End-to-End QoS Architecture and Inter-domain QoS Model across Multiple Domains

Xiuhua FU, Jiazheng Wang, Wenan ZHOU, Junde SONG
PCN&CAD Center
Beijing University of Posts and Telecommunications, Beijing, China
Tel: +86-010-62282617, Fax: +86-010-62282747
E-mail: fuxiuhua@gmail.com

Abstract—Providing end-to-end quality of service (QoS) guarantees in all-IP Networks is a challenging task that encompasses a set of multiple administrative domains. But from the existing proposed architecture point of view, mature solutions are not yet available for the provision of QoS across multiple domains administered by different organizations, especially under the FMC circumstance. So based on the researches of the contributions of many standard bodies to QoS, this paper presents an architecture that supports inter-domain QoS across the multi-provider domains, describes the full set of functions in the management, control and data planes. Then an inter-domain QoS model is proposed, which shows how requested QoS capabilities can be combined together using service level specifications (SLSs) agreed between adjacent domains to construct an appropriate end-to-end QoS path that is supported across multiple domains.

Key words—QoS, inter-domain, RACS, SLA, SLS

I. INTRODUCTION

Over the past several years there has been a considerable amount of research within the field of quality of service (QoS) support for communication networks. To date, most of the work has been within the context of individual architectural planes such as the separate management plane, control plane and data transmit plane, and focus on specific network in general. Along with the rapid development of the next generation network, Quality of Service in NGN networks becomes a hot topic in the industry. Many standard bodies and academic communities have been increasingly looking for an architecture that can provide consistent network independent end-to-end QoS, including 3GPP, ETSI, ITU-T, MSF, EuQoS, and so on. Despite there are some corresponding similarity in approach for them, there are some differences due to their goals are different. The 3GPP solution[1][2] is focused on meeting the needs of 3G mobile networks, and lacks a number of facilities that the other QoS solutions do support based around MPLS and NAT traversal since these are not requirements in a 3G network. ETSI TISPAN has spent a considerable effort in defining a next generation network architecture. As part of this solution it has defined a Resource and Admission Control Subsystem (RACS)[3][4]. The RACS architecture in its initial release is restricted to the access network segment of the network and as such the ETSI TISPAN architecture has not yet considered the requirements for core network QoS. The ITU-T has set up a focus group on NGN which is defining an architecture for end-to-end QoS control and signalling. The RACS of ITU-T[5] is fundamentally compatible with the ETSI RACS architecture. The MSF QoS approach[6] is characterized by its scope of ambition, to be able to offer a guarantee as good as the PSTN for voice and multi-media services over a packet network and its decision to use a bandwidth manager. EuQoS is a consortium of organizations whose main objective is to research, develop, integrate, test, validate and demonstrate end-to-end QoS technologies to support advanced QoS aware applications[7]. A detailed survey will be described in Section II.

Most research to date has focused on supporting QoS within a single administrative domain. However, delivery of end-to-end QoS requires that Providers must interact more closely with each other to co-operate and to establish peering agreements (SLS).The intention is to enable a provider to extend its QoS over multiple domains, thus enabling the provider to offer reachability to networks beyond its own domain. Mescal projects all specified some business models for these interactions across the multi-provider global Internet[8][10]. However there is less work on inter-domain QoS provisioning for heterogeneous networks in the literature.

The rest of the paper is organized as follows. We review the current state of QoS support in architectural frameworks in Section II. In recognition of the above limitations, an end-to-end QoS architecture in heterogeneous networks is proposed in Section III. Following this, Section IV describes the inter-domain QoS negotiation and deliverability emphasizing on the hop-by-hop cascaded model. Section V concludes the paper.

II. A SURVEY OF QOS ARCHITECTURES

Many standard bodies and academic communities have been increasingly looking for an architecture that can provide

This work is undertaken in the Hope-QM project, which is funded by the Ericsson Corporation

consistent network independent end-to-end QoS, including 3GPP, ETSI, ITU-T, MSF, EuQoS, and so on.

In release 6, 3GPP have defined an end to end QoS solution that incorporates a Policy Decision Function (PDF), an Application Function (AF) and an IP border router or gateway (namely GGSN in 3GPP network) [1][2]. AF is an element offering applications that require the control of IP bearer resources, and maps QoS-related application level parameters (e.g. SIP/ SDP) into policy set-up information, and sends this information to the PDF. PDF is proposed for the service-based local policy control. It makes policy decisions based on session and media related information obtained from the AF, and communicates these decisions to IP border gateway. Also 3GPP solution defines two interfaces among the three entities. Gq interface which is between PDF and AF, uses a modified version of the Diameter protocol which removes much of the AAA functions of the protocol but adds significant 3GPP enhancements to support the definition of media streams and classifiers. Go interface which is between PDF and IP border gateway, utilizes COPS-PR based upon the IETF framework PIB, but 3GPP have defined their own PIB. The 3GPP solution is focused on meeting the needs of 3G mobile networks, and lacks a number of facilities that the other QoS solutions do support based around MPLS and NAT traversal since these are not requirements in a 3G network.

ETSI TISPAN has spent a considerable effort in defining a next generation network architecture. As part of this solution it has defined a Resource and Admission Control Subsystem (RACS)[3][4], which includes SPDF (service-based PDF) and A-RACF (Access-Resource and Admission Control Function). Additionally, TISPAN addresses the aspects of the RCEF (Resource Control Enforcement Function), BGF (Border Gateway Function) and AF that are associated to RACS. The SPDF provides the AF with a single point of contact. The A-RACF is always in the access network and supports the resource reservation method "proxied QoS reservation request with policy-push mechanism ".So in its initial release the ETSI TISPAN architecture has not yet considered the requirements for core network QoS.

The ITU-T has set up a focus group on NGN which is defining an architecture for end-to-end QoS control and signaling[5]. The RACS of ITU-T is fundamentally compatible with the ETSI RACS architecture. A RACF network administrative domain shall contain at least one PD-FE (Policy Decision Function) with associated PE-FEs (Policy Enforcement Functional Entity). Depending on the business model and implementation choices, the PD-FE and PE-FE may be part of Access Network Domain or part of Core Network Domain or be present in both Access and Core Network Domains. The implementation and physical configuration of PD-FE and TRC-FE (Transport Resource Control Functional Entity) are flexible, which can be distributed or centralized and can be a stand-alone device or part of in an integrated device.

The Multi-service Switching Forum (MSF) mission is to accelerate the deployment of open communications system, the focus is on development of architectures and industry agreements that enable interoperability and innovation in a rapidly evolving environment. The MSF QoS approach[6] is characterized by its scope of ambition, to be able to offer a guarantee as good as the PSTN for voice and multi-media services over a packet network and its decision to use a bandwidth manager. This solution has a number of components including Call agent, Bandwidth Manager, Edge Node, Core Node, Session Border Controller. The Bandwidth Manager is the core key component. It receives reservation requests from the call agent, identifies and may determine the path through the network for the call and allocates any resources. The MSF is focused on the needs of large scale carrier PSTN evolution.

EuQoS (End to End Quality of Service over Heterogeneous Networks) is a consortium of organizations whose main objective is to research, develop, integrate, test, validate and demonstrate end-to-end QoS technologies to support advanced QoS aware applications. From the horizontal view, the EuQoS architecture[8] makes a clear separation between the application plane and control plane from the transfer plane. Again, the control plane is sliced between a technology independent layer control by a Resource Manager (RM) and a technology dependent layer control by a Resource Allocator (RA). From the vertical view, the EuQoS architecture makes a clear separation between the various access technology and the different core network involved in the end-to-end QoS path connection.

III. A PROPOSED END-TO-END QOS ARCHITECTURE

There is a considerable degree of consensus between the 3GPP, ETSI, ITU-T, MSF and EuQoS with regard to resource (e.g. bandwidth) mangers and QoS solutions. But there are some differences for the QoS solutions, because their goals are not identical. However with the development of NGN and the fixed mobile convergence (FMC), it is necessary to the QoS solutions as a whole, which is a coherent architecture for providing end to end quality of service over heterogeneous networks, especially under the FMC circumstance. Here we propose an end-to-end QoS architecture which is fit for heterogeneous FMC networks.

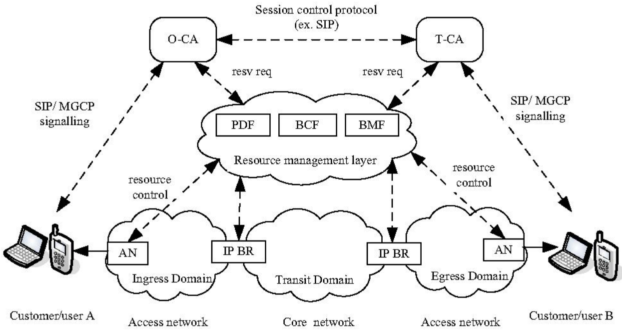

Figure1.The proposed end-to-end QoS architecture

O-CA: Originating-Call Agent

T-CA: Terminating-Call Agent

PDF: policy decision function

BCF: bearer control function

BMF: bandwidth management function

AN: Access node

IP BR: IP Border Router

This QoS architecture has a number of components which are described here:

Call agent – The call agent performs a route lookup and determines that the next hop, provides call control functions. It performs resource reservation within the operator's network by requesting resources from the resource management layer based on information related to the call, such as the media type of the call and the codecs required, user profiles, SLAs, operator network policy rules, and service priority. In this scenario there are two call agents involved: the originating call agent (O-CA) and the terminating call agent (T-CA). Each call agent (both the O-CA and the T-CA) may request capacity for a given network segment from the resource management layer or the T-CA may request capacity from the entire network. In the particular case of 3GPP IMS, the call agent is the P-CSCF which acting as a SIP proxy.

Resource management entity – The resource management entity forms the heart of the proposed QoS solution. It receives reservation requests from the call agent, identifies and may determine the path through the network for the call and allocates any resources required in the network, and performs Call Admission Control (CAC) based on the information from the Call agent and related operator policies. From the different standard bodies and academic communities view, there have defined different entities in resource management layer, such as PDF in 3GPP network, BCF in backbone IP network, BMF in packet network, they performs similar function in different networks. For end-to-end QoS architecture, the QoS negotiation and transfer between the different peering resource management entities are the key issues. In section 4, we will propose an inter-domain QoS model and show how QoS information be delivered to manage the resource of the selected optimized end to end QoS path. For simplify, we will abstract the different resource management entities denoted as resource manager (RM).

In data transport layer, the end to end path involves three domains in generally, ingress domain, transit domain and egress domain. Ingress domain and egress domain may belong to different access technology networks. Core network may involves several IP-based transmit domains. AN may be a layer two access node with some limited additional classification and traffic marking capabilities. The IP edge node may be a traditional edge router additionally resource allocation function and policy enforcement function. RMs contact access nodes of the caller/callee access networks and IP border router (IP BR) of the core transmit network, the former may interface with the latter to perform per flow control and path selection. The AN and IP BR could also perform a CAC based on network technology dependent which represents the reality. Not only network resources are taking into account, but also constraints to enforce the QoS.

As for customers or end users, the caller and callee may be a mobile network user or a fixed network user. Customer/user A can initiate a call to customer/user B using a protocol such as SIP, or MGCP. The call setup signaling is received at the originating call agent and is transmitted hop-by-hop to the terminating call agent.

It is meaningful to explore the interfaces and the corresponding protocols that the proposed QoS architecture has adopted. The interface between the application layer and the resource management layer, allows QoS resource request information needed for QoS resource authorization and reservation to be exchanged. It shall be capable to support the resource control for both fixed and mobile access networks, and should support the NAPT/firewall control and NAT Traversal as needed. For the equivalent interfaces, there are some different considerations, some is lightweight and optimized for specific requirements, and some are not decided. However there is a trend to converge resource reservation and charging functions, so in such an environment Diameter becomes a more appropriate choice of protocol. The interface between the resource management layer and data transport layer, adopts COPS-PR to conform to that of most QoS solutions above mentioned. NSIS[9] is chosen for communication between the resource management entities (RMs). It was chosen as it is the natural upcoming IETF new signalization for IP.NSIS will be the basis for signalling interactions between RMs. Despite its relatively immature state in the standards bodies, the basic NSIS functionality is defined, which allows the development of a simplified version and adoption in the end to end QoS architecture.

IV. INTER-DOMAIN QOS MODEL

End-to-end QoS has been seldom studied in its inter-domain aspects, particularly within the scope of the heterogeneous networks. In the section we are intended to be a contribution in this direction. In general, the loosely coupled is much easier to come true in the fixed and mobile convergence networks, therefore we define a peering model. Each domain contracts iSLS with its adjacent domains. Thus, peering QoS agreements are not between networks more than one hop away. This type of peering agreement may be extended to provide QoS connectivity from an ingress domain to an egress domain that may be several domains away.

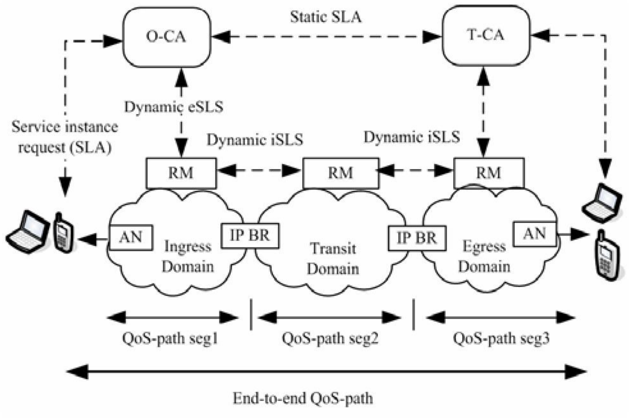

Figure2. Inter-domain QoS peering model

In the next generation network, more and more service providers will emerge in the industry. It is likely that the caller and callee are serviced by different SPs. And it is necessary that different SPs need to negotiate some service level agreements (SLAs) to guarantee to communication with each other administered by different SPs. Each SP has an SLA (Service Level Agreement) established between its users, which defines what kind of resources and prices was agreed to be offered to each user. When a user originates a new session or a new call, it is in fact that he is requesting a service instance with the service specific SLA. Call agent is responsible for estimating whether the caller/callee have the right to continue the call setup of the service instance, which may be based on users subscription and SPs' policies and their SLAs.

On the other hand, it needs to make resource reservation and select an optimal end-to-end QoS path during the call setup. When is the call setup signaling received at the originating call agent, the call agents must perform resource reservation by instructing to the first RM within the ingress domain under the form of an eSLS (end-to-end Service Level Specification).The first RM performs its CAC, is responsible of the end to end QoS commitment, and checks if it exists a suitable QoS path since the end to end QoS path is selected once at the beginning of the path. Additionally, each RM performs the following same actions: performing resources checking for its own QoS path segment and forwarding the remaining part of QoS request and the selected QoS path to the next RM. The SLS splitting follow the rules:

$$iSLS(k+1)=iSLS(k)-lSLS(k+1);k>=1$$

$$iSLS(1)=eSLS-lSLS(1);$$

Here，lSLS denotes the QoS parameters that belong to the domain own by the RM. For the end to end QoS path, it means from a source Access Network to a destination Access Network. It is the result of the sequence of individual path and may be view as a sum and concatenation of individual path setup in the different network partition. The mechanism gives more freedom.

V. CONCLUSION

The delivery of end-to-end QoS across the multi-domains requires different service providers and network operators to cooperate so as to deliver the required service. In this paper firstly the related QoS standard activities and projects in 3GPP, TISPAN, ITU-T, MSF and EuQoS were introduced. Based on the survey, the paper proposed an end-to-end QoS architecture, and main function entities were described. Then an inter-domain QoS model is proposed, which shows how requested QoS capabilities can be combined together using service level specifications (SLSs) agreed between adjacent domains to construct an appropriate end-to-end QoS path that is supported across multiple domains.

ACKNOWLEDGMENT

This work was undertaken in the Hope-QM project "Research on end to end QoS management for heterogeneous network", which is funded by the Ericsson Corporation. I would like to thanks all members of the project for all kinds of support and help that I received during this research.

REFERENCES

[1] 3GPP TS 23.207v6.6.0, End-to-end Quality of Service (QoS) concept and architecture(Release 6), September 2005

[2] 3GPP TR 23.802v1.1.0, Architectural Enhancements for End-to-End Quality of Service (QoS) (Release 7), July 2005

[3] ETSI TS 185 001 V1.1.1, TISPAN; NGN QoS Framework and Requirements, November 2005.

[4] ETSI ES 282 003 V1.1.1, TISPAN RACS Functional Architecture, June 2006

[5] ITU-T study group13, Draft Recommendation Y.RACF Version 8.1, Geneva, 16-27 January 2006

[6] MSF-TR-ARCH-005-FINAL, "Bandwidth Management in Next Generation Packet Networks", August 2005, http://www.msforum.org

[7] IST/EuQoS project, "End to End Quality of Service over Heterogeneous Networks", http://www.euqos.org

[8] IST/MESCAL project, "An architectural framework for Inter-domain quality of service provisioning", http://www.mescal.org

[9] R. Hancock and all, "Next Steps in Signalling (NSIS): Framework", RFC4080, IETF, June 2005.

[10] Michael P. Howarth and Paris Flegkas, "Provisioning for Interdomain Quality of Service: the MESCAL Approach", IEEE Communications Magazine, June 2005, pp.129-137.