

# Superseded

## PacketCable™ Audio/Video Codecs Specification

**PKT-SP-CODEC-I01-991201**

**Interim**

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## Document Status Sheet

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### Key to Document Status Codes:

<b>Work in Progress</b>	An incomplete document designed to guide discussion and generate feedback that may include several alternative requirements for consideration.
<b>Draft</b>	A document in specification format considered largely complete, but lacking review by Members and vendors. Drafts are susceptible to substantial change during the review process.
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<b>Released</b>	A stable document, reviewed, tested and validated, suitable to enable cross-vendor interoperability.

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# 1 INTRODUCTION

## 1.1 Purpose

This draft document defines the audio and video codec specifications for the PacketCable™ project, selected under the direction of the CableLabs® Executive Committee. It is being issued to facilitate design and field-testing leading to the early market entry of an interoperable, high-quality, cost-effective, and secure multi-media network.

## 1.2 Scope

This document addresses interfaces between PacketCable client devices for audio and video communication. Specifically, it identifies the audio and video codecs necessary to provide the highest quality and the most resource-efficient service delivery to the customer. This document also specifies the performance required in client devices to support future PacketCable codecs. Additionally, this document describes suggested methodology for optimal network support for codecs.

## 1.3 Document Overview

This document covers the following major topics:

- Network issues affecting and influenced by codecs, along with a discussion of codec implications on network design (Section 3).
- Client device requirements necessary to support codecs (Section 4).
- Audio codec specifications (Section 5).
- Video codec requirements and specifications (Section 6).

## 1.4 Requirements Syntax

Throughout this document words that are used to define the significance of particular requirements are capitalized. These words are:

“MUST”	This word or the adjective “REQUIRED” means that the item is an absolute requirement of this specification.
“MUST NOT”	This phrase means that the item is an absolute prohibition of this specification.
“SHOULD”	This word or the adjective “RECOMMENDED” means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before choosing a different course.
“SHOULD NOT”	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
“MAY”	This word or the adjective “OPTIONAL” means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

Other text is descriptive or is explanatory.

## 1.5 Phasing of Requirements

The codec requirements contained in this specification cover both audio and video Multimedia Terminals (MTAs). The term MTA-2 is used to define a terminal supporting video.

In the initial phase of PacketCable, MTAs are not required to support the MTA-2 requirements as defined in Section 6 of this specification. MTAs **MUST** support the requirements for audio terminals as defined in Sections 3, 4, and 5.

Support for video terminals will be **REQUIRED** in later phases of PacketCable. All MTA-2s **MUST** support the requirements defined in Section 6.

## 2 OVERVIEW

The quality of audio and video delivered over the PacketCable architecture will depend on multiple factors - the end device performance, the network's inherent quality, and the intelligence of the system resource allocation policy. This document defines mandated codecs and capabilities supporting audio and video applications, with a particular emphasis on the stringent requirements of IP-based voice communications.

Acceptable voice communications functionality imposes strict latency and packet-loss criteria on IP implementations and will thus stress system resources, particularly if bandwidth becomes congested or saturated. Video applications - while more forgiving to dropped packets and latency - require bandwidth of at least an order of magnitude more than audio applications. The PacketCable architecture is designed to support both types of applications simultaneously.

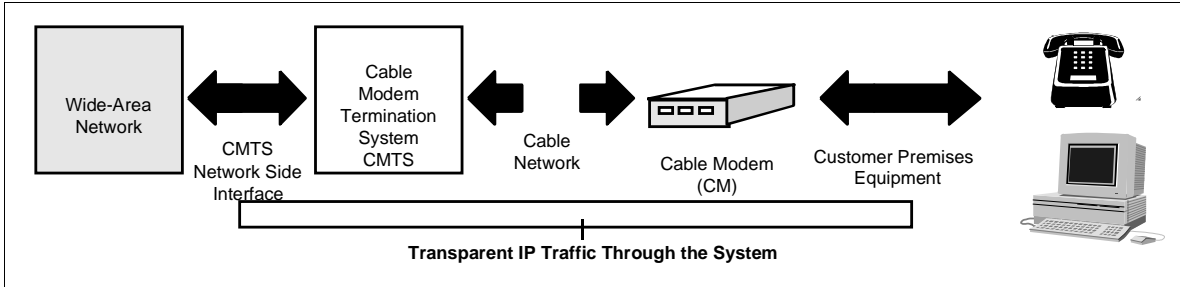
Speech and video compression are evolving technologies. New algorithms are being enabled as more sophisticated and higher performing processors become available at lower cost. Additionally, the system infrastructure and mechanisms for allocating resources will evolve. Due to this dynamism, the priority in designing the architecture is to define a robust system to accommodate evolving technology without creating a legacy burden.

Therefore, the PacketCable philosophy will be to establish cost-effective envelopes for network and device performance to enable the most appropriate current technology, while allowing upgrades as technology and market needs evolve. To address near-term market needs, this document will also specify codec and performance mandates to deliver the quality-of-service necessary for launching competitive services.

### 2.1 Service Goals

Cable operators are interested in deploying high-speed data communications systems on cable television systems. Comcast Cable Communications, Inc., Cogeco, Cox Communications, Tele-Communications, Inc., Time Warner Cable, MediaOne, Inc., Rogers Cablesystems Limited, Le Groupe Vidéotron, and Cable Television Laboratories, Inc. (on behalf of the CableLabs member companies) have decided to prepare a series of interface specifications that will permit the early definition, design, development, and deployment of packet data over cable systems on a uniform, consistent, open, non-proprietary, multi-vendor interoperable basis.

The intended service enables voice communications, video, and data services based on bi-directional transfer of Internet protocol (IP) traffic between the cable system headend and customer locations over an all-coaxial or hybrid fiber/coax (HFC) cable network, defined by the DOCSIS (Data Over Cable Service Interface Specification) series of specifications [DOCSIS1] [DOCSIS2]. This is shown in simplified form in Figure 1.



**Figure 1. Transparent IP Traffic through the Data-Over-Cable System**

The transmission path over the cable system is realized at the headend by a cable modem termination system (CMTS), and at each customer location by a cable modem (CM). At the headend (or hub), the interface to the data-over-cable system is called the cable modem termination system-network side interface (CMTS-NSI), and is specified in [DOCSIS2]. At customer locations, the interface is called the cable-modem-to-customer-premises-equipment interface (CMCI). The intent is for operators to transfer IP traffic transparently between these interfaces.

## 3 BACKGROUND

This section outlines the PacketCable architecture support elements and the DOCSIS network infrastructure necessary to deliver quality audio and video service. It is intended to clarify external interfaces and functional requirements necessary to implement the targeted audio and video quality using speech and video codecs.

The key requirement for voice communications using IP transmission is the ability to attain “toll” or better audio quality. Given the variable nature of shared packet mediums and the stringent human-factor requirements of this quality standard, it is necessary to optimize multiple system parameters to attain this goal. Additionally, PacketCable has been tasked with offering superior quality, exceeding current PSTN standards where feasible. Key requirements from the PacketCable product definition requiring architectural optimization for codecs follow.

### 3.1 PacketCable Voice Communications Quality Requirements

As defined in the PacketCable product definition [PCPROD], requirements for toll-quality voice communications service in PacketCable include numerous metrics to ensure competitive or superior quality and service to the PSTN. In order to support these requirements, network plant and equipment may have to be groomed. In order to provide guidelines for that grooming, several network implications affecting codec performance are discussed below.

### 3.2 Network Preparation for Codec Support

The critical areas of network performance, which must be optimized in tandem with codecs, are packet loss, latency, and jitter. Elaboration of network/codec implications for each of these areas follows.

#### 3.2.1 Packet Loss Control

There is a direct correlation between packet integrity and audio quality. Anecdotal codec research suggests initial 3% packet loss rate results, on average, in a reduction in MOS scores of 0.5 point, on a scale of 5. Due to less than pristine normal conditions and human-detectable compromises with most codecs, this resulting audio quality for a 3% packet loss rate will be well below PSTN “toll” quality. Above 3%, codec performance falls off rapidly, and resulting voice quality is unacceptable.

Applications and/or codecs may provide error correction or concealment mechanisms, which may increase latency through buffering. Once latency thresholds have been exceeded, the tradeoff between latency and fidelity becomes an untenable situation.

#### 3.2.2 Latency Control

Control of overall latency requires a hand-in-hand effort by the system resources and the application—in this case, a speech or video application dominated by the codec component.

There are multiple device elements and network components inducing latency during traversal of an audio signal from capture of the speaker's voice until reception at the receiver's ear. The primary contributors to latency for an on-net voice communication along this path are:

- Audio sampling and analog-to-digital conversion.
- Buffering of samples (audio framing, plus look-ahead).
- Compression processing.
- Packetization of compressed data.
- Local network (DOCSIS) traversal.
- Routing to the backbone network.
- Backbone traversal.
- Far-end reception of packets and traversal of local access.
- Buffering of out-of-order and delayed packets.
- Decoding, decompression, and reconstruction of the audio stream.

The major contributors to codec-related latency in the network are described below.

### **3.2.2.1 Latency Control: Buffering**

While network jitter and corresponding buffering increase call latency, another source of buffering can be induced by the application as a corrective response to severe packet loss. Although the ultimate solution to additional buffering delay is a pristine network, realistically some packet loss will occur.

Accounting for lost packets suggests the need for support concealment or reconstruction of lost data, and in many instances these techniques employ some mechanism of redundant information encoding, temporally shifting and embedding audio frames in the data stream. This not only increases the effective bandwidth requirement, but also creates, in effect, an additional buffer to allow for reassembly, increasing latency.

In order to apply certain reconstruction methodologies in an optimal fashion, the application needs accurate data regarding the statistical characteristics of the media stream. Some information is available through real-time control protocol (RTCP) mechanisms, such as a gross measure of packet loss. Additional information, such as burst frequency and predictive time-of-day effects, would improve the potential of the application to make optimal adjustments. Planning for the collection and analysis of this type of network information will allow developers more options in the future, potentially creating applications that will increase network utilization efficiency or quality.

### 3.2.2.2 Latency Control: Optimal Framing/Packetization

As outlined in Section 3.2.1, the loss of audio data frames can have a severe impact on audio quality. The packing of multiple audio frames into a single packet will exacerbate the problem, effectively expanding the loss of one packet into the loss of multiple adjacent audio frames of data. This also increases latency by buffering larger portions of audio samples prior to sending.

One way to minimize these effects is to send small packets containing the minimum number of frames. This will increase bandwidth use by increasing the header-to-data ratio for packets, but will minimize latency and potentially increase reconstruction quality. This suggests that the optimal packet size for voice applications is fairly small, containing compressed information for one, two, or, at most, three frames of sampling data (typically corresponding to 10, 20, or 30 milliseconds of voice frames).

### 3.2.2.3 Latency Control: Packet Timing Optimization

To avoid additional buffering delay, packets **MUST** be sent at a rate equal to integral multiples of the audio sample frame rate of the codec. This synchronization results in lockstep between the codec framing and packet transmission.

The frame sizes of the mandatory codecs (see Section 5.2) are shown in Table 1.

**Table 1 Frame Sizes of the Mandatory Codecs**

Codec	Frame Size (msec)
G.729/A	10
G.728	2.5
G.711	2.5

### 3.2.3 Codec Transcoding Minimization

Transcoding occurs whenever a packetized voice signal encounters an edge device without compatible codec support. Transcoding introduces additional latency during the decode/recode stage. Additionally, if transcoding resources at the edge gateway are shared, additional delay can be introduced.

Transcoding between compressed codecs also results in degradation of the original sample, as current codec compression techniques are not lossless. In the event that a combination of transcoding and packet loss causes a signal to be reduced below minimum quality, it is likely that a higher bandwidth codec will be employed. Thus, transcoding artifacts can result in the unintended side effect of higher system bandwidth utilization.

In the case of on-net and off-net IP connections, transcoding can be eliminated if all necessary codecs are supported on the client. This is, in fact, impractical but can be optimized statistically if a device supports multiple codecs and can be updated periodically.

### 3.2.4 Bandwidth Minimization

There are two primary mechanisms that client devices may employ to minimize the amount of bandwidth used for their audio/video applications:

- A compressed, low bitrate codec may be applied, thus reducing the bandwidth required.
- A codec may employ some form of variable bitrate transmission.

The selection of codecs occurs at the device's discretion or via network selection, depending on the protocol employed. Regardless, this takes place after the initial capabilities exchange to determine a compatible codec between endpoints, and assumes that the requested bandwidth is granted by the bandwidth broker element.

Variable rate transmission may occur when a codec employs methods resulting in a non-constant bitstream representation of voice data. Voice activity detection (VAD)—silence suppression—is a basic form of variable rate transmission, sending little or no data during speaker silence periods. More advanced variable bitrate encoding (VBR) occurs when a codec dynamically optimizes the compression bitstream.

## 4 DEVICE REQUIREMENTS FOR AUDIO CODEC SUPPORT

As markets evolve, endpoint codecs will change too, and neither a provider nor a customer can be expected to replace their cable modem/MTA frequently to accommodate these market changes. Given the rapid growth of the digital wireless market in particular, it is likely that, at some point, a statistically significant portion of voice communications will require a new codec in the standard suite in order to maintain voice quality.

Since interconnection between diverse codecs requires transcoding - which introduces unwelcome latency and artifacts—one goal of the PacketCable network is to minimize transcoding. Thus, a forward-looking approach to codec evolution is necessary - one which supports the most important interconnect codecs, as well as improved performance of on-net codecs introduced in the marketplace over the next several years.

However, now and for the immediate future, it is not cost-feasible to provide support for every possible interconnecting codec. Thus, a compromise must be established limiting the required power of the processors and local memory. Therefore, PacketCable requires a minimum threshold of programmable upgradability in its MTA devices, as described below. These requirements include support for downloading new software from an authorized system resource, headroom in processing for slightly more complex new codecs, and additional local storage to hold program data.

### 4.1.1 Dynamic Update Capability

All MTA devices **MUST** be capable of downloading new software from authorized sources.

### 4.1.2 Maximum Service Outage

If the MTA supports life-line services (such as 911 emergency service), service disruption **MUST NOT** exceed 20 seconds when downloading new software to the MTA.

### 4.1.3 Minimum Processing Capability

All MTA devices **MUST** be capable of supporting the equivalent execution of two G.728 or G.729E encode/decode pairs, and simultaneously performing two encode/decode pairs using G.711.

### 4.1.4 Minimum Audio Codec Storage Capability

All MTA devices **MUST** be capable of maintaining simultaneously, in device memory or storage, all mandatory and recommended codecs specified herein (i.e. equivalent storage for G.711, G.728, and G.729 Annex E). Although the present specification does not mandate either G.728 or G.729 Annex E, this requirement

provides reserve capacity for additional codecs to be provisioned to the MTA in the future.

Although it is necessary to provide storage for all mandatory and recommended codecs, the minimum run-time memory only needs to support one of the recommended codecs along with G.711, subject to the minimum processing specification in 4.1.3.

## 5 AUDIO CODECS SPECIFICATIONS

### 5.1 Feature support

Offering a competitive and/or superior product requires support for more than toll-quality delivery of audio. In addition to features and signaling capabilities, which are beyond the scope of this document, the audio codec application must provide transparent support for certain audio features. These include general detection mechanisms, DTMF, fax, analog modem, echo compensation, and hearing-impaired support.

#### 5.1.1 DTMF support

Dual-tone multi-frequency (DTMF) support allows employment of dual-tone multiple frequency signals by either an autodialing system or through manual entry of tones. In order for DTMF tones to be captured correctly by the receiving device, tonal integrity (frequency accuracy and signal duration) must be maintained even through compression and transcoding.

MTA devices **MUST** successfully pass DTMF tone transmissions. The specified codecs **MUST** be capable of transparently passing these tones in-band.

#### 5.1.2 Fax and Modem Support

PacketCable needs to support analog fax and modem interfaces for two reasons. First, fax and modem equipment are common in residences, and customers will continue to use these familiar devices for some years to come. Second, even with cable modem access, many SOHO or ISP users will continue to access their dial-up networks using a traditional modem.

In order to provide customers with access for analog fax and modems, the MTA devices **MUST** be able to detect fax/modem signals and signal these detections using the appropriate protocol. The codec at each end is then switched to G.711 for the remainder of the session. Additionally, echo compensation is disabled for the duration of the fax/modem session. After the fax/modem session has completed, echo compensation is re-enabled.

A more robust solution for supporting fax is to employ fax relay. Fax relay involves demodulating the T.30 transmission and sending control and image data over the IP network. At the receiving end, the received data is remodulated and sent to the fax terminal using another T.30 session. This is described in the ITU-T standard T.38. Client devices **MAY** employ fax relay.

#### 5.1.3 Echo Compensation Support

When end-to-end delay in an audio communication is more than 20 milliseconds, an artifact called line echo can occur. This echo, if not removed, will be heard by the remote talker (thus it is also called talker echo) whenever he or she speaks.

Line echo is created at the telephone interface of the MTA, or the PSTN interface of the PSTN gateway. A device called a hybrid coil (or hybrid) converts the separate audio transmit and receive signals (four-wire interface) into a single two-wire interface compatible with a standard telephone. This conversion by the hybrid creates an echo back to the remote talker. An echo canceller is used to remove this echo.

Line echo cancellation **MUST** be provided in PacketCable MTA and Gateway devices to mitigate the effects of line echo. This echo canceller **MUST** allow both parties to speak simultaneously (double-talk), so that one talker does not seize the line and block out the other user from being heard.

During periods when only the remote talker is speaking, the local echo canceller **SHOULD** either inject comfort noise or allow some noise to pass through to the remote talker, so that a “dead-line” is not perceived. However, if local voice activity detection (VAD) is enabled, either the noise injection **SHOULD** be disabled, or the echo canceller **SHOULD** communicate its state with the VAD, in order for the VAD to not estimate the injected noise mistakenly as the true background noise.

In an application where the MTA is located in a home, the length of the echo canceller is typically short (eight msec or less). For PSTN gateway applications, the echo canceller length is typically much longer (32 msec or longer). Vendors **MAY** choose to differentiate their products by providing longer echo canceller lengths suitable for their application, or other programmable parameters.

In applications where a non-standard telephone interface is used (e.g., microphone and headset), echo cancellation may not be necessary. However, where a microphone and speakers are used, acoustic echo cancellation may be necessary, and vendors implementing these products **SHOULD** employ acoustic echo cancellation.

The performance of the line echo canceller **SHOULD** comply with either ITU G.165 or ITU G.168.

#### **5.1.4 Asymmetrical Services Support**

MTA devices **SHOULD** be capable of supporting employment of different codecs for upstream and downstream audio channels. This allows potential optimization of device resources, network bandwidth, and user service quality.

#### **5.1.5 Hearing-impaired Services Support**

For over one million hearing-impaired North Americans and 20 million North Americans with some amount of hearing loss, TTY (teletype technology) equipment can be the primary communication link to the outside world. This type of equipment has evolved lacking the type of standardization allowing broad interoperability among international manufacturers. The ITU, as recently as February 1998, adopted the V.18 standard to begin alleviating this problem. Recommendation V.18 attempts to outline a procedure, which includes protocol negotiation, for connecting these devices.

Since CPE for the hearing impaired consists of text input/output devices coupled with voice-band modems, any system designed to support them would need to be able to

pass DTMF and voice-band modem tones coherently. Of the list of proposed voice codecs, only G.711 would be able to achieve this, given that the other standards are not designed for passage of complex tones associated with modem communications. Typically, these devices will interface to the PSTN via an acoustical coupler to a phone or with a regular RJ-11 telephone jack.

MTA devices **MUST** support detection of ITU V.18 hearing-impaired tones, including V.18 Annexes A, B, F, and G. Upon detection of a V.18 signal, the codec at each end is then switched to G.711 for the remainder of the session. Additionally, echo compensation is disabled for the duration of the V.18 call. It is optional to disable echo cancellation for Annex B because it is DTMF-based. After the session has completed, echo compensation is re-enabled.

### 5.1.6 $\mu$ -law and A-law Support

Both companding modes ( $\mu$ -law and A-law) of G.711 **MUST** be supported. If the analog-to-digital interface at the encoder uses A-law encoding, then A-law encoding must be selected for G.711 encoding. Otherwise, if the analog-to-digital interface at the encoder uses  $\mu$ -law encoding, then  $\mu$ -law encoding must be selected for G.711 encoding.

However, if one end of a voice connection uses an A-law interface, while the other end uses  $\mu$ -law, then the A-law decoder **MUST** transcode the incoming  $\mu$ -law packets to A-law, while the  $\mu$ -law decoder **MUST** transcode the incoming A-law packets to  $\mu$ -law.

## 5.2 Mandatory Codecs

The following codecs **MUST** be supported in all MTAs.

### 5.2.1 G.711

G.711 **MUST** be supported in all MTAs. This codec provides toll-quality bitrate and is ubiquitous. It provides the “fallback” position for services such as fax, modem, and hearing-impaired services support, as well as common gateway transcoding support. In addition, G.711 is used as the fallback mode if there are not enough resources to establish a new connection using the requested codec (e.g. two channels of the **RECOMMENDED** G.728 or G.729 Annex E are already in existence, and there are not enough resources for a third connection to use a compressed codec). G.711 is IPR free.

## 5.3 Recommended Codecs

In addition to G.711, it is **RECOMMENDED** that MTAs also support at least one of the following codecs.

### 5.3.1 G.728

G.728 SHOULD be supported in all MTA's. PacketCable has as a mandate to provide toll or superior voice quality. G.728 is a mid-bitrate (16 kb/s), high-quality solution. Mandating a codec in this range provides high quality, low-bandwidth performance for on-net calls and ensures the highest possible performance for applications such as IVR systems. In addition, it provides superior background noise handling, as well as medium quality music carriage.

### 5.3.2 G.729 Annex E

G.729 Annex E SHOULD be supported in all MTA's. PacketCable has as a mandate to provide toll or superior voice quality. G.729E is a mid-bitrate (11.8 kb/s), high-quality solution. Mandating a codec in this range provides high quality, low-bandwidth performance for on-net calls and ensures the highest possible performance for applications such as IVR systems. In addition, it provides superior background noise handling, as well as medium quality music carriage.

## 5.4 Optional Features

### 5.4.1 Wideband Codecs

Given that the majority of early customers will be “black phone” users, support for a wideband (*i.e.*, greater than circuit voice bandwidth) codecs is not being mandated. However, some vendors optionally MAY choose to differentiate their product by selecting components that will support higher fidelity in the event a wideband codec is provisioned through methods specified in Section 4.1.1.

### 5.4.2 Optional Codecs

A vendor MAY supply any codecs not described herein.

### 5.4.3 Voice Activity Detection (VAD)

A vendor MAY employ VAD to reduce bandwidth consumption. If employed, this capability MUST be optional, allowing disabling. Some codecs have associated VAD implementations (e.g. G.729B), while many others do not (e.g. G.711 and G.728). In the latter cases, the VAD implementation MUST adhere to the IMTC Voice-Over-IP Forum Service Interoperability Implementation Agreement 1.0, dated December 1, 1997.

## 5.5 Session Description of CODECS

Session descriptor protocol (SDP) messages are used to describe multimedia sessions for the purposes of session announcement, session invitation, and other forms of multimedia session initiation. SDP descriptions are used in both Network Call Signaling (NCS) [PACKET1] and Distributed Call Signaling (DCS) [DCS1]. This

section describes the required specification of the codec in SDP, and the required mapping of the SDP description into RSVP flowspecs.

A typical SDP description contains many fields that contain information regarding the session description (protocol version, session name, session attribute lines, etc.), the time description (time the session is active, etc.), and media description (media name and transport, media title, connection information, media attribute lines, etc.). The two critical components for specifying a codec in an SDP description are the media name and transport address (m) and the media attribute lines (a).

The media name and transport address (m) are of the form:

```
m=<media> <port> <transport> <fmt list>
```

The media attribute line(s) (a) are of the form:

```
a=<token>:<value>
```

A typical IP-delivered voice communication would be of the form:

```
m=audio 3456 RTP/AVP 0
```

```
a=ptime:10
```

On the transport address line (m), the first term defines the media type, which in the case of an IP voice communications session is audio. The second term defines the UDP port to which the media is sent (port 3456). The third term indicates that this stream is an RTP Audio/Video profile. Finally, the last term is the media payload type as defined in the RTP Audio/Video Profile (reference RFC1890). In this case, the 0 represents a static payload type of u-law PCM coded single channel audio sampled at 8KHz. On the media attribute line (a), the first term defines the packet formation time (10ms).

Payload types other than those defined in RFC 1890 are dynamically bound by using a dynamic payload type from the range 96-127, as defined in RFC2327, and a media attribute line. For example, a typical SDP message for G.726 would be composed as follows:

```
m=audio 3456 RTP/AVP 96
```

```
a= rtpmap:96 G726-32/8000
```

The payload type 96 indicates that the payload type is locally defined for the duration of this session, and the following line indicates that payload type 96 is bound to the encoding “G726-32” with a clock rate of 8000 samples/sec.

CODECS defined in this specification MUST be encoded with the following string names in the rtpmap parameter:

**Table 2 Codec RTPMap Parameters**

Codec	Rtpmap Parameter
G.726 at 16kb/s	G726-16/8000
G.726 at 24 kb/s	G726-24/8000
G.726 at 32 kb/s	G726-32/8000
G.726 at 40 kb/s	G726-40/8000
G.728	G728/8000
G.729A	G729A/8000
G.729E	G729E/8000

In addition, G.711 MAY be encoded with a dynamic payload type code, in an rtpmap parameter using the name PCMU/8000.

For every defined CODEC (whether it is represented in SDP as a static or dynamic payload type), the following table describes the mapping that MUST be used from either the payload type or ASCII string representation to the bandwidth requirements for that CODEC.

The mapping of RTP/AVP code to RSVP Flowspec (as used by Dynamic Quality of Service [DQOS1]) MUST be according to the following table:

**Table 3 Mapping of Session Description Parameters to RSVP Flowspec**

Parameters from Session Description			Flowspec parameters		Comments
RTP/AVP code	Rtpmap	Ptime (msec)	Values $b, m, M^1$	Values $r, p^2$	
0	<none>	10	120 bytes	12,000 bytes/sec	G.711 using the Payload Type defined by IETF
0	<none>	20	200 bytes	10,000 bytes/sec	
0	<none>	30	280 bytes	9,333 bytes/sec	
96-127	PCMU/8000	10	120 bytes	12,000 bytes/sec	G.711 PCM, 64 kb/sec, default CODEC
96-127	PCMU/8000	20	200 bytes	10,000 bytes/sec	
96-127	PCMU/8000	30	280 bytes	9,333 bytes/sec	
96-127	G726-16/8000	10	60 bytes	6,000 bytes/sec	
96-127	G726-16/8000	20	80 bytes	4,000 bytes/sec	
96-127	G726-16/8000	30	100 bytes	3,333 bytes/sec	
96-127	G726-24/8000	10	70 bytes	7,000 bytes/sec	
96-127	G726-24/8000	20	100 bytes	5,000 bytes/sec	
96-127	G726-24/8000	30	130 bytes	4,333 bytes/sec	

<sup>1</sup>  $b$  is bucket depth (bytes).  $m$  is minimum policed unit (bytes).  $M$  is maximum datagram size (bytes).

<sup>2</sup>  $r$  is bucket rate (bytes/sec).  $p$  is peak rate (bytes/sec).

Parameters from Session Description			Flowspec parameters		Comments
RTP/AVP code	Rtpmap	Ptime (msec)	Values b,m,M <sup>1</sup>	Values r,p <sup>2</sup>	
2	<none>	10	80 bytes	8,000 bytes/sec	G.726-32, identical to G.721, which is assigned Payload Type 2 by IETF
2	<none>	20	120 bytes	6,000 bytes/sec	
2	<none>	30	160 bytes	5,333 bytes/sec	
96-127	G726-32/8000	10	80 bytes	8,000 bytes/sec	
96-127	G726-32/8000	20	120 bytes	6,000 bytes/sec	
96-127	G726-32/8000	30	160 bytes	5,333 bytes/sec	
96-127	G726-40/8000	10	90 bytes	9,000 bytes/sec	
96-127	G726-40/8000	20	140 bytes	7,000 bytes/sec	
96-127	G726-40/8000	30	190 bytes	6,333 bytes/sec	
15	<none>	10	60 bytes	6,000 bytes/sec	G.728, assigned Payload Type 15 by IETF
15	<none>	20	80 bytes	4,000 bytes/sec	
15	<none>	30	100 bytes	3,333 bytes/sec	
96-127	G728/8000	10	60 bytes	6,000 bytes/sec	G.728, LD-CELP, 16kb/s
96-127	G728/8000	20	80 bytes	4,000 bytes/sec	
96-127	G728/8000	30	100 bytes	3,333 bytes/sec	
18	<none>	10	50 bytes	5,000 bytes/sec	G.729A, identical to G.729, assigned Payload Type 18 by IETF
18	<none>	20	60 bytes	3,000 bytes/sec	
18	<none>	30	70 bytes	2,333 bytes/sec	
96-127	G729A/8000	10	50 bytes	5,000 bytes/sec	G.729A, CS-ACELP, 8kb/s, 10ms frame size with 5ms lookahead
96-127	G729A/8000	20	60 bytes	3,000 bytes/sec	
96-127	G729A/8000	30	70 bytes	2,333 bytes/sec	
96-127	G729E/8000	10	55 bytes	5,500 bytes/sec	G.729E, CS-ACELP, 11.8kb/s, 10ms frame size with 5ms lookahead
96-127	G729E/8000	20	70 bytes	3,500 bytes/sec	
96-127	G729E/8000	30	85 bytes	2,833 bytes/sec	

## 6 VIDEO REQUIREMENTS

### 6.1 Overview

Packet-based video applications are one of the major potential enhancements to a PacketCable service offering. Residential and business video conferencing, distance learning, and distance selling are just a few of the applications possible.

Yet this technology is nascent, and the precise content, form, and technology delivery for mass-market video applications is still gestating. The goal at this point for the PacketCable effort is to clarify minimum video requirements for the most important current or anticipated interactive video applications, providing guideposts for implementations to maximize interoperability and customer satisfaction.

This section addresses details of video communication over the PacketCable network—in particular, the video codec requirements. The H.261 and H.263 standards (as well as H.245, or a functionally equivalent specification) are the basis and reference for this specification; highlights of these recommendations important to PacketCable are illustrated here. Additionally, issues that have dependencies upon other PacketCable resources, such as signaling and quality-of-service (QoS), are outlined.

### 6.2 PacketCable Video Devices

The PacketCable Multimedia Terminal Adapter 2 (MTA-2) offers video in addition to audio communication. As with the audio-only PacketCable terminals, the functional basis of the MTA-2 will be requirements specified in the *PacketCable Product Definition* [PCPROD], along with capabilities required to support the protocol specifications described in the *Network Based Call-Signaling Protocol Specification* [PACKET1].

### 6.3 Video Encoder Requirements

The video encoder provides a self-contained digital bitstream that may be combined with a media bitstream and/or signals. The video decoder performs the reverse process. Pictures are sampled at an integer multiple of the video-line rate. This sampling clock and the digital network clock are asynchronous. The transmission clock is provided externally. The video bitrate may be variable. In H.263, no constraints on the video bitrate are given; the terminal or the network, as determined by the CMS or gatekeeper, will provide constraints.

For reasons of interoperability, all PacketCable MTA-2 terminals providing video communications **MUST** be capable of encoding and decoding video according to H.261. This will permit video communication without the transcoding of video with terminals across the other networks, such as H.320 terminals across an ISDN network or an H.324 terminal across a PSTN network. The use of H.261 establishes a common denominator across all communication networks and retains backward compatibility with existing systems.

However, H.263 is the preferred video codec and recommended for use in PacketCable systems for a variety of reasons. Therefore, all PacketCable MTA-2 terminals providing video communications **MUST** also be capable of encoding and decoding video according to H.263. The most important improvement in H.263 is the advancement in motion estimation accuracy to a half-pixel, yielding a lower bit-per-picture requirement at a given bitrate. This, as well as several other advancements in the H.263 baseline codec and Annexes listed below, result in a higher frame rate and/or resolution at a given bitrate versus H.261.

## 6.4 Video Format Requirements

As stated in the H.263 recommendation:

“To permit a single recommendation to cover use in and between regions using 625- (PAL) and 525- (NTSC) line television standards, the source coder operates on pictures based on a common intermediate format (CIF). The standards of the input and output television signals, which may, for example, be composite or component, analogue or digital and the methods of performing any necessary conversion to and from the source coding format are not subject to recommendation.”

The possible resolutions for the H.261 are CIF and quarter common intermediate format (QCIF). The possible resolutions for H.263 are sub-QCIF (SQCIF), QCIF, CIF, 4CIF, and 16CIF. CIF and QCIF are defined in H.261; SQCIF, 4CIF and 16CIF are defined in H.263.

**Table 4 Number of Pixels Per Line and Number of Lines for Each Picture Format**

Picture Format	Number of pixels for luminance (dx)	Number of lines for luminance (dy)	Number of pixels for chrominance (dx/2)	Number of lines for chrominance (dy/2)
SQCIF	128	96	64	48
QCIF	176	144	88	72
CIF	352	288	176	144
4CIF	704	576	352	288
16CIF	1408	1152	704	576

An MTA-2 **MUST** support CIF and QCIF at a minimum. CIF is required for casual videoconferencing usage and is efficient for conferencing with a reasonable amount of motion at bitrates ranging from 128 kbps to 768 kbps. QCIF is required for interoperability with other endpoints not capable of encoding or decoding CIF, or if the MTA-2 is required to encode or decode two or more video streams in the case of a multi-point call.

MTA-2 implementations **MAY** employ SQCIF, 4CIF, and 16CIF.

SQCIF is any active picture size less than QCIF, filled out by a black border, and coded in the QCIF format. SQCIF could be used for multiple encode or decode streams, as well as interoperability with a very low bit-rate channel such as wireless.

4CIF and 16CIF are suitable for applications requiring very high resolution per frame as 4CIF exceeds the resolution of NTSC displays and 16CIF is 4x this format. Examples of applications for 4CIF and 16CIF are high-resolution snapshots, document cameras, corporate business conferencing, and broadcast-quality streaming video. Snapshots and still frames at these resolutions are possible at all frame rates. Motion video at these resolutions typically will require a very high bit-rate depending upon the desired frame rate.

For all these formats, the pixel aspect ratio is the same as that of the CIF format. (NOTE: The resulting picture aspect ratio for H.263 SQCIF is different from the other formats.)

Other video codecs, and other picture formats, MAY also be employed, depending upon mutual device negotiation. The MTA-2 terminal optionally MAY send more than one video channel at the same time, for example, to convey the speaker and a second video source. The MTA-2 terminal optionally MAY receive more than one video channel at the same time, for example, to display multiple participants in a distributed multipoint conference.

The video bitrate, picture format, and algorithm options, which can be accepted by the decoder, MUST be defined during the capability exchange. The encoder MAY transmit any or all options that are within the decoder capability set. The decoder SHOULD generate requests for preferred modes, but the encoder MAY ignore these requests if they are not mandatory modes. Decoders indicating capability for a particular algorithm option also MUST be capable of accepting mandatory video bitstreams that do not make use of that option.

MTA-2 terminals MUST be capable of operating in asymmetric video bit-rates, frame rates, and picture resolutions (if more than one picture resolution is supported). For example, this will allow a CIF-capable terminal to transmit QCIF while receiving CIF pictures.

As stated in the H.263 recommendation, when each video logical channel is opened, the maximum operating mode to be used on that channel MUST be signaled to the receiver. The maximum mode signaled includes maximum picture format, algorithm options, maximum codec bitrate, *etc.*, as defined in H.263.

The header within the video logical channel indicates which mode, within the stated maximum, actually is used for each picture. For example, a video logical channel opened for CIF format may transmit CIF, QCIF, or SQCIF pictures, but not 4CIF or 16CIF. A video logical channel MAY negotiate subsets of options, but MUST not use options that were not signaled.

## 6.5 H.263 Annexes

In addition to the H.263 baseline codec, there are several annexes that can improve the picture quality (with respect to frame rate, resolution, and bit-per-pixel coding efficiency). All of these annexes MAY be supported as optional codec features. Brief descriptions (from the H.263 recommendation) of each of the annexes follows. In order to guide vendor development and to encourage the highest common denominator of video quality possible employing the H.263 standard, the descriptions include *recommendations* of the applicability and/or usefulness of the H.263 annexes to the PacketCable video codec effort.

### Annex D. Unrestricted Motion Vector Mode

Does two things: (1) Allows motion vectors to point outside the picture boundaries; and (2) allows for longer motion vectors. Adds some complexity in the motion estimation process, but the longer vectors may be useful for larger picture sizes.

*Recommendation:* MTA-2's SHOULD employ this mode.

### Annex E. Syntax-based Arithmetic Coding

Describes an alternate method of coding VLC codeword symbols. Adds considerable complexity with only marginal gain in compression performance. May also suffer in the error resiliency department.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

### Annex F. Advanced Prediction Mode

Main contribution is overlapped block motion compensation (OBMC), which yields much smoother prediction. There is a considerable increase in complexity, and Annex J (below) accomplishes much the same thing (with lower complexity). Despite this, it's still beneficial or, at the very least, should be the first "high complexity option" chosen.

*Recommendation:* MTA-2's SHOULD employ this mode.

### Annex G. PB-Frames Mode

Describes a method for increasing temporal resolution (especially for lower bitrates) through the use of bidirectionally predicted B-frames. Adds complexity and delay, plus the B-frames tend to take a hit in quality.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

### Annex H. Forward Error Correction for Coded Video Signal

Describes a method for forward error correction (FEC) for the H.263 video signal.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

### Annex I. Advanced INTRA Coding Mode

Describes an alternate method of coding INTRA blocks. Requires only small increase in complexity, but yields only minimal quality gain.

*Recommendation:* MTA-2's SHOULD employ this mode.

#### Annex J. Deblocking Filter Mode

Describes a simple edge-deblocking filter used inside the video-coding loop (as opposed to a non-standardized postprocessing filter). Resulting quality is comparable in many cases to that obtained using Annex F (above), but with far fewer and much simpler calculations.

*Recommendation:* MTA-2's SHOULD employ this mode.

#### Annex K. Slice Structured Mode

Permits the use of (mostly) arbitrary resynchronization points within a picture (as opposed to GOB resynch points only), making it quite amenable to packet-based transports. Increases error resilience with little gain in complexity. Small (subpicture-duration) increase in delay, just as if GOB resynch points had been used.

*Recommendation:* MTA-2's SHOULD employ this mode.

#### Annex L. Supplemental Enhancement Information

Describes the format for sending supplemental information related to a picture or pictures, *e.g.*, picture freeze/release. A necessity for multipoint communications. Negligible increase in complexity.

*Recommendation:* MTA-2's SHOULD employ this mode.

#### Annex M: Improved PB-Frames Mode

Similar to Annex G (above), but with an improved methodology. Same general shortcomings (*i.e.*, complexity, delay), however.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

#### Annex N: Reference Picture Selection Mode

Modifies the temporal prediction process by allowing the use of pictures other than the immediately preceding picture as a reference picture for prediction. May be useful in error-prone environments. Increases complexity and storage requirements. Requires a back channel.

*Recommendation:* MTA-2's MAY employ this mode.

#### Annex O. Temporal/SNR/Spatial Scalability

Describes methods to implement temporal (frame rate), SNR (picture quality), and/or spatial (picture size) scalability. In other words, being able to decode a sequence at multiple levels of perceived quality, *i.e.*, layered video codecs. Substantial increase in complexity and bitrate, as well as an increase in delay in many cases.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

#### Annex P. Reference Picture Resampling

Describes a process in which the reference picture used for prediction is resampled ("warped") prior to prediction.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

Annex Q. Reduced Resolution Update Mode

Allows reduced [spatial] resolution updates to a reference picture having a higher resolution.

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

Annex R. Independently Segmented Decoding Mode

Improves error resilience by localizing errors to only a segment (or slice; see Annex K, above) of a picture. Significantly improves error robustness in the presence of packet loss. Yields some loss in compression efficiency, however, as well as a moderate increase in complexity.

*Recommendation:* MTA-2's SHOULD employ this mode.

Annex S. Alternative INTER VLC Mode

Specifies an alternate VLC coding table for INTER-coded pictures in order to increase compression efficiency. Minimal improvement, at the expense of error detection capability (VLC table switching relies on the number of decoded coefficients being > 64, removing the ability to detect this sort of run-length error).

*Recommendation:* MTA-2's SHOULD NOT employ this mode.

Annex T. Modified Quantization Mode

Modifies the operation of the quantizer, *e.g.*, step size, DCT coefficient range. Improves color representation (especially in high-motion sequences) and adds additional error detection capability. Minimal increase in complexity.

*Recommendation:* MTA-2's SHOULD employ this mode.

A summary of these recommendations is presented in the table below. Also listed (for purposes of comparison only) are the three levels of preferred mode support described in Appendix II of H.263.

**Table 5 H.263 Annexes and their Applicability to PacketCable**

Annex	H.263 Preferred Modes			PacketCable?
	Level 1	Level 2	Level 3	
D		x	x	Y
E				N
F			x	Y
G				N
H				N
I	x	x	x	Y
J	x	x	x	Y
K		x	x	Y
L	x	x	x	Y
M			x	N
N				Y/N
O				N
P		x	x	N
Q				N
R			x	Y

S			x	N
T	x	x	x	Y

## 6.6 Multipoint Conferencing Support

In addition to the basic operation for encoding and decoding video streams, the MTA-2 MAY include support for multipoint conferences. If so, there are several commands particular to the video codec that enable multipoint support. These are:

### 6.6.1 Freeze Picture Request

Causes the decoder to freeze its displayed picture until a freeze picture release signal is received or a time-out period of at least six seconds has expired. The transmission of this signal is by external means.

### 6.6.2 Fast Update Request

Causes the encoder to encode its next picture in INTRA mode with coding parameters to avoid buffer overflow. The transmission method for this signal is by external means.

### 6.6.3 Freeze Picture Release

A signal from an encoder that has responded to a fast update request and allows a decoder to exit from its freeze picture mode and display decoded pictures in the normal manner. This signal is transmitted in the picture header of the first picture coded in response to the fast update request.

### 6.6.4 Continuous Presence Multipoint (CPM)

In H.263, a negotiable CPM mode is provided in which up to four independent H.263 QCIF bitstreams can be multiplexed as independent “sub-bitstreams” into one new video bitstream. Capability exchange for this mode is signaled by external means. Each sub-bitstream is considered as a normal H.263 bitstream and shall, therefore, comply with the capabilities that are exchanged by external means. The information in each individual bitstream is also completely independent from the information in the other bitstreams; for example, the picture rates for the different H.263 bitstreams may be different from one another.

## 6.7 Signaling Messages

At the time of this draft specification, the precise signaling protocol for all client devices has not been specified, but the following discussion demonstrates the necessary signals, whatever the protocol.

H.245 provides an example of essential signaling components vital to an MTA-2 video call. Not only can H.245 be used for the exchange of capabilities at the initialization of a call, it may also be used during a call for several video and

conference-centric commands. A list of mandatory (M) and optional (O) signals from the H.245 command set are listed below for receiving and transmitting MTA-2s. The mandatory commands (or their functional equivalents) MUST be implemented in the PacketCable signaling system.

**Table 6 H.245 Commands that are Applicable to PacketCable**

Message	Receiving MTA Status	Transmitting MTA Status
Send Terminal Capability Set	M	M
Encryption	O	O
Flow Control	M	O
End Session	M	M
Miscellaneous Commands		
Equalize Delay	O	O
Zero Delay	O	O
Multipoint Mode Command	M	O
Cancel Multipoint Mode Command	M	O
Video Freeze Picture	M	O
Video Fast Update Picture	M	O
Video Fast Update GOB	M	O
Video Fast Update MB	M	O
Video Temporal Spatial Trade Off	O	O
Video Send Sync Every GOB	O	O
Video Send Sync Every GOB Cancel	O	O
MCLocationIndication	M	O
Terminal ID Request	O	O
Terminal List Request	O	O
Broadcast Me	O	O
Cancel Broadcast Me	O	O
Make Terminal Broadcaster	O	O
Send This Source	O	O
Cancel Send This Source	O	O
Drop Terminal	O	O
Make Me Chair	O	O
Cancel Make Me Chair	O	O
Drop Conference	O	O
Enter H.243 Password	O	O
Enter H.243 Terminal Id	O	O
Enter H.243 Conference ID	O	O
Request Terminal ID	O	O
Terminal ID Response	O	O
Terminal List Response	O	O
Video Command Reject	O	O
Make Me Chair Response	O	O

## Appendix A. Codec Comparison Tables

The tables below summarize standard speech coder characteristics<sup>3</sup>.

**Table 7. ITU and ETSI Speech Coders**

Standards Body	ITU	ITU	ITU	ITU	ITU	ITU	ETSI	ETSI	ETSI
<b>Recommendation</b>	G.711	G.726	G.728	G.729	G.729A	G.723.1	GSM-(FR)	GSM-(HR)	GSM-(EFR)
<b>Coder Type</b>	Compounded PCM	ADPCM	LD-CELP	CS-ACELP	CS-ACELP	MPC-MLQ & ACELP	RPE-LTP	VSELP	ACELP
<b>Dates</b>	1972	1990	1992/4	1995	1996	1995	1987	1994	1995
<b>Bitrate</b>	64 kb/s	16-40 kb/s	16 kb/s	8 kb/s	8 kb/s	6.3 & 5.3 kb/s	13 kb/s	5.6 kb/s	12.2 kb/s
<b>Peak Quality<sup>4</sup></b>	Toll	≤Toll	Toll	Toll	Toll	≤Toll	<Toll	=GSM	Toll
<b>Background Noise<sup>5</sup></b>	Toll	≤ Toll	Toll	≤ Toll	≤ Toll	≤ Toll	<Toll	< GSM	Toll
<b>Tandems<sup>6</sup></b>	Toll	Toll	Toll	< Toll	< Toll	< Toll	<< Toll	< GSM	Toll
<b>Frame Erasures<sup>7</sup></b>	No mechanism	No mechanism	3%	3%	3%	3%	3%	3%	3%
<b>Complexity (MIPS)</b>	<<1	~1	~30	≤20	≤11	≤18	~4.5	~30	~20
<b>RAM</b>	1 byte	<50 bytes	2 kbytes	<2.5 kbytes	2 kbytes	2.2 kbytes	1 kbytes	12 kbytes	9 kbytes
<b>Frame Size</b>	0.125 ms	0.125 ms	0.625 ms	10 ms	10 ms	30 ms	20 ms	20 ms	20 ms
<b>Look Ahead</b>	0	0	0	5 ms	5 ms	7.5 ms	0	4.4 ms	0
<b>Codec Delay<sup>8</sup></b>	0.25 ms	0.25 ms	1.25 ms	25 ms	25 ms	67.5 ms	40 ms	44.4 ms	40 ms

<sup>3</sup> Some of the data in the Code Comparison Tables is from “Current Methods of Speech Coding.” R.V.Cox. *International Journal of High Speed Electronics & Systems*, Vol 8, No 1 (1997) pp 13–68.

**Table 8. North American Wireless Speech Coders**

<b>Standards Body</b>	TIA	TIA	TIA	TIA	TIA
<b>Recommendation</b>	IS-54	IS-641	IS-96	IS-127	IS-133
<b>System</b>	TDMA	TDMA	CDMA	CDMA	CDMA
<b>Coder Type</b>	VSELP	ACELP	QCELP	ACELP	CELP
<b>Dates</b>	1990	1995	1993	1997	1997
<b>Bitrate</b>	7.95 kb/s	7.4 kb/s	0.8-8.5 kb/s	0.8-8 kb/s	0.8-13 kb/s
<b>Peak Quality<sup>4</sup></b>	= GSM	Toll	= GSM	Toll	Toll
<b>Background Noise<sup>5</sup></b>	<< Toll	< Toll	<< Toll	< Toll	Toll ?
<b>Tandems<sup>6</sup></b>	<< Toll	< Toll	<< Toll	< Toll	Toll ?
<b>Frame Erasures<sup>7</sup></b>	3%	3%	3%	3%	3%
<b>Complexity (MIPS)</b>	20	20	20	20	20
<b>RAM</b>	2K	4K	2K	4K?	4K
<b>Frame Size</b>	20 ms	20 ms	20 ms	20 ms	20 ms
<b>Look Ahead</b>	5 ms	5 ms	5 ms	5 ms	5 ms
<b>Codec Delay<sup>8</sup></b>	45 ms	45 ms	45 ms	45 ms	45 ms

**Table 9. G.729 Series Table and Discussion**

<b>Standards Body</b>	ITU	ITU	ITU	ITU
<b>Recommendation</b>	G.729	G.729A	G.729D	G.729E
<b>Coder Type</b>	CS-ACELP	CS-ACELP	CS-ACELP	CS-ACELP
<b>Dates</b>	1995	1996	1998	1998
<b>Bitrate</b>	8 kb/s	8 kb/s	6.4 kb/s	11.8 kb/s
<b>Peak Quality<sup>4</sup></b>	Toll	Toll	< Toll	Toll
<b>Background Noise<sup>5</sup></b>	≤ Toll	≤ Toll	< Toll	Toll
<b>Tandems<sup>6</sup></b>	< Toll	< Toll	< Toll	Toll
<b>Frame Erasures<sup>7</sup></b>	3%	3%	3%	3%
<b>Complexity (MIPS)</b>	≤20	≤11	<20	<30
<b>RAM</b>	<2.5 kbytes	2 kbytes	<2.5 kbytes	<4 kbytes
<b>Frame Size</b>	10 ms	10 ms	10 ms	10 ms
<b>Look Ahead</b>	5 ms	5 ms	5 ms	5 ms
<b>Codec Delay<sup>8</sup></b>	25 ms	25 ms	25 ms	25 ms

G.729 was finalized in 1995 originally by the ITU to be a toll quality 8 kb/s standard. In that year, the ITU was requested to create a low-complexity coder for simultaneous voice and data. G.729A was created as a low-complexity version that is fully interoperable with G.729. G.729B is a speech/silence detector and comfort noise generator. It can be used with either G.729 or G.729A to provide an option for variable rate usage, also known as discontinuous transmission. G.729C contains the floating-point versions of G.729 and G.729A. G.729D is a 6.4 kb/s version of G.729. It was created to provide an optional lower rate that can be used briefly for periods of network congestion, or when more bits are needed for channel error protection. Its quality is less than that of G.729 or G.729A. G.729E is a higher rate version of G.729 designed to provide higher quality for background noise conditions, music, and tandems. It is a hybrid coder. It codes each frame two different ways and selects the

<sup>4</sup> Peak quality means clean input speech and clear channel for single encoding.

<sup>5</sup> Background noise refers to overall performance in background noises such as car noise, babble, office, and music with an input SNR of 15-20 dB.

<sup>6</sup> Tandems refer to the performance of the coder for multiple asynchronous encodings. Toll quality is defined as the performance of 32 kb/s G.726. Coders such as G.729, G.723.1, and others, are known to degrade more quickly with multiple tandems than G.726.

<sup>7</sup> Frame erasures refers to the rate at which the MOS score is approximately 0.5 MOS worse than the peak quality for that coder.

<sup>8</sup> Codec delay is equal to the sum of the look-ahead plus two times the frame size. The ITU uses this formula because it is assumed that the processing of a single device to encode and decode must be accomplished in one frame-size time or less. The transmission time is a function of the network, as are other delays for a telephone call.

method that appears to give the greater fidelity. Its forward-adaptive mode uses CS-ACELP. Its backward-adaptive mode features a 30th-order backward-adaptive LPC synthesis filter and no pitch predictor. This mode is better for music, and it has greater complexity than the original G.729 coders have.

**Table 10: Bandwidth Attributes of Codecs<sup>9</sup>**

Codec	Bitrate (kb/s)	Bytes/10ms	Frms/pckt	Bytes/pckt	Packets/s	Bytes/s	Kb/s
G711-10ms	64	80	1	120	100	12000	96
G711-20ms	64	80	2	200	50	10000	80
G711-30ms	64	80	3	280	33.33	9332.4	74.7
G.726.16-10ms	16	20	1	60	100	6000	48
G.726.16-20ms	16	20	2	80	50	4000	32
G.726.16-30ms	16	20	3	100	33.33	3333	26.7
G.726.24-10ms	24	30	1	70	100	7000	56
G.726.24-20ms	24	30	2	100	50	5000	40
G.726.24-30ms	24	30	3	130	33.33	4332.9	34.7
G.726.32-10ms	32	40	1	80	100	8000	64
G.726.32-20ms	32	40	2	120	50	6000	48
G.726.32-30ms	32	40	3	160	33.33	5332.8	42.7
G.726.40-10ms	40	50	1	90	100	9000	72
G.726.40-20ms	40	50	2	140	50	7000	56
G.726.40-30ms	40	50	3	190	33.33	6332.7	50.7
G.728-10ms	16	20	1	60	100	6000	48
G.728-20ms	16	20	2	80	50	4000	32
G.728-30ms	16	20	3	100	33.33	3333	26.7
G.729A-10ms	8	10	1	50	100	5000	40
G.729A-20ms	8	10	2	60	50	3000	24
G.729A-30ms	8	10	3	70	33.33	2333.1	18.7

<sup>9</sup> This table is intended to provide essential access network bandwidth-related information for each codec listed. Although some of the listed codecs (e.g., G.711, G.726) are sample-based rather than frame based, for anticipated purposes of flow management, frame-oriented packet sizes are listed. The three most important packet sizes are shown, corresponding to low latency (10, 20, and 30 ms) samples. Packet header overhead is calculated at 40 bytes, with 12 bytes RTP, 8 bytes UDP, and 20 bytes IP contributions. Note that G.729E is shown at a byte-boundary 12 kb/s, which includes the 2 bits/frame not currently defined. Variable bit rate VAD implementations for each codec are not listed.

## Appendix B. Glossary

<b>AAA</b>	Authentication, Authorization and Accounting
<b>Access Control</b>	Limiting the flow of information from the resources of a system only to authorized persons, programs, processes or other system resources on a network.
<b>Active</b>	A service flow is said to be “active” when it is permitted to forward data packets. A service flow must first be admitted before it is active.
<b>Admitted</b>	A service flow is said to be “admitted” when the CMTS has reserved resources (e.g. bandwidth) for it on the DOCSIS network.
<b>AF</b>	Assured Forwarding. A Diffserv Per Hop Behavior.
<b>AH</b>	Authentication header is an IPSec security protocol that provides message integrity for complete IP packets, including the IP header.
<b>A-link</b>	A-Links are SS7 links that interconnect STPs and either SSPs or SCPs. ‘A’ stands for “Access”.
<b>Announcement Server</b>	An announcement server plays informational announcements in PacketCable network. Announcements are needed for communications that do not complete and to provide enhanced information services to the user.
<b>AMA</b>	Automated Message Accounting., a standard form of call detail records (CDRs) developed and administered by Bellcore (now Telcordia Technologies)
<b>Asymmetric Key</b>	An encryption key or a decryption key used in a public key cryptography, where encryption and decryption keys are always distinct.
<b>AT</b>	Access Tandem
<b>ATM</b>	Asynchronous Transfer Mode. A protocol for the transmission of a variety of digital signals using uniform 53-byte cells.
<b>Authentication</b>	The process of verifying the claimed identity of an entity to another entity.
<b>Authenticity</b>	The ability to ensure that the given information is without modification or forgery and was in fact produced by the entity who claims to have given the information.
<b>Authorization</b>	The act of giving access to a service or device if one has the permission to have the access.
<b>BAF</b>	Bellcore AMA Format, another way of saying AMA
<b>BPI+</b>	Baseline Privacy Interface Plus is the security portion of the DOCSIS 1.1 standard which runs on the MAC layer.
<b>CBC</b>	Cipher block chaining mode is an option in block ciphers that combine (XOR) the previous block of ciphertext with the current block of plaintext before encrypting that block of the message.
<b>CBR</b>	Constant Bit Rate.
<b>CA</b>	Certification Authority - a trusted organization that accepts certificate applications from entities, authenticates applications, issues certificates and maintains status information about certificates.
<b>CA</b>	Call Agent. In this specification “Call Agent” is part of the CMS that maintains the communication state, and controls the line side of the

	communication.
<b>CDR</b>	Call Detail Record. A single CDR is generated at the end of each billable activity. A single billable activity may also generate multiple CDRs
<b>CIC</b>	Circuit Identification Code. In ANSI SS7, a two octet number that uniquely identifies a DSO circuit within the scope of a single SS7 Point Code.
<b>CID</b>	Circuit ID (Pronounced “Kid”). This uniquely identifies an ISUP DS0 circuit on a Media Gateway. It is a combination of the circuit’s SS7 gateway point code and Circuit Identification Code (CIC). The SS7 DPC is associated with the Signaling Gateway that has domain over the circuit in question.
<b>CIF</b>	Common Intermediate Format
<b>Cipher</b>	An algorithm that transforms data between plaintext and ciphertext.
<b>Ciphersuite</b>	A set which must contain both an encryption algorithm and a message authentication algorithm (e.g. a MAC or an HMAC). In general, it may also contain a key management algorithm, which does not apply in the context of PacketCable.
<b>Ciphertext</b>	The (encrypted) message output from a cryptographic algorithm that is in a format that is unintelligible.
<b>CIR</b>	Committed Information Rate.
<b>Cleartext</b>	The original (unencrypted) state of a message or data.
<b>CM</b>	DOCSIS Cable Modem.
<b>CMS</b>	Cryptographic Message Syntax
<b>CMS</b>	Call Management Server. Controls the audio connections. Also called a Call Agent in MGCP/SGCP terminology.
<b>CMTS</b>	Cable Modem Termination System, the device at a cable head-end which implements the DOCSIS RFI MAC protocol and connects to CMs over an HFC network.
<b>Codec</b>	COder-DECoder
<b>Confidentiality</b>	A way to ensure that information is not disclosed to any one other than the intended parties. Information is encrypted to provide confidentiality. Also known as privacy.
<b>COPS</b>	Common Open Policy Service Protocol is currently an internet draft which describes a client/server model for supporting policy control over QoS Signaling Protocols and provisioned QoS resource management.
<b>CoS</b>	Class of Service. The type 4 tuple of a DOCSIS 1.0 configuration file.
<b>CSR</b>	Customer Service Representative
<b>Cryptoanalysis</b>	The process of recovering the plaintext of a message or the encryption key without access to the key.
<b>Cryptographic algorithm</b>	An algorithm used to transfer text between plaintext and ciphertext.
<b>DA</b>	Directory Assistance
<b>DE</b>	Default. A Diffserv Per Hop Behavior.
<b>Decipherment</b>	A procedure applied to ciphertext to translate it into plaintext.
<b>Decryption</b>	A procedure applied to ciphertext to translate it into plaintext.
<b>Decryption key</b>	The key in the cryptographic algorithm to translate the ciphertext to plaintext

<b>DHCP</b>	Dynamic Host Configuration Protocol.
<b>DHCP-D</b>	DHCP Default - Network Provider DHCP Server
<b>Digital certificate</b>	A binding between an entity's public key and one or more attributes relating to its identity, also known as a public key certificate
<b>Digital signature</b>	A data value generated by a public key algorithm based on the contents of a block of data and a private key, yielding an individualized cryptographic checksum
<b>DNS</b>	Domain Name Server
<b>Downstream</b>	The direction from the head-end toward the subscriber location.
<b>DSCP</b>	Diffserv Code Point. A field in every IP packet which identifies the Diffserv Per Hop Behavior. In IP version 4, the TOS byte is redefined to be the DSCP. In IP version 6, the Traffic Class octet is used as the DSCP. See Appendix A.
<b>DOCSIS</b>	Data Over Cable System Interface Specification.
<b>DPC</b>	Destination Point Code. In ANSI SS7, a 3 octet number which uniquely identifies an SS7 Signaling Point, either an SSP, STP, or SCP.
<b>DQoS</b>	Dynamic Quality of Service, i.e. assigned on the fly for each communication depending on the QoS requested
<b>DTMF</b>	Dual-tone Multi Frequency (tones)
<b>EF</b>	Expedited Forwarding. A Diffserv Per Hop Behavior.
<b>E-MTA</b>	Embedded MTA – a single node which contains both an MTA and a cable modem.
<b>Encipherment</b>	A method used to translate information in plaintext into ciphertext.
<b>Encryption</b>	A method used to translate information in plaintext into ciphertext.
<b>Encryption Key</b>	The key used in a cryptographic algorithm to translate the plaintext to ciphertext.
<b>Endpoint</b>	A Terminal, Gateway or MCU
<b>EO</b>	End Office
<b>Errored Second</b>	Any 1-sec interval containing at least one bit error.
<b>ESP</b>	IPSec Encapsulation Security Payload protocol that provides both IP packet encryption and optional message integrity, not covering the IP packet header.
<b>ETSI</b>	European Telecommunications Standards Institute
<b>Event Message</b>	Message capturing a single portion of a connection
<b>FGD</b>	Feature Group D signaling
<b>F-link</b>	F-Links are SS7 links that directly connect two SS7 end points, such as two SSPs. 'F' stands for "Fully Associated"
<b>Flow [IP Flow]</b>	A unidirectional sequence of packets identified by ISO Layer 3 and Layer 4 header information. This information includes source/destination IP addresses, source/destination port numbers, protocol ID. Multiple multimedia streams may be carried in a single IP Flow.
<b>Flow [DOCSIS Flow]</b>	(a.k.a. DOCSIS-QoS "service flow"). A unidirectional sequence of packets associated with a SID and a QoS. Multiple multimedia streams may be carried in a single DOCSIS Flow.
<b>FQDN</b>	Fully Qualified Domain Name. Refer to IETF RFC 821 for details.
<b>Gateway</b>	Devices bridging between the PacketCable IP Voice Communication world

	and the PSTN. Examples are the Media Gateway which provides the bearer circuit interfaces to the PSTN and transcodes the media stream, and the Signaling Gateway which sends and receives circuit switched network signaling to the edge of the PacketCable network.
<b>H.323</b>	An ISO standard for transmitting and controlling audio and video information. The H.323 standard requires the use of the H.225/H.245 protocol for communication control between a “gateway” audio/video endpoint and a “gatekeeper” function.
<b>Header</b>	Protocol control information located at the beginning of a protocol data unit.
<b>HFC</b>	Hybrid Fiber/Coax(ial [cable]), HFC system is a broadband bi-directional shared media transmission system using fiber trunks between the head-end and the fiber nodes, and coaxial distribution from the fiber nodes to the customer locations.
<b>H.GCP</b>	A protocol for media gateway control being developed by ITU.
<b>HMAC</b>	Hashed Message Authentication Code – a message authentication algorithm, based on either SHA-1 or MD5 hash and defined in RFC 2104.
<b>HTTP</b>	Hyper Text Transfer Protocol. Refer to IETF RFC 1945 and RFC 2068.
<b>IANA</b>	Internet Assigned Numbered Authority. See <a href="http://www.ietf.org">www.ietf.org</a> for details.
<b>IC</b>	Inter-exchange Carrier
<b>IETF</b>	Internet Engineering Task Force. A body responsible, among other things, for developing standards used in the Internet.
<b>IKE</b>	Internet Key Exchange is a key management mechanism used to negotiate and derive keys for SAs in IPSec.
<b>IKE-</b>	A notation defined to refer to the use of IKE with pre-shared keys for authentication.
<b>IKE+</b>	A notation defined to refer to the use of IKE, which requires digital certificates for authentication.
<b>Integrity</b>	A way to ensure that information is not modified except by those who are authorized to do so.
<b>IntraLATA</b>	Within a Local Access Transport Area
<b>IP</b>	Internet Protocol. An Internet network-layer protocol.
<b>IPSec</b>	Internet Protocol Security, a collection of Internet standards for protecting IP packets with encryption and authentication.
<b>ISDN</b>	Integrated Services Digital Network
<b>ISUP</b>	ISDN User Part is a protocol within the SS7 suite of protocols that is used for call signaling within an SS7 network.
<b>ISTP</b>	Internet Signaling Transport Protocol
<b>ISTP – User</b>	Any element, node, or software process that uses the ISTP stack for signaling communications.
<b>ITU</b>	International Telecommunication Union
<b>IVR</b>	Interactive Voice Response System
<b>Jitter</b>	Variability in the delay of a stream of incoming packets making up a flow such as a voice communication.
<b>Kerberos</b>	A secret-key network authentication protocol that uses a choice of cryptographic algorithms for encryption and a centralized key database for

	authentication.
<b>Key</b>	A mathematical value input into the selected cryptographic algorithm.
<b>Key Exchange</b>	The swapping of public keys between entities to be used to encrypt communication between the entities.
<b>Key Management</b>	The process of distributing shared symmetric keys needed to run a security protocol.
<b>Keying Material</b>	A set of cryptographic keys and their associated parameters, normally associated with a particular run of a security protocol.
<b>Key Pair</b>	An associated public and private key where the correspondence between the two are mathematically related, but it is computationally infeasible to derive the private key from the public key.
<b>Keyspace</b>	The range of all possible values of the key for a particular cryptographic algorithm.
<b>LATA</b>	Local Access and Transport Area
<b>Latency</b>	The time, expressed in quantity of symbols, taken for a signal element to pass through a device.
<b>LD</b>	Long Distance
<b>LIDB</b>	Line Information Data Base, containing information on customers required for real-time access such as calling card personal identification numbers (PINs) for real-time validation
<b>Link Encryption</b>	Cryptography applied to data as it travels on data links between the network devices.
<b>LLC</b>	Logical Link Control, used here to mean the Ethernet Packet header and optional 802.1P tag which may encapsulate an IP packet. A sublayer of the Data Link Layer.
<b>LNP</b>	Local Number Portability. Allows a customer to retain the same number when switching from one local service provider to another.
<b>LSSGR</b>	LATA Switching Systems Generic Requirements
<b>MAC</b>	Message Authentication Code - a fixed length data item that is sent together with a message to ensure integrity, also known as a MIC.
<b>MAC</b>	Media Access Control. It is a sublayer of the Data Link Layer. It normally runs directly over the physical layer.
<b>MC</b>	Multipoint Controller
<b>MD5</b>	Message Digest 5 - a one-way hash algorithm which maps variable length plaintext into fixed length (16 byte) ciphertext.
<b>MDCP</b>	A media gateway control specification submitted to IETF by Lucent. Now called SCTP.
<b>MDU</b>	Multi-Dwelling Unit. Multiple units within the same physical building. The term is usually associated with high rise buildings
<b>MEGACO</b>	Media Gateway Control IETF working group. See <a href="http://www.ietf.org">www.ietf.org</a> for details.
<b>MG</b>	The media gateway provides the bearer circuit interfaces to the PSTN and transcodes the media stream.
<b>MGC</b>	An Media Gateway Controller is the overall controller function of the PSTN gateway. It receives, controls and mediates call signaling information between the PacketCable and PSTN.

<b>MGCP</b>	Media Gateway Control Protocol. Protocol follow on to SGCP.
<b>MIB</b>	Management Information Base
<b>MIC</b>	Message integrity code, a fixed length data item that is sent together with a message to ensure integrity, also known as a MAC.
<b>MMC</b>	Multi-Point Mixing Controller. A conferencing device for mixing media streams of multiple connections.
<b>MSO</b>	Multi-System Operator, a cable company that operates many head-end locations in several cities.
<b>MSU</b>	Message Signal Unit
<b>MTA</b>	Media Terminal Adapter – contains the interface to a physical voice device, a network interface, CODECs, and all signaling and encapsulation functions required for VoIP transport, class features signaling, and QoS signaling.
<b>MTP</b>	The Message Transfer Part is a set of two protocols (MTP 2, 3) within the SS7 suite of protocols that are used to implement physical, data link and network level transport facilities within an SS7 network.
<b>MWD</b>	Maximum Waiting Delay
<b>NANP</b>	North American Numbering Plan
<b>NANPNAT</b>	North American Numbering Plan Network Address Translation
<b>NAT Network Layer</b>	Network Address Translation Layer 3 in the Open System Interconnection (OSI) architecture; the layer that provides services to establish a path between open systems.
<b>Network Layer</b>	Layer 3 in the Open System Interconnection (OSI) architecture that provides network information that is independent from the lower layers.
<b>Network Management</b>	The functions related to the management of data across the network.
<b>Network Management OSS</b>	The functions related to the management of data link layer and physical layer resources and their stations across the data network supported by the hybrid fiber/coax system.
<b>NCS</b>	Network Call Signaling
<b>Nonce</b>	A random value used only once which is sent in a communications protocol exchange to prevent replay attacks.
<b>Non-Repudiation</b>	The ability to prevent a sender from denying later that he or she sent a message or performed an action.
<b>NPA-NXX</b>	Numbering Plan Area (more commonly known as area code) NXX (sometimes called exchange) represents the next three numbers of a traditional phone number. The N can be any number from 2-9 and the Xs can be any number. The combination of a phone number's NPA-NXX will usually indicate the physical location of the call device. The exceptions include toll-free numbers and ported number (see LNP)
<b>NTP</b>	Network Time Protocol, an internet standard used for synchronizing clocks of elements distributed on an IP network
<b>NTSC</b>	National Television Standards Committee which defines the analog color television, broadcast standard used today in North America.
<b>Off-Net Call</b>	A communication connecting a PacketCable subscriber out to a user on the PSTN
<b>On-Net Call</b>	A communication placed by one customer to another customer entirely on the

	PacketCable Network
<b>One-way Hash</b>	A hash function that has an insignificant number of collisions upon output.
<b>OSP</b>	Operator Service Provider
<b>OSS-D</b>	OSS Default – Network Provider Provisioning Server
<b>OSS</b>	Operations Systems Support. The back office software used for configuration, performance, fault, accounting and security management.
<b>PAL</b>	Phase Alternate Line – the European color television format which evolved from the American NTSC standard.
<b>PDU</b>	Protocol Data Unit
<b>PKCS</b>	Public Key Cryptography Standards, published by RSA Data Security Inc. Describes how to use public key cryptography in a reliable, secure and interoperable way.
<b>PKI</b>	Public Key Infrastructure - a process for issuing public key certificates, which includes standards, Certification Authorities, communication between authorities and protocols for managing certification processes.
<b>PKINIT</b>	The extension to the Kerberos protocol that provides a method for using public key cryptography during initial authentication.
<b>PHS</b>	Payload Header Suppression, a DOCSIS technique for compressing the Ethernet, IP and UDP headers of RTP packets.
<b>Plaintext</b>	The original (unencrypted) state of a message or data.
<b>Pre-shared Key</b>	A shared secret key passed to both parties in a communication flow, using an unspecified manual or out-of-band mechanism.
<b>Privacy</b>	A way to ensure that information is not disclosed to any one other than the intended parties. Information is usually encrypted to provide confidentiality. Also known as confidentiality.
<b>Private Key</b>	The key used in public key cryptography that belongs to an individual entity and must be kept secret.
<b>Proxy</b>	A facility that indirectly provides some service or acts as a representative in delivering information there by eliminating a host from having to support the services themselves.
<b>PSC</b>	Payload Service Class Table, a MIB table that maps RTP payload Type to a Service Class Name.
<b>PSFR</b>	Provisioned Service Flow Reference. An SFR that appears in the DOCSIS configuration file.
<b>PSTN</b>	Public Switched Telephone Network.
<b>Public Key</b>	The key used in public key cryptography that belongs to an individual entity and is distributed publicly. Other entities use this key to encrypt data to be sent to the owner of the key.
<b>Public Key Certificate</b>	A binding between an entity's public key and one or more attributes relating to its identity, also known as a digital certificate.
<b>Public Key Cryptography</b>	A procedure that uses a pair of keys, a public key and a private key for encryption and decryption, also known as asymmetric algorithm. A user's public key is publicly available for others to use to send a message to the owner of the key. A users private key is kept secret and is the only key which can decrypt messages sent encrypted by the users public key.
<b>PCM</b>	Pulse Code Modulation – A commonly employed algorithm to digitize an

	analog signal (such as a human voice) into a digital bit stream using simple analog to digital conversion techniques.
<b>QCIF</b>	Quarter Common Intermediate Format
<b>QoS</b>	Quality of Service, guarantees network bandwidth and availability for applications.
<b>RADIUS</b>	Remote Access Dial-In User Service, an internet protocol (RFC 2138 and RFC 2139) originally designed for allowing users dial-in access to the internet through remote servers. Its flexible design has allowed it to be extended well beyond its original intended use
<b>RAS</b>	Registration, Admissions and Status. RAS Channel is an unreliable channel used to convey the RAS messages and bandwidth changes between two H.323 entities.
<b>RC4</b>	A variable key length stream cipher offered in the ciphersuite, used to encrypt the media traffic in PacketCable.
<b>RFC</b>	Request for Comments. Technical policy documents approved by the IETF which are available on the World Wide Web at <a href="http://www.ietf.cnri.reston.va.us/rfc.html">http://www.ietf.cnri.reston.va.us/rfc.html</a>
<b>RFI</b>	The DOCSIS Radio Frequency Interface specification.
<b>RJ-11</b>	Standard 4-pin modular connector commonly used in the United States for connecting a phone unit into the wall jack
<b>RKS</b>	Record Keeping Server, the device which collects and correlates the various Event Messages
<b>Root Private Key</b>	The private signing key of the highest level Certification Authority. It is normally used to sign public key certificates for lower-level Certification Authorities or other entities.
<b>Root Public Key</b>	The public key of the highest level Certification Authority, normally used to verify digital signatures that it generated with the corresponding root private key.
<b>RSA Key Pair</b>	A public/private key pair created for use with the RSA cryptographic algorithm.
<b>RSVP</b>	Resource reSerVation Protocol
<b>RTCP</b>	Real Time Control Protocol
<b>RTO</b>	Retransmission Timeout
<b>RTP</b>	Real Time Protocol, a protocol defined in RFC 1889 for encapsulating encoded voice and video streams.
<b>S-MTA</b>	Standalone MTA – a single node which contains an MTA and a non DOCSIS MAC (e.g. ethernet).
<b>SA</b>	Security Association - a one-way relationship between sender and receiver offering security services on the communication flow .
<b>SAID</b>	Security Association Identifier - uniquely identifies SAs in the BPI+ security protocol, part of the DOCSIS 1.1 specification.
<b>SCCP</b>	The Signaling Connection Control Part is a protocol within the SS7 suite of protocols that provides two functions in addition to those that are provided within MTP. The first is the ability to address applications within a signaling point. The second function is Global Title Translation.
<b>SCP</b>	A Service Control Point is a Signaling Point within the SS7 network,

	identifiable by a Destination Point Code, that provides database services to the network.
<b>SCTP</b>	Simple Control Transmission Protocol.
<b>SDP</b>	Session Description Protocol.
<b>SDU</b>	Service Data Unit. Information that is delivered as a unit between peer service access points.
<b>Secret Key</b>	The cryptographic key used in a symmetric key algorithm, which results in the secrecy of the encrypted data depending solely upon keeping the key a secret, also known as a symmetric key.
<b>Session Key</b>	A cryptographic key intended to encrypt data for a limited period of time, typically between a pair of entities.
<b>SF</b>	Service Flow. A unidirectional flow of packets on the RF interface of a DOCSIS system.
<b>SFID</b>	Service Flow ID, a 32-bit integer assigned by the CMTS to each DOCSIS Service Flow defined within a DOCSIS RF MAC domain. Any 32-bit SFID must not conflict with a zero-extended 14-bit SID. SFIDs are considered to be in either the upstream direction (USFID) or downstream direction (DSFID). USFIDs and DSFIDs are allocated from the same SFID number space.
<b>SFR</b>	Service Flow Reference, a 16-bit message element used within the DOCSIS TLV parameters of Configuration Files and Dynamic Service messages to temporarily identify a defined Service Flow. The CMTS assigns a permanent SFID to each SFR of a message.
<b>SG</b>	Signaling Gateway. An SG is a signaling agent that receives/sends SCN native signaling at the edge of the IP network. In particular the SS7 SG function translates variants ISUP and TCAP in an SS7-Internet Gateway to a common version of ISUP and TCAP.
<b>SGCP</b>	Simple Gateway Control Protocol. Earlier draft of MGCP.
<b>SHA – 1</b>	Secure Hash Algorithm 1 - a one-way hash algorithm.
<b>SID</b>	Service ID. A 14-bit number assigned by a CMTS to identify an upstream virtual circuit. Each SID separately requests and is granted the right to use upstream bandwidth.
<b>Signed and Sealed</b>	An “envelope” of information which has been signed with a digital signature and sealed by using encryption.
<b>SIP</b>	Session Initiation Protocol is an application layer control (signaling) protocol for creating, modifying and terminating sessions with one or more participants.
<b>SIP+</b>	Session Initiation Protocol Plus is an extension to SIP.
<b>SNMP</b>	Simple Network Management Protocol
<b>SOHO</b>	Small Office/Home Office
<b>SPI</b>	Security Parameters Index - a field in the IPSEC header that along with the destination IP address provides a unique number for each SA.
<b>SS7</b>	Signaling System Number 7. SS7 is an architecture and set of protocols for performing out-of-band call signaling with a telephone network.
<b>SSP</b>	Signal Switching Point. SSPs are points within the SS7 network that terminate SS7 signaling links and also originate, terminate, or tandem switch calls.
<b>STP</b>	Signal Transfer Point. An STP is a node within an SS7 network that routes signaling messages based on their destination address. It is essentially a packet

	switch for SS7. It may also perform additional routing services such as Global Title Translation.
<b>Subflow</b>	A unidirectional flow of IP packets characterized by a single source and destination IP address and source and destination UDP/TCP port.
<b>Symmetric Key</b>	The cryptographic key used in a symmetric key algorithm, which results in the secrecy of the encrypted data depending solely upon keeping the key a secret, also known as a secret key.
<b>Systems Management</b>	Functions in the application layer related to the management of various open systems Interconnection (OSI) resources and their status across all layers of the OSI architecture.
<b>TCAP</b>	Transaction Capabilities Application Protocol. A protocol within the SS7 stack that is used for performing remote database transactions with a Signaling Control Point.
<b>TCP</b>	Transmission Control Protocol
<b>TD</b>	Timeout for Disconnect
<b>TFTP</b>	Trivial File Transfer Protocol
<b>TFTP-D</b>	Default – Trivial File Transfer Protocol
<b>TGS</b>	Ticket Granting Server used to grant Kerberos tickets.
<b>TGW</b>	Telephony Gateway
<b>TIPHON</b>	Telecommunications & Internet Protocol Harmonization Over Network.
<b>TLV</b>	Type-Length-Value tuple within a DOCSIS configuration file.
<b>TN</b>	Telephone Number
<b>ToD</b>	Time of Day Server
<b>TOS</b>	Type of Service. An 8-bit field of every IP version 4 packet. In a Diffserv domain, the TOS byte is treated as the Diffserv Code Point, or DSCP.
<b>Transit Delays</b>	The time difference between the instant at which the first bit of a PDU crosses one designated boundary, and the instant at which the last bit of the same PDU crosses a second designated boundary.
<b>Trunk</b>	An analog or digital connection from a circuit switch which carries user media content and may carry voice signaling (MF, R2, etc.).
<b>TSG</b>	Trunk Subgroup
<b>Tunnel Mode</b>	An IPSEC (ESP or AH) mode that is applied to an IP tunnel, where an outer IP packet header (of an intermediate destination) is added on top of the original, inner IP header. In this case, the ESP or AH transform treats the inner IP header as if it were part of the packet payload. When the packet reaches the intermediate destination, the tunnel terminates and both the outer IP packet header and the IPSEC ESP or AH transform are taken out.
<b>UDP</b>	User Datagram Protocol, a connectionless protocol built upon Internet Protocol (IP).
<b>Upstream</b>	The direction from the subscriber location toward the head-end.
<b>VAD</b>	Voice Activity Detection
<b>VBR</b>	Variable bit-rate
<b>VoIP</b>	Voice over IP
<b>WBEM</b>	Web-Based Enterprise Management (WBEM) is the umbrella under which the DMTF (Desktop Management Task Force) will fit its current and future

	specifications. The goal of the WBEM initiative is to further management standards using Internet technology in a manner that provides for interoperable management of the Enterprise. There is one DMTF standard today within WBEM and that is CIM (Common Information Model). WBEM compliance means adhering to the CIM. See <a href="http://www.dmtf.org">www.dmtf.org</a>
<b>X.509 certificate</b>	a public key certificate specification developed as part of the ITU-T X.500 standards directory

## Appendix C. References and Bibliography

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## Appendix D. Revisions

### Engineering Change Numbers

ECN	Date Ratified	Summary

## Appendix E. Acknowledgements

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