QoS signaling for Service Delivery in NGN/NGS Context

Noëmie Simoni, Yijun Wu
Network and Computer Science department
Institute Telecom/TELECOM ParisTech
Paris, France
e-mail: simoni@telecom-paristech.fr,
yijun333@hotmail.com

Chunyang Yin
Network and Computer Science department
Institute Telecom/TELECOM ParisTech
Paris, France
e-mail: chunyang.yin@gmail.com

***Abstract*—The evolution of next generation network raises the issue of exploiting customizable services for a nomadic user within the environment of heterogeneity and mobility. In this context, the E2E QoS (Quality of Service) always remains as a challenge. In fact, the E2E supposes that apart the network resource, the service should be taken into account as an important resource, in the form of service component, i.e., we should also provision and monitor the service resource and verify the conformation to the QoS contract. In this paper, we propose a "dynamic user oriented end-to-end QoS signaling" for the service delivery in order to provision and dynamically negotiate the different services in the NGN environment. This end-to-end signaling extends to process the service delivery to maintain QoS continuity. The related sequence diagrams are defined and a demonstration is implemented with the purpose of presenting the feasibility of our proposals.**

Keywords-NGN; service delivery; QoS signaling

I. INTRODUCTION

As networks are evolving towards NGN (Next Generation Network), the environment is becoming more and more complex. NGN is characterized by heterogeneity mobility and user centric.

The deployment of such NGN raises the issue of development of Next Generation Service (NGS). The mobility challenges to offer service continuity in a personalized way for end users. Moreover, the personalization puts the user in the centre position in the architecture (user centric). An end-to-end service session should integrate user's preferences with the dynamic context, which includes end user terminals, access networks, core networks and services (heterogeneity).

If we follow the same strategy, then the user becomes the center of the consideration. Therefore, first, since the user is probably across the heterogeneous environment, to deal with the different providers or to gain the benefits from this evolving environment. For example, a travelling user is in a café bar where the WiFi service is offered. He is glad to grasp this chance to check his emails, but he has only the email account settings on his laptop and he's not in the mood to configure his telephone for that moment. Therefore, the different terminals are desired to be integrated before the execution phase of a user's service session. On the other side, user is also willing to benefit from the NGN mobility supports to have the service continuity. Mobility allows the end user to communicate regardless of location, used device, access mode and multiple spatial network domains. Finally, he wants to always keep his personality when the system choosing or adapting the services for him through his pertinent preferences.

All these requirements lead us to focus on the service delivery with the service continuity. The service delivery we mentioned above is different with the traditional media delivery. Media delivery focuses on the data transfer solution treating the service continuity by shifting the access point and the corresponding supporting services in the network layer. The QoS is obliged to be recalculated and sometimes the delivery is interrupted.

What's more, to insure the E2E (End-to-End) QoS, today's media delivery E2E QoS solution, aiming the network resources, is no more sufficient. The service should also be taken into account as an important type of resource as well as network resource. To compose the service as service components is a possible way to separate the service resources from the network resources. We should not only provision and monitor the service resources as well as the network resources, but also dynamically verify the conformation to the QoS contract established between service providers and user.

In fact, the aiming user-centric session should allow users to access services in a customized way (composition of service) with QoS continuity. Therefore, a more flexible E2E QoS signaling is desired to support the service delivery and guarantee the QoS continuity. Its principle task is to negotiate the QoS and user information among service components for subscribers across any mobile or fixed network with any user appreciated equipment during the provisioning phase. During the real time of the user session, it can help to dynamically manage the session on the QoS level to have the QoS continuity.

In this paper, we propose a QoS signaling which covers the end-to-end provisioning for demanded service and maintains the provided service conform to the SLA (Service Level Agreement) during the real time service session. Quality of Service in this paper is seen from end-user's standpoint which means that the QoS assessment should be performed regards to the users' requirements.

The remainder of this paper is organized as follows. In Section II, the requirements of user-centric session are introduced. In Section III, the related works in signaling protocol are presented and analyzed. In Section IV, a dynamic E2E QoS signaling is proposed based on a service and sub-network integrated architecture. In order to examine the feasibility of our proposition, in Section V, the functional specification is detailed by explaining a user case and scenarios which take user's needs into account with corresponding sequence diagram, and the implementation part is presented. Finally, Section VI is the conclusion and gives out the perspectives.

II. USER CENTRIC SESSION REQUIREMENTS

We have mentioned that there's an important characteristics of NGN: user centric. However, what will be introduced by this change? The telecommunication world evolves and becomes now user centric in opposition to system centric (behavior is constrained by the system) and network centric (behavior is constrained by the network). Therefore, user-centric requirements are expressed by user-related information, such as QoS parameters and user's preferences etc. This information can be defined in the user's profile. On the provider side, QoS commitments should match these user's requirements. These commitments can be defined in the customer contract SLA. As Figure 1 shows, the user's profile in the centre represents the user in the E2E session. This conception contains the essential requirements as below:

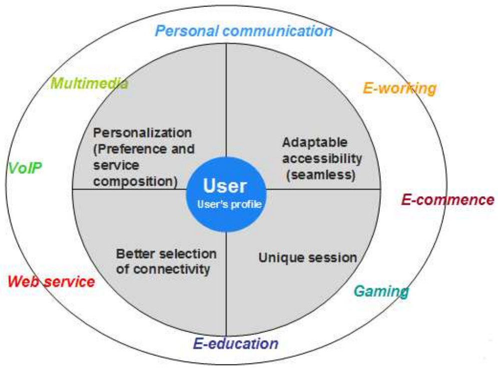

Figure 1. User-centric session requirements

- Personalization according to user's preferences and the user profile. In order to meet the personalization of service delivery, a more flexible deployment of services (service aggregation) as well as a loose coupling architecture between service elements (service composition) is appreciated.
- Unique user session for converged services delivery from different providers in a top-down way. It means that we don't need lance several sessions for different media service demanded by user. It is possible to have different media demanded in one session through difference transactions.
- Better selection of connectivity with QoS in a dynamic manner according to user's preferences (QoS, location, agenda, etc.) for the media delivery.
- Adaptable accessibility to services regardless of terminal used. End users may have different user equipment (UE) in a Seamless Userware vision according to user's preferences [1].

III. RELATED WORK

An end-to-end session goes through the user's equipment, the connectivity network session (access and core network) and the service session. In each sub-session, it has his own method for the QoS issue, for example, GPRS (General Packet Radio Service) Tunnelling Protocol (GTP) used in between SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support Node) allows the SGSN to adjust QoS parameters in a session GPRS on a user's behalf (PDP context); Session Initial Protocol (SIP) used between user and application server works with Session Description Protocol (SDP) for defining and negotiating the QoS parameters of media streams. We find that there is nothing for the service level.

For the requirements of user-centric session, signaling should support broadening personalization coverage with QoS through composition of services in service levels to enhance capability of adaptation in mobility and heterogeneous environment. In this new context, we have evolved from a client/server architecture for a demanded application to a distribute architecture with a composition of services for a continuity of session demanded.

Before presenting our proposals, we analyze the existing related work on the architectural proposals (IMS) and signaling proposals (SIP, NSIS) aiming at end-to-end QoS in this section. IMS (IP Multimedia Subsystem) architecture gives a converged network control layer. SIP is a signaling protocol of the session layer for media QoS control with the media. NSIS (Next Step In Signaling) is a signaling protocol of network layer to transferring with QoS parameters and. These proposals are in the network level to maintain the QoS, and there is nothing for the dynamic resource reservation of service.

A. IMS

IMS architecture defined by 3GPP (3rd Generation Partnership Project) creates one common access independent signaling platform for providing multiple services [2][3][4]. It implements the QoS mechanisms in management and control planes, i.e. policy control in the management plane and admission control in the control plane. In the TISPAN (Telecommunications and Internet converged Services and Protocols for Advanced Networking) NGN architecture[5][6][7], not only core networks but also access networks or even terminals on the user side have QoS related control and management functions.

IMS integrates the network convergence but not the service convergence. In addition, IMS provides access to a service while still following client-server architecture as a tight coupling. In fact, we need a loose coupling for the service trans-organization in order to favor the personalization of service.

 ISBN: 978-1-61208-126-7

B. SIP

SIP as the basic protocol at IMS control layer and one of the multimedia communication system framework protocols [8], is the application layer protocol used to establish, change, or terminate a multimedia session. SIP enables flexible interaction of several media in one session.

As far as QoS is concerned, SIP uses SDP to describe the media in the session and negotiate QoS requested in the network layer [9]. Moreover, SIP can filter information according to User Profile to implement application servers before establishment of a session.

However, SIP does not cover description of service component behavior, and is not even able to communicate the QoS related information among the components in order to re-provision services during an active session in a mobility environment committed to user's contract.

C. NSIS

NSIS focuses on developing a protocol to manipulate QoS resource states along the data path in the network. NSIS is concerning to media delivery. But their work does not cover all the service resources in order to cover overall service delivery which is more direct user relationship.

The QoS NSLP (NSIS Signaling Layer Protocol) proposed by NSIS (Next Step in Signaling) work group in IETF (Internet Engineering Task Force) provides flexibility on patterns of signaling messages that are exchanged [10]. The proposed specification of QoS (QSPEC) carries a collection of objects that can describe QoS specifications in a number of different ways, named QoS Desired, QoS Available, QoS Reserved and Minimum QoS. A generic template which contains object formats for the QoS description has been designed to ensure interoperability while using the basic set of objects [11]. NSIS focuses on developing a protocol to manipulate QoS resource states along the data path in the network. NSIS is concerning to media delivery.

However their work does not cover service resources which are essential in service delivery, where we should also reserve the QoS for each service component in a session.

Facing to the NGN/NGS needs, the desired solutions should concern the QoS control for all the resources in a user-centric session, not just the network ones but also the service ones. The related work analysed above is still just in the network layer for the QoS control of media delivery.

IV. PROPOSITION: USER-CENTRIC QOS SINGALING

From a user centric point of view, the E2E QoS could be enhanced by including service components as resources. In order to satisfy the E2E QoS in the user-centric session, we propose a "dynamic user oriented E2E QoS control" supporting QoS provision and dynamic management (negotiation and adaptation). We develop this signaling on the existing SIP protocol framework and call it enhanced SIP (SIP+). SIP+ is able to circulate the media description and service component description for service delivery provisioning. We introduce firstly the VSPN (Virtual Private Service Network) architecture (§A) on which our proposition is built, then we explain the E2E QoS provisioning protocol (§B). Finally, we detail the dynamic QoS signaling which converges the management information in control messages during the exploitation with a state chart (§C).

A. Architecture dimension

In order to manage the service resources, we constitute VPSN with networked Service Elements (SEs) (Figure 2). This network is virtualized because the service components have sufficient abstraction features and they are mutually sharable. This network is private because it responses to a service request of a particular customer with specific QoS needs. The VPSN translates the logic of the requested service and links the service nodes according to "semantic routing" for the service composition. The VPSN proactively maintains this QoS to meet the customer's SLA. Concerning the QoS communication and interworking solution between the separated service and network layer, based on IMS platform, in [12], authors have proposed a binding mechanism in the E2E user-centric session to correlate the information generated in the three parts (User equipment, network and service). These three levels would be aware of and self-adapt to any change for the dynamic QoS information management. This information are stocked in database on two sides: Infosphere, in user side, which provides personalization and ambient resources information around end-user; and an enhanced UPSF (User Profile Server Function) in operator's side which offers an informational inference on all the resources [13]. The link is thus established integrating with sub-networks.

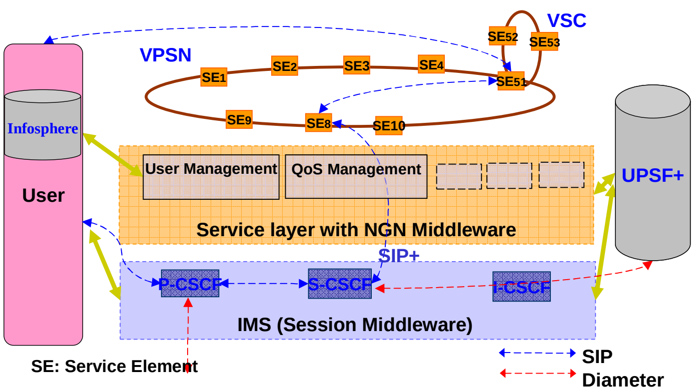

Figure 2. Global architecture of SIP+

We propose a VSC (virtual service community) to manage the QoS and functional equivalent service components in a community. VSC is a group of SEs that has the same functionality with an equivalent QoS. In case that a component is no longer suitable for a user session, another member could replace it and keep the QoS continuity.

We map the proposal on the ETSI (European Telecommunications Standards Institute) IMS. Service components are in the different container (for example: Application Server). The NGN middleware offers the basic services, which enables QoS management, user management

 ISBN: 978-1-61208-126-7

and other management functions. Service components are thus managed by NGN middleware. The NGN middleware selects and invokes services at the reception of SIP message from the IMS session middleware. These service components are chained into VPSN according to the service logic by the SIP+. Moreover, the service components can negotiate QoS information with end users through SIP+.

B. E2E QoS provisioning protocol

Enhanced SIP works in service layer to provision the resources for the E2E user-centric session based on our QoS model (four criteria: availability, delay, reliability and capability). This unified QoS model is applicable to all the resources in a session. These criteria can be applied to any QoS classification (Diffserv, Interserv, etc.) and can be also easily measured according to specific parameters. During the service's deployment and provisioning, these four criteria are divided into three categories: conception value, current value and threshold value.

The **conception value** is decided at the phase of service conception. It introduces the maximum possibilities of the node's treatments and the link's interactions.

The **current value** is calculated during provisioning and exploitation to reflect the service's behavior in real time.

The (**minimum/maximum) threshold value** defines the range on which the node normally operates. They are alert thresholds avoiding the current value exceeds the limitation.

Under the help of these modeling tools, the SIP+ could provide a QoS description in high level covering an overall service requested by end-user in a top-down declination (service node QoS, network QoS, equipment QoS) approach, as Figure 3 shows.

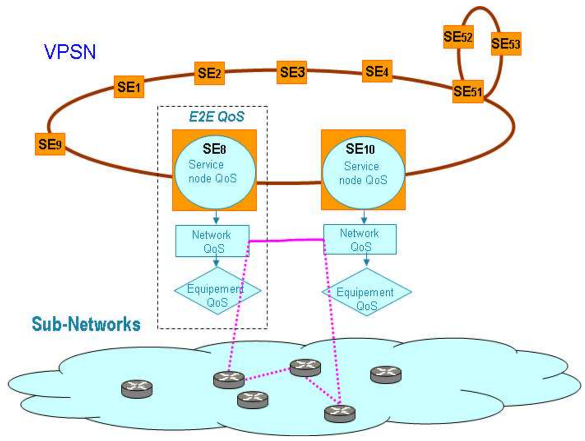

Figure 3. E2E QoS description

The service node QoS contains the non functional characteristics of service. The network QoS collects the routing table which records the QoS of all the possible paths in the transport layer. The equipment QoS is the QoS view of the machine (CPU and memory etc).

The recursive calculation of the QoS between the levels enables the E2E QoS aggregation across multiple providers. If service nodes are activated, the real-time QoS condition is recalculated and updated in the QoS table. The latter will probably cause the recalculation of the network QoS.

NSIS has four kinds of QSPEC (QoS Specification) objects which consist of a number of parameters describing the condition and constraints of traffic as well as traffic classifier for the resource reservation in the network layer. The SIP+ aims at provisioning service resources in the same way as NSIS. Therefore, we propose a QoS description template in the SIP+ which has two objects: Demanded QoS and Current QoS (Figure 4). In each object, QoS parameters are classed into four QoS criteria.

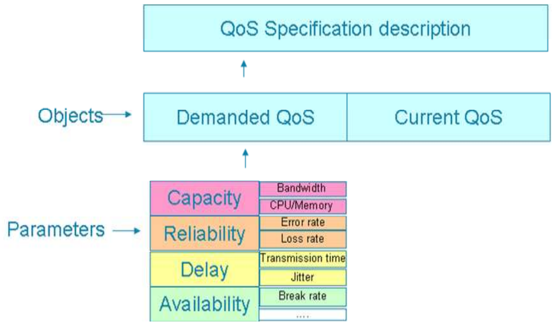

Figure 4. SIP+ QoS description template

In each node of VPSN, it has a QoS agent which stores a contracted QoS (Threshold range values) according to the SLA. The Demanded QoS and Offered QoS are negotiated during the phase of provisioning after service deployment according to the Contracted QoS. These QoS parameters are taken into account during the QoS provisioning. Thus, the service components have knowledge of the contract to fulfill and the image of its current performance.

The service request (INVITE) message contains the demanded QoS. If the demanded QoS value is less than the current value; the demanded SE gives an "OK" response with the offered QoS. This service component will be activated. On the contrary, if the desired QoS value is more than the current value, the service component will not be activated. When the E2E provisioning ends, the session is activated. Figure 5 shows the corresponding QoS values in existing NSIS, SIP and our proposal SIP+.

NSIS (Network)	SIP (Network)	SIP+ (Service)
QoS Desired	Desired	Demanded QoS (conform with contracted QoS)
QoS Available	Current	Current value (Monitoring Value)
QoS Reserved		
Minimum QoS		

Figure 5. SIP+ vs. SIP and NSIS

 ISBN: 978-1-61208-126-7

C. Dynamic QoS control for service delivery

Dynamic QoS signaling gives the possibility of corrective actions to various problems (mobility, user's preference) during the service delivery in order to maintain the QoS (Session continuity). New service components could be added; meanwhile activated service components could be replaced by others. Service component's QoS condition (In contract/out contract) in the management system, which is got from comparison of current value and threshold range values, could be notified from time to time during the service delivery via the SIP+ NOTIFY message so as to maintain dynamically the QoS conform to the contract. The state chart of QoS control procedure is shown in Figure 6.

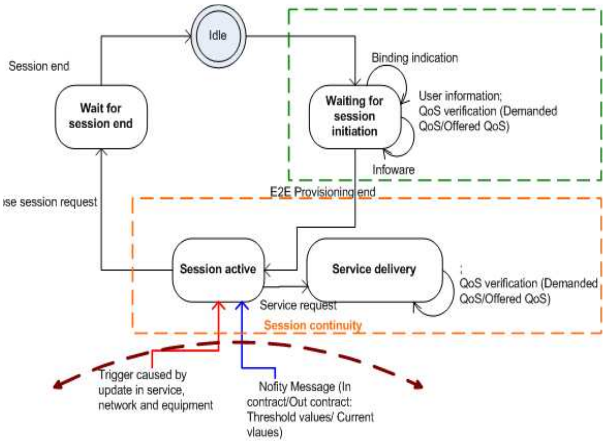

Figure 6. State chart of QoS control in service layer

In an open session, when the QoS condition in one node changes, i.e., the current value exceed the threshold value, the VSC to which this service component belongs will firstly perform self-management to find another service component with the equivalent QoS to replace it. VSC manages the SEs in terms of QoS management. For instance, VSC could look for the suitable SE that can replace the QoS degraded one. If it fails, the QoS control could interact with the user system in the database and re-provision the QoS in the VPSN in order to find another node with a QoS commitment according to user's preference (Figure 7). Meanwhile, the sub-network establishes a QoS path simultaneously. Therefore, the user-centric session keeps continuous.

In the end-to-end session QoS signaling, we define four management states for each service node. The state chart of service component management is shown in Figure 7.

UNAVAILABLE means the node is not accessible for the user or is unreachable due to user's mobility.

AVAILABLE means the node can be accessed but not activated yet.

ACTIVABLE means the node is ready to use. The node is considered to be activated when it has been chosen to be a part of the VPSN and can be executed at any time.

ACTIVATED means the node joins a real time transaction of a user centric session; its resource is being consumed. In this state, the QoS control agent checks the resource in real-time. If its behavior conforms to QoS contract, the state is changed to "IN CONTRACT". If the behavior does not conform to QoS contract, the state is changed to "OUT contract". And the VSC launches the process of self-management to find another service component to replace it.

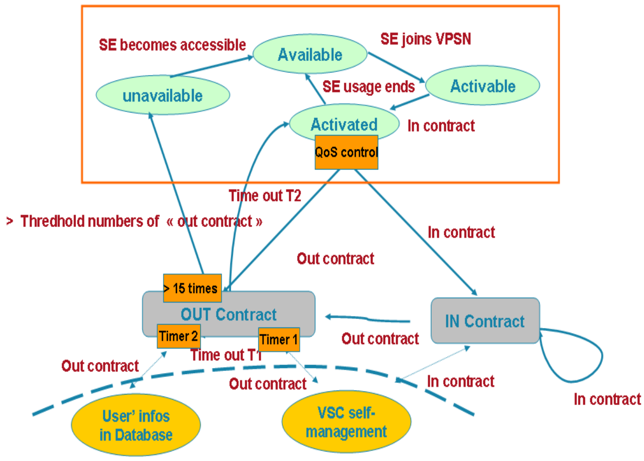

Figure 7. State chart of service component management

IN CONTRACT means that the QoS condition is in the scope of contract signed by the user and operator.

OUT CONTRACT means that the QoS condition is out of scope of contract signed by the user and operator. After receiving the first "OUT contract" in the message, the node arms a timer (Timer 1) to wait for the VSC processing. If the VSC does not find a solution till timeout (Time 1), the node will solicit database (inforsphere & infoware) to modify the contracted QoS according to the user preference. The node arms a Timer 2 for this process. Until Timer 2 time out, the QoS control agent checks the current resource with the updated QoS contract in ACTIVATED.

If the activated node receives continuously the "Out contract" in the header of NOTIFY messages that the received number exceed the threshold numbers for deactivating, the node turns into **UNAVAILABLE** state.

In addition, we identify the events that cause transition of the state. User Initiated Events (User preference), and Service Initiated Events (self-management of service components in the virtual service community) are external events that trigger state change of service node. Meanwhile the QoS condition (In contract/Out contract) and the timer in the entities are needed to be notified in the VPSN during the service delivery. The latter are therefore identified as internal events.

V. FUNCTIONAL SPECIFICATION AND DEMONSTRATION

In this section, we describe a user case and related sequence diagrams with the purpose of presenting the functional specification of the concepts proposed and a demonstration. Based on a user case (§A) highlighting the specificities of the NGN context and the diagram sequences which are relevant to the scenario in our user case, we will present finally the demonstration (§B).

A. User case

The user case (Figure 8) clearly highlights the specificities of the NGN context. It shows terminal mobility, user mobility and session mobility with QoS continuity while the user moves across heterogeneous networks according to his preferences. In an "E2E user-centric session" vision, user could enjoy different types of media in one unique session in a customized way. The scenarios details are described as below.

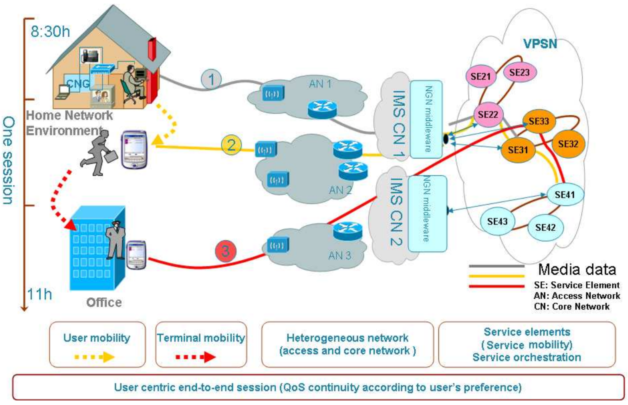

Figure 8. User case

While at home, the end-user Bob starts his PC at 8h30 in the morning and engages in a Video service SE22 and Web service SE 31. Bob uses his home network environment and accesses to the service through an Access Network AN1. Before leaving his home, Bob switches terminals (User Mobility), leaving his PC for his PDA. At this point, Bob, as a pedestrian, prefers to receive his messages in vocal mode rather than in text mode (User's preference). Therefore, a Text to Voice service component (SE41) is invited into the opened session to adapt the new terminal according to user's preference. When arriving at work, Bob's PDA is still attached to the same service but the Web service element (SE31) is replaced by the SE33 in the same VSC (service mobility) for keeping QoS continuity in one session. At 11AM, Tom closes the session, which he opened at home at 8h30AM.

For the user, all the operations are transparent.

In our demonstration, we will implement a scenario that the SE31 is replaced by SE33 with QoS continuity. We call this procedure as "service mobility". The SE31 (like other SEs in the VPSN) notifies its QoS notification (IN/OUT contract) to elements of its VSC in a peer to peer way. When SE31 is "OUT Contract", the VSC finds another SE (SE33) to take place of SE31 within a limited time. The SE33 is then introduced in this session. In this way, the service components in one session can always keep their QoS "IN contract" according to SLA, the service mobility is done seamlessly.

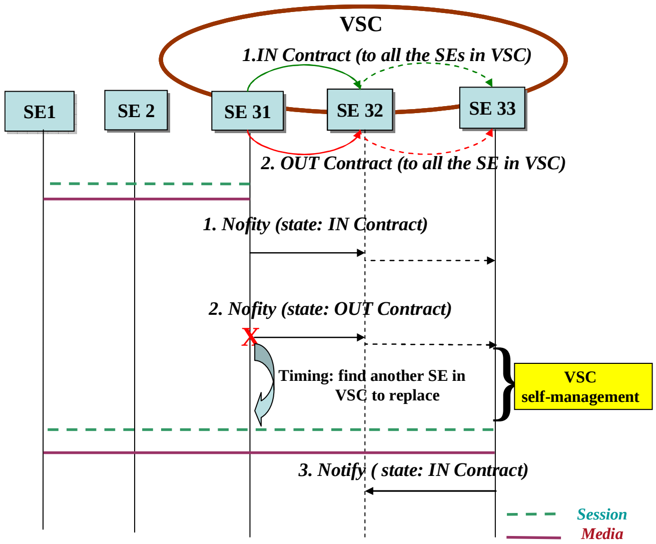

Figure 9. Service mobility related sequence diagram

The management result "IN" or "OUT" Contract is delivered in the signaling message SIP NOTIFY message from time to time in the VPSN.

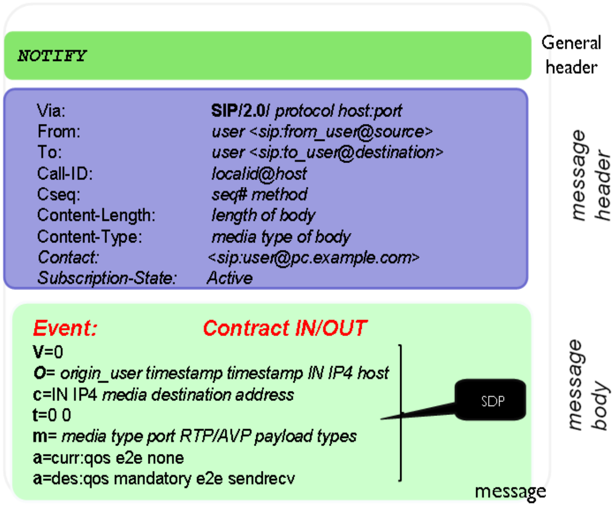

Figure 10. Structure of NOTIFY message

The structure of SIP NOTIFY message is shown in Figure 10. A SIP message, both the request and the response, contains a start-line followed by one or more headers and a message body. The CONTRACT IN/OUT is proposed to add into the message body (in red) of SIP to inform the management information during the process of service delivery. The NOTIFY body is used to report the condition on the resource being monitored (current value comparing with threshold values).

B. Specification of experimental platform and demontration

The identified scenarios are experimented on our

 ISBN: 978-1-61208-126-7

platform [14] in laboratory. This platform is consisted of the OpenIMS Module (FOCUS) [15] which contains the essential blocks of IMS core (P-CSCF, I-CSCF, S-CSCF) and HSS+ in Oracle [16], and service platform (Service is offered as a composition of service elements considering the QoS management, security, mobility management and charging aspects) developed in SUN's GlassFish [17] container with SIP JAIN supporting SIP server development (for SIP+ module). The detailed architecture of our technical platform is shown in Figure 11.

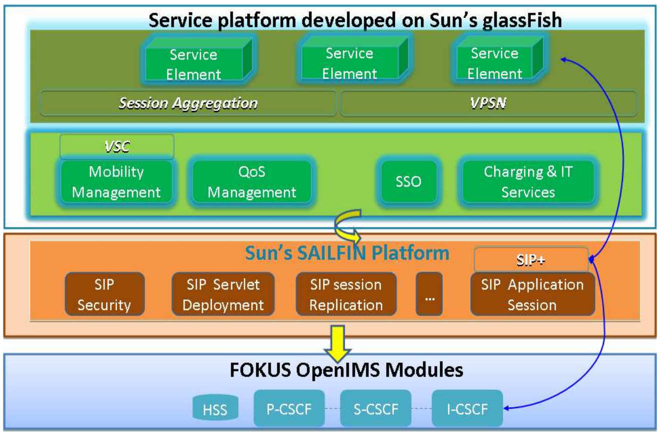

Figure 11. Experiment platform

SIP+ module developed basing on SIP JAIN, notifies the QoS states among the service elements, and relays QoS information between service layer and IMS control layer. In our demonstration, we present the QoS management information (In/Out contract) exchanged between two service elements in VSC. As the Figure 9 shows, the SE31 is active in the VPSN, and it sends the NOTIFY messages to the SE32 which is in the same VSC for informing the QoS event (In/Out contract). The global architecture of implementation is shown in Figure 12. The Data Base enables the SIP server to compare the current QoS value with the threshold QoS value. The result will tell if the SE's QoS is in or out contract.

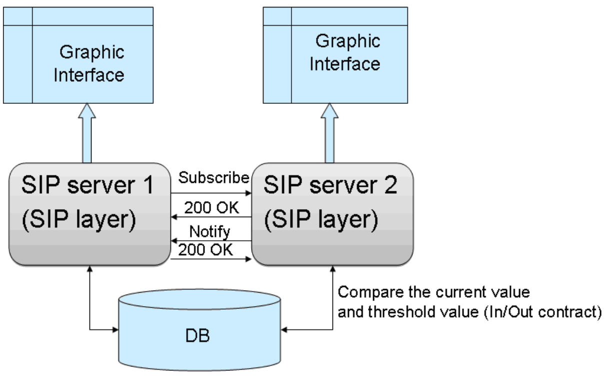

Figure 12. Global architeure of implementation

In order to easily show the messages exchanged between two SEs, we create a graphic interface for each service element. It is shown in Figure 13.

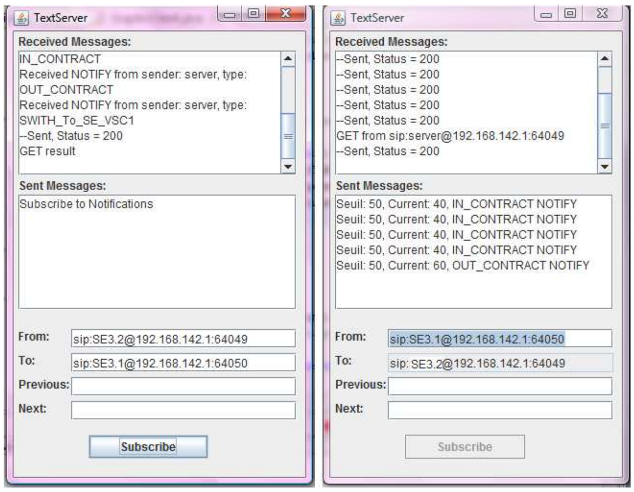

Figure 13. Messages exchanged in graphic interfaces

VI. CONCLUSION AND FUTURE WORK

End users expect to have a continuous comprehensive service throughout the whole session while moving (terminal mobility) or changing terminal (user mobility). During this session, a service is considered as a composition of elements in order to adapt to any change (session mobility). In such a user-centric approach, today's control and management approaches aim at how to managing the QoS through media delivery. However, those solutions are unable to cover this E2E QoS issue to allow user-centric oriented service to be carried out properly.

In this paper, we propose a QoS signaling (SIP+) in the service layer which covers end-to-end provisioning and SLA contract conformity. During the provisioning, SIP+ takes the behavior of the service component and the user's expectation into consideration as well as media resources in the network. During the service delivery, information from management system (monitoring results "In contract" and "Out contract") can be notified in the service layer via SIP+ control message to maintain E2E SLA. Finally, a user case and scenarios with related sequence diagrams are specified for analyzing the feasibility of our proposal. And a scenario is experimented in our platform. The following work is to integrate our implementation within our global platform (VirtuOR's virtual router [14], FOCUS OpenIMSCore [15] and SUN's GlassFish [16] [17]) for analyzing the performance.

ACKNOWLEDGMENT

The authors thank to all the members of ETSI STF 360, and also thank to the members of ANR's project UBIS for their work on our platform.

REFERENCES

[1] Sasan Rostambeik, Noëmie Simoni, Antoine Boutignon: Userware: A framework for next generation personalized services. Computer Communications 30(3): 619-629, 2007

[2] Miika Poikselkä, Georg Mayer, Hisham Khartabil, and Aki Niemi, "The IMS: IP Multimedia Concepts and Services", 2nd edition, Wiley, 2006

[3] 3GPP TS 23.228 version 8.6.0 (2010-06), Universal Mobile Telecommunications System (UMTS); LTE;IP Multimedia Subsystem (IMS), Stage 2, Release 8

[4] ETSI TS 123 228 V8.6.0 (2008-10): Digital cellular telecommunications system (Phase 2+)

[5] ETSI TS 185 006 V2.0.0 (2008-03), Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Customer Devices architecture and Reference Points

[6] ETSI ES 282 001 V2.0.0 (2008-03), NGN Functional Architecture

[7] ETSI TS 185 005 V2.0.0 (2007-07), Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Services requirements and capabilities for customer networks connected to TISPAN NGN

[8] RFC 3261: SIP (Session Initiation Protocol) July, 2002-06

[9] 3GPP TS 24 229 V10.1.0 (2010-09): 3rd Generation Partnership Project; Technical Specification Group Core Network; IP Multimedia Call Control Protocol based on Session Initiation Protocol (SIP) and Session Description Protocol (SDP) Stage 3, Release 10

[10] NLSP for QoS. Available: http://www.ietf.org/html.charters/nsis-charter.html , December, 2010

[11] QoS NSLP QSPEC Template. Available: http://www.ietf.org/html.charters/nsis-charter.html

[12] N. Simoni and Y. Wu.: NGN Charging in enhanced IMS. ICN'08: 87-92, Cancun, Mexico

[13] N. Simoni, C. Yin, and G. Du Chéné.: An intelligent user centric middleware for NGN: Infosphere and AmbientGrid. COMSWARE 08: 599-606. Bangalore, India

[14] http://www.virtuor.fr/, December, 2010

[15] http://www.openimscore.org/, January, 2011

[16] http://www.oracle.com/index.html, Januarry, 2011

[17] http://glassfish.java.net/public/downloadsindex.html#top, December, 2010