International Journal of Engineering Research and Reviews **ISSN 2348-697X (Online)**
Vol. 3, Issue 1, pp: (8-14), Month: January - March 2015, Available at: www.researchpublish.com

Quality of Service Control in NGN

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Abstract: **This paper represents the Quality of Service (QOS) in next generation network. We outline primarily standardized QOS control architectures with respect to the service and transport strata of NGN. And discuss the conditions of QOS in NGN connectivity and QOS in NGN user terminals. This information is useful regarding the identification of adequate QOS monitoring points in order to provide a resource-saving QOS monitoring approach.**

Keywords: **NGN, QOS.**

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1. INTRODUCTION

Quality of Service (QOS) is currently considered to be one of the key features of the NGN concept [1]. A variety of networks currently provide disparate services using different architectures and policies. These networks provide separate vertically integrated services. The next generation network (NGN) is an IP based packet switched network that provides a single network capable of carrying any and all services. Unlike circuit switched networks such as the public switched telephone network (PSTN), IP networks originally lacked control mechanism for quality of service (QOS) since they were designed to provide best effort delivery without QOS [2]. QOS can be mainly guaranteed via two ways; a simple mechanism by over-provisioning in a node and a link bandwidth sharing mechanism under connection oriented architectures. The former is extremely simple since it does not require QOS architecture.

2. NEXT GENERATION NETWORK (NGN) AND QUALITY OF SERVICE (QOS)

In 2004, the ITU-T (International Telecommunication Union – Telecommunication Standardization Sector) released its definition of NGN in. The term NGN stands for a telecommunication network concept that can be characterized by a number of key features including, amongst others, “Packet-based data transport” and “Quality of Service support”. Although the term “Packet-based data transport” does not refer to any particular technology or protocol, IP (Internet Protocol) is the most likely network protocol choice for an NGN environment. The use of SIP (Session Initiation Protocol) for NGN service provisioning and signaling is widely accepted.

2.1- The NGN architecture:

Figure 1 shows the principle structure of an NGN.

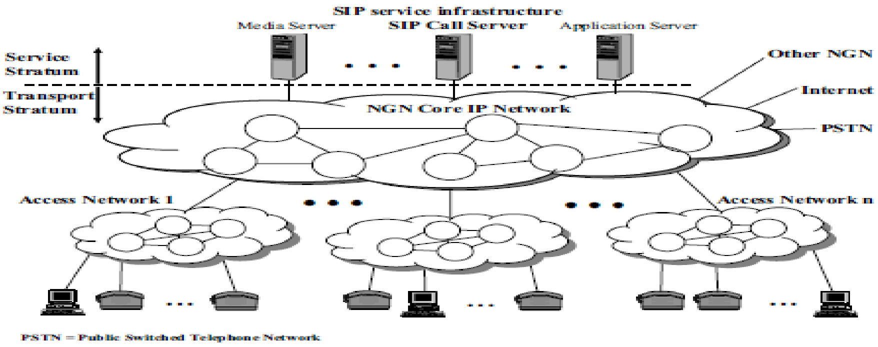


Figure: 1 Principle structure of a SIP-based NGN

In the NGN architecture considered within this paper, SIP was chosen as the service signaling protocol. An NGN can be logically divided into a service stratum and a transport stratum. Utilizing SIP for service control and signaling, an NGN's service stratum provides services and applications to the NGN subscribers, such as (in the simplest case) the initiation of a VoIP (Voice over IP) session. In terms of SIP, the service stratum comprises a SIP server infrastructure. The NGN's transport stratum provides IP connectivity and IP transport to the user terminals (such as VoIP phones). It consists of any arbitrary IP transport infrastructure, including both access and core networks. The user terminals are connected to interfaces (such as a DSL interface (Digital Subscriber Line)) provided by several access networks. By transmitting IP packets over this interface, the user equipment uses SIP to communicate with the NGN service stratum (e.g., to setup media sessions to other users' end systems). Once a media session is established, media data are exchanged peer-to-peer between the involved NGN user terminals. Hence, after session initiation, the service stratum is not involved in the media data exchange.

2.2- QOS for real-time telecommunication services:

For services provided within telecommunication networks, the term QOS has been defined as the "collective effect of service performance which determine the degree of satisfaction of a user of the service". For packet-based media data transport, the quality of a real-time based telecommunication service as experienced by a service user directly depends on the network performance of the respective transport network. the network performance of an IP transport network is characterized by the packet loss ratio, the transfer delay, and the transfer delay variation (jitter).

2.3- Integrated framework for comprehensive QOS control in SIP-based NGN:

The authors proposed in a previous study a framework for QOS control, aiming to address the scalability issues related to QOS provision in SIP-based NGN. all action required for the control of the QOS affecting media sessions is performed within the NGN service stratum (i.e., cross-strata communication is avoided). Therefore, the framework has to be provided with an integrated mechanism for the collection of information on the QOS affecting any ongoing and future media session.

3. COMPARISON OF QOS CONTROL ARCHITECTURES

In this section, QOS control architectures defined in five standards bodies are reviewed and compared:

- Cable Lab
- DSL Forum
- The 3rd Generation Partnership Project (3GPP)
- ETSI
- and ITU-T

Cable Lab:

Defines the dynamic QOS (DQOS) control architecture for the hybrid fiber and coaxial (HFC) network. The architecture is designed for the uniqueness of the HFC network. In the HFC network, multiple cable modems (CMs) share an upstream channel to the cable modem termination system (CMTS). The bandwidth sharing is controlled based on a layer 2 medium access control (MAC) protocol called data over cable system interface specification (DOCSIS). The layer 2 level QOS guarantee mechanism is defined from DOCSIS version 1.1. The goal of the DQOS is to support the QOS guaranteed through the HFC network.

DSL:

The DSL forum defines the resource control at the DSL (digital subscriber line) access network. Unlike Cable network, a DSL modem is connected to the subscriber through the dedicated line. Layer 2 level dynamic QOS control between a DSL modem and a digital subscriber line access multiplexer (DSLAM) is not required.

The 3rd Generation Partnership Project (3GPP):

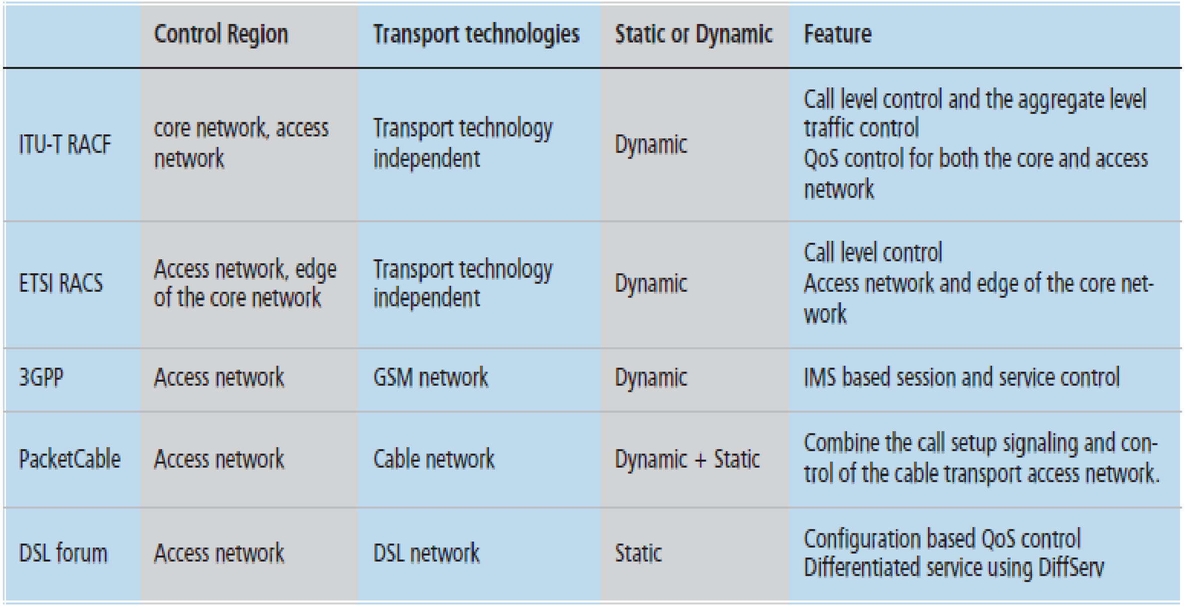
The 3GPP was originally founded for developing new service architecture over cellular networks, especially for the global system for mobile communication (GSM) network. During this effort, the 3GPP developed the IP multimedia subsystem (IMS) for controlling the IP multimedia services in the areas of session control, service control, and subscriber database management.

ETSI & ITU-T:

The QOS architecture defined in ETSI and ITU-T, assumes the independence of the service stratum and the transport stratum. In this case, the requested QOS from the application signaling can be dynamically changed, and the transport architecture must be able to reserve network resources for the QOS request. The architectures defined in ITU-T and ETSI focus on dynamic QOS. CableLab defines both aspects.

Primary services can be established at configuration time. Dynamic addition of service also is possible by the QOS signaling. DQOS defined in PacketCable defines the dynamic aspect of the QOS control. The RACF and the RACS also consider the characteristics of the DSL environment in their development so that they can be directly applied to those environments to achieve dynamic QOS control.

Table 1: Comparison of resource management architectures



	Control Region	Transport technologies	Static or Dynamic	Feature
ITU-T RACF	core network, access network	Transport technology independent	Dynamic	Call level control and the aggregate level traffic control QoS control for both the core and access network
ETSI RACS	Access network, edge of the core network	Transport technology independent	Dynamic	Call level control Access network and edge of the core network
3GPP	Access network	GSM network	Dynamic	IMS based session and service control
PacketCable	Access network	Cable network	Dynamic + Static	Combine the call setup signaling and control of the cable transport access network.
DSL forum	Access network	DSL network	Static	Configuration based QoS control Differentiated service using DiffServ

The resource control architectures defined in the previously mentioned two standards bodies — Packet Cable and DSL Forum — focus on a specific transport technology (i.e., HFC network and DSL network). Unlike these two, the resource and admission control functions (RACFs) of ITU-T and the resource and admission control sub-system (RACS) of ETSI define the resource control architecture in a more general aspect, figure2.

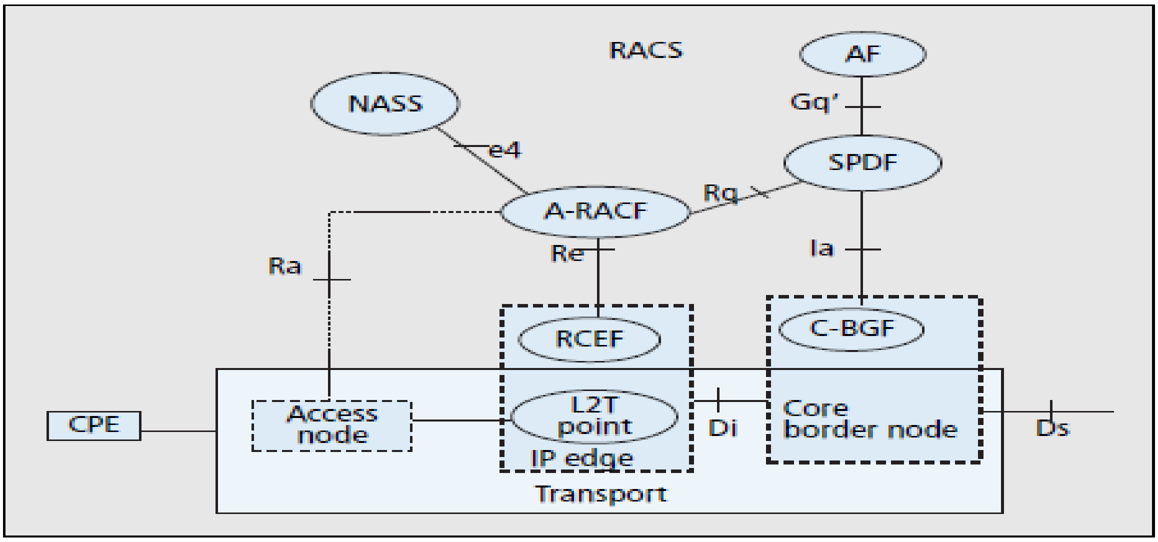


Figure: 2 ETSI RACS functional architecture

4. OVERVIEW OF ITU-T RACF

As explained in the previous section, the ITU-T NGN QOS control architecture covers the broad aspect. Its QOS control architecture and procedure. In this section, detailed information on RACF is provided; the functional architecture of the RACF is described in figure 3.

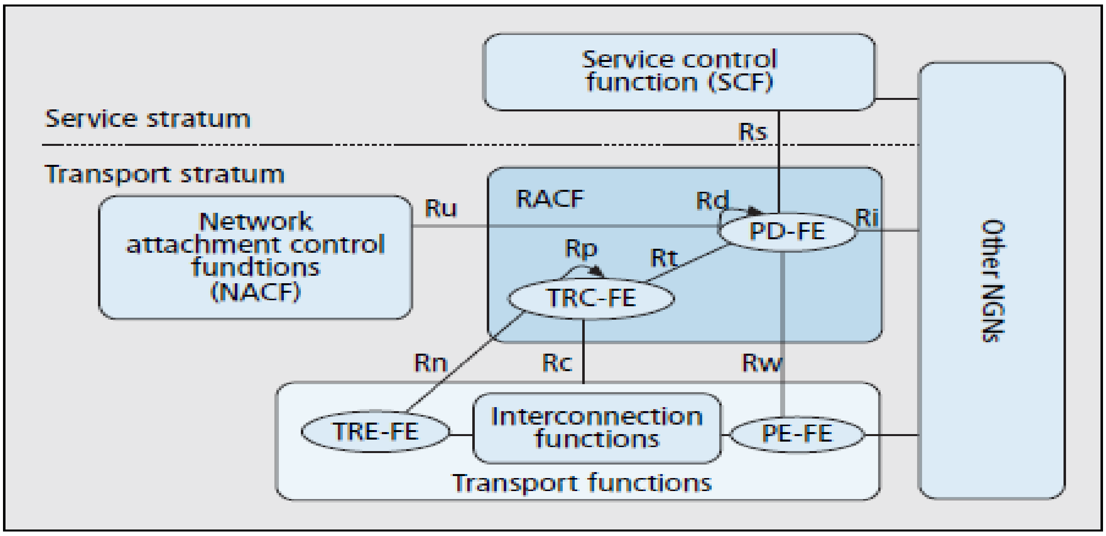


Figure: 3 ITU-T RACF functional architecture

As mentioned previously, one of the important concepts in IUT-T NGN architecture is the independence of the transport stratum and the service stratum. For example, in the case of the Skype service that provides VoIP service, the voice traffic passes through the Internet network after the call set-up signaling is made between the host and the signaling server. The voice traffic passes through the network operated by a certain network operator (e.g., Verizon). However, the network provider cannot profit from the premium traffic passing through its own network. The service provider also has a problem in deploying the high quality service, because no QOS request/guarantee mechanism is available from the network side.

To solve this problem, ITU-T NGN assumes the independence between the service and the transport. Under the concept of the independence of the service and transport functions, the required network resource and service reliability are provided by the network side upon request from the service stratum. The service stratum is responsible for the application signaling, and the transport stratum is responsible for reliable data packet forwarding and traffic control. The service stratum can be a simple application server or a full-blown system such as IMS.

The transport control function serves as an arbitrator connecting the two stratums. It determines the admission of the service request based on the network resource state and the policy of the network provider. It also controls the network equipment to allocate the actual resources in the network. The RACF is the function that determines the availability of the resources and appropriately controls the network element.

The RACF defines the QoS control scenarios for the user terminals and the customer premise equipment (CPE) with the various QoS signaling capabilities. The user terminal is classified as one of the following three types:

- Type 1: a terminal that does not have QOS signaling capability
- Type 2: a terminal recognizing the service level QOS (e.g., SIP terminal with QOS capability)
- Type 3: a terminal with path coupled QOS signaling capability (e.g., RSVP)

QOS control can be done either in pull mode or in push mode. In push mode, the PD-FE sends the QOS policy to the transport equipment (PE-FE) once the QOS request defined is received from the SCF. In pull mode, the PDFE receives the QOS request from the PE-FE after the PE-FE receives the QOS request from the path-coupled QOS signaling. To support both push and pull mode, the RW reference point between the PD-FE and the PE-FE should be bidirectional.

The type 1 and type 2 terminals are controlled in push mode, and the type 3 is controlled in pull mode. The QOS requirement of a type 1 terminal is determined in SCF, because a type 1 terminal cannot specify the QoS information in a signaling. Type 2 has the QOS requirement already defined in a signaling when it requests a resource.

An exemplary QoS control scenario in push mode is illustrated in Figure4. The explanation of each step is as follows:

1. The CPE sends the service requests to the call signaling server. In this request, a QOS parameter may not be specified if the CPE is type 1. In this case, the SCF should determine the QOS parameter in the application level.
2. The SCF function identifies the IP address of the terminating CPE and sends the service request. To identify the destination address, a proxy call signaling server maybe involved.
3. The terminating CPE responds to the service request.
4. The SCF sends a resource request to the PD-FE of the core network. The resource request contains the QOS requirement. This figure assumes that the SCF obtained the address information of the destination CPE. When the SCF sends the resource request to the PD-FE, the source and destination IP addresses are specified in the message.
5. After receiving the request, the PD-FE makes an admission decision based on the network operator's policy.
6. If the request is acceptable in the core network, the PD-FE of the core sends a request to the PD-FE of the access network to verify the decision of the access network.
7. The PD-FE of the core and access networks checks the resource availability from the TRC-FE that is monitoring the resource status of the network region and responds to the resource check request. Note that the admission decision is made in the two functional entities — PD-FE and TRC-FE. The PD-FE makes the policy based decision and the TRC-FE makes the resource based decision.
8. In the access network, the PD-FE confirms to the NACF that the requested QOS does not exceed the authorized maximum bandwidth defined in the access network user profile. The subscription check to NACF may not be necessary if the information is pushed to the PD-FE when the CPE is attached to the network.
9. After the results of the policy check, resource check, and subscription check are confirmed as acceptable, the PD-FE controls the PE-FE at the boundary of the regional network.
10. After the SCF receives the response of the resource request in step 4, it sends the response to the service request.

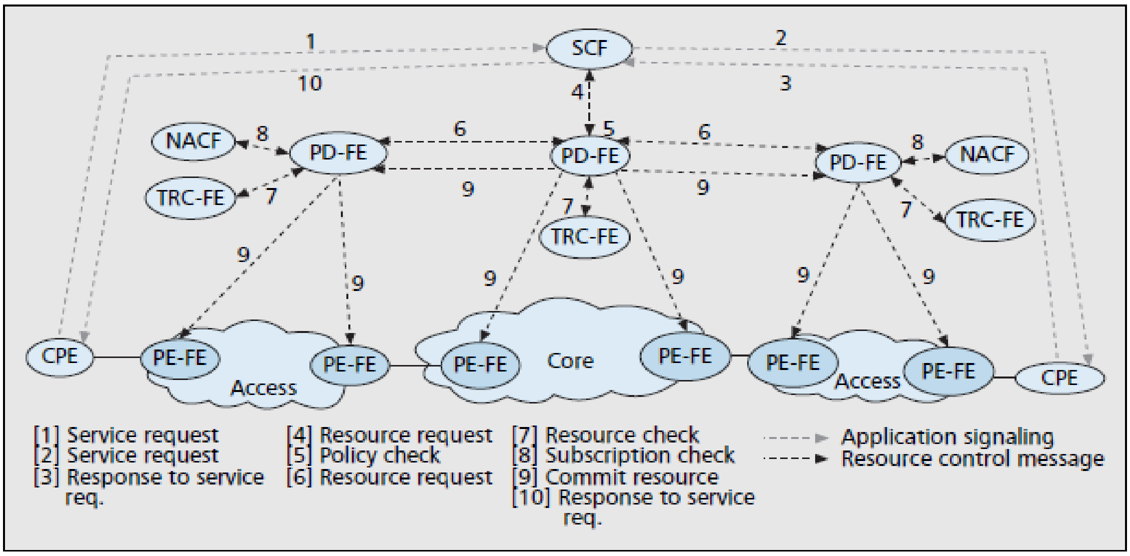


Figure: 4 Example of the end-to-end QOS control scenario in push mode

Following steps 1–9 in Figure4, application level signaling is completed in the same way as in push mode. During these steps, the requested service is pre-authorized. The CPE may receive the authorization token in the response of the service request in step 9. After the sender receives the response, the source and destination CPE can exchange the service request confirmation in step 10 before starting the path-coupled signaling. In step 11, the CPE initiates the path coupled QOS signaling. After receiving the QOS request, the PE-FE sends the QOS request to the PD-FE to check if the service has been authorized. The CPE may send the authorization token in the path-coupled signaling message. In this case, the PD-FE can simply check the token value to confirm the pre-authorization of the request. After the PD-FE confirms the authorization, it sends the gate control to the PE-FE to open the gate and allocate there source. In the PE-FE, the path-coupled signaling can be implemented in a termination, snooping, and proxy mode. For scalability purposes, the path-coupled QOS signaling can be implemented in termination mode or proxy mode.

The example of Figure 5 assumes the termination mode where the first edge node (PE-FE) terminates the QOS signaling and performs the policy pull QoS request to the PD-FE. Proxy mode also can be used to reduce the signaling overhead. In this case, the PE-FE can aggregate and de-aggregate the QOS signaling message.

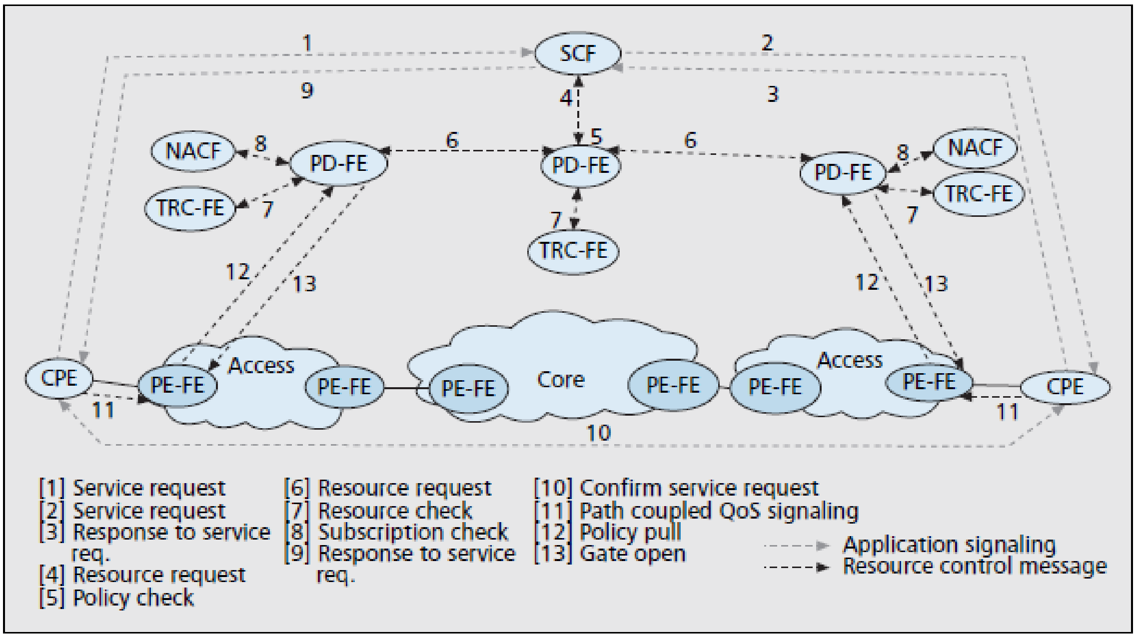


Figure: 5 Example of the end-to-end QOS control scenario in pull mode

The RACF also defines the network address and port translation (NAPT) control function. Based on the network policy, NAPT is used to hide the network address details or to resolve the shortage of address space. The SCF is responsible for changing the address information in the application signaling. The PD-FE checks if NAPT control is required and controls the edge device (PE-FE) to modify the IP address of the data packet. Figure 6 shows the NAPT control procedure in RACF architecture. The figure shows the case when two hosts (A and B) communicate with IP addresses A and B and User Datagram Protocol (UDP) port number PA and PB respectively.

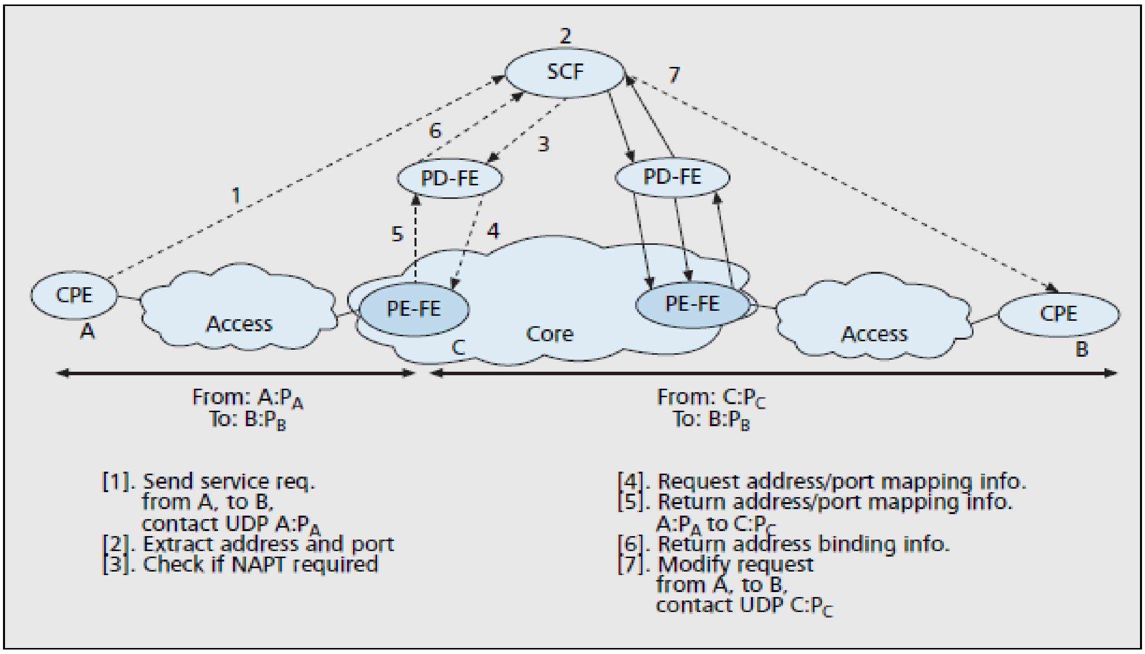


Figure: 6 Control procedures for NAPT control

5. CONCLUSIONS

Several control architectures have been developed for supporting the QOS in the packet-based network. ITU-T RACF provides the general architecture covering both access and core networks. The current RACF specifies the functional architecture and control procedure in the IP level. There are still many open issues, and continuing effort is under way to solve the issues.

For the new services such as fixed mobile convergence and IPTV services, QOS control for mobility and the multicast condition must be developed. QoS control in a home network is another open issue for future QoS control.

In a further step we plan to adopt the herewith introduced QOS recognition mechanism into an NGN simulation environment, based on network simulation software such as ns2 or opnet.

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