PacketCable™ 2.0

Quality of Service Architecture Technical Report

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Abstract

This technical report describes the QoS architecture for PacketCable™ networks, including all major system components, the various functional groupings and the network interfaces necessary for the management of QoS. The intended audience for this document includes developers of equipment intended to be conformant to PacketCable specifications, and network architects who need to understand the PacketCable QoS architecture.

This technical report describes the PacketCable QoS architecture and associated interfaces. It contains the following information:

- A reference architecture;
- Description of the various functional groupings within the architecture;
- High level goals of the architecture;
- Detailed description specific architectural components;
- Reference Points.

The PacketCable specifications take precedence over this technical report if the technical report contradicts any specification requirements.

Contents

Figures

Tables

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1 INTRODUCTION

This technical report provides an overview of the PacketCable Quality of Service (QoS) architecture. Specifically, it describes the way in which PacketCable Multimedia is used to provide QoS applications built on top of PacketCable. To aid the reader in understanding the PacketCable QoS architecture, the high level goals and specific logical components and interfaces defined are discussed in this technical report. CableLabs has issued this technical report and associated specifications to facilitate design and field-testing leading to the manufacture and interoperability of conforming hardware and software by multiple vendors.

1.1 PacketCable Overview

The PacketCable network architecture describes a set of functional groups and logical network entities grouped by service functions, as well as a set of reference points that support the information flows exchanged between these functional groups and network entities, see the PacketCable Architecture Framework Technical Report, [ARCH-FRM TR].

1.2 PacketCable Multimedia Overview

PacketCable Multimedia defines an IP-based platform for delivering QoS-enhanced multimedia services over DOCSIS 1.1 or greater, (for the remainder of this document, references to DOCSIS assume DOCSIS 1.1 or greater) access networks. This platform expands on the core capabilities of PacketCable (e.g., QoS authorization and admission control, event messages for billing and other back-office functions, and security) to support a wide range of IP-based services beyond telephony. That is, while the PacketCable architecture is customized for the delivery of residential telephony services, the PacketCable Multimedia architecture offers a general-purpose platform for cable operators to deliver a variety of IP-based multimedia services that require QoS treatment. For this reason, specific services are not defined or addressed in this report.

Although the PacketCable Multimedia platform is based upon PacketCable work, the full voice infrastructure defined in PacketCable is not a prerequisite to the deployment of multimedia services. Rather, it is intended that a particular cable operator may choose to initially deploy either voice or multimedia services, with the assurance that these platforms will seamlessly integrate and interoperate if and when they are deployed in parallel.

2 REFERENCES

2.1 Normative References

There are no normative references in this document.

2.2 Informative References

This Technical Report uses the following informative references:

[ARCH-FRM TR]	PacketCable Architecture Framework Technical Report, PKT-TR-ARCH-FRM-V02-061013, October 13, 2006, Cable Television Laboratories, Inc.
[DQoS]	PacketCable Dynamic Quality of Service Specification, PKT-SP-DQOS1.5-I02-050812, August 12, 2005, Cable Television Laboratories, Inc.
[MM ARCH]	Multimedia Architecture Framework, PacketCable Technical Report, PKT-TR-MM-ARCH-V02-051221, December 21, 2005, Cable Television Laboratories, Inc.
[PCMM]	PacketCable Multimedia Specification, PKT-SP-MM-I03-051221, December 21, 2005, Cable Television Laboratories, Inc.
[PKT 24.229]	PacketCable SIP and SDP Stage 3 Specification 3GPP TS 24.229, PKT-SP-24.229-I02-061013, October 13, 2006, Cable Television Laboratories, Inc.
[CPD]	PacketCable Control Point Discovery Specification, PKT-SP-CPD-I02-061013, October 13, 2006, Cable Television Laboratories, Inc.
[PAMI]	PacketCable Application Manager Interface Specification, PKT-SP-PAMI-I02-061013, October 13, 2006, Cable Television Laboratories, Inc.
[RFC 3264]	IETF RFC 3264, An Offer/Answer Model with Session Description Protocol (SDP), June 2002.
[RFC 3890]	IETF RFC 3890, A Transport Independent Bandwidth Modifier for the Session Description Protocol (SDP), September 2004.

2.3 Reference Acquisition

CableLabs Specifications:

- Cable Television Laboratories, Inc., 858 Coal Creek Circle, Louisville, CO 80027;
  Phone 303-661-9100; Fax 303-661-9199; Internet: http://www.cablelabs.com /
- Internet Engineering Task Force (IETF), Internet: http://www.ietf.org
  Note: Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time.
  The list of current Internet-Drafts can be accessed at http://www.ietf.org/ietf/1id-abstracts.txt

3 TERMS AND DEFINITIONS

This specification uses the following terms:

IMS Release 6	3GPP IP Multimedia Subsystem Suite of Specifications – approved version Release 6.
P-CSCF	Proxy CSCF (Call Session Control Function).
QoS	Quality of Service. Method used to reserve network resources and guarantee availability for applications.

4 ABBREVIATIONS AND ACRONYMS

This specification uses the following abbreviations:

AM	Application Manager
DQoS	Dynamic Quality of Service
DOCSIS®	Data Over Cable Service Interface Specifications
DSCP	Differentiated Services Code Point
CM	DOCSIS-compliant cable modem
CMTS	Cable Modem Termination System
MSO	Multiple Service Operator
NAT	Network Address Translation
NCS	Network-Based Call Signaling
SDP	Session Description Parameter
SIP	Session Initiation Protocol
WS	Web Services

5 QOS REQUIREMENTS AND SCOPE

The objective of this document is to provide an architecture definition for a UE device to obtain access to PacketCable network resources. In particular, it describes a comprehensive mechanism for a PacketCable network to request specific QoS resources required to support the media associated with SIP sessions over a DOCSIS network.

This architecture also recognizes that PacketCable will provide QoS for a wide variety of applications and services (voice, video, etc.); as such, it provides a generic mechanism to request access network resources and does not require applications to be aware of access network topology.

5.1 Requirements

The following is a list of requirements that are considered essential for developing a general-purpose QoS architecture to satisfy the services envisioned for PacketCable:

- The QoS architecture must service flow creation for UEs that are not QoS aware through a network-initiated policy push.
- Define a PacketCable Application Manager (PAM), which will mediate QoS interaction between the P-CSCF and the Multimedia infrastructure.
- Support packet marking and classification from the access network such that a QoS mechanism (e.g., Differentiated Services) can be used in the backbone network.
- The PAM must receive sufficient information from the P-CSCF regarding each flow that makes up a session such that it can:
    - Construct an appropriate classifier while accommodating NAT traversal mechanisms.
    - Construct a flow spec or alternative traffic profile that reflects the Least Upper Bound of the resource requirements of any alternative codec that may be permitted for the flow, including bandwidth, packetization rate, and scheduling type.
    - Determine the type of media so that it can select an appropriate Differentiated Services Code Point (DSCP).
- The PAM must receive sufficient information from the P-CSCF for each session such that it can:
    - Construct a suitable correlation identifier for accounting records.
    - Identify the subscriber for the purposes of accessing subscriber profile data.
    - Recognize if the session must be given higher priority (e.g., an emergency call).
- The interface must allow reservation and commitment of resources to occur in separate steps.

5.2 Scope

The current scope of the PacketCable QoS architecture is limited to the DOCSIS-based access portion of a cable operator's network and on how the PacketCable network can request QoS resources from the PacketCable Multimedia framework. Therefore, the architecture described in this technical report does not address the case of a roaming UE that may attach to the PacketCable network from non DOCSIS-based access networks.

Further, this architecture does not prohibit the use of the QoS capabilities in CableHome-enabled networks. However, providing QoS in a CableHome network is not within the scope of this document.

6 QOS ARCHITECTURE FRAMEWORK

Within the overall goal to leverage existing industry standards whenever possible, a specific objective is to align with the IMS architecture and specifications being developed by 3GPP. Specifically, PacketCable will align with IMS Release 6 and reuse many of the basic IMS components and reference points. Another equally important objective is to make use of the rich set of QoS capabilities provided by PacketCable Multimedia.

PacketCable must support a policy push model in order to interface with PacketCable Multimedia. Release 6 of the IMS provides two related mechanisms for providing the Quality of Service and charging for the IP service flows that make up multimedia sessions. Service Based Local Policy (SBLP) provides a mechanism for the authorization, establishment and modification of IP bearers using an authorization token similar to the PacketCable Dynamic Quality of Service Architecture [DQoS]. As in DQoS, the establishment of PDP contexts using SBLP requires active involvement of QoS-aware User Equipment.

The second mechanism is Flow Based Charging (FBC). FBC provides a means to identify, police, and charge for the IP flows that make up a session using a network initiated push mechanism similar to PacketCable Multimedia. However, FBC does not provide a mechanism for the establishment of new bearers (or service flows.) Neither SBLP nor FBC as defined in IMS Release 6 provides the complete information necessary to support the establishment of service flows using PacketCable Multimedia. Future alignment with the Policy and Charging Control work being undertaken in IMS release 7 is possible.

6.1 QOS Architecture Reference Model

The PacketCable QoS architecture is illustrated in Figure 1. The QoS infrastructure defined in IMS Release 6 is not sufficiently access-agnostic to satisfy the requirements of PacketCable. Therefore, PacketCable uses the PacketCable Multimedia components including the Policy Server, CMTS, and Cable Modem. The PacketCable Application Manager is a specialized Application Manager that receives session-level QoS requests via SOAP from the P-CSCF and creates and manages the PacketCable Multimedia Gates for each flow in the session using the PacketCable Multimedia pkt-mm-3 interface.

The QoS architecture does not prohibit the use of the IMS-defined Gq reference point for those UEs that may access services over a GPRS network. Figure 1 illustrates the co-existence of the IMS-defined QoS architecture for GPRS-based devices with the PacketCable Multimedia QoS architecture used for UEs accessing services via a DOCSIS network.

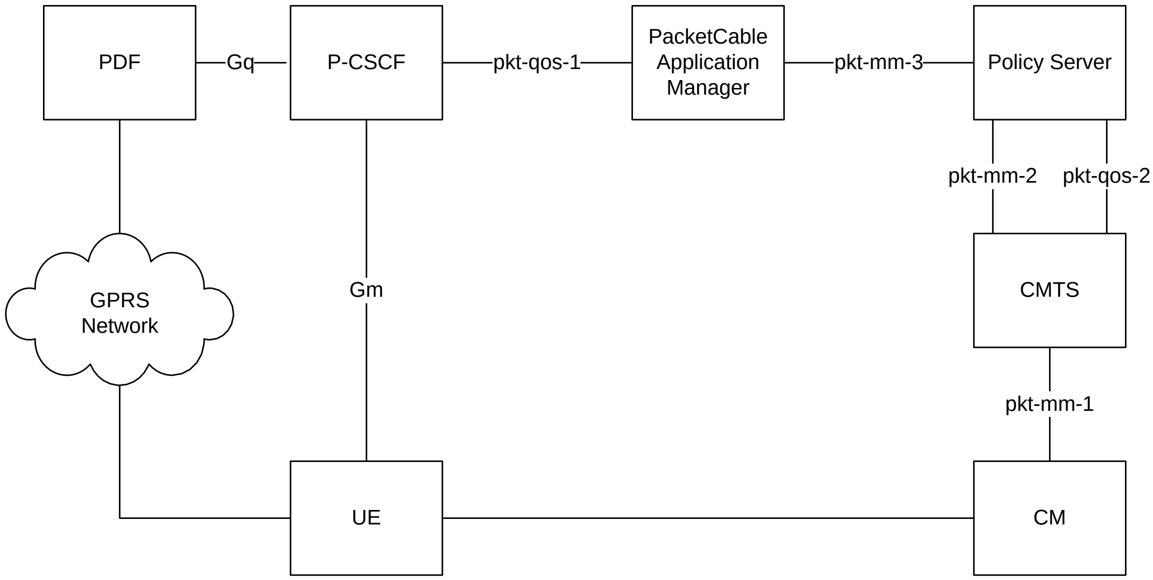


Figure 1 - QoS Signaling Reference Points

Reference points pkt-mm-1 through pkt-mm-3 are defined by PacketCable Multimedia. PacketCable introduces new QoS reference points pkt-qos-1 and pkt-qos-2. Table 1 describes these interfaces briefly while Table 2 provides a brief description of each network element.

Table 1 - QoS Reference Points

Reference Point	PacketCable Network Elements	Reference Point Description
pkt-mm-1	CMTS – CM	The CMTS uses DOCSIS-defined DSX signaling to instruct the CM to setup, teardown, or change a DOCSIS service flow in order to satisfy a QoS request.
pkt-mm-2	Policy Server – CMTS	The interface supports proxy QoS requests on behalf of a UE. This interface is fundamental to the policy-management framework. It controls policy decisions, which are pushed by the Policy Server (PS) onto the CMTS, and is defined by [PCMM]. In some scenarios, this interface is also used to inform the PS when QoS resources have become inactive.
pkt-mm-3	PAM-PS	This interface allows the PacketCable Application Manager (PAM), a specialized Application Manager defined in PacketCable, to request that the PS install a policy decision on the CMTS on behalf of the UE, and is defined by [PCMM]. This interface may also be used to inform the PAM of changes in the status of QoS resources.
Gm	UE -P-CSCF	Allows the UE to communicate with the P-CSCF for registration and session control. This reference point is SIP-based and is described in [PKT 24.229].

Reference Point	PacketCable Network Elements	Reference Point Description
Mw	CSCF – CSCF	Allows the communication and forwarding of signaling messaging among CSCFs in support of registration and session control. This reference point is SIP-based.
Gq	P-CSCF – PDF	The Gq interface is used for session-based policy set-up information exchange between the Policy Decision Function (PDF) and the P-CSCF.
pkt-qos-1	P-CSCF- PAM	This SOAP/XML based interface between the P-CSCF and PacketCable Application Manager conveys session-level QoS information. The PAM uses this information to form suitable messages for pkt-mm-3 interface and is defined by [PAMI].
pkt-qos-2	Policy Server – CMTS	The Policy Server uses the Control Point Discovery Protocol to determine the serving CMTS in the network for a given UE. This reference point is based on PacketCable specification [CPD].

Table 2 - QoS Network Elements

PacketCable Network Element	Brief Description
UE	A UE is a client and interacts with the network to access services and provides interfaces to users or entities.
P-CSCF	The P-CSCF parses the SDP in SIP messages and implements the web service client interface to provide QoS by interacting with Application Manager. It reserves, commits, and removes QoS on access network.
PacketCable Application Manager (PAM)	The PacketCable Application Manager is responsible for managing QoS resources in the access network as requested by the P-CSCF. The PacketCable Application Manager receives session-level QoS messages from the P-CSCF, and formulates and sends PacketCable Multimedia QoS messages to the Policy Server.
Policy Server (PS)	The Policy Server acts as an intermediary between Application Manager(s) and CMTS(s). It applies network policies to Application Manager messages and proxies then to the CMTS.
Cable Modem Termination System (CMTS)	The CMTS is a device at a cable headend that implements the DOCSIS RFI MAC protocol and connects to CMs over an HFC network.
Cable Modem (CM)	DOCSIS-compliant cable modem.

6.2 Relationship with 3GPP IMS Release 6

The PacketCable specifications include an enhanced version of 3GPP IMS Release 6 TS 24.229 to document the QoS requirements for the call control protocol using SIP and SDP. A summary of the modifications to TS 24.229 follows:

- Added requirement to include the "b=" media descriptor and the "TIAS" bandwidth modifier defined in [RFC 3890] to describe the bandwidth required for the session.

- Additional SDP types are added to the SDP profile definition for User Agents. The SDP types include:
  - Packet time (a=ptime) – The type must be included by UEs to indicate the packetization time that the UE expects to receive traffic.
  - Maximum packet rate (a=maxprate) – This type must be included when the UE is using a non-well-known PacketCable codec.

6.3 Relationship with Multimedia pkt-mm-11

The PacketCable Multimedia architecture also defines a web services-based interface to the Application Manager from an upstream Application Server. This interface is labeled pkt-mm-11 in the Multimedia technical report [MM ARCH]. While this interface could be used by the P-CSCF to interface with the PacketCable Application Manager, a new interface was developed to allow for more efficient P-CSCF operation. The Multimedia-defined interface would require a double translation of the session parameters, resulting in extra overhead on the P-CSCF to translate the session parameters into a generic QoS request. The PacketCable-defined interface allows the P-CSCF to simply pass the session parameters in whole to the PacketCable AM, which is then responsible for the translation to a valid PacketCable Multimedia QoS message. This approach reduces the amount of translations required and allows the P-CSCF to maintain a more access network-agnostic implementation.

7 ARCHITECTURE DESCRIPTION

Section 6 described a set of logical network entities grouped by specific service functions (QoS), as well as a set of reference points that support the information flows exchanged between the functional groups and network entities. This section provides a more detailed discussion of those logical elements and the associated reference points which are new to the PacketCable architecture. It also provides an overview of other topics related to the QoS architecture that are not documented elsewhere.

7.1 Functional Components

In this section, additional detail is provided on the PacketCable Application Manager and P-CSCF and their roles as related to the QoS architecture. The remaining functional elements are described in the Multimedia technical report or the PacketCable Architecture Framework technical report and are not repeated here, as their descriptions do not require further discussion.

7.1.1 P-CSCF

In addition to its role in providing the UE connectivity to the PacketCable network, the P-CSCF is also responsible for reserving, committing, and releasing QoS resources for a given session. It is important to note that the P-CSCF does not actually determine the QoS resources necessary for the session; rather, it simply proxies the session description information to the PacketCable Application Manager and indicates whether to reserve or commit the resources for the session. While the architecture supports a two-phase commit operation (reserve followed by a commit), there are no requirements on the P-CSCF to follow this approach. A single-phase commit (reserve and commit resources in a single request) may be used.

Once the session has ended, the P-CSCF releases the resources allocated to the session.

7.1.2 PacketCable Application Manager (PAM)

The PacketCable Application Manager is primarily responsible for determining the QoS resources needed for the session, based on the received session descriptors and managing the QoS resources allocated for a session.

Determining the QoS resources for a session involves interpreting the session descriptor and calculating how much bandwidth is required, determining the traffic scheduling type, and populating the traffic classifiers. This also involves determining the number of flows necessary for the session (voice only vs. voice and video session) and managing the association of the flows to the session.

7.1.3 Relationship between P-CSCF and PAM

The PacketCable Multimedia architecture provides a well-understood relationship between the PAM and PS. The relationship between the P-CSCF and PAM is described here. The QoS architecture was not developed with any pre-conceived relationship between the two network elements. While the choice of how to deploy P-CSCFs and PAMs and their associated cardinality is mainly a deployment decision, the following figures represent what are believed to be the most popular deployment scenarios.

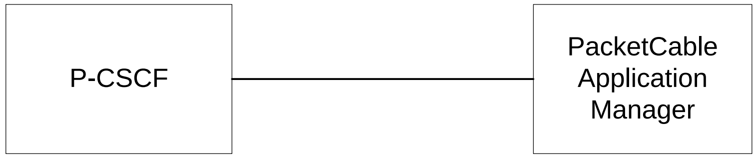


Figure 2 - One to One

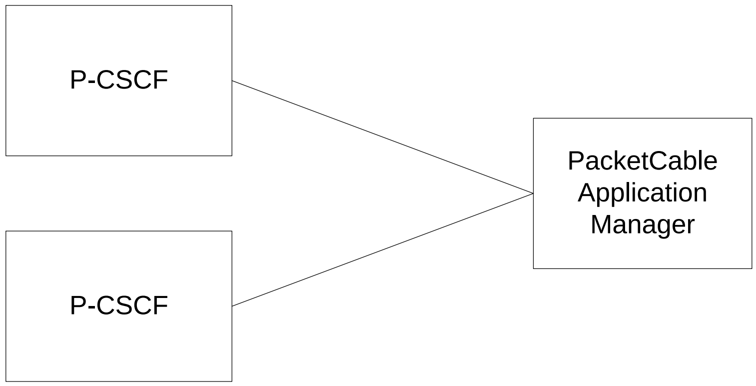


Figure 3 - Many to One

Figure 2 illustrates a one-to-one relationship between the P-CSCF and the PAM. Such a deployment scenario, while extremely simple to manage, may not be the most efficient use of resources. Figure 3 illustrates a many-to-one relationship between the P-CSCF and the PAM. This scenario maintains the simplicity of a one-to-one relationship (since the P-CSCF does not have to determine which PAM to send its request to), but may more efficiently utilize PAM resources.

Another possible scenario not shown is a one-to-many relationship (or many-to-many). In this case, the P-CSCF may communicate with multiple PAMs. While such a scenario is supported, no guidance is provided on how the P-CSCF determines which PAM to send its requests to. Such a scenario may become necessary as the network evolves and different application managers are invoked for different access networks, or in certain roaming cases.

7.2 Protocol Interfaces and Reference Points

This technical report has identified several interfaces, or reference points, in the PacketCable QoS architecture. The majority of these reference points are existing interfaces defined by PacketCable Multimedia. An overview of the P-CSCF to PAM protocol interface is provided within this section, as it is the only interface defined by PacketCable.

It is possible that this interface may not exist in a given vendor's product implementation. For example, if a P-CSCF vendor chooses to integrate the PAM within the P-CSCF, the P-CSCF-to-PAM interface would be internal to that product.

7.2.1 P-CSCF – PAM Interface Description

The P-CSCF to PAM interface is based on Web Services. It allows the P-CSCF to request and delete Quality of Service resources within a PacketCable Multimedia-enabled DOCSIS network.

The PacketCable Application Manager Web Services Interface enables a P-CSCF to request QoS handling in the access network based on the Session Description Protocol (SDP) parameters contained in the offer and answer as defined in [RFC 3264]. The PAM uses the PacketCable Multimedia pkt-mm-3 interface to communicate these requirements to a PacketCable Multimedia Policy Server.

7.3 Application of QoS Policy within PacketCable

The term policy control has often been used to describe the process by which a new dynamic service flow or bearer is created in the access network at the request of an application. This makes sense, since establishing a new service flow in the access network involves the installation of a new dynamic policy in the policy enforcement point. This dynamic policy determines the treatment of the packets that make up the new service flow within the access network throughout the duration of the session.

The focus of this section is higher levels of policy, which may affect the disposition of a user request as it is processed within the network. Such policies could be implemented at several levels in the network in order to further the business needs of the network operators. Levels where policy can be applied include:

- Application Level: Applications may employ policy to constrain use of an application based on subscription or other information.
- Signaling Network Level: For example, network or subscription-based restrictions on the use of certain media parameters in an SDP offer may be enforced in a PacketCable network by the P-CSCF or S-CSCF, respectively, by sending a negative response to the SIP message as described in [PKT 24.229] sections 6.2 and 6.3.
- Bearer Network Level: Each of the network elements in the bearer network (PacketCable Application Manager, Policy Server and CMTS) serve unique roles as they relate to policy control. A more detailed discussion of the roles for each network element follows:
    - The PacketCable Application Manager is the entry point from the SIP network into the access network QoS system. The PAM is in a position to apply policy, which takes into consideration the limited service provided by the P-CSCF and potentially subscription-based information.
    - The Policy Server may receive messages from multiple application managers, including but not limited to PacketCable Application Managers. Policies applied at the PS can optimize the use of access network resources between multiple applications and traffic types.
    - The CMTS is responsible for admission control and may have policies that control the allocation of resources among various types of traffic based on session class and possibly on the authorization model used, such as PacketCable and PacketCable Multimedia.

In some cases similar policy decisions could be made at more than one level in the network. The choice of at what level to implement a given policy will be based on such criteria as:

- Access to required information.
- Performance impacts of implementing policy at that level.
- The ease of implementing policy at a given level.

Ultimately policy will be implemented at the level in the network that best furthers the business needs of the cable operator.

7.4 Routing of QoS Request

Assuming a P-CSCF to PAM relationship as described in Section 7.1.3, the routing of QoS requests is static, meaning that each P-CSCF is provisioned with a single AM (with the possibility of a secondary AM in the event of a failure), to which all its QoS requests are sent. If a multiple P-CSCF to multiple AM relationship is used, the routing of requests is outside the scope of this effort.

The Multimedia architecture is currently silent on how QoS requests are routed between the PAM and PS and between the PS and CMTS. Given this gap, PacketCable has defined a dynamic mechanism for PS to CMTS QoS message routing. This procedure is described in [CPD] and is based on a path-coupled query approach. A path-coupled query approach is one where the query follows the same path through the network as any other packet destined for a given UE. This mechanism allows the PS to leverage the underlying routing protocols to ensure the proper CMTS is identified based on the IP address of the UE in question.

The PAM to PS routing of QoS requests is not defined in PacketCable.

Appendix I Example Procedures

This chapter describes example operational behavior based on the interfaces and requirements defined in PacketCable. The Call flows provided in this section are for reference only to facilitate understanding of the PacketCable QoS architecture.

I.1 UE Originated Successful Call

Figure 4 illustrates a successful UE Originated call flow. In the example below, the P-CSCF initiates the QoS process when it receives a SIP message with an SDP offer (usually an INVITE). The P-CSCF passes the SDP offer to the PAM via the defined QoS interface. The PAM is then able to translate the preliminary session needs into PacketCable Multimedia requests. This usually results in multiple PacketCable Multimedia Gates being created (e.g., a standard audio call would have one upstream gate and one downstream gate).

The PAM-generated PacketCable Multimedia request is then passed to the Policy Server for policy checks. These policy checks are usually done at the network level, meaning that the Policy Server ensures the request satisfies network-based policies (the amount of resources being requested is within limits, the scheduling type is appropriate for the service, etc.). Once these requests pass the Policy Server checks, they are passed on to the CMTS for action.

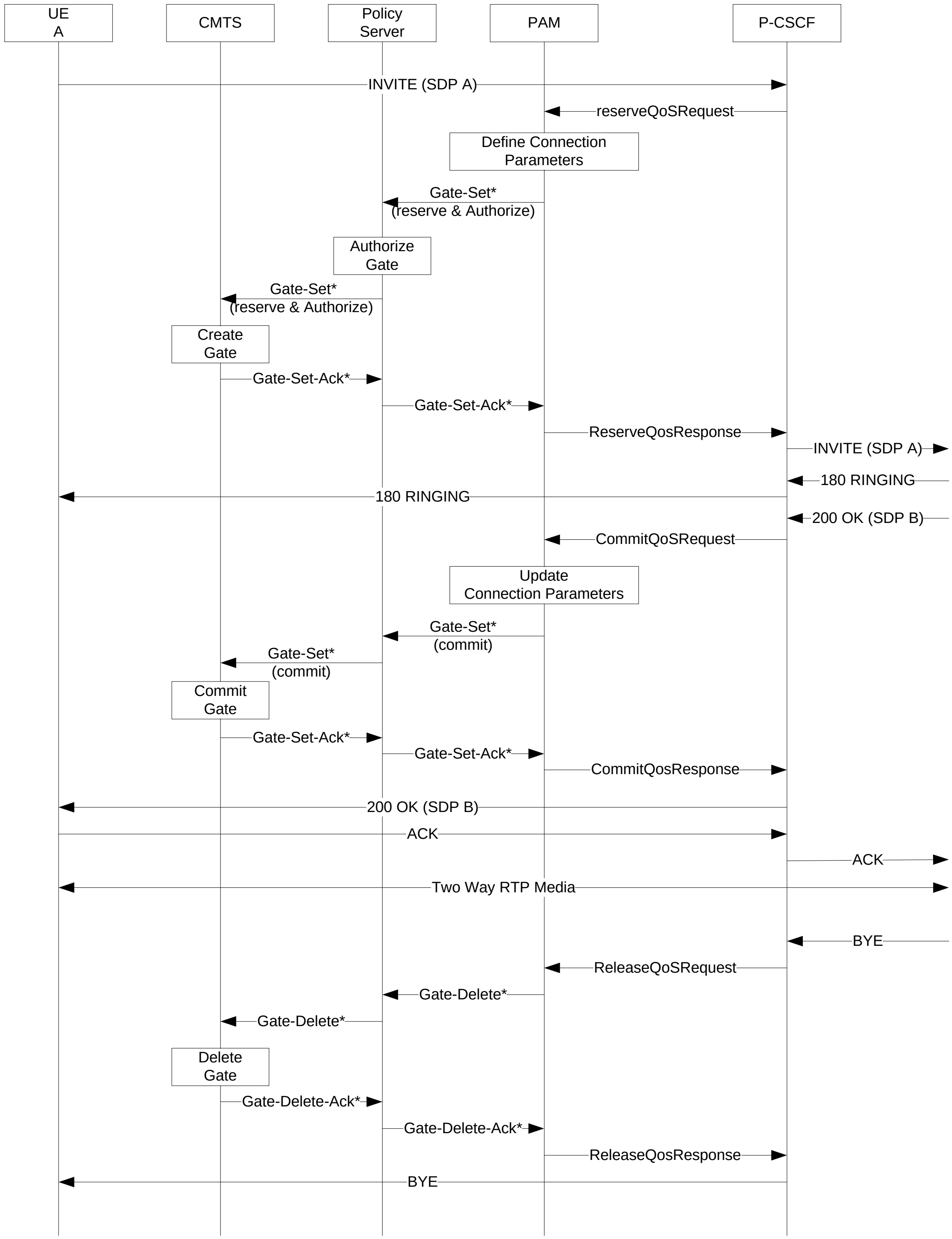
Upon receipt of the resource request, the CMTS is responsible for admission control and resource allocation. This process ensures that the CMTS has adequate resources to honor the request. Once the request has passed admission control and resource allocation, the CMTS installs the necessary flows and notifies the Cable Modem serving the UE via the DOCSIS-defined Dynamic Service Exchange (DSX) messaging interface. At this stage the resources are only reserved; they are not actually available for use. Rather, they have been allocated by the CMTS and can no longer be allocated to other services. Once the CM has been successfully notified of the resource allocation, the CMTS returns a flow identifier to the Policy Server, which then passes it back to the requesting PAM.

Once the P-CSCF receives the SDP answer, it has enough information about the remote party to commit the resources for the session. It does this by passing the SDP answer to the PAM. The PAM then (in conjunction with the SDP offer) translates this into a new PacketCable Multimedia request that updates the previously reserved resources. As long as the updated request is equal to or less then the reserved resources, it is essentially guaranteed to be granted.

Once the resources are committed, the session can begin using the established flows and received the desired QoS.

Upon receipt of a BYE, the P-CSCF releases the resources associated with the session through a ReleaseQoSResources request.

Figure 4 illustrates an example of a UE Originated successful call.



Note 1: * indicates there may one or more of these messages based on the session type

Figure 4 - Example UE Originated Successful Call

Appendix II Acknowledgements

We wish to thank the vendor participants contributing directly to this document:

Vikrant Karan – Ellacoya Networks (Lead Editor)

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Tom Miller – Siemens

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