DEPLOYING ENHANCED IP SERVICES USING PACKETCABLE™ MULTIMEDIA QOS CONTROL

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Abstract

As operators seek to deploy enhanced services, the PacketCable Multimedia initiative allows them to deliver high-volume multimedia services with committed QoS levels. PacketCable Multimedia allows operators to deliver QoS-enhanced multimedia services—including both residential and business video telephony and conferencing services over DOCSIS 1.1 access networks. This paper will discuss how the PacketCable Multimedia initiative builds on PacketCable 1.x to support enhanced IP multimedia services. It will explain how Applications Managers and Policy Servers on the network can act as proxies for clients to request QoS levels from the Cable Modem Termination System (CMTS) for multimedia sessions, and it will provide examples of several multimedia applications.

INTRODUCTION

PacketCable Multimedia defines an architecture to deliver QoS-enabled services over an IP-based cable infrastructure. It enhances the original PacketCable telephony centric architecture to allow flexible support for a broad array of multimedia services. Thus operators can support a wide variety of applications and services beyond voice.

The key aspect of this CableLabs® specification is that it defines a multimedia architecture that is application-agnostic. Application managers and policy servers act as proxies to request QoS on behalf of client applications so that the client itself does not need to be directly involved with the QoS signalling. This abstraction layer between the application and the QoS infrastructure simplifies the addition of new services.

PacketCable Multimedia offers significant opportunities for enhanced services because operators can deliver QoS-enhanced multimedia services over DOCSIS access infrastructure while using industry standards to ensure QoS control across metro and core networks.

Multimedia applications present special challenges to broadband network operators, and evolving multimedia services will continue to present unique bandwidth, QoS, and latency requirements. The objective of the PacketCable Multimedia initiative is to define the core framework required to support QoS-base multimedia applications. It leverages the foundations established by the DOCSIS 1.1 and PacketCable 1.x specifications to allow network operators to efficiently deploy profitable IP multimedia services.

PACKETCABLE 1.X COMPARED TO PACKETCABLE MULTIMEDIA

The PacketCable specifications were originally developed for telephony services to provide a mechanism to establish IP flows over the HFC network with defined QoS levels. PacketCable Multimedia builds on the concepts of the PacketCable QoS architecture but rather than being targeted at a specific application (telephony) it is deliberately application-agnostic.

This enables features originally developed for VoIP (e.g. QoS authorization, admission control, event messages for billing, security) to be used to deliver enhanced multimedia services.

Multimedia applications are bandwidth-intensive and sensitive to transmission delay within the network. The PacketCable Multimedia architecture was developed to allow operators to deliver a variety of IP-based multimedia services and applications that require committed QoS levels.

This service delivery framework provides general-purpose QoS, event-based accounting, authentication, and security founded upon the PacketCable 1.x specifications. But PacketCable Multimedia generalizes and extends 1.x in order to support a broader spectrum of applications and services. It supports both peer-to-peer, client-based services as well as server-based services.

The PacketCable Multimedia signaling framework provides applications with access to the full range of QoS capabilities defined in DOCSIS 1.1. This includes all scheduling algorithms including best effort, constant and variable bit rate services, and both symmetric and asymmetric upstream/downstream bandwidth characteristics.

PacketCable 1.x supports telephony services using the Dynamic Quality of Service (DQoS) specification. The user has an intelligent endpoint that communicates with a Call Management Server (CMS) through an Embedded Multimedia Terminal Adaptor (eMTA).

With the PacketCable Multimedia approach, the client device may not be intelligent and client-to-server signaling is isolated from network QoS signalling. The client requests enhanced services from network-based servers, and services are delivered based on network policies.
In the original PacketCable architecture the CMS both provided application-processing logic and implemented network policies. With PacketCable Multimedia, these two functions are separated and the interface between the components exposed and defined using the Common Open Policy Service (COPS) protocol.

PacketCable used the concept of event messages to track telephony-specific events. The telephony specific messages have been replaced with generic policy events but the overall structure of the event messages is the same. In the PacketCable 1.x model the eMTA signaled directly to the CMTS to request QoS based on its understanding of the telephony application. In the PacketCable Multimedia framework, the Cable Modem Termination System creates the DOCSIS service flows associated with the client based on information received from the policy server.

UNDERSTANDING THE PACKETCABLE MULTIMEDIA ARCHITECTURE

The major network elements within the PacketCable Multimedia Architecture include:

- Application Manager (AM)
- Policy Server (PS)
- Cable Modem Termination System (CMTS)
- Record Keeping Server (RKS)
- Client

Application Manager

The Application Manager (AM) is responsible for application or session control. It may be a general-purpose engine such as a SIP proxy server capable of supporting multiple SIP-based application types or may support a single application such as a gaming server accessed via a Web browser. In either case, the client talks directly to the AM (over the IP network) and either explicitly requests the resources to initiate a QoS-enabled service or simply requests a service which has implicit QoS needs known to the AM. The AM then formats a request to the Policy Server and attempts to reserve the QoS resources.

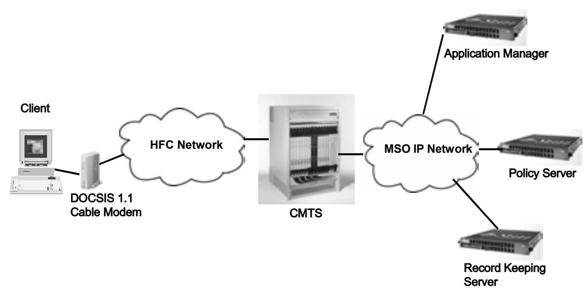
Policy Server

The PacketCable Multimedia architecture allows for and indeed expects multiple application managers to exist in a network. These managers must all use a pool of shared resources e.g. HFC bandwidth which can be made available by multiple devices. Thus any QoS requests are directed to a further intermediary device which mediates between the AMs and the CMTS/routers. This device is termed a Policy Server (PS) and is responsible for coordinating the QoS requests for multiple AMs and delivering the commitments necessary to the multimedia applications.

In a typical network the AMs may be under the control of multiple application service providers whereas the PS would be under the control of the network operator. Thus the PS applies policy as defined by the network operator and manages the relationship between AMs and CMTS platforms at the edge of the network. The PS implements operator-defined authorization and resource management procedures.

The PS devices are located in the MSO's managed network and are responsible for making QoS-related policy decisions based on rules defined by cable operators. Each operator can therefore establish its own network policies. For example, an MSO could establish policies for the number of concurrent authorizations for a particular subscriber or service.

PacketCable Multimedia Network Architecture



Cable Modem Termination System

The Cable Modem Termination System (CMTS) is responsible for enforcing QoS-related policy decisions. It performs admission control and manages HFC network resources through DOCSIS service flows. The CMTS is based at the edge of the HFC network and communicates with the Policy Server using the COPS/TCP protocol and with the Record Keeping Server using RADIUS/UDP.

It supports a single-phase reservation model where access network resources are simultaneously reserved and committed for immediate use, as well as a two-phase reservation model in which access network resources are initially reserved and then committed for use as they are required at a later time. The CMTS also provides the boundary between the access and metropolitan networks so operators can implement end-to-end QoS for applications and subscribers.

Record Keeping Server

The Record Keeping Server (RKS) performs a mediation function between the PacketCable Multimedia elements and the back-office applications for billing purposes. It receives event messages pertaining to policy decisions from the PS, and receives notification of actual QoS grants from the CMTS.

Client

A multimedia client is a logical entity that can send or receive flows. The client can be any one of a diverse range of devices, such as a PC, gaming console, videophone, etc. It communicates with the AM via an application-specific signaling protocol. In many cases this will be a standard such as SIP but any protocol understood by both client and AM (such as PacketCable NCS) may be used. This protocol is not defined in the specification so application creators and operators have maximum flexibility; the client does not directly request QoS, the AM does so on behalf of the client. PacketCable Multimedia discusses three types of clients:

Client Type 1 are endpoints that lack specific QoS awareness or signaling capabilities

Client Type 2 supports QOS signaling based on PacketCable DQoS. It is aware of PacketCable Multimedia QoS and communicates with an AM to request service and obtain permission to obtain services from the access network.

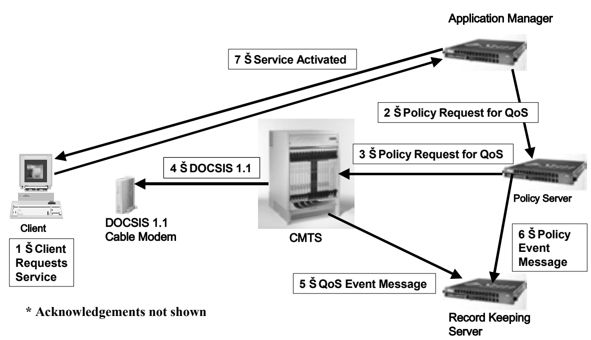
Client Type 3 requests QoS using the Resource Reservation Protocol (RSVP) without AM interaction

The AM will request QoS for Type 1 clients based on its understanding of the application. The client will not request QoS explicity. Type 2 and 3 clients are QoS aware and request explicit QoS parameters. Type 2 clients do this via the AM while Type 3 clients bypass the proxies and talk directly to the CMTS. Currently, only Type 1 clients are specified.

SAMPLE PACKETCABLE MULTIMEDIA MESSAGE SEQUENCE

It is helpful to view a simplified message sequence for requesting QoS for an application. In this example, an application running on a PC client requests bandwidth from the AM (step 1), which checks with the PS to ensure that business rules permit the allocation (step 2). The PS confirms availability of resources (to the best of it's knowledge), authorizes the QoS grant and requests the CMTS to deliver the QoS required to support the application (step 3).

Sample Message Sequence



The CMTS determines whether the bandwidth is available, and if so it sets up a QoS enabled flow across the access network to the client's cable modem using DOCSIS 1.1 signalling (step 4). If the CMTS can also act as a MultiProtocol Label Switching (MPLS) Label Edge Router (LER) it may also create a virtual path across the metro network to provide a QoS-enabled connection to centralized server resources. Thus resources can be reserved end-to-end between the client and the broadband network operator's server. (If the CMTS is not capable of acting as an LER, the PS may initiate setup of the virtual path in the metropolitan network). The CMTS sends a QoS event message to the RKS (step 5), and the PS similarly sends a policy event message (step 6) so the operator can bill the subscriber appropriately for its use of network resources. Finally the data path is set up and the service activated (step 7).

A FRAMEWORK FOR QOS CONTROL

The CMTS controls DOCSIS 1.1 QoS service flow mechanisms and the operator can support time-based and volume-based network resource authorization. The CMTS informs the PS, which informs the AM when a volume limit or time limit is reached. The event mechanism enables operators to implement event-based network auditing.

Application-layer QoS requests are translated into DOCSIS QoS parameters by the CMTS. The CMTS creates DOCSIS service flows and determines the cable modem the client is connected to based upon the Subscriber ID (IP address). DOCSIS service flows are established on-demand based on policy and released upon session completion.

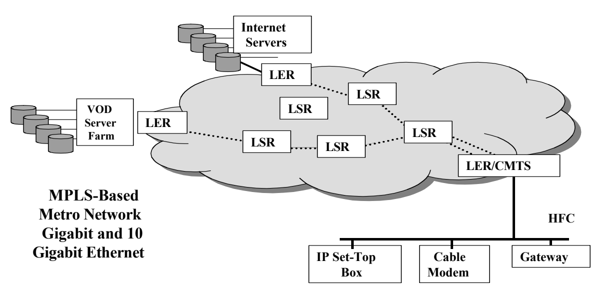
With this framework, deploying new services and applications is simple and fast. The CMTS and the cable modem are unaware of any specific application—they simply provide the QoS. The PacketCable Multimedia specification therefore requires no QoS signaling capabilities in the client device. Policy—and the ability to deliver QoS—are pushed from AM-to-PS, PS-to-CMTS, and CMTS-to-CM. PacketCable Multimedia can co-exist with PacketCable 1.x telephony so operators can support telephony as well as enhanced multimedia services over the same infrastructure.

DATA PLANE

Two distinct mechanisms are required to provide QoS to multimedia traffic flows over large IP networks. At the edge of the network, bandwidth is typically scarce and devices deal with a limited number of traffic flows. In this region QoS can be provided most effectively on demand at a per-flow level.

But on the metro network, bandwidth is relatively abundant but the infrastructure is shared between tens-of-thousands of clients. Thus, core switches and routers must support hundreds-of-thousands of flows. If these devices were to operate at an individual flow level the amount of data to be maintained would be massive and systems would simply not scale, so that an aggregation mechanism is needed. Current aggregated QoS mechanisms include IP-based differentiated services and MPLS-based traffic engineering. The CMTS/edge router must act as the transition point between the two QoS domains.

Data Plane Network Architecture



The data plane requires QoS control across both metro and access networks, with QoS on the access network delivered using DOCSIS 1.1 and QoS on the metro delivered using MPLS

Operators can implement QoS in the HFC access network using DOCSIS 1.1 and intelligent edge router/CMTS platforms that support per-flow queuing. If the edge router can also serve as an MPLS LER, then it can map packets from the per-flow QoS in the access network into aggregated traffic flows across the metropolitan network.

MPLS defines a mechanism to set up Label Switched Paths (LSPs) between endpoints at the edges of the MPLS network. Packets entering the network are assigned to a particular path and a label added to the packet identifying the LSP to be used. This label is used by the MPLS routers in the core of the MPLS network to forward the packet to its destination endpoint. The core network does not need to examine the packet headers beyond the label and can therefore focus on switching traffic to its destination as quickly and efficiently as possible. Each LSP can be associated with a Forwarding Equivalency Class (FEC), which defines specific QoS parameters so that the MPLS network can provide a mesh of QoS-enabled paths.

An intelligent edge router/CMTS platform at the edge of the network can therefore leverage the PacketCable Multimedia specification to deliver QoS across the HFC infrastructure using DOCSIS 1.1, and support QoS across metro and core networks using MPLS. The CMTS/edge router/LER provides the transition points between the two QoS domains so operators can deliver the QoS control necessary for enhanced multimedia services.

CONTROL PLANE

The network requires a control plane to signal QoS requirements and to setup and tear down QoS-enabled paths. All multimedia applications have similar requirements for QoS. They all generate IP packet flows (each packet of which requires the same QoS) that can be identified using an appropriate classifier. Thus a common data path forwarding mechanism can be designed and deployed to support them all (per-flow at the edge, aggregated in the core).

However the end systems for the IP traffic streams are radically different in terms of user interface, programmability, and sophistication. PacketCable Multimedia clients range from gaming devices to video phones to application software running on PCs. Therefore, multiple mechanisms will be required to provide the control path signaling based on the capabilities of the client system.

Operators use the control plane to establish the appropriate QoS between devices, and it enables resource reservation. The client device requests the appropriate QoS level, and the AM authorizes or rejects the request based on policies defined in the PS. Operators can therefore specify which applications or customers have the priorities to request resources. When a client requests resources, the AM will check with the PS to see if the client is entitled to those resources based on network policies. If the PS authorizes the services—and if those resources are indeed available—the QoS level will be assigned to the application.

There are several ways to support signalling between the client and the AM. For example, a user could go to a Web site and request resources, or requests could be generated using the Session Initiation Protocol (SIP) or the Network Control Signalling (NCS) protocol, defined by PacketCable 1.x.

Signaling from the AM to the PS and from the PS to the CMTS is conducted using COPS. The AM or PS can also use SNMP to check on the availability of resources within the network.

The CMTS will use DOCSIS 1.1 signalling to set up per-flow QoS reservations on the access network. It will aggregate multiple flows into the aggregated QoS mechanism of the MAN and set up aggregated QoS paths across the metropolitan network using MPLS Label Distribution Protocol (LDP) or the Resource Reservation Traffic Engineering (RSVP-TE) protocol.

The key feature of the control plane as defined for PacketCable Multimedia is that it provides a common QoS control plane within the network, which can support multiple client-to-AM signaling options.

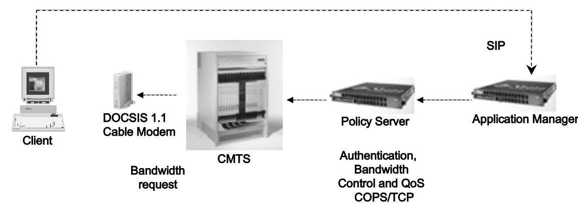
ENABLING ROBUST MULTIMEDIA APPLICATIONS

PacketCable Multimedia delivers the flexibility to efficiently support diverse applications over access, metro, and core networks. For example, MSOs can deploy VOD to residential subscribers. Signaling for VOD could be provided via SIP, with the Session Description Protocol (SDP) used for describing the multimedia sessions, including the QoS requirements.

In this case, the client requests an application flow with committed QoS levels using the SIP protocol. The VOD AM will check video resources and may provide authentication of the client and ensure that business rules permit the flow. It will then pass on the QoS request to the PS, which in turn may check with local policy prior to requesting QoS from the CMTS. The CMTS then provides the required connection levels to the client's cable modem.

Once the session is established, stream control can be implemented by the Real-Time Streaming Protocol (RTSP), a client-server multimedia presentation control protocol designed to leverage existing IP infrastructure. VOD signaling can be provided by SIP and SDP, and QoS can be provided on the access network using DOCSIS 1.1 and across metro and core networks using MPLS.

Multimedia and SIP



Another potential SIP-based application is video telephony service that can establish peer-to-peer voice and video sessions across the cable infrastructure.

In this application the caller issues an invite using the SIP protocol, and the AM and PS combine to provide a proxy server function. Once the call is authorized and connected, the data path is granted the necessary QoS and the voice and video call is established.

Operators can also deploy 1:N multimedia applications between groups of users, such as multiplayer gaming services. Game players from leading vendors are increasingly network-enabled, and MSOs can leverage PacketCable Multimedia to offer high-performance experiences with QoS guarantees to gaming enthusiasts seeking an interactive, real-time multimedia experience.

SUMMARY

PacketCable Multimedia allows MSOs to deploy enhanced multimedia services over a common infrastructure. It is application-independent, so operators can deliver emerging multimedia services while retaining the flexibility to support evolving demand for new multimedia services not yet even imagined.

They can take advantage of industry standards to enable end-to-end QoS across access, metro, and core networks, and they can swiftly develop enhanced multimedia services on their own or in conjunction with third-party application vendors. Cable operators can protect their investments in network infrastructure by policing traffic flows and ensuring they charge for the volume and time of consumed network resources. The PacketCable Multimedia specification allows broadband network operators to deploy enhanced IP services with the QoS control necessary to increase revenues and profits.

ABOUT THE AUTHOR

Gerry White is Senior Director of Advanced Technology for Motorola Broadband's Network Infrastructure Solutions business and he has presented at NCTA several times. He is an experienced author and presenter, and has written papers and articles for many of the leading trade shows, industry exhibitions, and trade publications.

Previously, he was CTO of RiverDelta Networks, a provider of next-generation edge routing/CMTS solutions. He also served as Vice President and CTO of Arris Interactive, a leading provider of voice and data equipment within the CATV market. While at Arris, and its predecessor LanCity, White assumed a leading role in the industry's efforts to define, develop, and deploy standards-based voice and data technology.

Prior to LanCity, White held a number of senior technical positions at Concord Communications, Wang Laboratories, Hasler Ltd, and Cable and Wireless. White is the co-author of several patents and articles on data communications technology. He holds a BSc. (Honors) from University College in London.