InnoMedia

EXTENDING THE DQoS FRAMEWORK THROUGH DEVICE INITIATION

www.innomedia.com

InnoMedia, Inc.
128 Baytech Drive
San Jose, CA 95134, USA

V6.1 08/10

Abstract

MSOs have relied on DOCSIS and PacketCable™ 1.0/1.5 to provide the highly stringent quality of service (QoS) needed to capture market opportunities in IP Telephony. The solution, called DQoS, dynamically reserves bandwidth for critical voice sessions. However, under PacketCable™ 1.0/1.5, DQoS is possible only when the edge device is Network Control Signaling (NCS) capable. PacketCable™ Multimedia lifts this restriction of requiring NCS capable devices for DQoS, but defines a new architecture encumbered by a policy server to mediate non-NCS systems.

An alternative approach, Device-initiated DQoS, uses device-based DOCSIS UGS service flow management to extend the DQoS framework to non-NCS systems. This market ready approach, available from InnoMedia® offers an immediate solution to MSOs who intend to provide SIP Trunk or Hosted IP Centrex enterprise telephony services.

Table of Contents

Introduction

An MSO's ability to offer telephony service relies on delivering good quality of service (QoS). This is particularly important if the MSO wishes to open up new sources of revenue by targeting the enterprise market.
For enterprise IP Telephony, Session Initiation Protocol (SIP) is growing in importance. It not only offers a rich set of features but also makes unified communications a reality, thus allowing both cost reductions and productivity improvements for enterprise users. Based on the SIP signaling protocol, MSOs have started offering SIP trunking and hosted services to their enterprise customers, the former aimed at delivering premises-based IP telephony, while the latter is based on switching and features hosted and operated by the MSOs in their core networks.

SIP is an IETF-defined signaling protocol, used for controlling multimedia communication sessions such as voice and video calls over Internet Protocol (IP). It is an Application Layer protocol designed to be independent of the underlying transport layer.

At the transport layer, the MSO makes use of Dynamic Quality of Service (DQoS) to manage its available resources and ensure quality of service over its HFC access networks. DQoS utilizes DOCSIS Dynamic Service Flows within the Media Access Control (MAC) layer mechanism to allow higher layer applications to secure HFC access plant transport resources and ensure quality of service for target applications. The two existing systems that utilize DQoS to deliver QoS are PacketCable 1.0/1.5, and PacketCable Multimedia (PCMM).

PacketCable 1.0/1.5 is defined specifically for systems using the Network Control Signaling (NCS) protocol, while PCMM allows non-NCS systems (specifically SIP-based systems) to utilize DQoS through various network servers. In this paper, we introduce a technique, Device-initiated DQoS, which allows non-NCS, non-PCMM systems to tap into DQoS to deliver QoS-ensured applications. Device-initiated DQoS allows a trusted edge device to initiate DQoS upon user actions (e.g., initiating a phone call or receiving a phone call) when such a trusted device is equipped with stateful SIP-aware capabilities such as a SIP Application Layer Gateway (SIP ALG) or Back-to-back User Agent (B2BUA). It also enables such a device to initiate DQoS requests on behalf of other authorized LAN-based IP end points which may not be DQoS-aware. An example of such a trusted and intelligent device is an Enterprise SIP Gateway (ESG) or Enterprise Session Border Controller (ESBC), the use of which allows an MSO to offer scalable and QoS managed SIP trunking or hosted voice service to its enterprise customers.

Brief description of Dynamic Service Flow and Dynamic Quality of Service (DQoS)

A cable network consists of many fiber nodes and each can have many users connected to it. At any time, hundreds of high speed data and telephony users may be competing for bandwidth and resources. A DOCSIS system allocates bandwidth and resources through the use of Service Flows, which are unidirectional flows of packets with defined bandwidth and flow characteristics. There are a few types of Service Flows, the two most commonly used ones are the Unsolicited Grant Service (UGS) Flow and the Best Effort (BE) Service Flow. UGS gives a constant-bit-rate channel ideal for constant-bit-rate real-time voice communications, while BE provides an unguaranteed best effort path for non-real time, variable-rate data applications.

For a cable network to manage its limited resources for most efficient use, Service Flows need to be dynamic – they can be created, modified, and deleted. A Service Flow creation can be initiated by the Cable Modem (CM) at the instruction of a higher layer entity, or by the Cable Modem Termination System (CMTS) via a three-way DOCSIS MAC layer message exchange – Dynamic Service Addition (DSA): DSA -Request, DSA- Response, and DSA-Acknowledge. This is illustrated in Figure 1. Note that the DSA process can also be initiated by the CMTS.

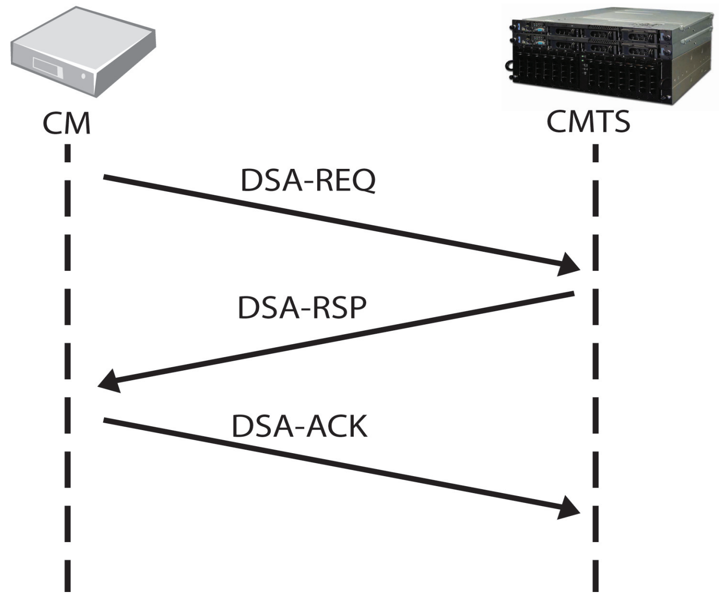


Figure 1. A three-way handshake process to complete a DSA request

A service flow can be modified via Dynamic Service Change (DSC) message exchanges. It can also be deleted through a two- way exchange of Dynamic Service Deletion (DSD) messages: DSD-Request and DSD-Response

DQoS is a policy-layer mechanism that defines a process for the various network elements to work together to provide QoS to PacketCable applications via the control of DOCSIS Dynamic Service Flows. In essence, DQoS allows network resources to be authorized, reserved, and committed so that real-time communications (e.g., voice calls) are given the required resource assignment (e.g., UGS Service Flows) dynamically.

The real time nature of IP Telephony requires highly stringent QoS. To ensure voice quality, three network elements are involved:

- The access network between the originating caller and the core network.
- The access network between the core network and the terminating caller
- The core network itself

Within the core network, QoS is handled using Differentiated Services Code Point (DSCP) marking or Multi-protocol Label Switching (MPLS). How backbone QoS is provided rests with core network design considerations that are outside the scope of the current discussion.

For the originating and terminating voice subscriber in the PacketCable network, QoS between the E-MTA and the CMTS in the DOCSIS network is provided via PacketCable DQoS. DQoS ensures that voice customers are given preferential treatment in receiving the amount of bandwidth they require and at the regular intervals needed for quality voice communications.

PacketCable 1.0/1.5 DQoS

Figure 2 illustrates the PacketCable 1.0/1.5 components and protocols involved in providing DQoS functionality. The signaling protocol used between an E-MTA and the Call Management Server (CMS) is Network Control Signaling (NCS), and the protocol used between the CMS and CMTS for gate messages is Common Open Policy Service (COPS).

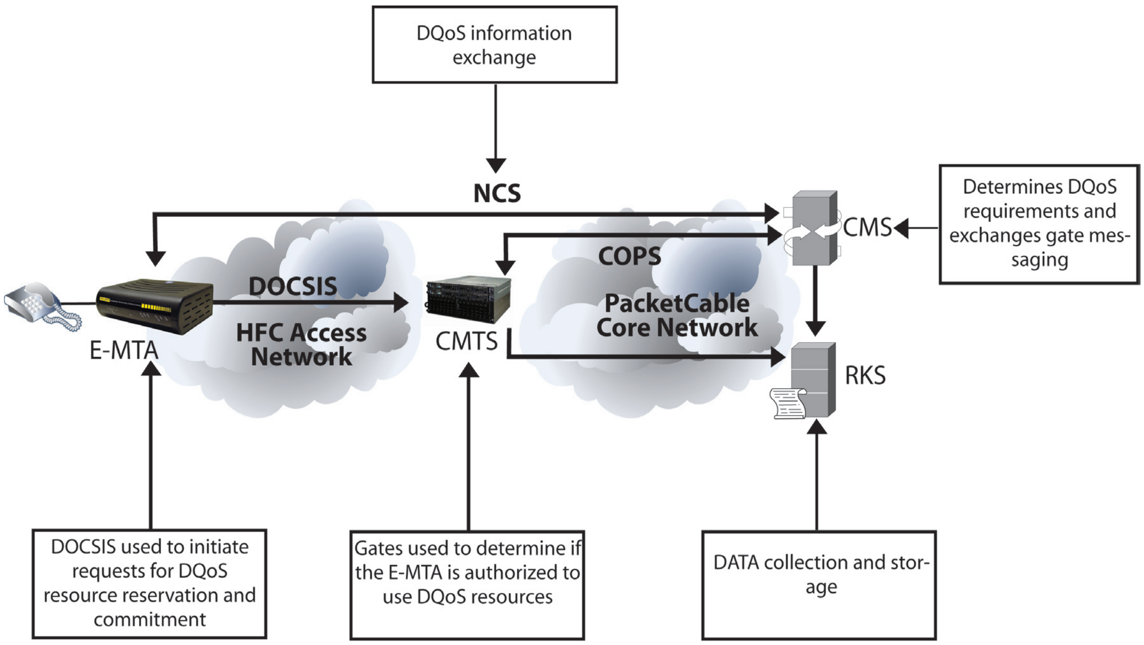


Figure 2. PacketCable 1.0/1.5 components and protocols involved in providing DQoS functionality

The key PacketCable components involved in providing DQoS functionality are described below:

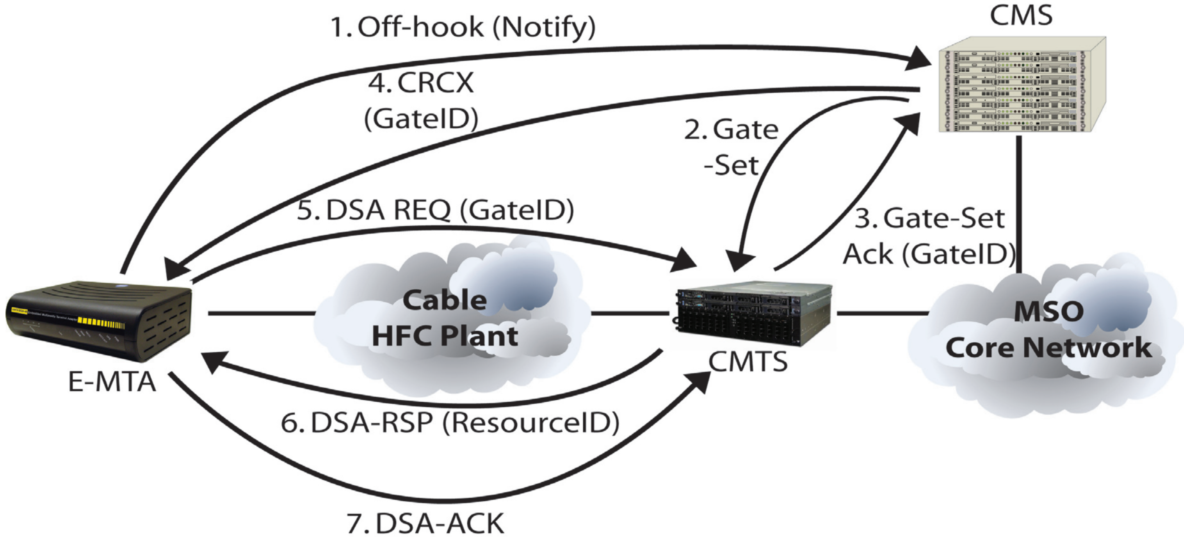
Embedded MTA (E-MTA) - DQoS information is exchanged between an E-MTA and the CMS using the NCS protocol. An embedded MTA internally signals its cable modem component to request QoS using the DOCSIS protocol. This is done through the use of DOCSIS 1.1 dynamic service flow messages exchanged between the CMTS and E-MTA.

CMTS - DOCSIS bandwidth is authorized, reserved, and committed by the CMTS. Access to this premium bandwidth is controlled at the CMTS by a DQoS gate, managing the premium DOCSIS resources. Because the CMTS is where DOCSIS resources are controlled, it is also referred to as the Policy Enforcement Point (PEP) in the DQoS architecture.

CMS - Gates are created on the CMTS under the direction of the CMS. Thus, the CMS also functions as a gate controller. The CMS directs the CMTS to set up DQoS gates and then relays this information to the MTA using the NCS protocol. Because the CMS is controlling the manipulation of DQoS gates, it is referred to as the Policy Decision Point (PDP) in the DQoS architecture.

RKS - Records DQoS usage and serves an accounting function.

Figure 3 is a simplified diagram of the PacketCable 1.0/1.5 DQoS mechanism.



1. E-MTA → CMS: off hook (Notify)
2. CMS (Gate Controller) → CMTS: Gate-Set
3. CMTS → CMS: Gate-Set-Ack (GateID)
4. CMS → E-MTA: CRCX (GateID) – Dynamic Service Flow establishment
5. E-MTA → CMTS: DSA REQ (GateID)
6. CMTS → E-MTA: DSA RSP (ResourceID)
7. E-MTA → CMTS: DSA ACK

Figure 3. Simplified diagram of PacketCable 1.0/1.5 DQoS

PacketCable Multimedia (PCMM)

The PacketCable 1.0/1.5 specifications discussed earlier were originally developed for telephony services to provide defined QoS levels. PacketCable Multimedia builds on the concept of the PacketCable QoS architecture and enables features originally developed for VoIP to be used to deliver other enhanced multimedia services, making it application-agnostic.

In PacketCable 1.0/1.5, a client (E-MTA) may be instructed by the CMS to initiated dynamic service flow establishment. With PacketCable Multimedia, client-to-server signaling is isolated from network QoS signaling and the client device may not be DQoS aware. Management is handled by network-based servers and delivered based on network policies.

In the original PacketCable architecture, the CMS both provided application-processing logic and implemented network policies. With PCMM, these two functions are separated and the interface between the components is COPS.

The major network elements within the PCMM architecture include:

ApplicationServer/Manager (AS/AM) - Performs application or session control and may be a general-purpose engine such as a SIP proxy server. The client talks directly to the AS/AM, and the AS/AM then formats a request to the Policy Server to request QoS resources.

Policy Server (PS) - PCMM is designed for multiple application managers using a pool of shared resources. Thus, QoS requests are directed to an intermediary device known as a Policy Server which mediates between the AS/AMs and the CMTS. The PS coordinates the requests and based on operator defined rules, delivers the commitment necessary to the multimedia applications.

CMTS - Continues its role of admission control and management of HFC network resources through DOCSIS service flows under PCMM. It communicates with the PS using the COPS protocol and with the record keeping server using Radius/UDP.

RKS - Receives notification of actual QoS grants, records the usage and serves an accounting function.

Client - PCMM allows for the client to be any one of a diverse range of devices. It communicates with the AS/AM via an application-specific signaling protocol such as SIP.

A high level diagram of PCMM components is shown in Figure 4 below:

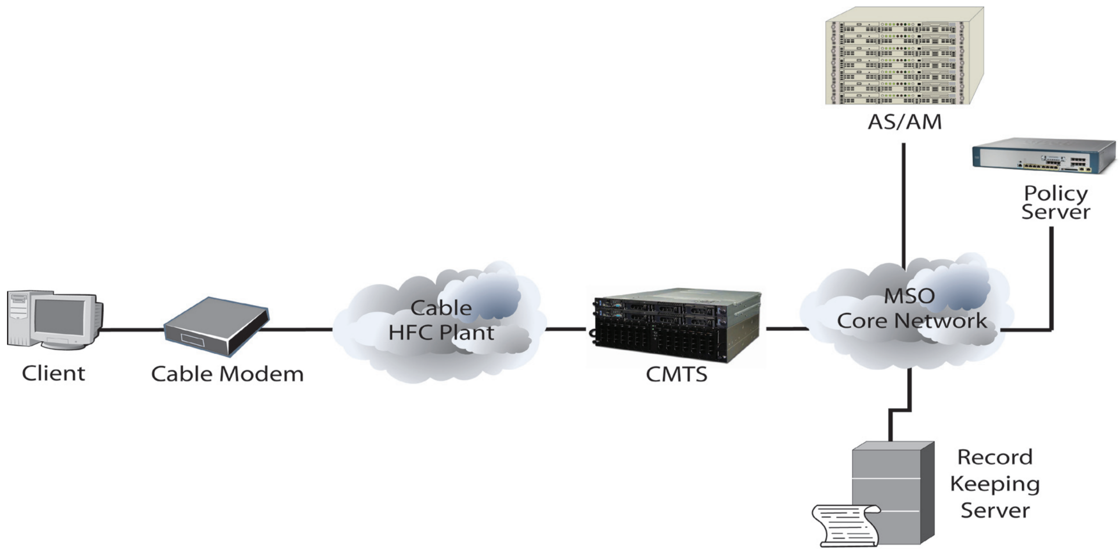
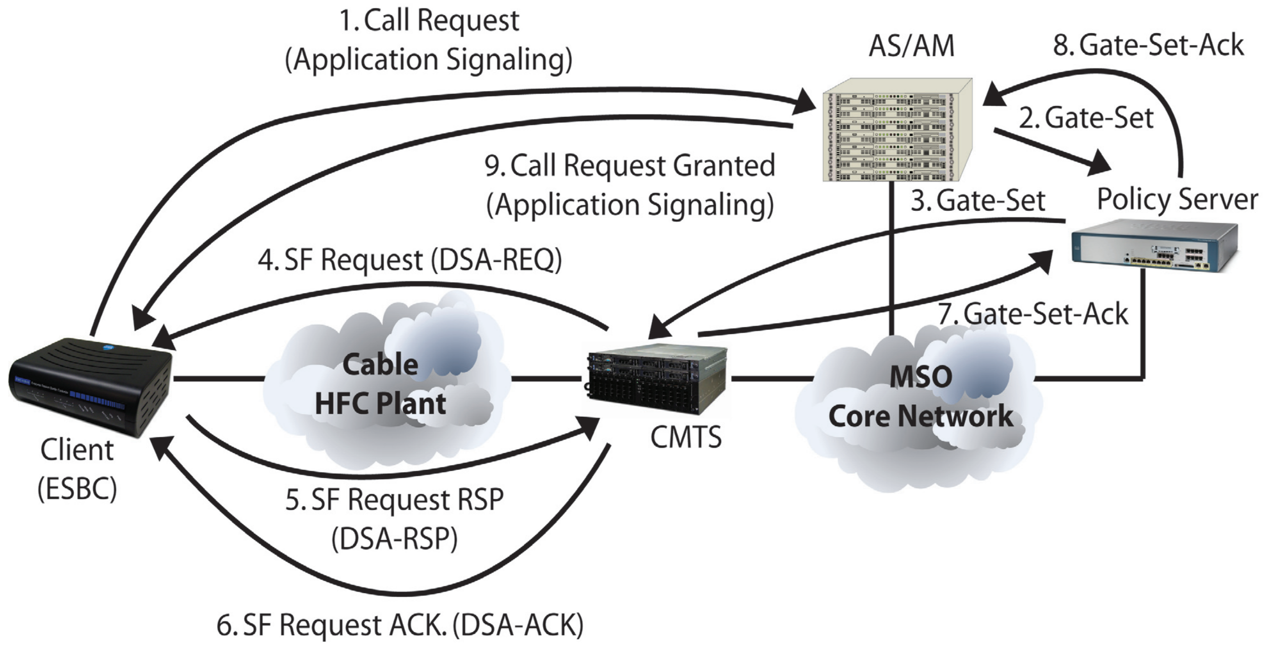


Figure 4. High Level Diagram of PCMM Components

PCMM is application independent which allows MSOs to offer telephony, multi-media and emerging services perhaps yet unforeseen. Its intent is to provide the flexibility to support all applications over common access, metro and core network infrastructures.

Figure 5 is a simplified diagram of PacketCable Multimedia (PCMM) network-based Quality of Service. The client shown here is an ESBC with an integrated Cable Modem (CM).



1. **Client → AS/AM: <u>Call Request</u> (SIP INVITE) Application Request**
2. **AS/AM → PS: Gate-Set**
3. **PS → CMTS: Gate-Set**
4. **CMTS → CM: <u>Service Flow Request</u> (DSA-REQ)**
5. **CM → CMTS: <u>Service Flow Request Response</u> (DSA-RSP)**
6. **CMTS → CM: <u>Service Flow Request Acknowledgement</u> (DSA-ACK)**
7. **CMTS → PS: Gate-Set-Ack (GateID)**
8. **PS → AS/AM: Gate-Set-Ack (GateID)**
9. **AS/AM → Client: <u>Call Request Granted</u> - Application Grant**

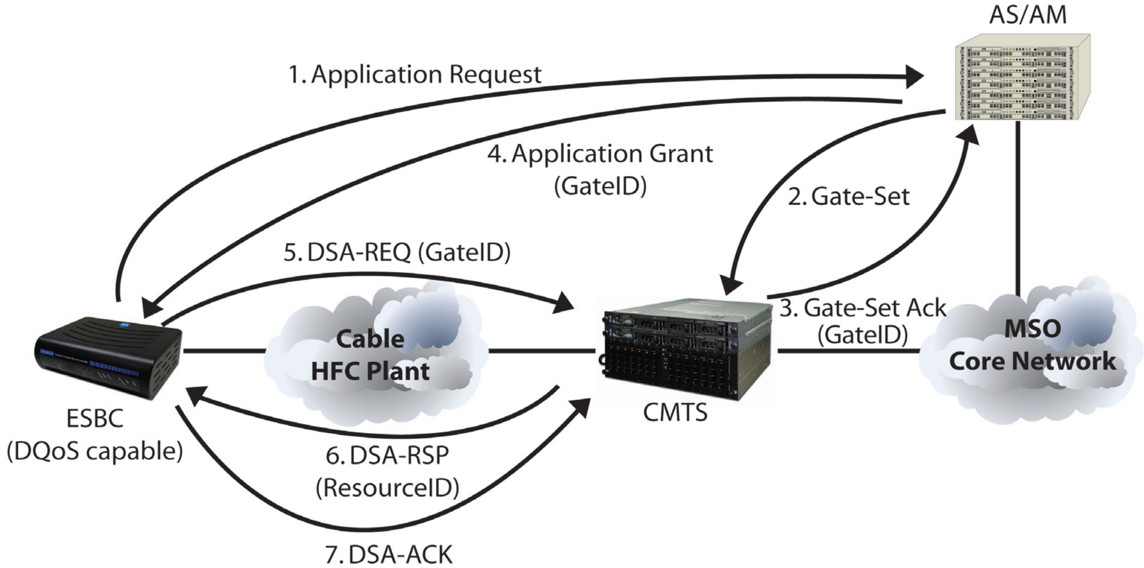
Figure 5: A simplified diagram of PacketCable Multimedia DQoS.

Device-initiated DQoS, its application and advantages

PacketCable 1.0/1.5 defines DQoS for NCS-based systems, and PacketCable Multimedia is a network-based DQoS scheme which requires network upgrades with the addition of policy servers and complex interactions among the various network server components. The PCMM approach, in particular, requires a specific architecture and server components not prevalent today in many MSO networks. An alternative approach, Device-initiated DQoS is introduced to address these limitations, allowing MSOs to immediately launch non-NCS based services with DQoS (e.g., SIP trunking or hosted voice services) on networks that are not yet PCMM ready.

Device-initiated DQoS

Device-initiated DQoS works in a similar fashion to PacketCable 1.0/1.5, but has no requirement to run the NCS protocol between the edge device and the application server (CMS in the case of PacketCable 1.0/1.5). It relies on an intelligent edge device with an embedded DOCSIS cable modem to initiate DOCSIS UGS service flow requests based on user or signaling events. A simplified Device-initiated DQoS scheme is shown in Figure 6.



1. ESBC → AS/Softswitch: Application Signaling
2. AS/Softswitch → CMTS: Gate-Set (Optional)
3. CMTS → AS/Softswitch: Gate-Set-Ack (GateID) (Optional)
4. AS/Softswitch → Embedded ESBC: Application Signaling (GateID*)
   * If GateID is not available → DQoS Lite

Service Flow Establishment:

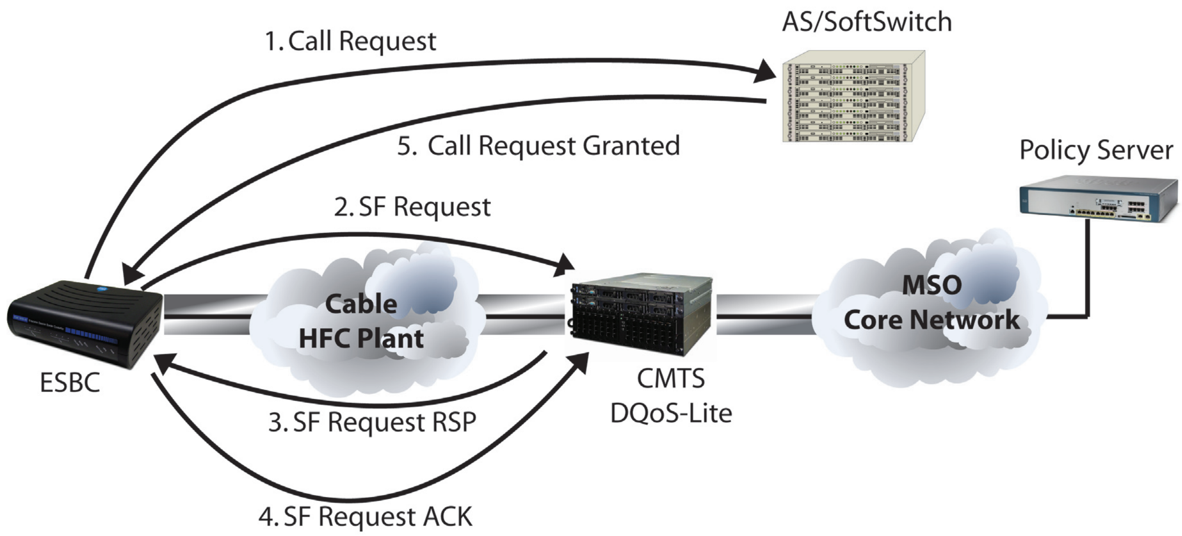
5. ESBC → CMTS: DSA REQ (GateID)
6. CMTS → ESBC; DSA RSP (ResourceID)
7. ESBC → CMTS: DSA ACK

Figure 6. Device-initiated DQoS Scheme

If there is no mechanism in place for the AS/Softswitch to deliver the DQoS resources identifying label (GateID) to the edge device such as the ESBC, then this configuration is known as DQoS Lite.

Device-initiated DQoS under DQoS Lite

DQoS Lite does not require the use of a GateID as long as the edge device is a trusted/authorized device (as in the case for the ESBC with an embedded cable modem). In such a case, GateID information is not exchanged between the AS/Softswitch and the edge device. The Device-initiated DQoS scheme under DQoS Lite is shown in Figure 7.



1. ESBC → AS/Softswitch: Call Request (SIP INVITE)
2. ESBC → CMTS: Service Flow Request (DSA Request)
3. CMTS → ESBC: Service Flow Request Response (DSA RSP)
4. ESBC → CMTS: Service Flow Request Acknowledgement (DSA ACK)
5. AS/Softswitch → ESBC: Call Request Granted (SIP 200 OK)

Figure 7. Device-initiated DQoS under DQoS Lite

Another advantage of Device-initiated DQoS is flexibility to support multiple devices. An Enterprise Session Border Controller (ESBC) or an Enterprise SIP Gateway (ESG) that is capable of Device-initiated DQoS cannot only initiate UGS service flow requests for itself (e.g., a user picking up the phone attached to the device's FXS ports), but for any other SIP client(s) connected to it via its LAN interface. These secondary SIP devices need not to have any access to or knowledge of the DQoS cable network as long as the ESBC or ESG is equipped with stateful SIP-aware capabilities such as being a SIP Application Layer Gateway (SIP ALG) or Back-to-back User Agent (B2BUA). In all these cases, the ESBC with Device-initiated DQoS can initiate UGS Service Flow requests on behalf of other authorized LAN-based IP end points when detecting legitimate SIP message flows. This is a very powerful scheme as it allows DQoS-unaware user agents (e.g., IP phones or IP PBXs) to receive DQoS-based services.

Device-initiated DQoS is featured in all InnoMedia ESBCs with ***Smart* DQoS**™ technology. ***Smart* DQoS**™ uses the embedded cable modem to explicitly request dynamic Service Flows to establish DQoS. With the InnoMedia's ESBC, DQoS is simple and automatic, ensuring voice quality whether delivered over SIP trunks or as a hosted SIP service. Using the concept of a trusted/authorized device, the ESBC represents an ideal demarcation point and empowers MSOs to instantly offer scalable QoS-ensured bundled services (SIP trunking, hosted voice, and high-speed data) over their existing cable networks. This is illustrated in Figure 8.

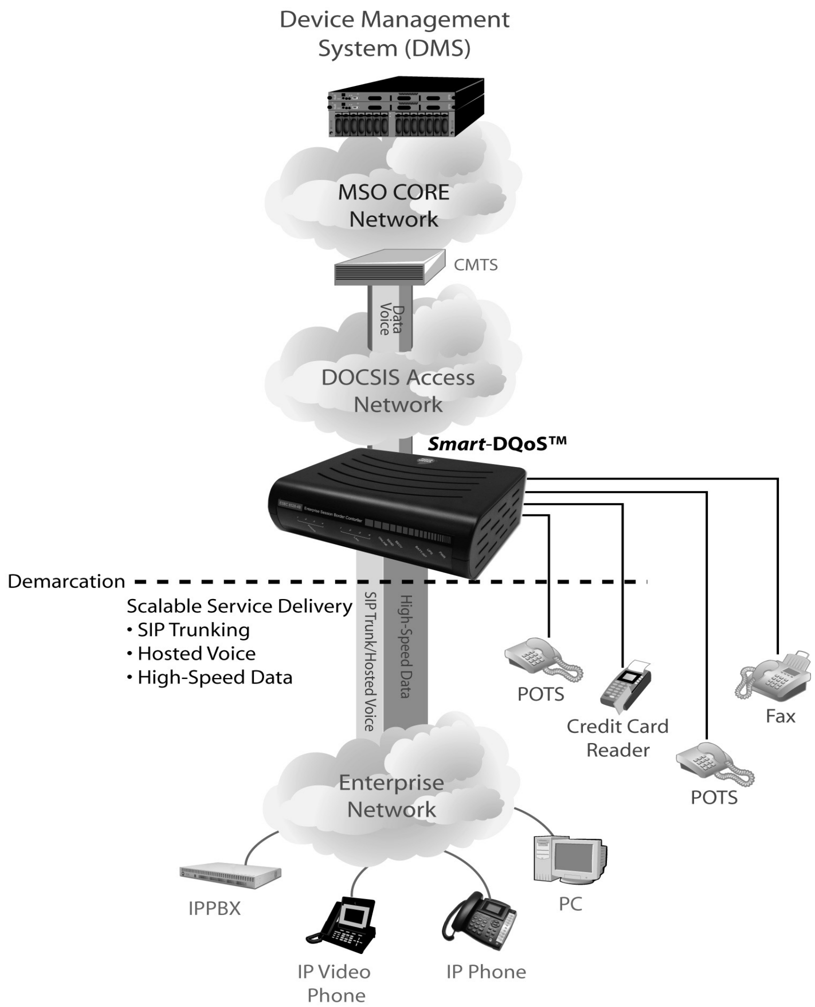


Figure 8. MSO Demarcation for QoS ensured bundled services.

As more businesses migrate to cable telephony voice, so grows the need to support SIP devices. Device-initiated DQoS on a DOCSIS network will make it infinitely scalable whether PCMM is implemented or not.