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Access, Terminals, Transmission and Multiplexing (ATTM); IPCablecom Services for delivering multimedia and voice over DOCSIS network infrastructure

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

1 Scope

The present document specifies IPCablecom, (also referred to as PacketCable) multimedia services over DOCSIS.

1.1 Purpose

The intent of the present document is to support the deployment of general Multimedia services by providing a technical definition of several IP-based signalling interfaces that leverage core QoS and policy management capabilities native to DOCSIS Versions 1.1 and greater. Throughout the present document, the term DOCSIS will be used to refer to any DOCSIS version greater than or equal to 1.1. For the purposes of the present document, Multimedia services may be defined as IP-based services (e.g. online gaming, video-conferencing, streaming media, etc.) requiring QoS-based network resources (as contrasted with services such as web browsing, e-mail, instant messaging and file-sharing that are commonly provided using best-effort flows). While telephony or voice-based services are not specifically excluded from this definition, the IPCablecom 1.x set of specifications provide coverage specific to this type of service delivery, and, therefore, those specifications should be consulted as appropriate.

IPCablecom Multimedia defines a service delivery framework that provides general-purpose QoS, event-based accounting, and security functionality founded upon the mechanisms defined in IPCablecom 1.x. However, due to the broader spectrum of applications and services addressed by this initiative, each of these functional areas has been revisited and generalized for the present purposes. Telephony-specific requirements and interfaces (e.g. call signalling, PSTN interconnection and electronic surveillance) are not part of IPCablecom Multimedia, while core functionality such as QoS resource management mechanisms, has been enhanced. Throughout this process, one of the primary objectives of this work has been to leverage and reuse as much of the existing body of IPCablecom 1.x investment, knowledge base, and technical functionality as possible.

Key features of the described Multimedia service delivery framework include:

- Simple, powerful access to DOCSIS QoS mechanisms supporting both time and volume-based network resource authorizations.

- Abstract, event-based network resource auditing and management mechanisms.

- A robust security infrastructure that provides integrity and appropriate levels of protection across all interfaces.

As outlined in the technical report [15], the current scope of the present document is limited to network-based QoS resource management and usage auditing capabilities. This approach was motivated by several criteria, including rapid time-to-market for QoS-enhanced Multimedia services (which may take the form of new applications or existing applications retrofitted per the present document), the absence of QoS signalling requirements on CPE devices, and security assurances provided by an absence of client-based QoS signalling.

In addition, the QoS signalling mechanisms outlined herein provide the foundation for client-based QoS signalling mechanisms which may be defined in the future. As such scenarios have already been considered and documented in the technical report, one of the secondary goals of the present document is to provide for smooth migration to a client-based model as market and technology advances dictate. It should also be noted that the scope of the QoS framework defined in the present document is limited to the access network and that the choice of specific backbone QoS strategies is left as an administrative decision to be addressed by each service provider as it deems best.

1.2 Relation to IPCablecom 1.x

Since its inception the IPCablecom initiative has been positioned as an IP-based Multimedia service deployment infrastructure, exploiting and enhancing the underlying QoS capabilities of the DOCSIS access network. Based on market demand and technology readiness, VoIP was chosen as the first IP-based service to leverage these unique broadband access network capabilities, as the IPCablecom 1.x suite of specifications simultaneously defines both a general QoS-based service delivery framework and a number of telephony-specific functional elements and mechanisms.

Specifically, the IPCablecom 1.x VoIP architecture provides specifications promoting multi-vendor interoperability and CableLabs certification and qualification in the following key telephony areas:

- Network-based call signalling (NCS)
- Inter-domain call signalling (CMSS)
- PSTN gateway and interop functionality (TGCP, ISTP)
- Access-network and backbone QoS capabilities (DQoS, IQoS)
- Event messaging with telephony-specific extensions (EM)
- CPE endpoint provisioning and monitoring (Provisioning and SNMP MIBs)
- Comprehensive suite of interface security mechanisms (Security)
- Primary-line telephony characteristics
- Electronic surveillance

Since the intent of the present document is to extract the functional core of this architecture in support of the enhancement and deployment of other Multimedia services, support for these telephony-specific features is not required, while the core QoS, event messaging and security mechanisms are emphasized and generalized. The result is a framework that provides IP-based access to DOCSIS access-network QoS mechanisms complemented by secure and robust authorization and audit mechanisms.

In keeping with the IPCablecom 1.x Dynamic Quality of Service (DQoS) model, the primary logical construct in support of QoS-based service delivery is a Gate (along with its accompanying authorization token). An IPCablecom Gate represents a policy-based authorization for a specific envelope of network resources characterized by a suite of QoS parameters, as well as classifiers for originating and terminating IP addresses and ports, which define and limit the scope of the associated QoS-enhanced flow.

IPCablecom 1.x defines a pre-authorization model in which Gates are created and installed at policy enforcement points (e.g. a CMTS) prior to actual network resource reservation or activation requests. This process, termed Gate Control, is managed through a COPS-based policy interface on the CMTS. In the present document, this interface is generalized and enhanced to allow for full lifecycle management of QoS-based service flows through this policy interface. That is, Gate installation and management is supplemented with service flow creation, modification and deletion functions to provide for network-based QoS service delivery.

To complement these enhanced QoS policy and signalling capabilities, the RADIUS-based event messaging infrastructure of IPCablecom 1.x is carried over, but with telephony-specific primitives tagged as optional. Since the EM protocol was designed with a considerable amount of generality and abstraction, this approach provides continuity with existing protocol and Record Keeping Server (RKS) implementation while still allowing Multimedia vendors to select from a set of supplementary protocol primitives on an as-needed basis. For example, if a QoS-based video conferencing service were being developed based on the present document, a number of telephony-specific EM message types (e.g. Call_Answer and Call_Disconnect) may map directly to the service's audit requirements.

Finally, in order to provide robust security for this Multimedia framework, IPsec will be applied to the COPS and RADIUS interfaces in a manner analogous to the corresponding interfaces in the IPCablecom 1.x architecture.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 102 639-4: "Access and Terminals, Transmission and Multiplexing (ATTM); Third Generation Transmission Systems for Interactive Cable Television Services - IP Cable Modems; Part 4: MAC and Upper Layer Protocols [ITU-T Recommendation J.222.2 (07/2007), modified]".

[2] IETF RFC 1305 (March 1992): "Network Time Protocol (Version 3) Specification, Implementation and Analysis".

[3] IETF RFC 2205 (September 1997): "Resource ReSerVation Protocol (RSVP) - Version 1 Functional Specification".

[4] IETF RFC 2210 (September 1997): "The Use of RSVP with IETF Integrated Services".

[5] IETF RFC 2211 (September 1997): "Specification of the Controlled-Load Network Element Service".

[6] IETF RFC 2212 (September 1997): "Specification of Guaranteed Quality of Service".

[7] IETF RFC 2474 (December 1998): "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers".

[8] IETF RFC 4546: "Radio Frequency (RF) Interface Management Information Base for Data over Cable Service Interface Specifications (DOCSIS) 2.0 Compliant RF Interfaces".

[9] IETF RFC 2748 (January 2000): "The COPS (Common Open Policy Service) Protocol".

[10] IETF RFC 2753 (January 2000): "A Framework for Policy-based Admission Control".

[11] IETF RFC 2866 (June 2000): "RADIUS Accounting".

[12] IETF RFC 3084 (March 2001): "COPS Usage for Policy Provisioning (COPS-PR)".

[13] ITU-T Recommendation J.163 (12/2007): "Dynamic quality of service for the provision of real-time services over cable television networks using cable modems".

[14] ITU-T Recommendation J.164 (12/2007): "Event message requirements for the support of real-time services over cable television networks using cable modems".

[15] PKT-TR-MM-ARCH-V03-091029: PacketCable ™ Technical Report "Multimedia Architecture Framework", Cable Television Laboratories, Inc.

NOTE: Available at http://cablelabs.com/specifications/PKT-TR-MM-ARCH-V03-091029.pdf.

[16] ITU-T Recommendation J.170 (11/2005): "IPCablecom security specification".

[17] ETSI ES 201 488-3 (V1.2.2): "Access and Terminals (AT); Data Over Cable Systems; Part 3: Baseline Privacy Plus Interface Specification".

[18] IETF RFC 2865: "Remote Authentication Dial In User Service (RADIUS)".

[19] IEEE 802.1D-1998: "IEEE Standard for Local Area Network MAC (Media Access Control) Bridges".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] IETF RFC 2751 (January 2000): "Signaled Preemption Priority Policy Element".

[i.2] SCTE 159-2 2010: "Multimedia Application and Service Part 2: IPCablecom Multimedia Web Services".

[i.3] IETF RFC 3168 (September 2001): "The Addition of Explicit Congestion Notification (ECN) to IP".

[i.4] IETF RFC 3171 (August 2001): "IANA Guidelines for IPv4 Multicast Address Assignment".

[i.5] IETF RFC 4291 (February 2006): "IP Version 6 Addressing Architecture".

[i.6] IETF RFC 791: "Internet Protocol".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Application Manager (AM): system that interfaces to Policy Server(s) for requesting QoS-based service on behalf of an end-user or network management system

cable modem: layer two termination device that terminates the customer end of an IP Cable Modem System

Client Type 1: represents existing "legacy" endpoints (e.g. PC applications, gaming consoles) which lack specific QoS awareness or signalling capabilities

NOTE: This Client knows nothing about Cable Modem, or IPCablecom messaging, and hence no related requirements can be placed upon it. Such clients may range from simple analog audio and video presentation devices to complex networked peripherals and consumer electronics, such as set-top boxes or gaming consoles. This Client communicates with an Application Manager to request service, and does not request QoS resources directly from the operator access network. The present document supports only client type 1.

Client Type 2: similar to an IPCablecom-T telephony MTA in that it supports QoS signalling based on IPCablecom DQoS

NOTE: This Client is aware of IPCablecom Multimedia QoS, and communicates with an Application Manager to request service and obtain a token for access-network resources. The client then presents this token when requesting QoS resources from the access network (pkt-mm-1, pkt-mm-6).

Client Type 3: requests QoS based on RSVP without Application Manager interaction

NOTE: This Client is aware of IETF standards-based RSVP and uses this protocol to request QoS resources from the access network directly from the CMTS.

DOCSIS: describes a specific cable modem technology

IPCablecom: ETSI deliverables including an architecture and a series of specifications that enable the delivery of real time services (such as telephony) over the cable television networks using cable modems

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AM Application Manager
ACK Acknowledge
AS Application Server
BCID Billing Correlation ID

NOTE: Defined in the IPCablecom Event Messaging specification.

CM Cable Modem
CMS Call Management Server
CMSS Call Management Server Signalling

CMTS Cable Modem Termination System
COPS Common Open Policy Service

NOTE: Defined in RFC 2748 [9].

DEC Decision
DQoS Dynamic Quality of Service
DSA Dynamic Service Add
DSC Dynamic Service Change
DSD Dynamic Service Delete
EM Event Message
FQDN Fully Qualified Domain Name
IETF Internet Engineering Task Force
IP Internet Protocol
ISTP Internet Signalling Transport Protocol
MGC Media Gateway Controller
MIB Management Information Base
MTA Multimedia Terminal Adapter
NAT Network Address Translation
NCS Network-based Call Signalling
PDP Policy Decision Point

NOTE: Defined in RFC 2753 [10].

PEP Policy Enforcement Point

NOTE: Defined in RFC 2753 [10].

PS Policy Server
PSTN Public Switch Telephone Network
QoS Quality of Service
RADIUS Remote Authentication Dial-In User Service

NOTE: Defined in RFC 2865 [18] and RFC 2866 [11].

RAP Resource Allocation Protocol

NOTE: Working Group in the IETF responsible for the definition and maintenance of the COPS protocol.

RCD Resource Control Domain
REQ Request
RFC Request for Comments

NOTE: Technical policy documents approved by the IETF which are available at http://www.ietf.org/rfc.html.

RFI Radio Frequency Interface

NOTE: Specification defining MAC and Physical layer interfaces between CMTS and CM network elements.

RKS Record Keeping Server
RSP Response
RSVP Resource Reservation Protocol

NOTE: Defined in RFC 2205 [3].

SCD Session Control Domain
TCP Transmission Control Protocol
TGCP Trunking Gateway Control Protocol
TLV Type-Length-Value

NOTE: Technique used in formatting protocol elements.

UDP User Datagram Protocol

NOTE: A connectionless protocol built upon Internet Protocol (IP).

UGS Unsolicited Grant Service

NOTE: DOCSIS RFI Annex B QoS scheduling type used for constant bit rate services (e.g. voice codecs).

UGS/AD Unsolicited Grant Service with Activity Detection
VoIP Voice over IP
VPN Virtual Private Network

4 Void

5 Technical Overview

This clause consists of background material which some readers may find to be useful context for the detailed protocol interface specifications that follow. The intent in this clause is to provide a high-level overview of the IPCablecom Multimedia architecture and the fundamental technologies upon which it is based.

5.1 QoS Background

As noted throughout the present document, one of the primary features of the IPCablecom Multimedia service framework lies in the fact that it provides IP-layer access to sophisticated QoS capabilities defined in DOCSIS versions 1.1 and greater and IPCablecom 1.x. This clause provides a brief overview of these capabilities as preparatory background for the detailed QoS policy and resource management discussion that follows.

5.1.1 DOCSIS QoS Summary

The DOCSIS 3.0 MAC and Upper Layer Protocols Interface Specification [1] defines a set of QoS facilities based on a fundamental network resource management construct known as a Service Flow. A Service Flow is defined as "a MAC-layer transport service which (1) provides unidirectional transport of packets from the upper layer service entity to the RF, and (2) shapes, polices, and prioritizes traffic according to QoS traffic parameters defined for the flow." In addition to this primary abstraction facilitating the reservation and scheduling of shared access network resources on a per-flow basis, a number of tangible supporting constructs are defined and used to manage these resources. Three of these are:

- Service Flow Encodings: type-length-value (TLV) encoded parameters used to define QoS parameters associated with a Service Flow.
- Classifier: type-length-value (TLV) encoded IP, Ethernet and IEEE 802.1D [19]/q parameters used to define and limit the scope of a flow in terms of originating and terminating endpoints.
- Payload Header Suppression Rules: type-length-value (TLV) encoded parameters used by the sending entity to suppress repetitive payload headers following the DOCSIS Extended Header field and used by the receiving entity to restore the suppressed header information. IPCablecom Multimedia does not support this functionality at this time.

While DOCSIS supports provisioned (i.e. static, long-lived Service Flows that are established during the CM registration process) and dynamic (i.e. transient Service Flows that are added, modified and deleted on an as-needed basis) QoS models, the IPCablecom Multimedia framework is primarily concerned with the dynamic variety as this allows for optimal network resource management through statistical multiplexing as service requirements demand.

Service Flow management is performed through MAC-layer DOCSIS Dynamic Service Add/Change/Delete (DSA/DSC/DSD) messaging, which may be initiated either by the CM or by the CMTS. DSA and DSC transactions take the form of a three-way exchange in which a request (REQ) is followed by a response (RSP) which is then acknowledged (ACK). DSD messages are simple two-way exchanges. A specific attribute known as a Confirmation Code is provided in each DSx response message and indicates the success or failure status of a transaction.