Inter-Domain QoS Control Mechanism in IMS based Horizontal Converged Networks

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Abstract— **IP Multimedia Subsystem standardized by 3GPP has attracted the endorsement of other network technology providers. IMS is the most complete IP base service control and management overlay (using SIP) that sets up an overlay on the under-laying transport infrastructure and provides the possibility of end to end IP based services. Adopting IMS as the service control overlay in different technologies like WLAN, xDSL and Cable allows their operators to share their infrastructure with 3G wireless networks not only in transport level but also in service level. This convergence which is called *Horizontal Convergence* is sought in *NGN-Next Generation Network* architecture. Provisioning end-to-end QoS in such heterogeneous paradigms is a challenging task according to the different strategy of resource reservation over different technology. In this paper we have defined new functionalities and interfaces in addition to some extension to the existing SIP signalling to resolve some of the existing problems existing in IMS *Policy based* QoS control model that don't let end-to-end QoS control between different technologies and domains.**

Keywords-component; IMS; Policy based Networks; SLA; NGN; Horizontal Convergence.

I. INTRODUCTION

A consistent end-to-end IP QoS is an essential for supporting real-time application and services with the desired level of quality for the customers of Next Generation Networks (NGN). Flexible QoS establishment needs tight coordination between session and transport level and it can't be considered only as a transport level task. Because even if different operators in different domains have achieved agreement on the IP QoS requirements of a specific service, they may configure their network elements (routers and switches) in different ways. For instance, the amount of resources which will be allocated to a video phoney may not be the same in two different network technologies/domains even if video phoney represents the same QoS class in the network elements (routers and switches) of these two networks.

3G has chosen a policy-based architecture to provide this co-ordination between session and transport level for QoS. The advantage of such architecture is that the resources in transport level will be reserved according to the parameters of QoS which are indicated in session signalling messages.

The implementation possibility of *policy based QoS architecture* in 3G is according to the emergence of IP Multimedia Subsystem (IMS) after 3GPP release 5. In fact, with introduction of IMS, 3G has created a clean split between signalling and transport level.

IMS is an IP based service control overlay on the transport level of 3G to provide essential and advanced IP telephony services for 3G subscribers [1]. SIP which is standardised by IETF is used in IMS as the signalling protocol to control multimedia sessions.

In the NGN project, ITU has decided to adopt IMS as the service overlay of next generation network [13].In fact, NGN considers the convergence of different technologies to create a single IP based network capable of carrying all services associated to public telecommunication networks as well as innovative multimedia services. This is why IP Multimedia Subsystem standardized by 3GPP [1] is reused in NGN to create converged services over hybrid transport layers, instead of vertically integration of different networks [2].

However, establishing a flexible and scalable end-to-end QoS control mechanism for Multimedia services in heterogeneous infrastructure of NGN where access to the services be achieved via different kinds of wireless-wired access technologies like UTRAN, WLAN, xDSL and Cable... is a challenging task. In fact the current QoS mechanism defined in 3G can not answer to the requirement of such heterogeneous network in NGN. Because, in the paradigm of NGN a multimedia session may pass through different technologies and administrative domains and in the existing architecture there is no way between different domains to exchange the QoS policies and limitation of their network as the *SLA-Service Level Agreement* dynamically and efficiently.

The limitations of the current system may be divided in three categories as follow:

A) the current policy based QoS control system in 3G is defined for a single domain and the limitation and policies of other domains/technologies are not considered. The result is that, if different domains/technologies are in the session route, the resources in different domains/technologies won't be reserved homogenously.

B) All of administrative domains need to exchange the SLA with other domains directly. This issue prohibit the scalability

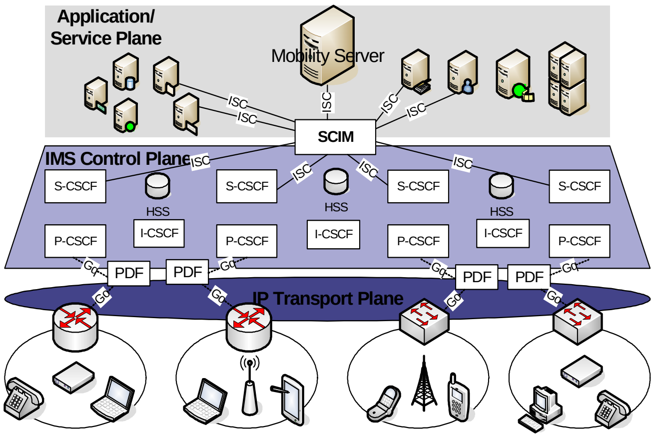

Figure 1. Horizontal Convergence of Different Network Technologies in NGN

in the paradigm of horizontal convergence of different technologies. Because there will be numerous domains in such paradigm and it is not possible for an operator to exchange its SLA with all of other domains and technologies.

C) In the case of access to a service via other access technology, the current architecture only considers the QoS policy of the core network where the service is provided.

This paper is proposing a scalable architecture to cope with these problems in the field of NGN.

The rest of the paper

In this architecture, the operators negotiate the SLA for their QoS services they have mutually contracted to provide. Hence, each operator defines its local polices based on the negotiated SLA and applies it to its network elements to implement t it. On the other hand, from the signalling point of view, in the current session signalling, in the SDP inside of the SIP messages the only QoS parameters that can be indicated by the user are codec and bit-rate [3] and the user can not express exactly his expectation about the QoS level of the required multimedia service; although it doesn't mean that the user receives a bad QoS but the user may wishes to have the choice in selecting the level of QoS for the same service because of the cost or end-device capabilities. For example, with the current QoS parameters in SDP, "video call" will be exactly mapped to a certain QoS class beyond of user choice but for a long international video call, the caller may desires an acceptable QoS but not a high quality to reduce his costs. In our work we have suggested some extension to SIP to exchange some additional QoS level information to satisfy the user QoS expectation for the requested multimedia service and help different administrative domains (or even different network technologies) negotiate SLA dynamically.

In the rest of the paper we will explain the policy-based architecture of 3G networks and current session signalling flow. Then we will present our solution on the base of SIP to overcome the existing weaknesses.

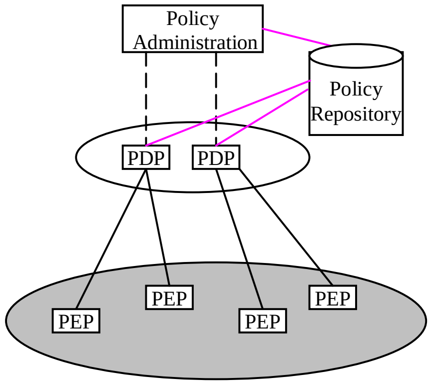

Figure 2. Policy based Architecture

II. Policy based Architecture in 3G Networks

Establishment of session for multimedia services like voice or video telephony, video streaming, MMS, Video Conferencing or virtual reality, needs co-ordination between bearer and session layer for QoS. After release 5, with the emergence of IMS, 3G architecture is a layered architecture with a clean split between transport (eg. SGSN, GGSN), session (eg. P-CSCF, I-CSCF, S-CSCF) and service planes [1].

Providing QoS is not only a transport level issue and session layer should be involved too. This is why 3GPP has chosen the policy based architecture to provide high quality transport media with efficient resource utilization. In a policy based network, policy rules describe behavior of the network in some high-level statement without going to the detail of network element configurations. In fact, policy rules are a set of conditions and instructions; whenever a request for a service fulfills a condition, the corresponding instruction will be performed. Figure 1 has depicted the proposed policy based architecture by IETF [9,10]. Four major functional entities are defined:

Policy Repository: All the policy rules exist in this entity. Policy Repository is usually implemented inside Policy Decision Point or separately as a LDAP (light-weight directory access protocol) directory server.

Policy Decision Point (PDP): This is logically a centralized entity that makes the policy decision according to the policy rules and the dynamic and static information of the network.

Policy Enforcement Point (PEP): PEPs enforce the policies in the network. They are network elements (especially edge routers) that will realize the polices for the resources by using software and hardware features (scheduling, queuing, classifying, traffic policy and shaping) in the network.

Policy Administration System: This is the point in which the operator define his policies. Policy Administrator System pushes the defined or modified policies to the Policy Repository and informs the PDPs about any modification in policies.

In policy management systems, there are two main models for interaction between PDPs and PEPs: *provisioning* and *Outsourcing* [10]. In the *provisioning* model, PDP decides which policy rules should be installed on PEP and then provision it for the resource reservation request coming to the PEP. In contrast, in *Outsourcing* model, a resource reservation request coming to PEP will trigger the process of policy request from PDP. Each model has some benefit and disadvantages. For example the Outsourcing increases the signaling load but it is more dynamic for special cases like link failure or time-dependent polices.

This policy based architecture is adopted in 3G architecture to establish end-to-end QoS for session based multimedia services. The policy based QoS control architecture creates coordination between 3G transport level and IMS as the service control overlay.

IMS (IP Multimedia Subsystem) was introduced in release 5 (and is being developed in releases 7) as an overlay on UMTS PS (Packet Switch) to support IP multimedia services. The data traffic is still managed by PS elements. However, session signaling passes through IMS. The most important IMS functionalities may be listed as follow:

Media Gateway Function (MGCF), Media Resource Function (MRF) and Call State Control Functions (CSCF). There are three kinds of CSCF: P-CSCF which acts as the SIP Proxy is the first contact point inside of IMS for user equipment (UE). The Serving CSCF (S-CSCF) resides in the home network and control the session by enforcing the service profile of the user via accessing to the home subscriber server (HSS). And the last one, Interrogating CSCF (I-CSCF) hides the network configurations for the external connections and in addition allocates the proper S-CSCF to the user (according to the user service profile) in the time of registration by interrogating HSS.

As a first contact point for a SIP request message (which conveys requested QoS specifications of the service inside) from a user, P-CSCF was chosen to host Policy Decision Function (PDF) in release 5. PDF acts same as PDP and enforces the policy rules to the PEP. However as depicted in Figure 3, in next releases PDF was introduced as an independent function and an interface (Gq) introduced between P-CSCF and PDF. With this revision, other non-SIP based servers are also able to express their session QoS requirement to the PDF. GGSN as the gateway of data flow to external network acts as the PEP and translate the policy rules to the IP flow control functions (labeling diffserv flow and traffic classification, Scheduling, Traffic Policy and admission Control, Traffic Shaping). To open a gate for a resource reservation request of a data flow, the PEP component of GGSN must verify the request with PDF in the signaling path. The Go interface make this co-ordination feasible. 3GPP has agreed on COPS-PR protocol as the communication protocol on the Go Interface [5].

III. LIMITATIONS OF CURRENT QOS CONTROL SYSTEM FOR HORIZONTAL CONVERGED NETWORKS

The horizontal convergence is an approach in contrast with traditional vertical convergence of service-specific networks. In vertical convergence, the inter-connection is only in bearer

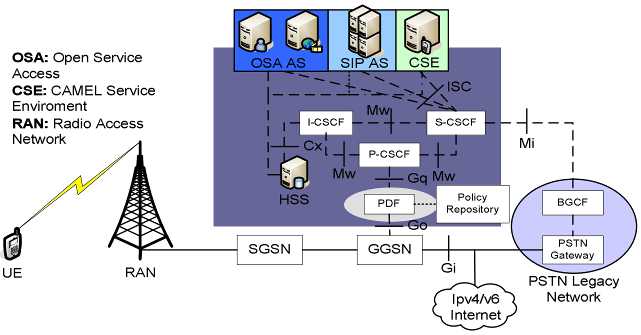

Figure 3. Policy Based QoS Control system adopted in 3G IMS

level. However, in horizontal convergence: Firstly, the users of one domain can benefit from the services developed in other domains and secondly different technologies can combine their services to create new advanced services and more capabilities for their clients.

Then, in such architecture it is very likely that: i) the data flow pass through different technologies and administrative domains. ii) The users of different domains request the services which are implemented in other technologies/domains. The current QoS control mechanism introduced in 3G don't allow different domains involved in the route of media to reserve the resources homogenously. The main reason is that different domains are not able to inform others about their policies for resource reservation. In consequence, for the same QoS class, different domains reserve their resources with different strategies and policies. This leads to discordant resource reservation in the data flow route.

On the other hand, different domains in converged paradigm should be able to exchange SLA with other operators, domains and technologies. This is very essential because without that, the users of other domains won't benefit from the services of other domains/technologies and this conflicts with the goal of *"horizontal" convergence*. However the existing architecture can not fulfil this requirement because each operators need to exchange its SLA with all other operators and technologies. But in a horizontally converged set of networks the number of network operators as well as service providers may be high and then it is not feasible for a domain to exchange SLA with all other operators.

In next section we introduce a flexible architecture to address these issues.

IV. ARCHITECTURE OF END-TO-END QOS FOR THE HORIZONTALLY CONVERGED TECHNOLOGIES IN NGN

As discussed in previous section, the defined end-to-end QoS architecture by 3GPP has some limitations that can't support E2E QoS for multi-domain data path and in addition, the existing architecture is not flexible enough to support access of different networks with different technologies to the core network.

The existing limitations can be divided in two categories: 1- QoS Control Architecture. 2- Inter-domain SLA. In this

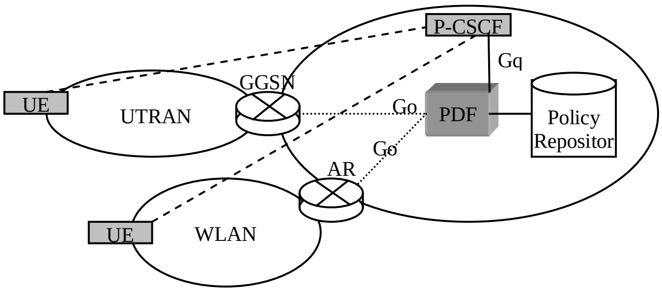

Fig 4 : Modified Architecture for Multi Domain E2E QoS : All the Edge/Access routers are controlled by the policies defined in UMTS core network

section we introduce two new architecture for QoS control and then in the next section we will introduce our solution for Inter-domain SLA.

In fact, in NGN architecture where fixed and mobile access technologies are converged, we need some more co-ordination between session and bearer layers; because, the QoS signaling and protocol, in addition to availability of resources in different technologies may be completely different. For example, in UTRAN (which is the UMTS access technology) the resource reservation is based on PDP-Packet Data Protocol and it is completely different from what is presented in xDSL technology or 802.11Q for WiFi.

In [6] an architecture like what is depicted in figure 4 is proposed for multi-access to IMS services. The PDF can control the edge routers of different access technologies. This solution is limited to the cases that: a) the operators of all access networks are the same or b) there is a big trust between two operators and the access network operator has agreed that the polices be pushed by the core network operator.

In fact this architecture is proposing a Master/Slave architecture where the policies are defined by a master operator and other networks should just obey those policies. Such an architecture is not acceptable for horizontal convergence saught in NGN. To cope with this problem, we have proposed two other architectures: in figures 5 the Local PDF (LPDF) will exchange the policies with the PDF in the core IMS (PDF) and controls the corresponding edge router.

In the one proposed in figure 6, Local Policy Repositories of each accesses network will exchanges their policies with a shared S-PDF and the S-PDF will control the edge routers of a certain access technologies in that proximity. Each architecture has its benefits and drawbacks and the use of them depend on the policies and capabilities of the access network operators. In the first architecture, for example for the SIP based applications P-CSCF as the SIP proxy should be implemented in the access network to transfer the session QoS parameters to this local PDF. This costs more but it is more dynamic, scalable and distributed. This architecture is more suitable for the access networks which had already had this kind of proxy for their home services.

On the other side, in the architecture of figure 6, there is no need for supporting the session signaling in the access networks and then the cost will be decreased. However, the

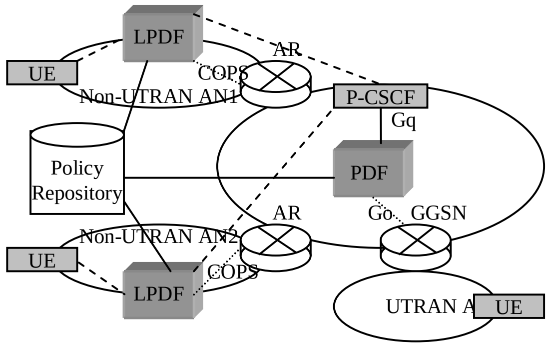

Fig 5 : Modified Architecture for Multi Domain E2E QoS : The access networks own their Local PDF to control the AR

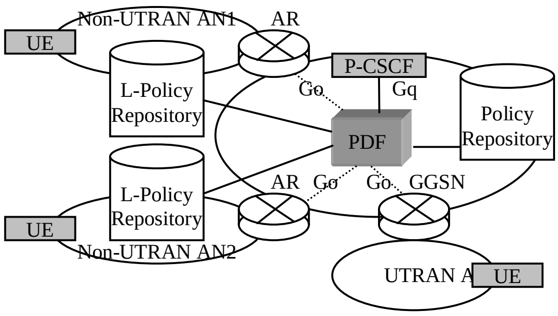

Fig 6 : Modified Architecture for Multi Domain E2E QoS : The access networks don't have their Local PDF to control the AR. But defines their policies themselves

policy exchange can't be as dynamic as the previous architecture and in addition the S-PDF may be the bottle-neck of the system.

In these two architectures, the policy repositories or PDFs are distributed in the access and core networks of different network technologies/domains. Therefore, all of the operators including access and core operators express their policies to be considered for the end-to-end resource reservation.

V. THE PROPOSED ARCHITECTURE FOR INTER-DOMAIN SLA

As mentioned before, in NGN it is very essential to define a scalable architecture for inter-domain/technology SLA. The current model for inter-domain SLA is not scalable because every operator needs to exchange SLA with all other operators directly. This is strictly impossible for the NGN with convergence of hybrid technology in the infrastructure and service level. In [7] some mechanisms to exchange dynamic SLA between end-user and service networks are introduced but the solution is not for inter-domain and inter-technology architecture.

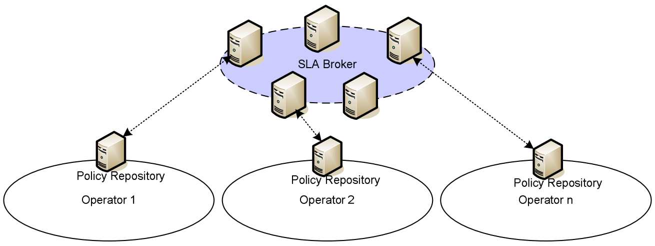

Figure 7. SLA Broker

To enable inter-domain SLA in a scalable manner, we have proposed the architecture of Figure7. In our inter-domain SLA model, there is a service provider that enables the service of SLA exchange for all operators in the blended network architecture of NGN. We call this operator SLA broker. In fact every operator defines its policies and SLA for the services it provides and registers them with this SLA broker. Then when the user of one domain requests a service which is hosted in another domain (or in the case of roaming) the SLA broker exchanges the SLA of the involved operators. Then with such architectures the operators don't need anymore to exchange their SLA with all other operators directly and this lead to a scalability of the system.

VI. CONCLUSION

In this paper we proposed two new architecture to cope with the existing limitations in the existing policy based QoS control mechanism of 3G networks for the horizontally converged networks in NGN. With the proposed architecture, every operator involved in the data flow route can express its policies and finally the resources in different domains will be reserved homogenously. In addition we have introduced the "SLA Broker" as a service provider in NGN in order to introduce a scalable Inter-Domain SLA exchange mechanism between different operators of a converged network. The proposed solutions are essential to achieve the goal of horizontal convergence of different technologies in NGN in order to blend different networks not only in transport infrastructure but also in service level.

RFERENCES

[1] 3GPP, "IP Multimedia Subsystem (IMS)," TS 23.228, Release 7, Jan. 2004.

[2] 3GPP, "Signaling flow for the IP multimedia call control based on SIP and SDP", TS 24.228, Release 5, March 2004.

[3] 3GPP, "End-to-end Quality of Service (QoS) concept and architecture ", TS 23.207, Release 6, March 2004.

[4] 3GPP, "End-to-End Quality of Service (QoS Signaling Flows", TS 29.208, Release 6, March 2004.

[5] Wei Zhuang, et al, "Policy-Based QoS Architecture in the IP Multimedia Subsystem of UMTS", IEEE Network, May/June 2003.

[6] Wolfgan Böhm, Peter Braun, "Policy Base Architecture for the UMTS Multimedia Domain", IEEE NCA 2003.

[7] Stefano Salsano, Luca Veltri, "QoS Control by Means of COPS to Support SIP-Based Applications", IEEE Network, March 2002.

[8] S Leroy, L Bos, J De Vriendt, " End-To-End UMTs Quality of Service Architecture For the Support of Real-Time IP Multimedia Services in UMTS R 5", IEE 3G Mobile Commuication Technology, May 2002.

[9] R. Yavatkar, D Pendarakis, R Guerin, " A Framework for Policy-based Admission control", IETF RFC 2753, Jan 2000.

[10] A. Westerinen et al., "Terminology for Policy Based Management", IETF RFC 3198, Nov. 2001.

[11] www.iptel.org

[12] www.vovida.org

[13] ITU-T Rec. Y.2001, "General Overview of NGN," Dec. 2004.