Customer QoS/SLA management web service that retrieves the customer profile and compares the actual KQIs to threshold values to determine if the QoS matches the SLA.

5. IMPLEMENTATION RESULTS

The platform has been validated by performing practical cases of multimedia services (IPTV) in an IMS network.

5.1 Trial infrastructure:

The test bed is composed of (Figure 6):

—A core router and two edge routers (Linux boxes) defining a DiffServ-enabled network on which are connected an IMS terminal ad an Application Server;

—This network is controlled by the OpenIMS (Open IMS Core) system which is deployed in the core router Linux box;

—A management server supports the QoS monitoring/Assurance functionality;

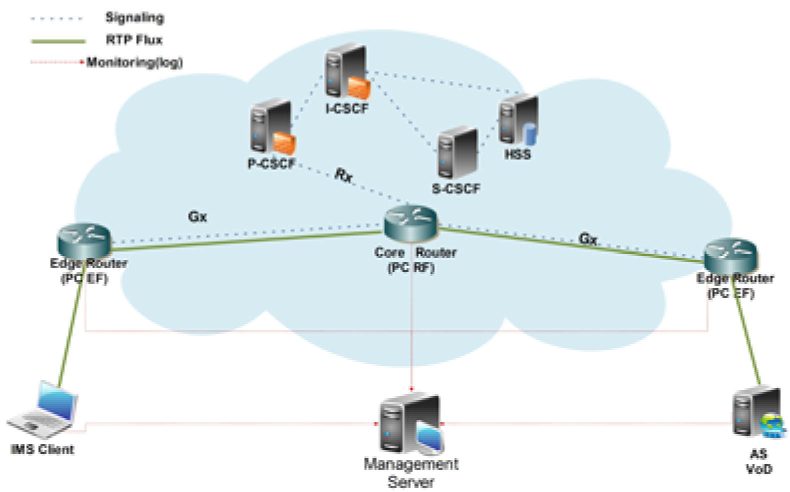

Figure. 6. Test bed infrastructure

5.2 Scenarios

Alice has registered in the IMS system with QoS classes Platinum. The goal is to perform SLA Assurance tests in three representative cases and to compare the results:

—No or only few competing services (FTP)

—Significant load of competing services

—Maximum load of competing services up to bandwidth saturation.

5.3 Results

—Case 1: The QoS offered to Alice and Bob matches the SLA contract, perceived video quality is satisfying (Figure 7)

—Case 2: the network conditions, hence the video quality, deteriorate proportionally to the mass of competing services for lost packets and reduced flow rate (Figure 8).

—Case 3: competing services overload the routers: the queues fill in the gateways, impacting delay and jitter. Routers discard packets in excess, this causes static pixels in the video (Figure 9) and in some cases service cancellation.

Figure. 7. Video bandwidth =128kbps

Figure. 8. Video bandwidth =76kbps

6. DISCUSSION

The platform succeeds in identifying accurately the deterioration of delivered services. The cost in terms of response time has been evaluated as well. It is observed that the response time for the Resource web service is much longer than for other web services, due to the complexity of its tasks (Figure10). The number of web services and their internal functionality has a considerable impact on the running time of the SLA verification. This led to limit the exposed eTOM processes to level 3 and to implement sub processes via internal java methods. The execution time of the verification is composite; it depends on time checking for each web service. This time varies depending on the number of provided operations and the time of the audit. Thus, during the first operations of SLA verification we note that the time of SLM&M module (exceeds 500 ms)

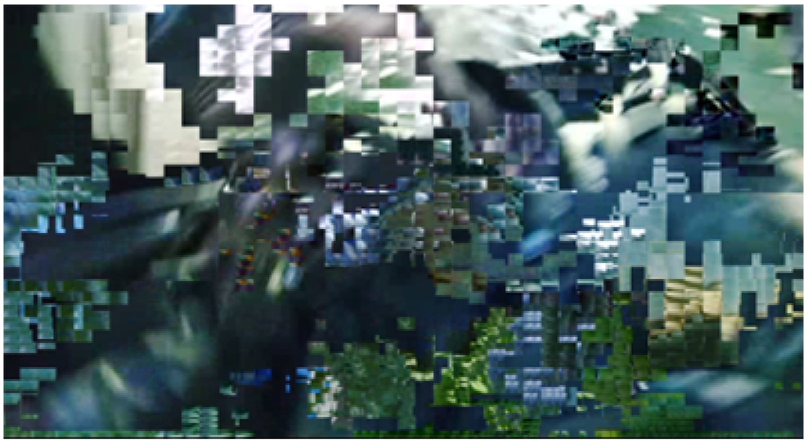

Figure. 9. Video bandwidth =40kbps

Figure. 10. Response time for different web services (Client: Alice)

is large that reflecting the message exchange with the entities of controls to get the parameters of services. The number of Web services invoked by the BPEL has a significant impact on the execution time of the SLA verification process .This explains our choice to expose the processes of the eTOM level 3 all by implementing the sub-process via regular duties. Similarly, the nature of the communication technology between entities plays a vital role in reducing the complexity and verification time, which highlights the advantage of using TCP/IP for exchange of parameters service and transmission performance indicators to upper layers.

7. ARCHITECTURE DEVELOPMENT

The issue within the SLM&M architecture is located mainly in the Resource layer or WS-Resource; the agents in different layers of the IMS require synchronization and continuous communication with WS-Resource, in order to forward sets of information. This communication can overload the network and may reduce flow performance and increase traffic congestion. Moreover, the diversity of performance management information increases the processing time in WS-Resource. The complexity of the system is mainly due to the combination of EJB modules or WS on the same server, in addition to heavy communication between Resources processes (RDCP, RPM) and dispersed agents throughout the network. In this architecture the centralization of web services allows irregular monitoring based on KPIs and KQIs, which must pass through the processes described by BPEL to evaluate the service. This estimation is accurate but requires heavy calculation and communication. The need for continuous monitoring of services and resources would require an even more distributed system architecture that would optimize the verification time as well as integrate the monitoring mechanisms throughout the service. Thus a distribution of EJB modules becomes necessary to incorporate mechanisms for monitoring but also for correcting the QoS degradation and anomalies. The functional architecture of the distributed SLM&M (Figure 11) consists of two main modules:

—**Assurance layer:** represents the SLA verification process as defined in eTOM specification for Customer and Service layers. Also, the synchronization module that is required for detection and control network events, such as planning activities and communications of a share distributed among the modules (module synchronization) and secondly between exposed Web Services Module (orchestration).

—**Monitoring Layer :** is distributed, and contains a set of agents and probes are able to recover all data in real time (signalization, logging, reservation, configuration, policy, routers status, etc. ..) and implements all of the process layer Resource use in verification of SLA: *Resource Data Collection & Processing Performance and Resource Management.*

The proposed functional architecture supports three communication types between different modules:

—TCP / IP between agents and the synchronization module,

—SOAP / XML between eTOM layers (Resource, Service, Customer)

—The ability to use XMLCONF [Xiaochao and Jinpeng, 2009] between entities of synchronization and management module in SLA violation case.

The distributed architecture allows the processing, comparison and collection of recovered parameters in real time from network entities, which differs from the centralized architecture, which provides intelligence to various entities and allows real-time management of performance data, and reduces communication as needed between the two layers Assurance and Monitoring The Resource processes are moved to each layer IMS and are adapted to meet the needs of its components, each layer defines a typical signalling used and a basic function on its entities, which offers a variety of operation of each process even if they share the same principle, the two processes Resource Data Collection & Processing and Resource Performance Management reflect the nature of their roles:

—AS Model : The processes RDC& P and RPM collects information about application servers, such as a media server VoD or IPTV that is divided into two main parts, a part of signalling and another that contains multiple media servers each one enables the streaming video channel provisioning. The process role is to provide all the information flows that are dynamic on each service and the status of each media server and the ports of communication and of course measure the QoS at source server.

—IMS Model: The module allows gathering information (signalling, data, and policies) for a particular session or a specific client. Processes use the IMS layer agents to collect information,

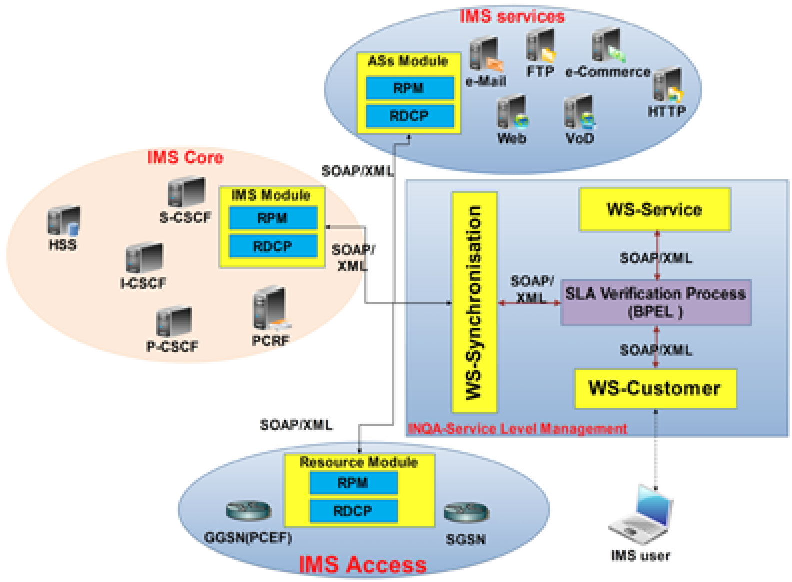

Figure. 11. Distributed Implementation Architecture

after filtering and aggregation of information in a suitable format; also provides control and ensures proper functioning of the monitoring entities and IMS entities.

—Resource Model : a main module, the process RDC&P integrates the functionality of monitoring agents of traffic and the router state, and alert the case of congestion, also retrieve any information from router (policy, QoS configuration, routing, protocol active and static traffic). In addition to these features, the routers compare the values of KPIs with the thresholds and send alerts when thresholds are exceeded or violated.

The agents in different layer of the IMS allow a continuous monitoring service performance, given their ability to carry out a traffic control function and thus a comparison with thresholds, the SLM&M can not only monitor a service with a SLA verification selectively or in time ranges but also a perform continuous monitoring with the both functionality proactive and reactive.

8. CONCLUSION

The proposed approach leverages the 3GPP QoS provisioning architecture with eTOM Assurance features monitoring the delivered QoS in real time. The platform will act as proactive supervisor of the IMS network to monitor the network behaviour, to correct and to anticipate degradations before failures occur at customer premises. The requirements are not only to produce, to manage and to send alarms based on events and thresholds in real time, but also to correlate network performance and the proposed root solution. Using SOA concepts and BPEL in Assurance and monitoring functions bridges the conceptual gap between the eTOM model and the actual implementation. Its modularity and openness will moreover facilitate the design and deployment of future problem-solving, decision making modules. The system monitoring should provide proactive service assurance that include plus performance monitoring based root-cause correlation and service impact analysis, a capacity to automates problem resolution by using BPEL based a predefined steps and knowledge base. Therefore the system monitoring moves from a reactive to proactive system and ensure an enormous potential to offer new benefits and revenue for IMS network operators.

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