Implementing Media Gateway Control Protocols

A RADVISION White Paper

January 27, 2002

Contents

Abstract

In IP centric networks, the well-known multimedia over IP protocols have their work carefully parceled out. SIP and H.323 essentially handle call setup, connect, and teardown, SDP handles session descriptions and RTP/RTCP handles real-time media transport. So, what do the **media gateway control protocols** handle? What is a media gateway control protocol? Why do we need one?

This White Paper aims to answer these questions and to describe the essentials of the well-known media gateway control protocols, MGCP and Megaco/H.248.

Who Needs a Media Gateway Control Protocol?

Media gateway control protocols were born out of the need for IP networks to interwork with traditional telephony systems and enable support of large-scale phone-to-phone deployments. Media gateway control protocols provide remote control of media streams as they transit between IP and traditional telephone networks.

Many people confuse media control with signaling. Signaling is the establishment of a session between two or more parties. In traditional telephone systems, signaling (D-channel) and media (B-channel) are carried separately. In VoIP networks, each needs to be handled by a different type of VoIP Gateway: a Signaling Gateway and a Media Gateway. Signaling Gateways translate the D-channel data to VoIP-compatible signaling protocols, such as ISUP-over-IP, SIP or H.323, and do not involve media gateway control protocols[1]. Media Gateways provide the bridge for media to seamlessly transit between PSTN and VoIP networks by ferrying media between B-channels and RTP streams. Media Gateways Controllers control Media Gateways by means of a **media gateway control protocol**.

Media gateway control protocols specify a master/slave architecture for decomposed gateways. The Media Gateway Controller is the *master* server, and one or more Media Gateways are the *slave* clients that behave like simple switches. One Media Gateway Controller can serve many Media Gateways. An important difference between SIP and H.323, and the media gateway control protocols is that the relationship between entities in SIP and H.323 is peer-to-peer, while the relationship between entities in media gateway control protocols is master/slave.

There is a fundamental difference between SIP and H.323 and media gateway control protocols. SIP and H.323 are signaling protocols that set up and manage calls, whereas media gateway control protocols define how media streams are set up and establish media paths between IP and other networks.

Key Benefits

The decomposed gateway architecture greatly eases the problems of management and expansion.

- **Management**—Media Gateways can be small and low-cost. They require minimum configuration and management. The Media Gateway Controller controls the Media Gateway, leading to simple and centralized management.
- **Scalability**—One Media Gateway Controller can support many Media Gateways. Growth can be dynamic and expansion requires little more than the installation of another Media Gateway.

[1]. This is by far the largest misconception about Media Gateway Control Protocols.

Traditional Implementations

Various types of applications require media gateway control protocols. This section describes some of the traditional applications that use Media Gateway Control Protocols.

Trunking Gateways

During a voice or video call or conference, two types of information streams are transmitted across the network—signaling information for call setup, connect and teardown, and media information for the voice or video stream transmission. The media streams are transmitted only after the signaling has successfully connected the participating parties.

Given the fundamental difference between the way PSTN and VoIP networks handle signaling and media data, there is a need to ensure seamless communication between VoIP networks and PSTN. Trunking Gateways help to ensure this seamless communication by handling the transmission of the media between IP and PSTN.

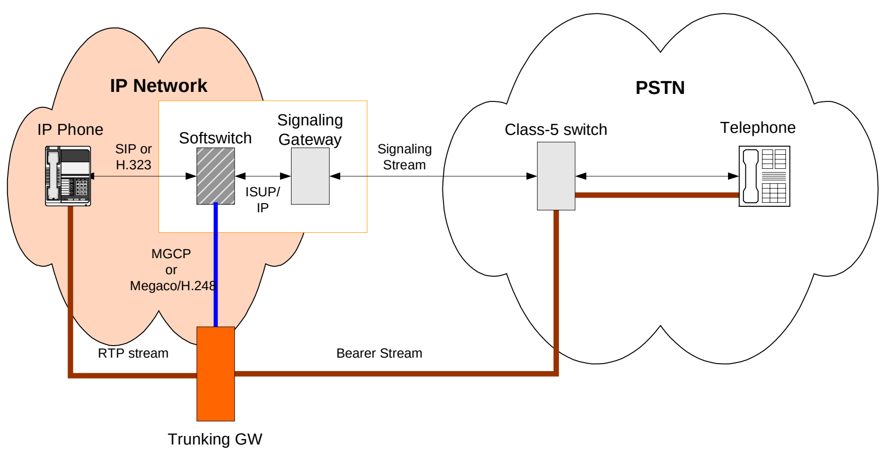

Figure 1: Trunking Gateways

In Figure 1, a Signaling Gateway (SG) is placed between an IP and a PSTN network for extracting and normalizing the incoming PSTN signaling to VoIP signaling. The Signaling Gateway works together with a Softswitch, to translate the Signaling into the particular VoIP signaling protocol required to reach VoIP endpoint, such as a SIP IP phone. The Softswitch also acts as an MGC, which controls an associated Trunking Gateway. The Trunking Gateway is a Media Gateway capable of ferrying media data between PSTN B-Channels and RTP streams. The Softswitch acting as an MGC directs the Trunking Gateway as to which B-channel is connected to which RTP stream. It may also direct the Trunking Gateway to transcode the media from one format to another or even mix various media streams together.

For example, when the IP Phone rings and someone picks up the receiver, an RTP (media) stream is sent towards the PSTN bearer channel. Since the Signaling Gateway cannot handle the RTP stream, the stream is sent to a Trunking Gateway. It is the responsibility of the Trunking Gateway to put the media stream into a bearer channel. The Softswitch provides media stream information to the Trunking Gateway.

The Softswitch (as a Media Gateway Controller) and the Trunking Gateway (as a Media Gateway) communicate by means of a media gateway control protocol such as MGCP or Megaco/H.248.

Residential Gateways

A Residential Gateway is a device that is positioned at the edge of a network, seamlessly connecting a home network to a public or broadband network. Residential Gateways typically combine the functions of a router, hub and modem for Internet access and computer connectivity. More advanced models also contain PBX-type functionality for advanced telephone capabilities in the home, as well as bringing in and routing audio, video, and networked games.

Millions of homes today have broadband access through either DSL or cable modems. Residential Gateways enable all the networked devices in a home to benefit simultaneously from high-speed connection.

Residential Gateways can also provide a practical solution for VoIP. Standard analog phones can be recycled and used as IP phones, reducing initial costs and the need to purchase new IP dedicated equipment.

Typically, Service Providers operate the Residential Gateways. Service Providers need to have control over services and the provisioning of the network. A Residential Gateway can be regarded as a Media Gateway managed by a Media Gateway Controller in a client/server architecture. This architecture is attractive to Service Providers since it provides them with the control they require.

The simplified scenario in Figure 2 shows two sets of analog phones. Each set is connected to a Residential Gateway. The Media Gateway Controller manages each Residential Gateway. The Media Gateway Controller handles call control and keeps track of the call states, while the Media Gateway is unaware of the states and can be considered a *slave* of the Media Gateway Controller.

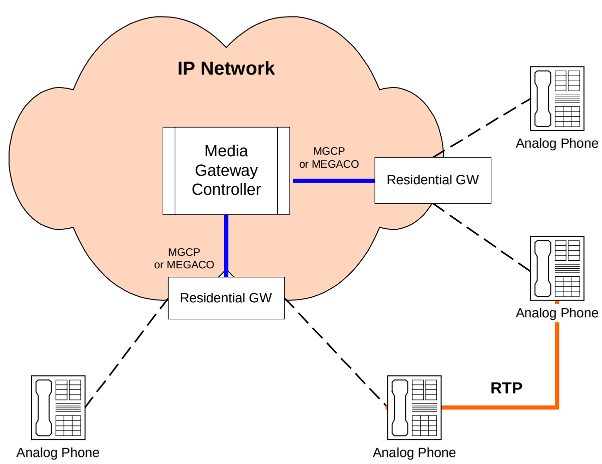

Figure 2: Residential Gateways

The Media Gateway Controller notifies the Media Gateways when to connect and when to send an RTP media stream between the two analog phones. It also instructs the Media Gateway about the capabilities of the media that will be sent via RTP. Media capabilities include type of codec, silence suppression, and echo control. The protocol that carries messages between the Media Gateway Controller and the Media Gateway is a media gateway control protocol such as MGCP or Megaco/H.248.

Conferencing Bridges

An important implementation of a media gateway control protocol is its use as a standard protocol for voice and video conferencing bridges. A video conferencing bridge is also called a Multipoint Conferencing Unit (MCU).

A voice or video conferencing bridge connects three or more conference participants so that they can communicate together. In addition to the call set up and control, the bridge ensures consistent voice and video quality, so that the participants can see and hear each other. Bridges have added features, such as focusing the camera on a speaker, locking the image on a particular participant, and audio mixing.

Conferencing bridges typically have an architecture of a controlling entity and one or more media servers. The controlling entity, or Multipoint Controller (MC), handles call setup and control. The media servers or Multipoint Processors (MP) manage the media. Until now most solutions have used a proprietary protocol between the controlling unit and the media servers. The media gateway control protocol provides a standard means of communication between the controlling entities and the media servers.

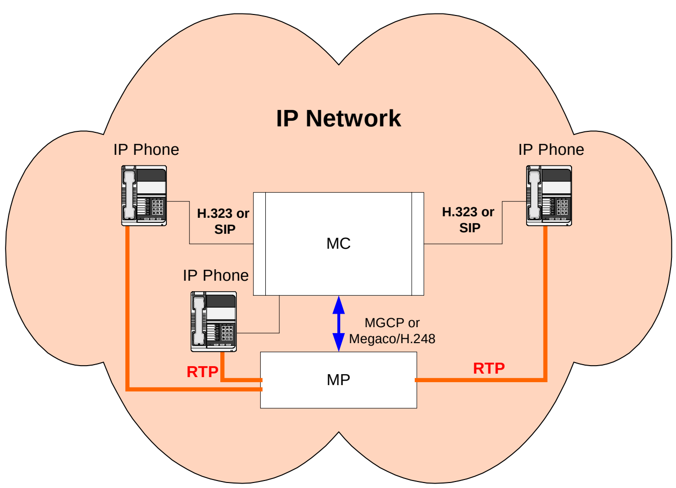

Figure 3: A Voice Conference Bridge

Figure 3 shows a multipoint voice conference in a VoIP network. The MC manages the call setup and control while the MP handles the media processing. For example, the MP does audio mixing by mixing all the incoming voice streams and sending them out again along the RTP channels. MGCP and Megaco/H.248 are particularly effective for enabling the MC to control the MP. The media gateway control protocol messages instruct the MP about which media streams to use, how to manipulate the streams, and where to send the streams.

IVR Announcement Servers

Interactive Voice Response (IVR) Announcement Servers deliver media messages. An IVR can be regarded as a Media Gateway controlled by a Media Gateway Controller. The protocol used between the Media Gateway Controller and the Media Gateway is a media gateway control protocol.

In Figure 4, a SIP Phone "A", attempts to call SIP Phone "C". "A" dials a wrong number. In this particular network, instead of letting the call fail, an IVR tells "A" that a wrong number has been dialed.

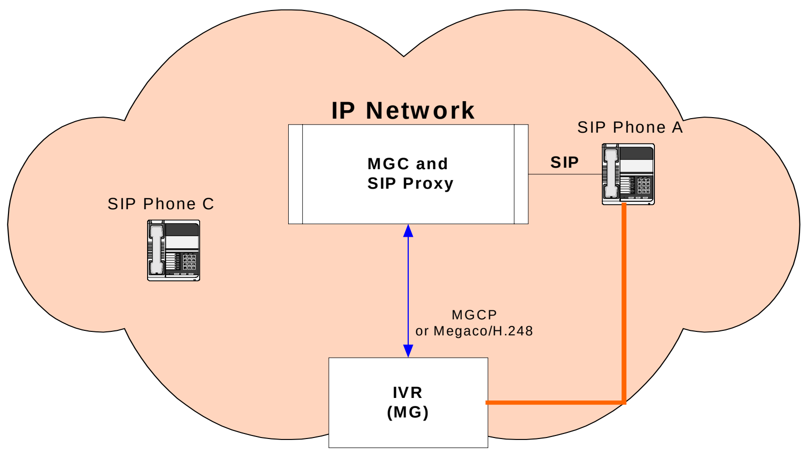

Figure 4: IVR Announcer

To accomplish this, the SIP Proxy, which also has Media Gateway Controller capabilities, establishes a connection between "A" and the IVR. The Media Gateway Controller instructs the IVR to open a media stream and play a recorded audio message to "A".

The Media Gateway Controller sends the instructions to the IVR (Media Gateway) using a media gateway control protocol. The protocol message includes the required codec (such as G.711) and where to send the media (RTP) stream.

Utilizing the Power of the Media Processor

In the previous section we described implementations of decomposed gateways where the media gateway control protocol acts as the interface between an intelligent server and a media-processing client.

The media gateway control protocols MGCP and Megaco/H.248 provide fine-grained control over media resources, and are not constrained by the limitations of signaling protocols such as SIP and H.323. When a signaling protocol is used to control a media server, the media server must act as a party in a call, rather than as a simple media resource. Consequently, the media server is forced into an "unnatural" and complex relationship with the media controller.

There is a growing realization that the media gateway control protocols provide a powerful advantage when setting up and controlling media. The media gateway control protocols are now being leveraged beyond simple decomposed gateway implementations to support a variety of media-rich applications.

The next sections describe three of these applications.

Multiple Media Processors in a Conferencing Bridge

In the section on Conferencing Bridges, we described a simple conferencing bridge comprising an MC that handles call setup and signaling and an MP that handles multipoint media processing. Media processing requires large quantities of CPU for audio and video mixing and transcoding. In a voice or videoconference, the MP processes the media streams of each participant. If the MP is not powerful enough, it can only handle a limited number of participants, causing a bottleneck and reducing the conferencing potential.

The bottleneck can be overcome by increasing processing power through the addition of more MPs, which provide more media processing power. The resulting increase in total media processing power allows the bridge to handle many more conferences and/or participants.

Only one MC is needed to control the calls and manage the conference. The MC interfaces with the multiple MPs using a media gateway control protocol. The standard MGCP or Megaco/H.248 protocols are media efficient and ideally suited for carrying the media instructions from the MC to the MPs.

Figure 5 shows how one MC and many MPs can support a large number of conference participants. Here, the MC communicates with the terminals using H.323 or SIP. The MPs send media streams to the terminals using RTP. The MC communicates with the MPs using MGCP or Megaco/H.248.

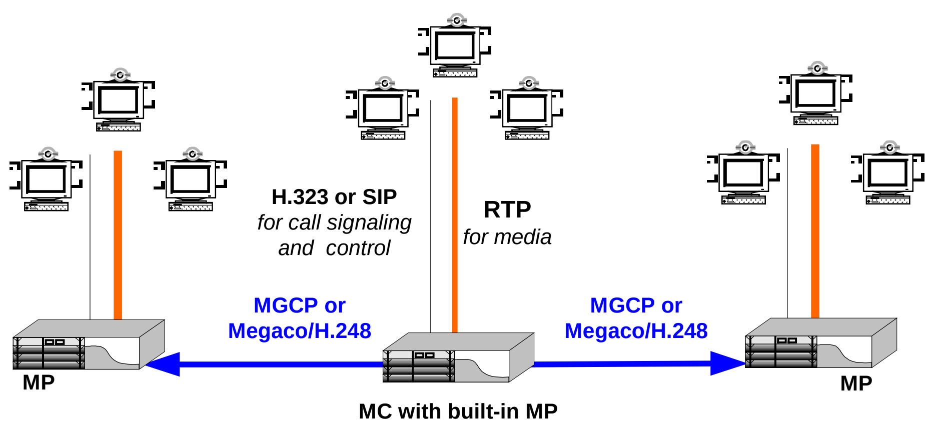

Figure 5: Conferencing Bridge with multiple MPs

Calling Card Application

Anyone who has used a calling card from a public telephone has probably had the unpleasant experience of being cut off when there are no more payment units left on the card. Instead of cutting off the speaker, it is far more customer-friendly to announce that the card is about to be depleted and a new card should be inserted. In an IP network, a media processing device can transmit the announcements to one of the parties in a call, while continuing the mixing and transmission of the voice streams to both parties.

A server handling the call setup and control, and the monitoring of the units on the card notifies the media processor to make the announcement to a specific phone. This is done without impacting the call setup or performing call transfers and other such call activities. An MP mixes and sends the media streams to a given IP address without the other party being aware that any changes are taking place.

Figure 6 shows the media flow of the above scenario after initial call setup.

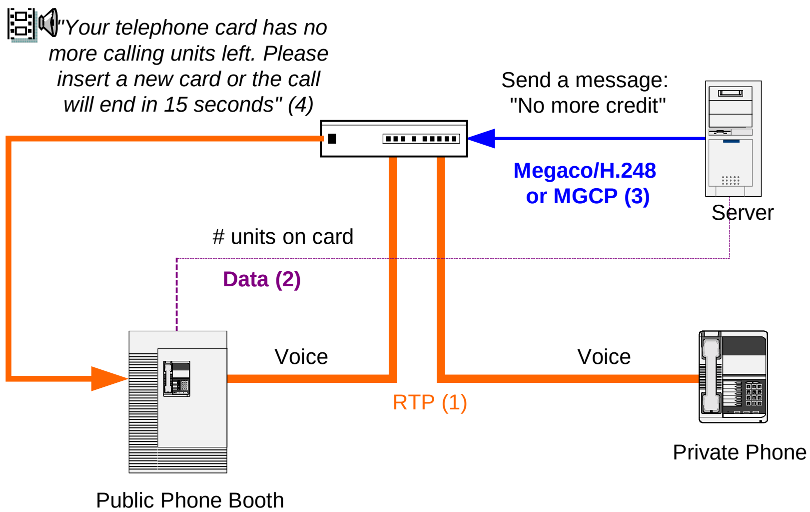

Figure 6: Calling Card Application

Once the connection has been established, the call proceeds between the two phones. The media (voice) is mixed by the Media Processor and travels along an RTP stream (1). The server monitors the number of payment units remaining on the card (data stream 2). When the card is almost empty, the server instructs the Media Processor (using a media gateway control protocol 3) to play a message announcing that there is no more credit. The Media Processor mixes the announcement with the media from both phones and sends this mix to the caller at the public phone (media stream 4). The person on the other phone hears the mixed voice stream without the announcement.

The server performs call setup and signaling, data processing activities, such as verifying the telephone card, and monitoring available units. The Media Processor performs media-crunching and media transmission.

Although the above scenario describes one public phone, the server can manage all the calls made from all the public phones within an area. The Media Processor would then take care of the media mixing and transmission for all the public phones in that area. Given this extended topology, the need for a separate Media Processor becomes more obvious, while the use of an efficient media-specific protocol between the server and the Media Processor guarantees greater efficiency and better service to the customer.

Call Center Application

Another application where efficient use can be made of media gateway control protocols is in a call center. A call center is an environment requiring complex routing and media management. Besides connecting callers to the appropriate agents, the call center needs to handle a number of media-specific services such as IVR, announcers, audio mixing (when more than one call agent participates in a call), supervisor listening, and voice recording. A Media Processor is well suited for handling this variety of media activities.

In the simplified call center shown in Figure 7, a server, which includes a gatekeeper for call control and call center software is connected to a PBX with a built-in media processor.

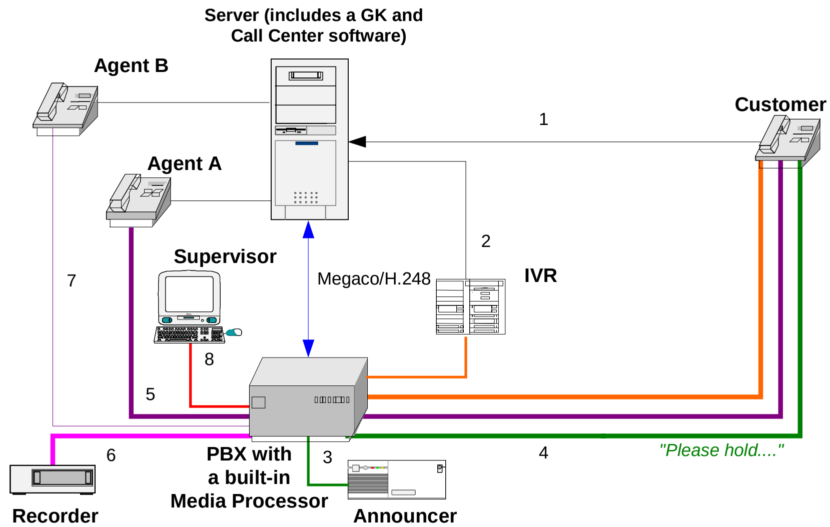

Figure 7: Call Center Application

In a typical scenario the following occurs: A customer calls into the call center (1). The IVR collects the necessary details and informs the server (2). The call center software decides what to do next. If one of the relevant agents is busy, the server sends a message to the PBX/Media Processor, telling it to play a message and music (to the customer). The Media Processor gets the message and music from the announcer (3) and sends it to the customer (4). When the customer is connected to an agent (5), the recorder begins recording the customer enquiry (6). A second agent may be invited to join the call (7), in which case the Media Processor takes care of audio mixing for the voice conference. At any stage, a supervisor may listen to the call (8).

The Media Processor is the hub of all media-related activities. Megaco/H.248 (or MGCP) is the protocol that carries the media-related instructions from the server to the Media Processor.

Summary

As the above scenarios show, the media gateway control protocols are being implemented in applications beyond the initial objectives of their designers. What is special about these media gateway control protocols? Why are developers adopting MGCP and Megaco/H.248 for their media applications?

The following section describes the design concepts of MGCP and Megaco/H.248 from which it will become clear that the fundamental objective of these protocols is the set up and control of media.

Media Gateway Control Protocol Fundamentals

Media Gateway protocols are indigenous to IP. Currently the best-known media gateway control protocols are MGCP and Megaco/H.248. Other media gateway control protocols include the Cisco proprietary media gateway control protocol “Skinny” and the predecessors of MGCP— Simple Gateway Control Protocol (SGCP) and the Internet Protocol Device Control (IPDC).

Initially, MGCP was a combination of SGCP and IPDC published as informational RFC2705. MGCP has been widely deployed and is maintained under the auspices of the Softswitch Consortium and PacketCable. Currently, the PacketCable profile of MGCP is being standardized in the ITU under Study Group 9.

The drive behind the development of Megaco/H.248 was the need to provide various requirements that were not addressed properly by MGCP. Conceptually, Megaco/H.248 is an evolution of MGCP. However the implementation is different and they are not directly compatible. Megaco/H.248 addresses the same types of applications as MGCP but in a more generic and elegant way.

Megaco/H.248 is a collaborative effort of the ITU and IETF, following an agreement by both bodies to cooperate on a single unified protocol. Megaco is published by the IETF as RFC3015. H.248 is published by ITU Study Group 16. The IETF and ITU-T compromised by agreeing to accept two syntaxes with the same semantics—one in text and the other in binary (ASN.1) format. In practice, the text format is much more popular than the binary format. Both protocols are identical (except for the boilerplate).

The Megaco/H.248 protocol is the most recent of the VoIP protocols to be ratified[2]. However, there is still much work to be done. At the time of writing this White Paper, a number of annexes to Megaco/H.248 that describe various packages are in different stages of standardization. The Megaco MIB is still being defined in the IETF, while Annex L of H.323 specifies the tunneling of Megaco/H.248 over H.323 for stimulus-based signaling. The Megaco working group in IETF has recently been re-chartered to work on a second generation of Megaco (version 2).

The following sections describe the fundamental entities of the MGCP and Megaco/H.248 models.

The MGCP Model

MGCP describes a call control architecture, where the intelligence of the call control is outside the gateways and handled by external call control elements. The MGCP assumes that these call control elements will synchronize with each other by sending coherent commands to the gateways under their control. MGCP is a master/slave protocol where the gateways are expected to execute commands sent by the call control elements. MGCP does not define a mechanism for synchronizing call control elements.

MGCP assumes a Connection model where the basic constructs are Endpoints and Connections.

[2] In November, 2000

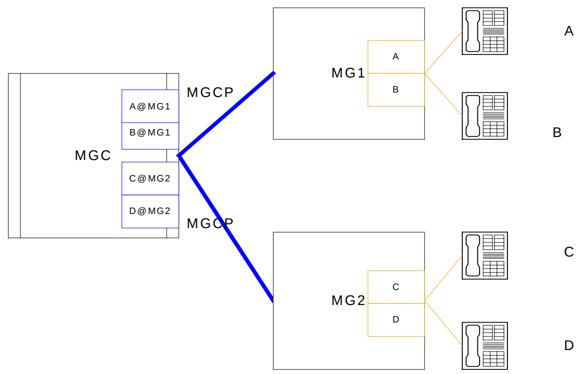

Figure 8: MGCP Endpoints and Connections

Endpoints

An Endpoint is a logical representation of a physical entity, such as an analog phone or a channel in a trunk.

Endpoints are sources or sinks of data and can be physical or virtual. Physical Endpoint creation requires hardware installation while software is sufficient for creating a virtual Endpoint. An interface on a gateway that terminates a trunk connected to a PSTN switch is an example of a physical Endpoint. An audio source in an audio-content server is an example of a virtual Endpoint.

For example, when you tell an Endpoint to “ring”, the Endpoint makes the analog phone actually ring. Or when someone picks up the receiver of an analog phone and it goes “off hook”, a Media Gateway will recognize that an event has occurred at the Endpoint and it will behave appropriately. In the Trunking Gateway described on page above, the bearer channel is an Endpoint.

Events and signals occur at Endpoints. A phone ringing is an event, while a phone off the hook is a signal.

In Figure 8 the Endpoints are A, B, C and D. The MGC knows four objects: A@MG1, B@MG1, C@MG2, D@MG2. Each MG knows two objects: MG1 knows about A and B, and MG2 knows about C and D.

When an event occurs at the physical phone, the Endpoint object of the phone in the MG recognizes that an event has occurred. The MG notifies the object of a particular Endpoint in the MGC. The MGC then acts accordingly and changes the state.

Connections

An Endpoint holds a set of Connections. Connections may be either point-to-point or multipoint. A point-to-point Connection associates two Endpoints. Once this association is established for both Endpoints, data transfer between these Endpoints can begin. A multipoint Connection is established by connecting the Endpoint to a multipoint session.

Connections can be established over several types of bearer networks—audio packet transmission using RTP and UDP over a TCP/IP network; audio packet transmission using AAL2 or another adaptation layer over an ATM network; and transmission of packets over an internal Connection. The Endpoints can be in separate gateways or in the same gateway for both point-to-point and multipoint Connections.

The Megaco/H.248 Model

Megaco/H.248 is a media gateway control protocol that addresses the requirements of decomposed gateways to achieve scalability and flexibility at low overall cost.

In Megaco/H.248 terms, a Media Gateway Controller is the external call and media control entity that handles the signaling and call processing intelligence. A Media Gateway is the network element that performs media processing and transmission, such as conversion between audio signals carried on telephone circuits and data packets carried over the Internet, or over other packet networks.

Using Megaco/H.248, Media Gateway Controllers control Media Gateways to set up media paths through the distributed network. Megaco/H.248 offers a flexible and abstract model that enables the bridging of converged networks (IP, ATM, Frame Relay and PSTN) for a wide range of multimedia applications.

The Megaco/H.248 model describes a connection model that contains the logical entities, or objects, within the MG that can be controlled by the MGC. The main entities are Contexts and Terminations. A Topology Descriptor describes media flow directions between Terminations in a Context.

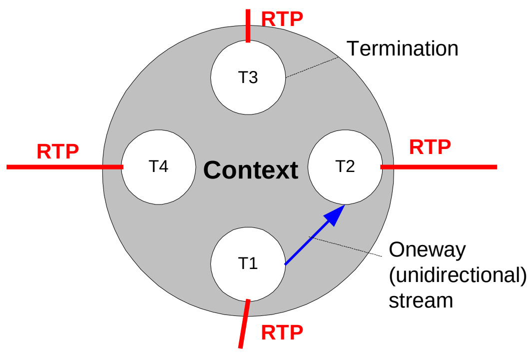

Figure 9: Megaco/H.248 Concepts

Contexts

A Context is a logical entity on an MG that is an association between a collection of Terminations. The Context describes the topology and the media mixing and/or switching parameters if more than two Terminations are involved in the association. A ContextID identifies a Context. A null Context contains all Terminations that are not associated with any other Termination.

Terminations

A Termination is a logical entity on an MG that sources and/or sinks media and/or control streams. Descriptors contain the properties that describe a Termination. These are included in commands. A Termination can be either physical or ephemeral. Physical

Terminations represent physical entities that have a semi-permanent existence. For example, a Termination representing a TDM channel might exist for as long as it is provisioned in the gateway. Ephemeral Terminations represent Connections or data flows, such as RTP flows, and usually exist only for the duration of their use in a particular Context.

Streams

Streams represent the media flows of the Termination. Streams flow between the Terminations in a context according to the rules specified by Topology Descriptors.

Topology Descriptor

A Topology Descriptor specifies media flow directions between Terminations in a Context. The default topology of a Context is that the transmission of each Termination is received by all other Terminations. A Topology Descriptor consists of a sequence of triples of the form (T1, T2, association). T1 and T2 specify Terminations within the Context. The association describes the flow between T1 and T2. Possible associations are one-way, both ways, or isolate (“no way”). Topology descriptors are. Figure 9 shows a Media Processor (MP) described in terms of its Megaco/H.248 Context and Terminations, T1, T2, T3 and T4. The topology is described in terms of Termination T1 connected to Termination T2 in a one-way direction (half duplex from T1 to T2). The stream is the flow of media between two Terminations within the Context. Currently, Megaco/H.248 defines the relation between all streams between two Terminations.

The Essential Differences

The Megaco/H.248 model is a much more complex than the MGCP model and it provides far greater flexibility when defining media control. For example, in MGCP you can set a mode such as “conference” to manage the stream mixing, but you cannot achieve the fine grain control that you can in Megaco/H.248, such as how to manage the media streams.

Following are the main differences between Megaco/H.248 and MGCP:

Megaco/H.248	MGCP
A call is represented by Terminations within a call Context.	A call is represented by Endpoints within Connections.
Call types include any combination of multimedia and conferencing.	Call types include point-to-point and multipoint.
Syntax is text or binary.	Syntax is text.
Transport layer is TCP or UDP.	Transport Layer is UDP.
Defined formally by the IETF and ITU.	Managed by the industry.

Future Directions

There are a number of issues currently under study or being defined for future versions of Megaco/H.248, such as:

- Fine grain control at the media stream level and not only at the Termination level—this is under preparation for Megaco/H.248 version 2.
- MIB for Megaco/H.248—a work group has been formed but is currently "on hold".
- New packages—such as a Media Server Package that defines events and signals for controlling a media server.

Conclusion

If we look at the development of media gateway control protocols from simple PSTN/VoIP interworking "enablers" to complex media-specific applications, it is clear that the media gateway control protocols have an important role to play in the future of IP networks and in particular, IP centric conferencing and media-related applications.

The introduction of standards, such as MGCP (de facto) and Megaco/H.248 (ratified by the IETF and ITU) guarantee future interoperability as the protocols evolve to meet more demanding market requirements.

The inherent client/server architecture of the protocols provides room for growth and possibilities of developing flexible, scalable applications. The media-oriented design of the protocols provide the opportunity for better media management as multimedia conferencing and other media-rich applications become a greater part of everyday life.

Glossary of Terms

Term	Description
H.323	The ITU standard for videoconferencing over packet switched networks
IDPC	Internet Protocol Device Control
IETF	The Internet Engineering Task Force
ISUP	ISDN User Part
ITU	International Telecommunications Union
IVR	Interactive Voice Response
MC	Multipoint Controller
Megaco	Media Gateway Control
MG	Media Gateway
MGC	Media Gateway Controller
MGCP	Media Gateway Control Protocol
MP	Multipoint Processor
PSTN	Public Switched Telephone Network
RTP/RTCP	Real-time Transport Protocol/ Real-time Transport Control Protocol
SDP	Session Description Protocol
SGCP	Simple Gateway Control Protocol
SIP	Session Initiation Protocol
SS7	Signaling System 7. The protocol used in the public switched telephone system.