World Applied Sciences Journal 7 (Special Issue of Computer & IT): 87-97, 2009
ISSN 1818.4952

Resource and Admission Control Architecture and QoS Signaling Scenarios in Next Generation Networks

[1]*Mahmoud Pirhadi,* [2]*Seyed Mostafa Safavi Hemami, and* [3]*Ahmad Khademzadeh*

[1]Islamic Azad University, Karaj Branch, Karaj, Iran
[2]Amirkabir University of Technology, Tehran, Iran
[3]Iran Telecom Research Center, Tehran, Iran

Abstract: This paper examines the state-of-the-art in the development of resource and admission control architectures for Next Generation Networks (NGN). The approach taken is, initially, to present some basic concepts for understanding and discussing quality of service in the context of NGN. Following this, we consider current research activities in international standardization organizations and then a detailed discussion on Resource and Admission Control Functions (RACF) architecture proposed by ITU-T. After this survey, we introduce some SIP-based call flows for call set-up and termination in NGN considering the role of RACF and QoS signaling in the call flows. Various scenarios are presented regarding different concepts such as single/two-phase schemes and single/multi-domain networks. We clarify the difference between these scenarios according to their call flows. This results in a more accurate understanding of resource control models, architectures and protocols that have been introduced up to now.

Key words: Next generation network . resource control . quality of service . RACF . call flow

INTRODUCTION

The concept of NGN as defined by ITU (International Telecommunication Union) and ETSI (European Telecommunications Standards Institute) can be outlined by several main key features, one of which is the Quality of Service (QoS) provisioning. Various services ranging from real-time multimedia services to data-transfer services to a fixed or a mobile user are expected to be supported by the NGN and such services can be provided with different QoS commitment levels, i.e. from best effort up to more stringent QoS levels.

According to ITU's definition, NGN is a packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS (Quality of Service).enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It offers unfettered access by users to different service providers [1].

One of the most important features of NGN is the independence of different layers. This feature is inherited from the Internet. Because of this feature, NGN is an open environment. This means that it is much easier to develop new and better services comparing to legacy networks such as PSTN. The benefits of migration from the legacy networks to NGN are clear, but on the other hand this migration can cause some serious challenges.

QoS provisioning is a critical challenge in next generation networks. Services which have been offered in PSTN so far should be offered now in NGN with the same or even better quality while these two networks are quite different from a technical point of view. In PSTN, QoS is guaranteed due to allocation of a dedicated circuit to each call, while in packet-based networks there is not any dedicated circuit and usually resources of the network are shared between all users. Different applications generate different types of traffic each of which has its own QoS requirements. Therefore, the network resources have to be managed so that each call gets enough resources to guarantee the quality of service.

Accordingly, one of the critical issues in development of next generation networks is that of resource management. This has made clear-sighted organizations such as ITU and ETSI to propose models and architectures for provision of resource management in NGN networks. The models and architectures include various elements in each layer and specified protocols are used between these elements. Some of these protocols have evolved and have become mature, while the others are still being developed.

This paper gives an overview of current standardization efforts for QoS and resource management in NGN and presents some QoS signaling call flows based on Session Initiation Protocol (SIP) according to the architecture proposed by ITU. The rest

Corresponding Author: Mahmoud Pirhadi, Islamic Azad University, Karaj Branch, Karaj, Iran

of the paper is organized as follows. The next section is an overview of related international research activities on NGN resource management. In section 3, we present the ITU's resource and admission control architecture and its relevant protocols. Various mechanisms and scenarios for QoS implementation in NGN are briefly described in section 4. Section 5 presents QoS signaling call flows in two main scenarios, i.e., single-domain and multi-domain, each of which are inspected in two schemes, i.e., single-phase scheme and two-phase scheme. Finally, Section 6 concludes the paper.

RELATED RESEARCH WORK

Over the past several years there has been a considerable amount of research within the field of QoS and resource management support for NGN. To date, most of the work has occurred within the context of architectural models and required protocols in different layers.

The main part of current international research activities in this field is being actively discussed in ITU.T, ETSI and IETF. Also some individual projects have been defined and executed by other organizations (e.g., EuQoS [2], NETQoS [3], MUSE [4], COST [5], Daidalos [6] and Eurolabs [7] projects and the MultiService Forum activities on bandwidth management architecture [8, 9]). The following subsections give an overview of the main activities in ETSI and IETF.

ETSI: ETSI NGN architecture is based on the IMS (IP multimedia subsystem) specification delivered by 3GPP (The 3rd Generation Partnership Project), which is the 3rd generation mobile network organization. Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) as a technical and standardization body of ETSI, developed the IMS architecture to fit the specific requirements of fixed-line networks. TISPAN presented a functional architecture for network resource management in the access and aggregation networks called Resource and Admission Control Subsystem (RACS).

The RACS is responsible for elements of policing control, including resource reservation and admission control in the access and aggregation networks [10]. There are some differences between RACS and the other architecture proposed by ITU called RACF. However, RACS can be viewed as a particular instantiation of ITU RACF which we are going to describe in the next section.

IETF: In the Internet Engineering Task Force (IETF), current QoS control work is focused on resource management and QoS signaling protocol completion, deployment, operation and refinement.

Two framework QoS solutions were proposed by IETF: resource reservation (Integrated Services - IntServ) and service classification (Differentiated Services -Diffserv). QoS signaling mechanisms were developed inside these frameworks. Currently, the IETF QoS policy framework considers policies of the network operator aimed at automated DiffServ and IntServ configurations [11]. The IETF Policy Framework is aimed at representing, managing, sharing and reusing policies in a vendor independent, interoperable and scalable manner [12, 13] and is based on the interactions of a policy management application, a policy repository, a policy decision and a policy enforcement point.

Most of the NGN/IMS protocols are standardized by IETF (e.g., the Session Initiation Protocol (SIP)). Some of these protocols will be introduced in sections 4 and 5.

RESOURCE AND ADMISSION CONTROL FUNCTIONAL ARCHITECTURE

ITU has recommended a specified architecture for Resource and Admission Control Functions (RACF) supporting end-to-end QoS in NGN [14, 15]. In this architecture RACF acts as the mediator between Service Control Functions (SCF) and transport functions for QoS-related transport. One of the basic functionalities of RACF is to make decisions according to defined policies based on resources status in transport layer and also based on utilization information, Service Level Agreements (SLA), network policy rules and service priorities. The RACF presents a view of transport network infrastructure to the SCF so that service providers do not need to know the details of the transport layer such as network topology, connectivity, resource utilization, QoS mechanisms, etc. The RACF interacts with the SCF and transport functions for the applications that require resource control in the transport layer. SIP-based call flows presented in this paper are examples of such applications.

The SCF represents the functional entities of NGN service layer such as call servers and SIP proxies which can request QoS resource and admission control for media flows of a given service via its interface to RACF.

The RACF applies control policies to transport resources, e.g., routers, upon SCF requests, determines whether transport resource is available and makes admission decisions. The RACF interacts with transport functions to control the following tasks in the transport

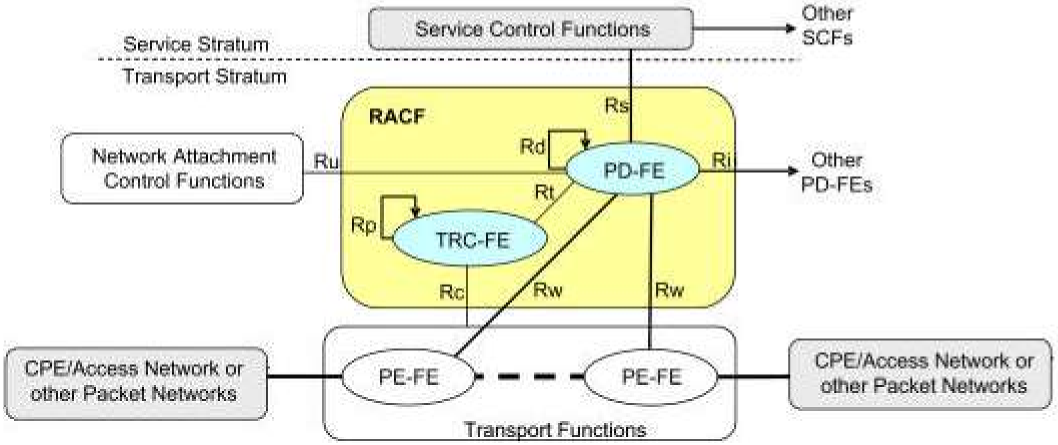

Fig. 1: Generic resource and admission control functional architecture in NGN [ITU.T Rec. Y.2111]

stratum from the QoS point of view: bandwidth reservation and allocation, traffic classification, traffic marking, traffic policing and priority handling [14, 15].

SCF, RACF and transport functions should interwork with the corresponding functions in other networks in such a way that services can be delivered in a multi-domain environment in which several providers or operators may exist.

Subsystems and interfaces of RACF: As illustrated in Fig. 1, functional entities of RACF are PD.FE (Policy Decision Functional Entity) and TRC.FE (Transport Resource Control Functional Entity).

The main functionality of PD.FE and TRC.FE is to make policy decisions and to determine network resources availability, respectively.

Dividing RACF into two distinct functions, i.e., PD.FE and TRC.FE, enables it to support variant networks within a general resource control framework. Also the PE.FE (Policy Enforcement Functional Entity) in the transport layer is a gateway at the boundary of different packet networks, e.g., edge routers and/or between the CPE (Customer Premises Equipment) and access networks. Dynamic QoS is enforced in PE.FE.

The capabilities of transport networks and associated transport profiles of the subscribers are considered in RACF to support the transport resource control function. The interaction between RACF and Network Attachment Control Functions (NACF) includes network access registration, authentication and authorization, parameter configuration, etc., for checking transport subscriber profiles [14].

NACF encompasses a collection of functional entities that provide a variety of functions for network management and configuration to provide user access based on the user profiles.

Table 1: RACF protocol recommendations

Interface	Supporting entities	Protocol	Rec. No.
Rs	SC.FE, PD.FE	DIAMETER	Q.3301.1
Rp	Between TRC.FE	RCIP	Q.3302.1
Rw	PD.FE, PE.FE	COPS.PR	Q.3303.1
		H.248	Q.3303.2
		DIAMETER	Q.3303.3
Rc	TRC.FE, T.FE	COPS.PR	Q.3304.1
		SNMP	Q.3304.2
Rt	PD.FE, TRC.FE	DIAMETER	Q.3305.1
Ru	PD.FE, NACF	DIAMETER	
Rd	PD.FE to PD.FE (intra-domain)	To be selected	Q.3306.x
Ri	PD.FE to PD.FE (inter-domain)	To be selected	Q.3307.x
Rn	TRC.FE, TRE.FE	Interface is for further study	..

Reference points and protocols: As illustrated in Fig. 1, RACF elements have interfaces, known as reference points, to other functions. Developed and under development protocols applicable to each reference point are depicted in Table 1.

- The reference point between SCF and PD.FE for resource control request is Rs. DIAMETER (Q.3301.1) is recommended for this reference point.
- The reference point between PD.FE and PE.FE for controlling policy enforcement is Rw. COPS.PR (Q.3303.1), H.248 (Q.3303.2) and DIAMETER (Q.3303.3) are recommended for this reference point.
- The reference point between TRC.FE and PD.FE for detecting and determining the requested QoS

resource in the involved network is Rt. DIAMETER (Q.3305.1) is recommended for this reference point.

- The reference point between TRC.FE and transport functions for collecting the network topology and resource status information of a network is Rc. For example, in the case that the transport network is an IP MPLS network, The Rc is used to collect the basic performance parameters per Label Switching Path (LSP) (i.e., the number of sent packets, the number of bytes sent and the number of dropped packets) for a MPLS tunnel. The TRC.FE collects the topology information from the individual LSRs (Label Switching Routers) or the management system. It is recommended that topology be derived from the hop list (i.e., the LSP route hop [RFC 3812]). COPS.PR (Q.3304.1) and SNMP (Q.3304.2) are recommended for this reference point.
- The reference point between NACF and PD.FE for checking CPE transport subscription information is Ru. DIAMETER is recommended for this reference point.
- The reference point between PD.FE instances in a single-domain is Rd. This is an intra-domain reference point. DIAMETER is recommended for this reference point.
- The reference point between PD.FE instances in a multi-domain environment is Ri. This is an inter-domain reference point. DIAMETER is recommended for this reference point.
- The reference point between two TRC.FE instances to detect availability of the requested QoS resource from edge to edge within a network is Rp. RCIP (Q.3302.1) is recommended for this reference point.
- The Rn reference point is used to control the transport elements (e.g., LER and LSR in MPLS network). The TRC.FE performs Element Resource Control and applies the resulted decisions to the TRE.FE through the Rn reference point at the aggregate level.

RESOURCE RESERVATION MECHANISMS AND SCENARIOS

In this section, we are going to introduce some mechanisms and scenarios of resource reservation after defining a number of basic concepts.

Resource control states: The QoS resource control process consists of three logical states. These states can occur in one or more steps.

Authorization: The QoS resource is authorized based on some policy rules. The authorized QoS determines and limits the maximum amount of resources that can be allocated to a specified user.

Reservation: The QoS resource is reserved based on the authorized resource and resource availability. The reserved resource can be used by best effort media flows when the resource has not yet committed in the transport functions.

Commitment: The QoS resource is committed for the requested media flows when the gate is opened and other admission decisions (e.g., bandwidth allocation) are enforced in the transport functions.

Resource control schemes: According to the diversity of application characteristics and performance requirements, the RACF supports three different schemes of resource control:

Single-phase scheme: Authorization, reservation and commitment are performed in one step. The requested resource is immediately committed after a successful authorization and reservation.

Two-phase scheme: Authorization and reservation are performed in one step followed by commitment in another step. Alternatively authorization is performed in one step, followed by reservation and commitment in another step.

Three-phase scheme: Authorization, reservation and commitment are performed in three steps sequentially [14].

QoS capability of CPE: According to the capability of QoS negotiation, CPEs can be categorized as follows:

Type 1: CPE without QoS negotiation capability (e.g., simple SIP-phones [16]). The CPE does not have any QoS negotiation capability at either the transport or the service layer. It can communicate with the SCF for service initiation and negotiation, but cannot ask for QoS resources directly.

Type 2: CPE with QoS negotiation capability at the service layer (e.g., SIP phone with SDP/SIP QoS extensions [17]). The CPE can perform service QoS negotiation (such as bandwidth) through service signaling, but is not aware of QoS attributes specific to the transport.

Type 3: CPE with QoS negotiation capability at the transport layer (e.g., Universal Mobile Telecommunications System User Equipment). The CPE supports RSVP-like or other transport signaling. It is able to directly perform transport QoS negotiation throughout the transport facilities.

Type 4: CPE with QoS negotiation capability at the RACF level (e.g., A home gateway with such capability) [14].

Resource control modes: Supporting the following QoS resource control modes RACF can handle different types of CPE and transport QoS capabilities:

- Push mode: The RACF makes the authorization and resource control decision based on special policy rules and independently instructs the transport functions to enforce the policy decision.
- Pull mode: The RACF makes a pre-authorization decision based on the policy rules upon SCF request and makes a re-authorization upon transport function request and then responds with the final policy decision for enforcement.

The push mode is suitable for the first two types of CPE. For the type 1 the SCF determines QoS requirements of the requested service on behalf of the CPE; for the type 2 the SCF extracts the QoS requirements from the service signaling. The pull mode is suitable for the type 3 which can directly request QoS resource reservation through transport QoS signaling.

Single-phase and two-phase resource control schemes can be used in push mode while two-phase and three-phase resource control schemes are more common to be used in pull mode [14].

Single-domain and multi-domain environments: In this paper we use the word domain to imply a set of network elements and resources having a common resource control. In other words, these elements and resources are controlled by the same RACF. Therefore a multi-domain structure has two or more RACFs each of which controls its own domain resources.

Given the above definitions there are different scenarios for call establishment and teardown considering resource control in NGN networks. This means that different messages are exchanged for call establishment and teardown between different network elements and hence a distinct call flow exists for each scenario. The next section investigates these call flows in some major scenarios in both single-domain and multi-domain structures. Call flow extraction is the first step in analyzing and evaluating models, architecture functionalities and resource control protocols.

CALL SET.UP SCENARIOS AND SIGNALING CALL FLOWS

Detailed call/session flows need to be developed for all applications and service types [18]. The purpose of such flows is to:

- Enable better understanding of how specific actions will be implemented at various reference points.
- Determine whether currently defined functionality is adequate.
- Ensure architectural efficiency for delivery of timely actions (e.g., setup delays should not be excessive).
- Determine whether multiple reference points can be “collapsed together” for better efficiencies.
- This section is going to investigate different protocols and exchanged messages used in call establishment/teardown considering the role of RACF and QoS signaling in the call flows.
- The call flows considered in this section are presented according to the following assumptions:
- SIP-based call flows are offered due to the inevitable importance of the SIP protocol in NGN [19].
- Signal flow is indicated among the main elements, i.e., CPE, SCF, RACF and PE.FE in order to prevent complexity of indication.
- All CPEs are assumed to be of the type 1 and therefore the presented scenarios are all in the push mode.

Figure 2 illustrates the topology, elements and QoS signaling protocols in the network. This architecture can be used for explanation of all scenarios.

Protocols: As mentioned before, most of the protocols used in NGN/IMS are standardized by the IETF. They are briefly described in this section.

SIP is introduced in RFC 3261 provided by IETF and is used to control the sessions and provide their signaling [16].

RFC 3312 is a protocol proposed to integrate resource management and SIP protocol [17]. The RFC 3312 contains the IETF proposal about negotiation of QoS session levels between users involved in a SIP call and introduces the concept of precondition. This is a set of constraints about the session, i.e., a defined QoS service level desired for the session.

DIAMETER [20] is a protocol proposed by ITU and used to provide the communication between SCF and RACF. RACF uses DIAMETER to request and

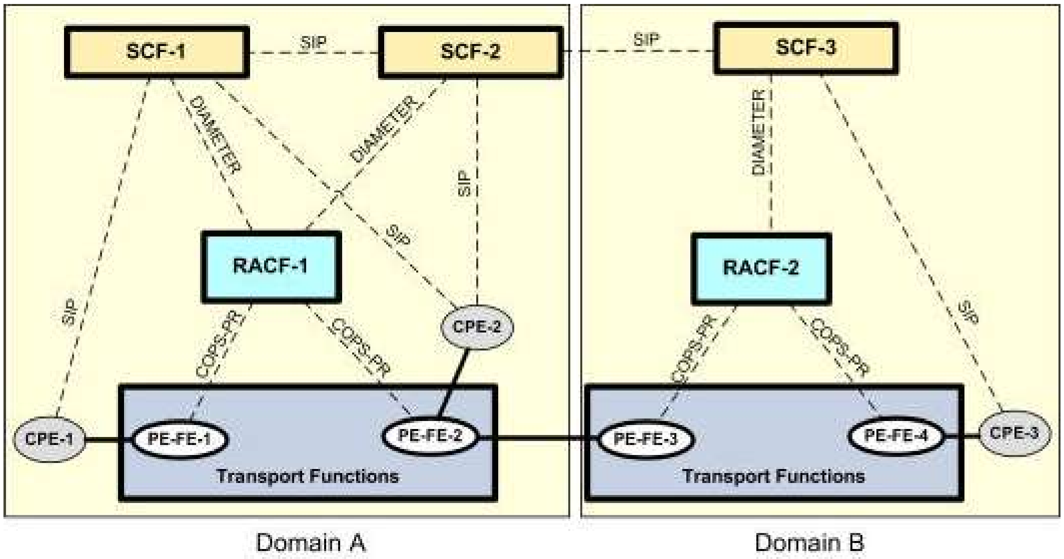

Fig. 2: Network architecture and QoS signaling protocols

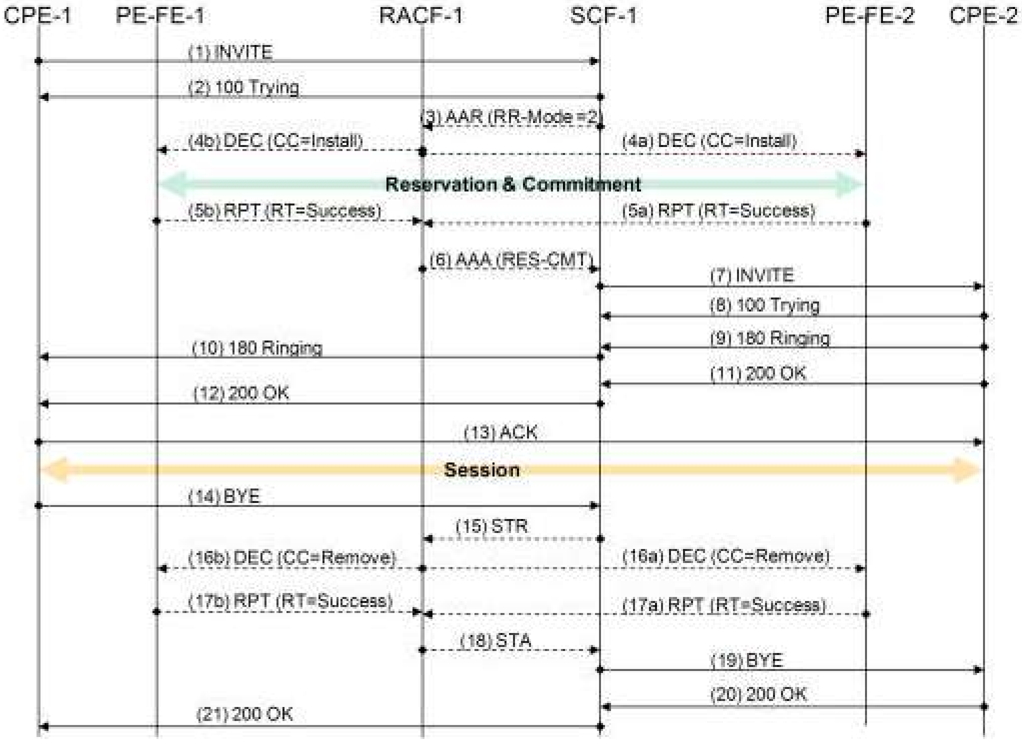

Fig. 3: Call flow of single-domain, one SCF, single-phase scheme

commit transport resources and to receive reports about transport resource usage [21]

IETF documents specify QoS policies based on IntServ and DiffServ provisioning technologies. The Common Open Policy Service (COPS) protocol [22] was standardized, which is aimed at exchange of policy infomation between PE.FE and PD.FE (RACF). COPS protocol is applicable to the Integrated Services (IntServ) architecture operating with the Resource reservation Protocol (RSVP).

COPS has been extended for Policy Provisioning (COPS.PR) in order to support more efficiently the Differentiated Services (DiffServ) networks. The COPS.PR protocol, acts between RACF and PE.FE and allows the RACF to push the admission decisions to the PE.FE and also allows the PE.FE to request the admission decisions when pull mode resource reservation mechanism is in use [23].

COPS has been originally designed for pull mode operation. The operation of push mode, as defined in COPS.PR, is inefficient, since it involves extra messaging between the PD.FE and the PE.FE. Because of these problems, it is needed to modify this protocol [24].

Single-domain scenarios: Single-domain call flows are inspected in this section using the four following scenarios:

- Single-domain, one SCF, single-phase scheme
- Single-domain, one SCF, two-phase scheme
- Single-domain, two SCFs, single-phase scheme
- Single-domain, two SCFs, two-phase scheme

Figure 3 depicts the call flow (set-up and termination) of the scenario 1. The call set-up function begins when the calling user issues an INVITE request (event 1) and ends (successfully) when the called user receives the corresponding ACK to its final 200 OK (event 13). In this scenario both CPEs are under the control of SCF.1 and are resided in RACF.1 domain.

- Events 1 & 2: Service is requested by CPE.1 from SCF.1. When the request is received, reservation and commitment steps are initiated. SCF.1 does not forward the *INVITE* message to CPE.2 before the end of reservation and commitment steps.
- Event 3: Resource reservation and commitment are requested by SCF.1 from RACF.1. The request is based on the DIAMETER protocol and is sent through the *AAR* command [20]. According to Q.3301.1 this request should have the *Resource-Reservation-Mode=2* option that means authorization, reservation and commitment steps should be performed in a single step [21].
- Event 4 (a & b): A command is issued from RACF.1 to PE-FEs for resource reservation and commitment in transport layer in a bidirectional path. This command is based on COPS.PR protocol and is issued through *DEC* message. This command should have the *Command-Code=1* option that means configuration should be installed [23].
- For the sake of simplicity extra COPS.PR messages and RSVP messages are not indicated.
- Event 5 (a & b): RPT messages are reported from PE-FEs to RACF. 1 which means resource reservation and commitment have been performed successfully [23].
- Event 6: Receiving RPT messages from both PE-FEs RACF.1 answers to SCF.1 through the *AAA* command which means resource reservation and commitment have been performed successfully [20, 21].
- Event 7: *INVITE* request is forwarded to CPE.2.
- Events 8.13: These events relates to the session establishment with respect to the RFC 3261 [16].
- Event 14: *BYE* request is sent by CPE.1 to SCF.1 to imply the end of session.
- Event 15: The DIAMETER message, *Session Termination Request (STR)*, is sent by SCF.1 to RACF.1 to release the resources [20, 21].
- Event 16 (a & b): DEC command is sent by RACF.1 to PE-FEs to release the transport resources. This command is based on COPS.PR protocol and should have the *Command-Code=2* option that means configuration should be removed [23].
- Event 17 (a & b): *RPT* messages are sent by PE-FEs to RACF.1. This accounts for a successful resource release.
- Event 18: RACF.1 responds to SCF.1 about the successful resource release event through *Session Termination Answer* (*STA*) message based on DIAMETER protocol [20, 21].
- Events 19.21: These events relates to the session termination with respect to the RFC 3261 [16].

Figure 4 depicts the call set-up flow of the scenario 2. In this scenario both CPEs are under the control of SCF.1 and are resided in RACF.1 domain. This scenario is performed in the two-phase scheme.

The differences between the first and second scenarios are as follows:

- Event 3: Resource reservation is requested by SCF.1 from RACF.1. The request is based on the DIAMETER protocol and is sent through the *AAR* command. According to Q.3301.1 this request should have the *Resource-Reservation-Mode=1* option that means only authorization and reservation steps should be performed in one step [21].
- Event 12: Resource commitment is requested by SCF.1 from RACF.1. The request is based on the DIAMETER protocol and is sent through the *AAR* command. According to Q.3301.1 this request should have the *Resource-Reservation-Mode=3* option that means only commitment step should be performed [21]. This request will be sent when the

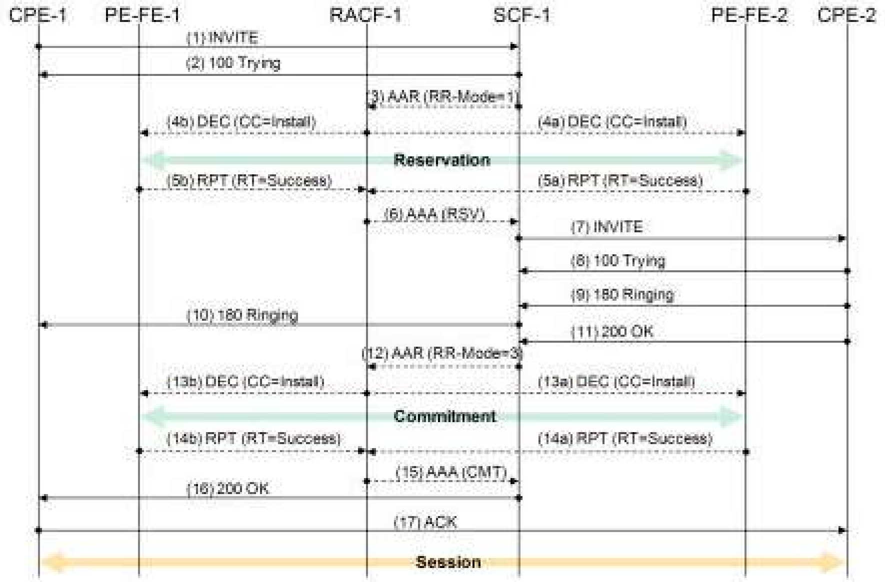

Fig. 4: Call flow of single-domain, one SCF, two-phase scheme

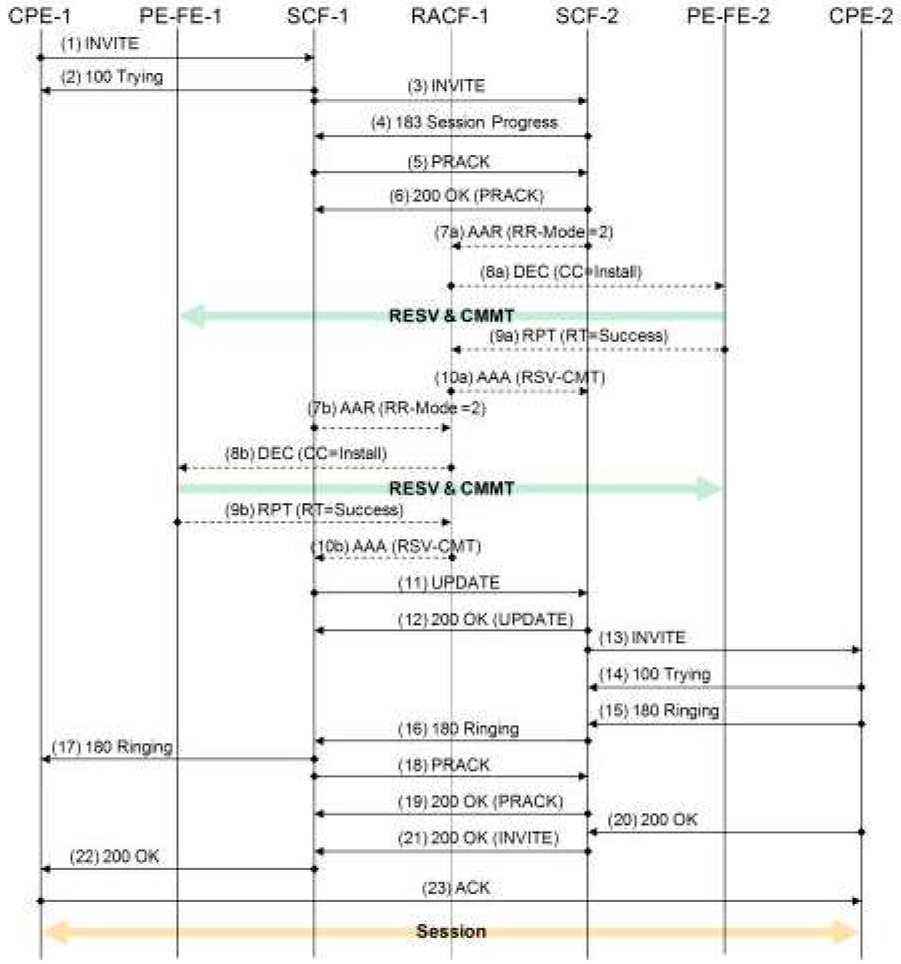

Fig. 5: Call flow of single-domain, two SCFs, single-phase scheme

message *200 OK* is received from CPE.2 to SCF.1 (Off-hook state).

As the figure indicates signaling flow has more events in the two-phase scheme than the corresponding single-phase. This causes more amount of call setup delay. Single-phase scheme has a smaller call setup delay than two-phase, however, in networks with limited resources two-phase scheme can outperform single-phase. This is owing to the fact that, in the two-phase scheme, network resources are only reserved but not committed during the time between ringing and going off-hook and hence these resources can be in use by the best effort traffic [25].

Figure 5 depicts the call set-up flow of the scenario 3. In this scenario each CPE is under the control of a distinct SCF. (CPE.2 is under the control of SCF.2.) However, CPEs are in the same RACF domain. As mentioned before, the CPEs have been assumed to be of Type.1; therefore RFC 3312 messages are sent by SCFs on behalf of CPEs. This scenario is performed in single-phase scheme.

Events of this call flow are similar to those of scenario 1 except that the signaling between SCFs is based on RFC 3312 [17]. Since there are two SCFs at both ends of the session, AAR requests are independently sent by each of SCFs to the RACF.1. In other words, resource reservation is performed autonomously in each direction.

The scenario 4 is similar to the previous one except that the scheme is two-phase. The main difference between the call flows of these scenarios is in resource reservation and commitment processes. In scenario 4 reservation request is sent by both SCFs to RACF.1 and only resource reservation process is started. When *200 OK* (*INVITE*) message is sent from the CPE.2 to SCF.2, commitment events are initiated. It is enough to send a commitment request from SCF.2 to the RACF, since RACF can send the commitment commands to both PE-FEs regarding the reservation status.

Multi-domain scenarios: The QoS signaling across multiple domains is an open issue [15]. In this section we propose a solution in which the inter-domain QoS signaling flows on the application layer.

Session establishment in multi-domain environments between two endpoints in two different domains requires exchange of QoS signaling between the domains. This signaling can be exchanged via three methods:

- Through application layer (i.e., between the SCFs)
- Via signaling between RACFs (i.e., through Ri reference point)
- Via transport functions (e.g., RSVP-like)

In the case that there is no transit network between the source and destination domains, QoS signaling can be transferred through either application layer or transport functions (first and third methods). Therefore, no direct communication is needed between RACFs.

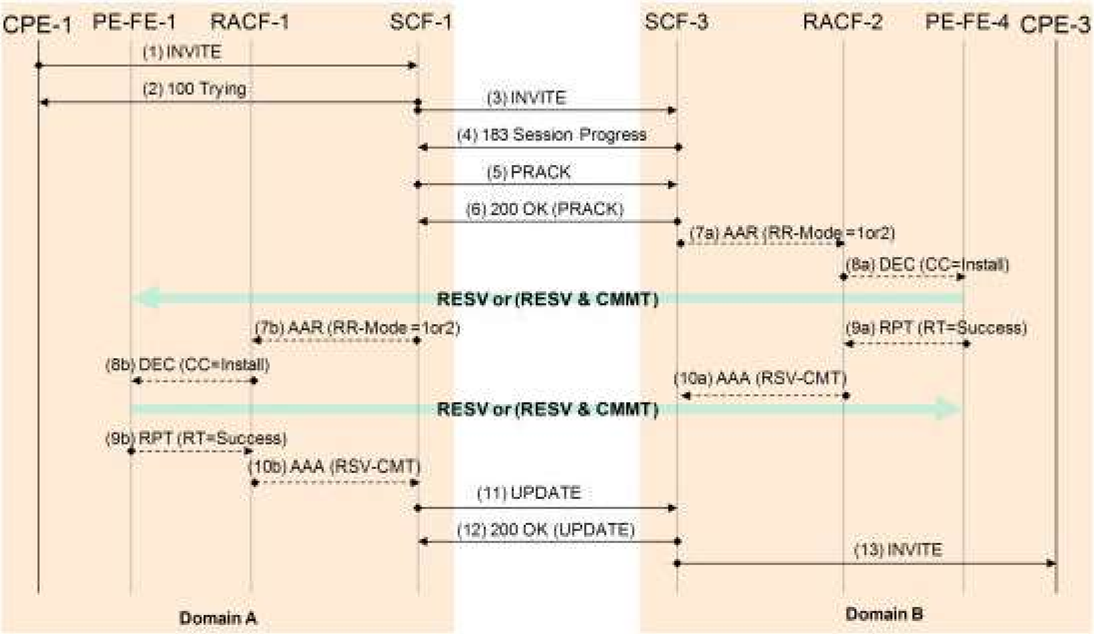

Fig. 6: A multi-domain call flow

If there is a transit network between the source and destination domains, the first method cannot be used, because transit networks do not usually hav application layer functions. Thus, the second and third methods can be used, considering that in the third method RACFs operate independently.

In this section a sample call flow is presented which there is no transit network between the two domains. This scenario can be derived from Fig. 2. In this scenario QoS signaling is exchanged between SCF.1 and SCF.3 based on RFC 3312 through the application layer and RACFs do not communicate directly.

Session is established between CPE.1 and CPE.3 resided in the control domains of RACF.1 and RACF.2, respectively. Policies are enforced to PE.FE.1 and PE.FE.4 in both ends. Figure 6 illustrates the call flow. The figure shows the events from the beginning to the Reservation & Commitment event for the single-phase scheme and/or to the Reservation event for the two-phase. The rest of the flow could be inferred from the call flows described before.

CONCLUSION

This paper presented the resource and admission control architecture in NGN and its related protocols developed and proposed by international standardization organizations. The ITU's model called RACF is discussed in detail. According to this architecture, we extracted some call set-up scenarios to show the role of RACF and QoS signaling in call flows. Call flow extraction is the first step in evaluating architectures and protocols, understanding how specific actions will be implemented at various reference points and determining whether current defined functionality is adequate.

In this paper, single-domain and multi-domain scenarios were investigated. While the intra-domain QoS signaling and required protocols are mature, work on inter-domain signaling scenarios remains in its early stages of development. Given that, the work presented in this paper contributes towards better understanding of different QoS signaling scenarios in both architectures.

Future work is intended to study the resource management and QoS signaling traffic in the proposed model and compare it to the total traffic of network to evaluate its architectural efficiency. Also we are going to study the call flows in detail and determine some parameters such as call set-up delay and compare the results to that proposed by ITU.

REFERENCES

1. ITU Rec, Y., 2001. General overview of NGN. Dec. 2004.
2. EuQoS Project Web Site, 2008. Home .EuQoS .End-to-end Quality of Service support over heterogeneous networks. http://www.euqos.eu.
3. NETQOS Project Web Site, 2008. Policy Based Management of Heterogeneous Networks for Guaranteed QoS. http://www.netqos.eu.
4. MUSE Project Web Site, 2008. Multi Service Access Everywhere. http://www.ist.muse.org.
5. COST Project Web Site, 2008. Traffic and QoS Management in Wireless Multimedia Networks. http://www.cost290.org.
6. DAIDALOS Project Web Site, 2008. Designing Advanced network Interfaces for the Delivery and Administration of Location independent, Optimised personal Services. http://www.ist. daidalos.org.
7. Eurolabs Project Web Site, 2008. European Distributed NGN Laboratories. http://www.ist. eurolabs.org.
8. MSF.TR.ARCH.005.FINAL, 2005. Bandwidth Management in Next Generation Packet Networks.
9. MSF.TR.ARCH.008.FINAL, 2006. Network Engineering to Support the Bandwidth Manager Architecture.
10. ETSI ES 282 003 v1.1.1, 2006. Resource and Admission Control Sub-system (RACS); Functional Architecture.
11. Snir, Y. *et al*., 2003. Policy Quality of Service (QoS) Information Model. RFC 3644.
12. Moore, B. *et al*., 2001. Policy Core Information Model ..Version 1 Specification. RFC 3060.
13. Moore, B., 2003. Policy Core Information Model (PCIM) Extensions. RFC 3460.
14. ITU Rec. Y. 2111, 2006. Resource and admission control functions in Next Generation Networks (Release 1).
15. ITU Draft Y. 2111, 2007. Resource and admission control functions in Next Generation Networks (Release 2). NGN.GSI/DOC-301.
16. Rosenberg, J. *et al*., 2002. SIP: Session Initiation Protocol. RFC 3261.
17. Camarillo, G. *et al*., 2002. Integration of Resource Management and Session Initiation Protocol (SIP). RFC 3312.
18. ITU TD 142 (WP 4/13), 2007. RACF Living List. Geneva.
19. Pirhadi, M., M. Safavi Hemami and A. Iravani Tabrizipoor, 2009. Call Set-up Time Modeling for SIP-based Calls in Next Generation Networks. ICACT, Korea.

20. Calhoun, P. *et al*., 2003. Diameter Base Protocol. RFC 3588.
21. ITU Draft Q. 3301.1, 2006. Resource control protocol no. 1 (rcp1) Protocol at the interface between service control entities and the Policy Decision Physical Entity (PD.PE).
22. Durham, D. *et al*., 2000. The COPS (Common Open Policy Service) Protocol.
23. Chan, K. *et al*., 2001. COPS Usage for Policy Provisioning (COPS.PR). RFC 3084.
24. Xu, H. *et al*., 2007. A Modification to COPS to Improve Implementation of Push Mode. Internet draft, work in progress. http://tools.ietf.org/id/draft.xu.cops.push.00.txt
25. Safavi Hemami, M., M. Pirhadi and A. Iravani Tabrizipoor, 2008. Analysis and Optimization of Resource Control Schemes in Next Generation Networks. K.INGN08, Geneva.