H.323

Packet-Based Multimedia Communications Systems

H.323 History

- H.323 is a product of ITU-T Study Group 16.
- Version 1: "*visual telephone systems and equipment for LANs that provide a nonguaranteed quality of service (QoS)*"was accepted in October 1996.
  - Focus on multimedia communication in a LAN
  - No support for guaranteed QoS
- Version 2: "*packet-based multimedia communications systems*"was driven by the Voice-over-IP requirements and was accepted in January 1998.
- Version 3 was accepted in September 1999 and has minor incremental features (caller ID, etc.) over version 2.
- Version 4 was accepted in November 2000 and has significant improvements over version 3.

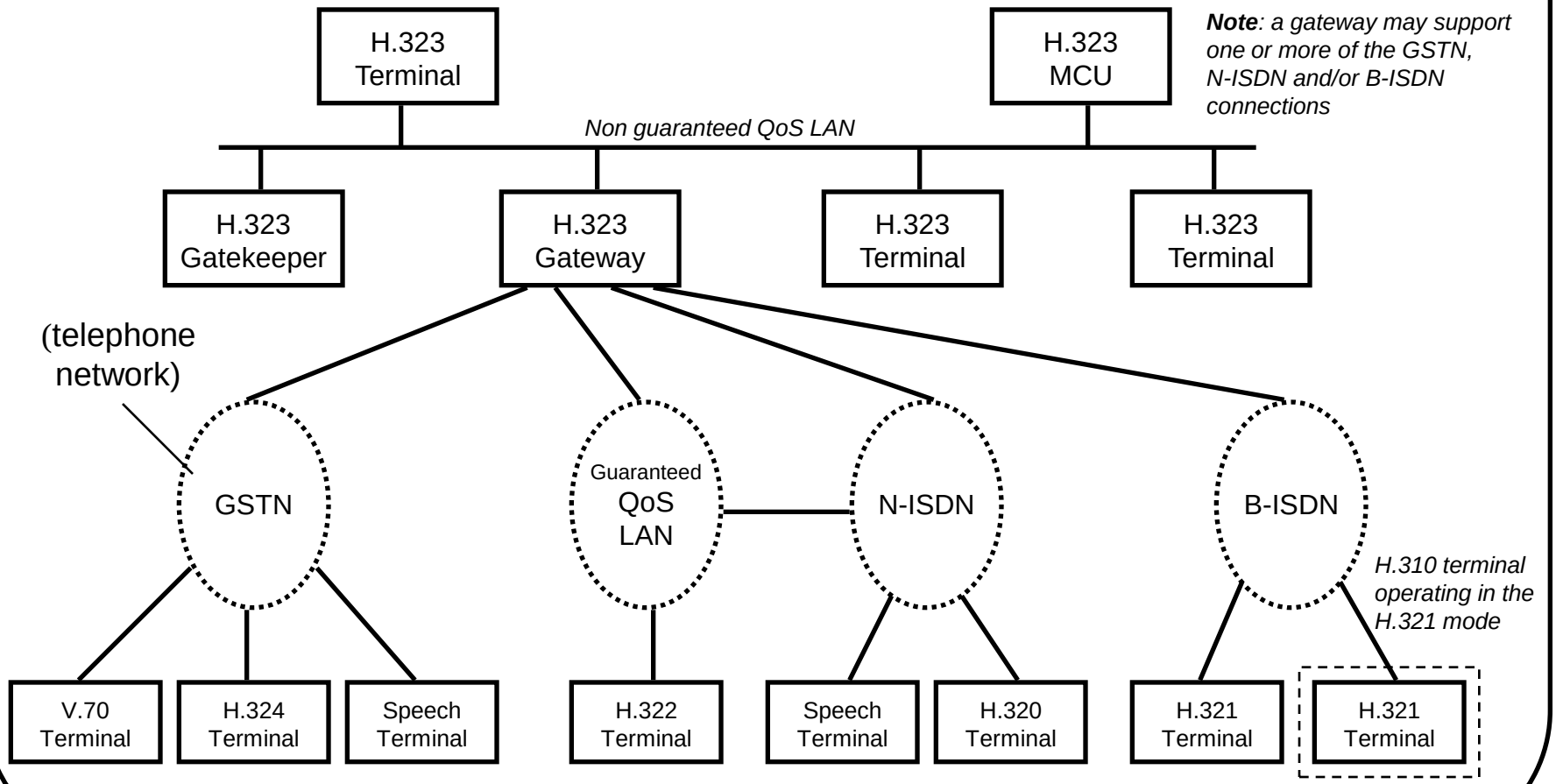
Web Resources

- Good H.323 tutorial, with a quiz at the end (recommended!):
  - **http://www.iec.org/tutorials/h323/**
- H.323 information site; has copies of all the draft standards of every version, plus several tutorials and whitepapers:
  - **http://www.packetizer.com/iptel/h323/**
- OpenH323 Project, aimed at providing free H.323 source code:
  - **http://www.openh323.org/**

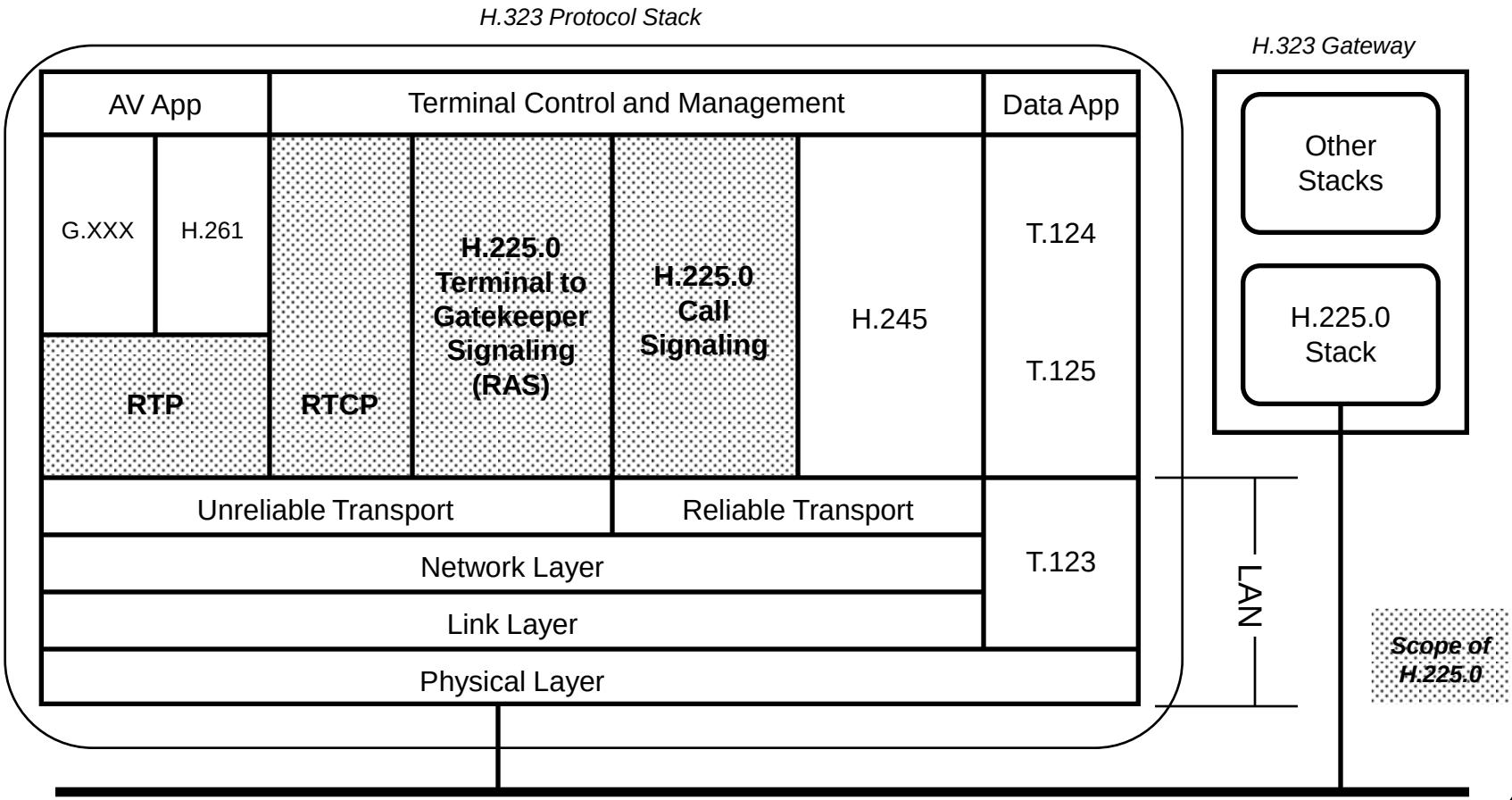
H.323 Documents

- H.323
  - Overview of video conferencing system
- H.225.0
  - RAS messages and protocols
  - Call setup channel procedures (Q.931)
  - Audio/Video packet formats (RTP)
- H.245
  - Specifies messages and protocols for H.245 Control Channel
- H.261, H.263, G.711, G.723, etc.
  - Audio and video compression methods

H.323 System


H.323 Terminal
H.323 MCU
Note: a gateway may support one or more of the GSTN, N-ISDN and/or B-ISDN connections
Non guaranteed QoS LAN
H.323 Gatekeeper
H.323 Gateway
H.323 Terminal
H.323 Terminal
(telephone network)
GSTN
Guaranteed QoS LAN
N-ISDN
B-ISDN
H.310 terminal operating in the H.321 mode
V.70 Terminal
H.324 Terminal
Speech Terminal
H.322 Terminal
Speech Terminal
H.320 Terminal
H.321 Terminal
H.321 Terminal

H.323 Stack


H.323 Protocol Stack
H.323 Gateway
AV App
Terminal Control and Management
Data App
G.XXX
H.261
RTP
RTCP
H.225.0 Terminal to Gatekeeper Signaling (RAS)
H.225.0 Call Signaling
H.245
T.124
T.125
Unreliable Transport
Reliable Transport
Network Layer
Link Layer
Physical Layer
T.123
LAN
Other Stacks
H.225.0 Stack
Scope of H.225.0

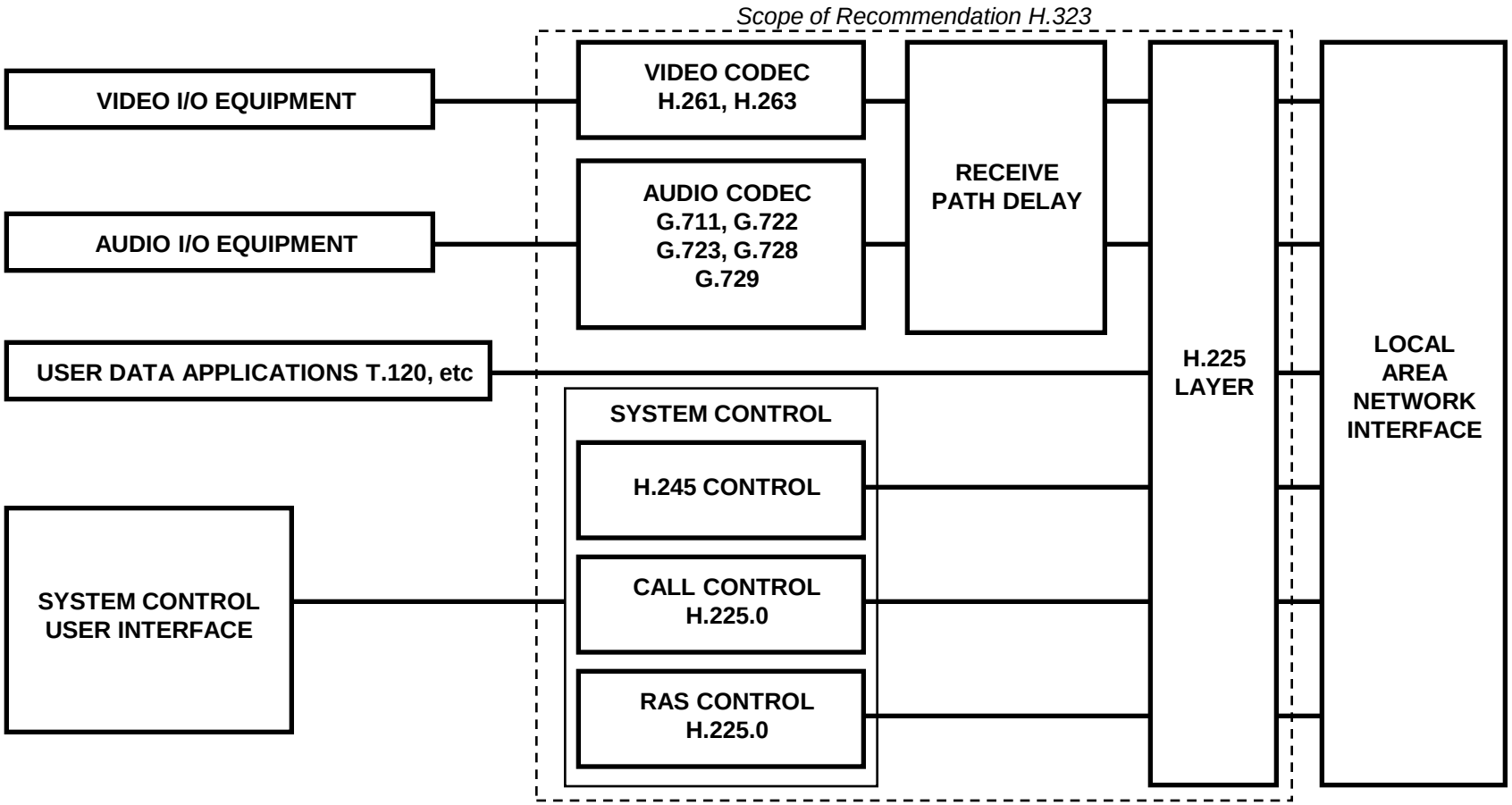
H.323 Entities (1)

- Terminal
  - An endpoint on the LAN which provides for real-time, two-way communications with another H.323 terminal, Gateway, or MCU
  - May provide audio, video, and/or data
- Gatekeeper
  - Provides address translation and controls access to the LAN
  - Performs bandwidth management
- Multipoint Control Unit
  - Provides the capability for 3 or more terminals and Gateways to participate in a multipoint conference

H.323 Entities (2)

- Gateway
  - Provides for real-time, two-way communication between H.323 terminals on a LAN and other ITU terminals on a wide-area network or another H.323 Gateway
  - Other ITU terminals include
    - H.310 (B-ISDN)
    - H.320 (N-ISDN)
    - H.321 (ATM)
    - H.322 (GQOS-LAN)
    - H.324 (GSTN)
    - V.70 (DSVD - Digital Simultaneous Voice and Data)

H.323 Terminal (1)



H.323 Terminal (2)

- Video Codec
  - Encodes and decodes video streams
  - Minimum H.261 QCIF
  - May support multiple simultaneous video streams
  - Support for video is optional
- Audio Codec
  - Encodes and decodes audio streams
  - Minimum G.711
  - May need to perform mixing
  - Support for audio is mandatory
- Receive Path Delay
  - Delay added to maintain synchronization and account for network packet arrival jitter

H.323 Terminal (3)

- T.120 Data Channel
  - Established as part of the H.323 call or prior to H.323 call
  - Uses a bi-directional H.245 logical channel
  - Other types of data channels are possible
- H.245 Control Function
  - Master/Slave determination
  - Capability exchange
  - Logical channel control
  - Mode request
  - Round trip delay determination
  - Maintenance loop signaling

H.323 Terminal (4)

- Call Control
  - Uses H.225.0 to establish a Call Signaling Channel between two H.323 endpoints
  - Opened prior to H.245 Control Channel
  - Independent of H.245 Control Channel and RAS channel
- RAS (Registration, Admission and Status) Control
  - Uses H.225.0 messages to perform registration, admission, bandwidth changes, status, and disengage procedures

H.323 Terminal (5)

- H.225.0 Layer
  - Located above transport layer (e.g TCP/UDP)
  - Defines communication between H.323 terminals using the same transport protocol
  - Establishes Call Signaling Channel
  - Defines RAS message formats
  - Establishes and manages logical channels as directed by H.245

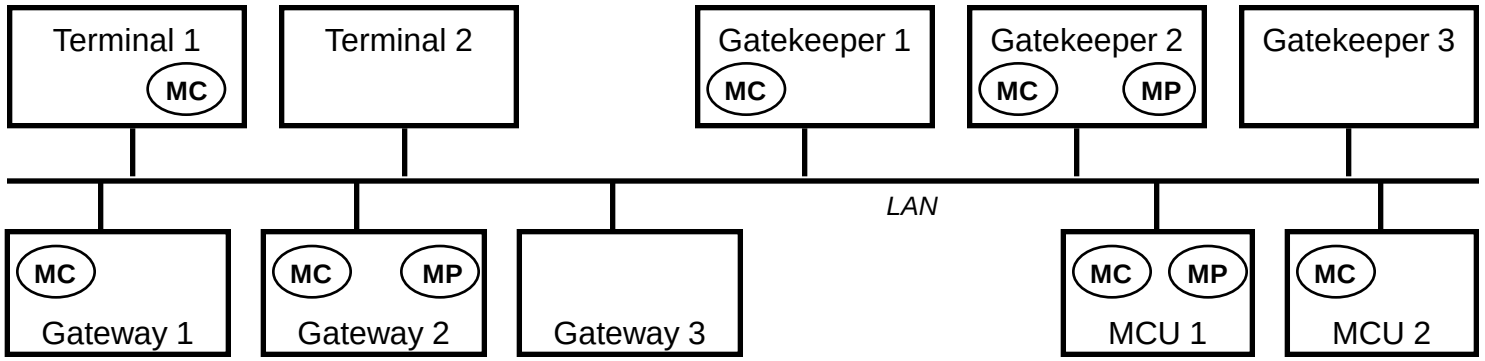
Gatekeeper

- Provides the following services:
  - Address translation between Transport Addresses and Alias Addresses
  - Admission control based on authorization, bandwidth, or other criteria
  - Dynamic bandwidth control during a conference
- Communicates with endpoints using the RAS channel

Multipoint Entities

MC: Multipoint Controller

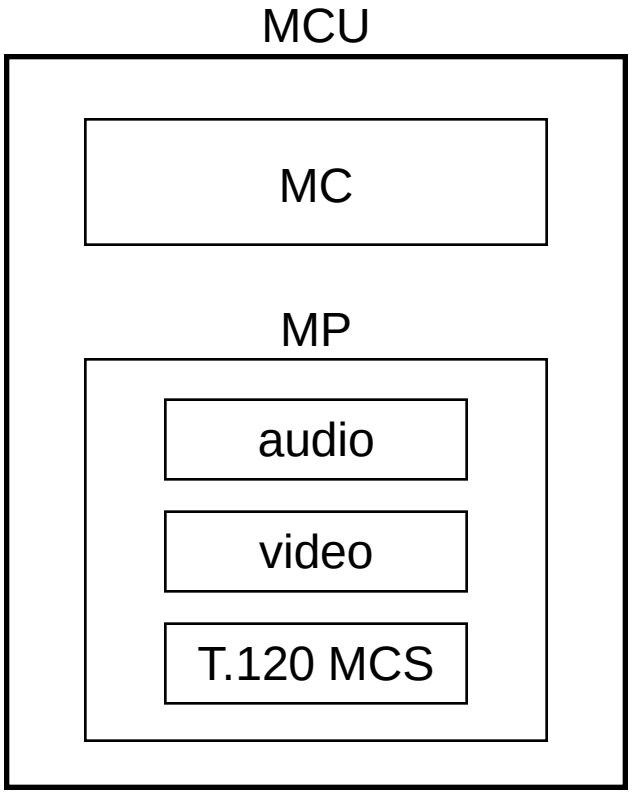
MP: Multipoint Processor



***Note**: gateway, gatekeeper and MCU may be a single device*

Multipoint Control Unit

- Provides support for multipoint conferences
- Consists of one Multipoint Controller (MC) and zero or more Multipoint Processors (MP)
- Typically contains a separate MP for audio, video, and T.120 data
- May be co-located with a Gateway or Gatekeeper



Multipoint Controller (MC)

- May be located in an MCU, Gatekeeper, Gateway, or Terminal
- Endpoints participating in a multipoint conference must connect to an MC on the H.245 Control Channel
  - Explicit connection to an MC located in an MCU
  - Implicit connection to an MC located in a Gateway, Gatekeeper, or Terminal
- Master/Slave procedure of H.245 is used to elect the Active MC for a conference if multiple MCs are present

Multipoint Controller Functions

- Performs capability exchanges with each endpoint and determines the Selected Communication Mode (SCM)
  - SCM may be common for all endpoints
  - A Multipoint Processor may be used for format conversion to allow difference SCMs within the same conference
- Assigns terminal numbers to each endpoint in the conference
- Maintains a list of all conference participants
- Handles procedures for Ad Hoc multipoint conferencing

Multipoint Processor (MP)

- Used for processing of audio/video/data streams in a centralized or hybrid multipoint conference
- Video stream processing
  - Switching - select which video source to transmit to all endpoints
  - Mixing - combine multiple video sources into a single stream which is transmitted to all endpoints
- Audio stream processing
  - Performs switching, mixing, or both to provide N output audio streams from M input audio streams
  - Each audio output may have a different combination of input
  - Audio transmitted by and endpoint is not included in the audio stream which is returned to them

Types of Conferences

- Point-to-Point Conference
  - Conference between two H.323 terminals or and H.323 terminal and an switched circuit network (SCN) terminal
- Multipoint Conference
  - Conference between 3 or more terminals on the LAN or SCN
  - Controlled by a single Multipoint Controller per conference
  - May involve H.321 MCUs on the SCN

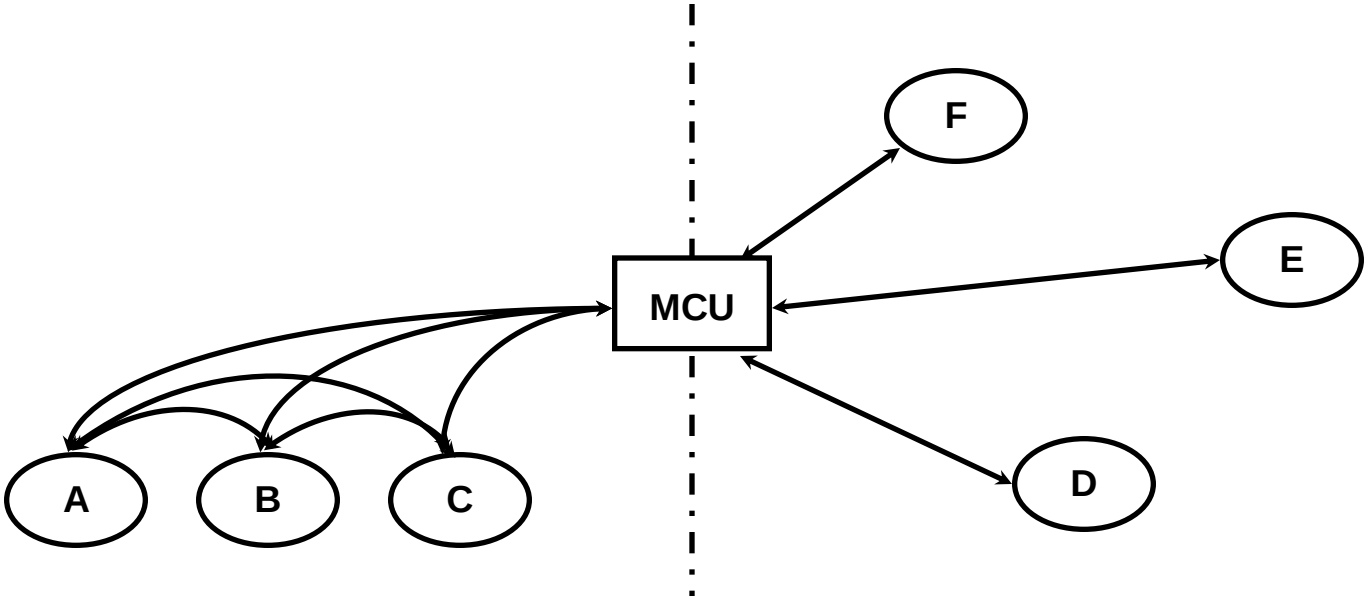
Multipoint Conferences

- Centralized Multipoint Conference
  - All participating terminals transmit their control, audio, video, and/or data streams to an MCU in a point-to-point fashion.
  - MCU processes audio/video/data and returns processed streams to each terminal
- Decentralized Multipoint Conference
  - Participating terminals multicast audio and video to all other participating terminals
  - Terminals communicate with the MCU using the H.245 Control Channel for conference management purposes
  - Data stream centrally processed by MCU

Hybrid Multipoint Conferences

- Combination of centralized and decentralized multipoint conference
- Centralized Audio/Decentralized Video
  - Terminals multicast video to all other terminals
  - Unicast audio to MCU for central processing
- Decentralized Audio/Centralized Video
  - Terminals unicast video to MCU for central processing
  - Multicast audio to all other terminals

Mixed Multipoint Conferences



- D,E,F participate in centralized mode
- A,B,C participate in decentralized mode
- Terminals are not aware of mixed nature of the conference

Ad Hoc Multipoint Conference

- Conference that was originally established as a point-to-point conference and later expanded into a multipoint conference
- An entity in the initial point-to-point call must contain a Multipoint Controller

H.323 Entity Addressing (1)

- All H.323 entities are referenced using a Transport Address which consists of two parts
  - LAN Address
    - Network layer address of the H.323 entity as defined by the (inter)network layer protocol in use (e.g. an IP address)
    - Mapped to the layer one address as defined in the (inter)networking protocol
  - TSAP Identifier
    - Piece of information used to multiplex several transport connections which share the same LAN address (e.g. TCP port number)
    - May be (pre)assigned statically or may be dynamically allocated

H.323 Entity Addressing (2)

- May also use Alias Address
  - E.164 address (phone number), user name, email address, etc.
- One Transport Address may have multiple Alias Addresses
- Alias to Transport Address translation is performed by the Gatekeeper

H.245 Control Channel

- Transport address for the H.245 Control Channel is exchanged on the Call Signaling Channel
- May be routed directly or through gatekeeper (just like Call Signaling Channel)
- Used to exchange capabilities, create logical channels, and exchange multipoint commands

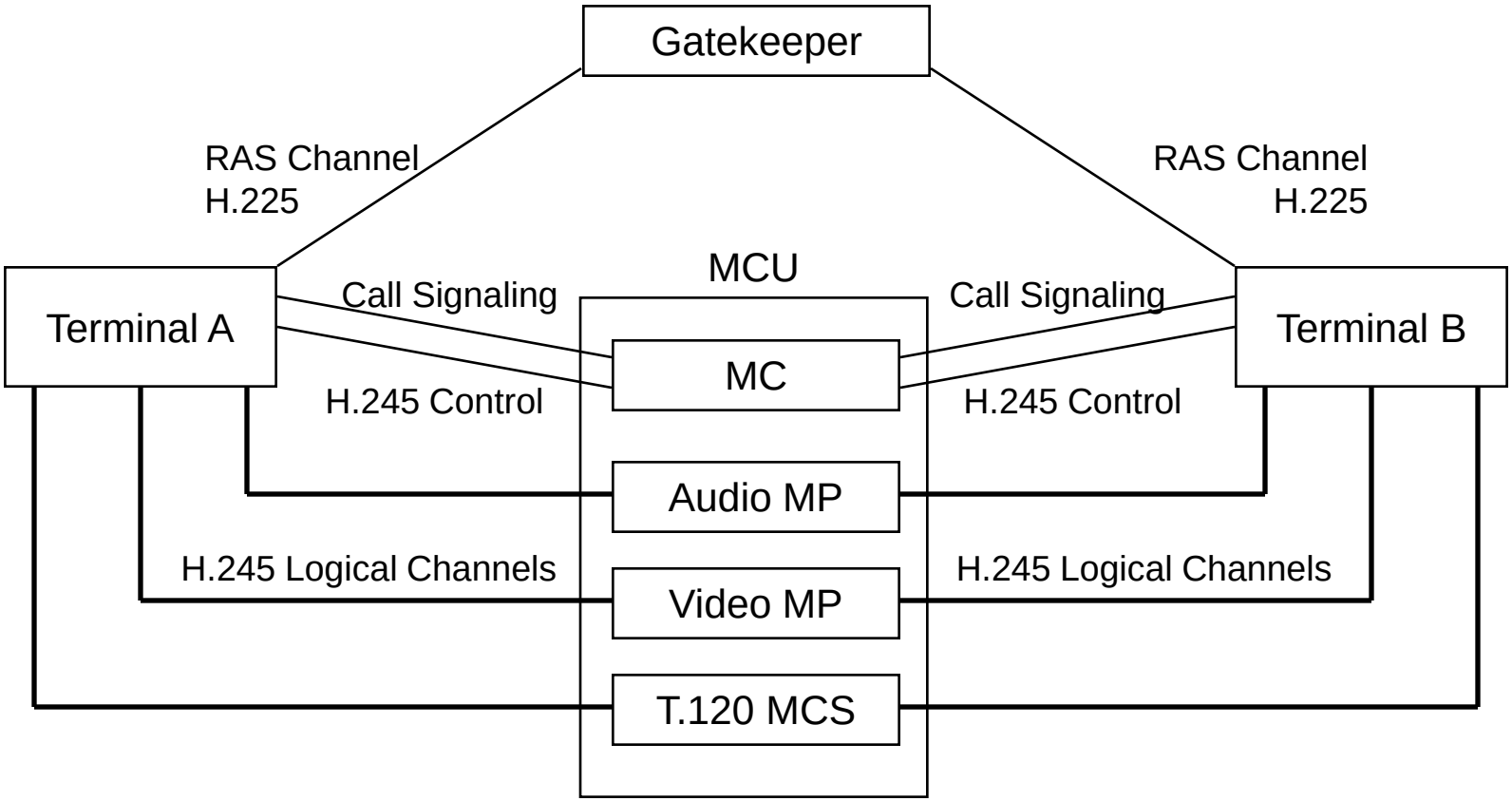
H.245 Capability Exchange

- All endpoints send out a Terminal Capability Set
  - List of all audio, video, and data capabilities supported by the endpoint
  - Separate set for transmit and receive capabilities

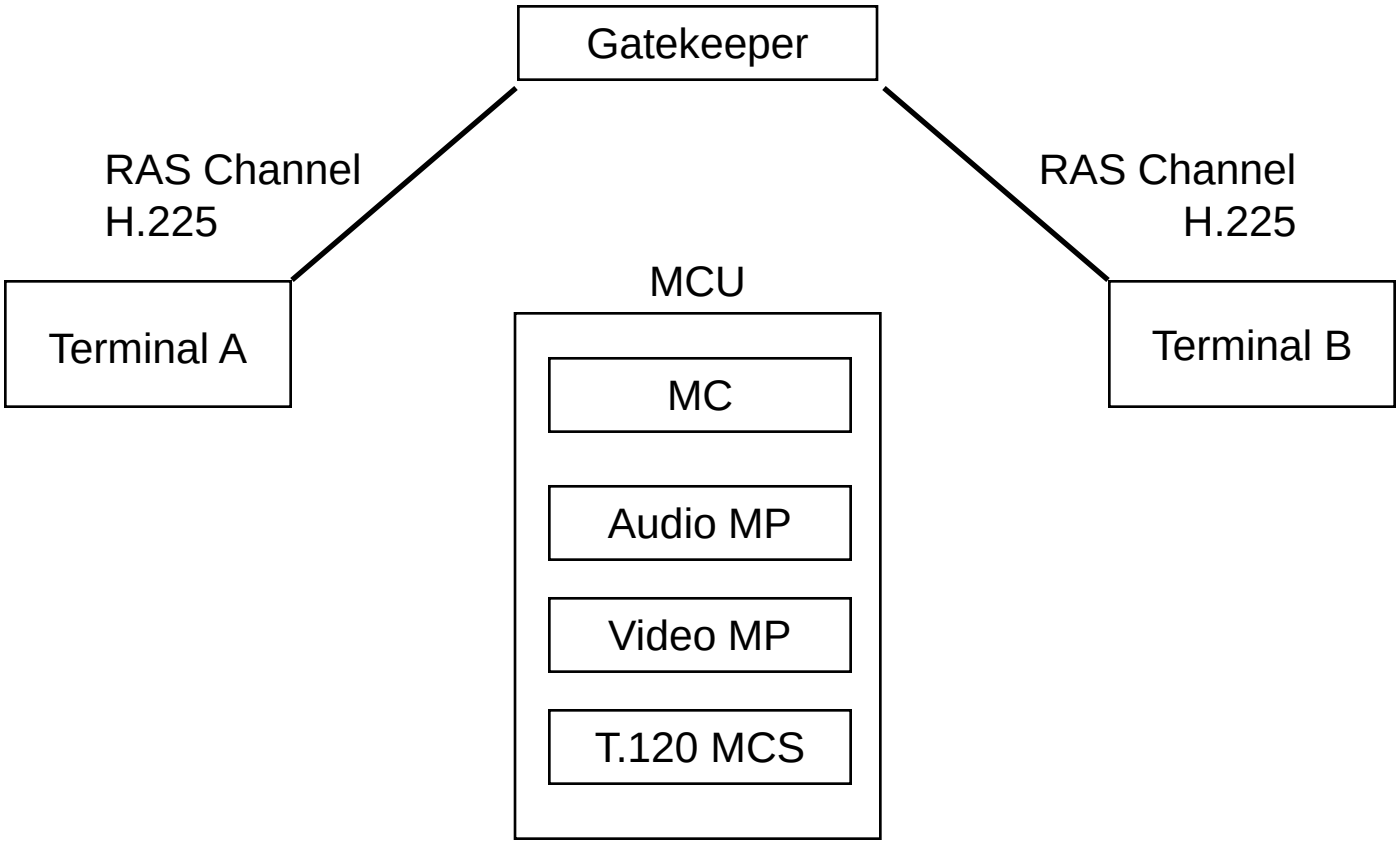
H.323 Call Setup Procedures

- Step 1 (optional): Endpoint - Gatekeeper communication
- Step 2: Setup initial connection with the MCU using the Call Signaling Channel
- Step 3: Setup H.245 Control Channel with the MCU
- Step 4: Setup additional logical channels for audio/video/data

H.323 Conference



Step 1: Endpoint - Gatekeeper Communication



RAS Channel

- Provides communication between gatekeepers and endpoints
- Supports the following procedures
  - gatekeeper discovery
  - Registration/Unregistration
  - Location Request (Alias/Transport address lookup)
  - Admission control
  - Bandwidth changes
  - Status Request

RAS Gatekeeper Discovery Procedures

- Used to determine the gatekeeper with which an end station should register
- Manual Discovery
  - The end station is configured with the Transport Address of the gatekeeper (e.g. initialization file)
- Automatic Discovery
  - Sends the GRQ (Gatekeeper Request) message to a well-known Gatekeeper Discovery Multicast Address and well-known Gatekeeper RAS Channel TSAP identifier
  - Gatekeeper responds with GCF (confirm) or GRJ (reject)
  - If multiple gatekeepers respond, the terminal selects the gatekeeper it wants to use.

RAS Registration Procedures

- Endpoints send an RRQ (Registration Request) message to the gatekeeper's RAS Channel Transport Address determined in the Gatekeeper Discovery Procedure
- RRQ contains
  - Transport Address(es) of the endpoint
  - Aliases used for the endpoint
  - Terminal type (terminal, MCU, gateway, or gatekeeper)
- Gatekeeper responds with RCF (confirm) or RRJ (reject)
- Possible reasons for Registration Reject:
  - duplicate alias
  - security issues

Endpoint Location Procedures

- Used to determine the Transport Address of another endpoint using the endpoint's alias
- An endpoint transmits an LRQ (Location Request) message containing the alias of the other endpoint
  - May be transmitted to a specific gatekeeper
  - May be multicast to the well-known Discovery Multicast Address
- Gatekeepers respond with LCF (Location Confirm) containing the Transport Address of the second endpoint
- Gatekeepers may respond with LRJ (Location Reject) if the Transport of the second endpoint is unknown

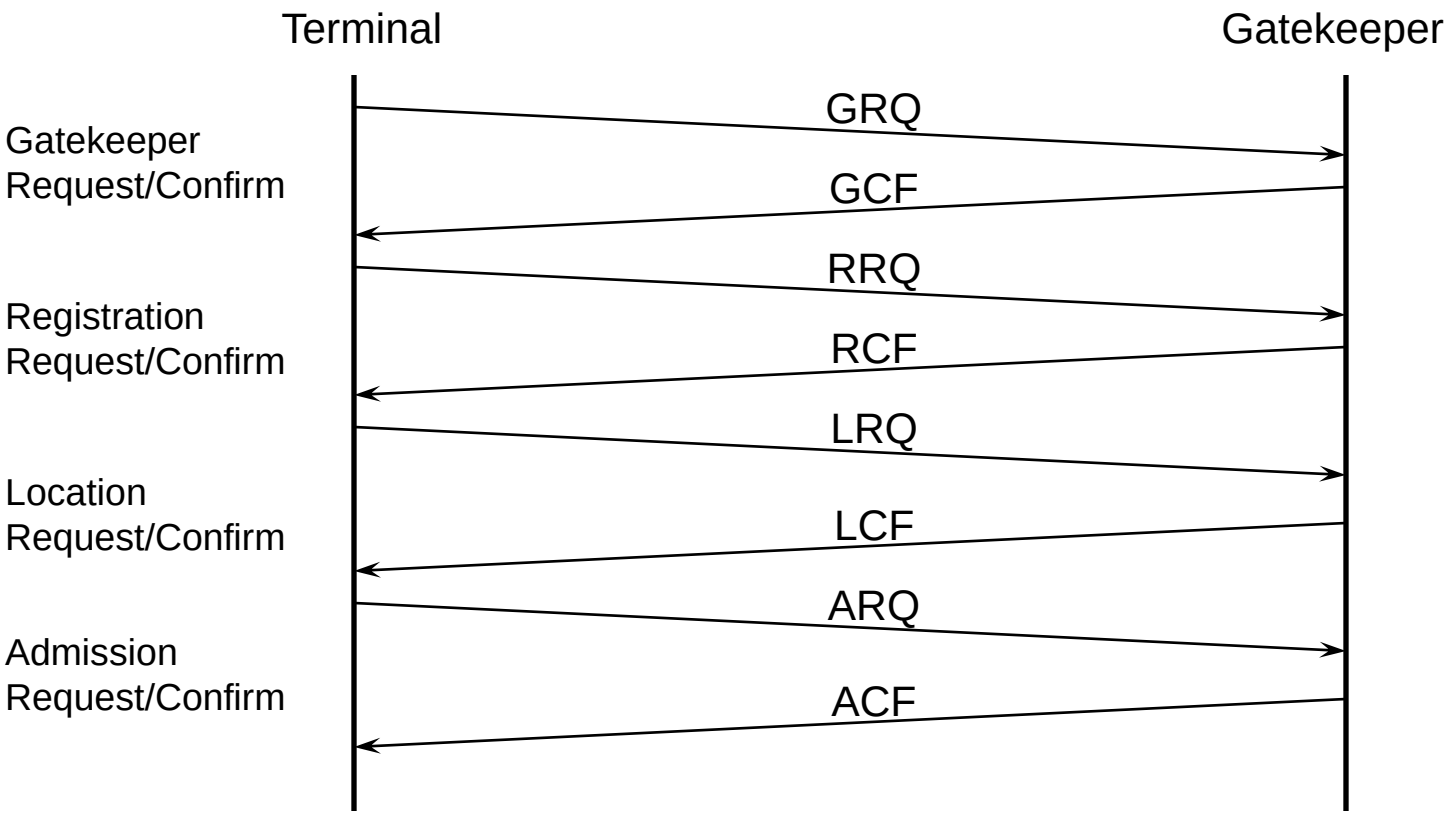
Admission Control Procedures

- Before initiating a conference, the endpoints must request permission from the Gatekeeper (if present)
- Endpoint transmits ARQ (Admission Request) which specifies the required bandwidth for the conference
- Gatekeeper may admit the conference (ACF - confirm) or reject the conference (ARJ - reject)
- The gatekeeper indicates in the ACF if the calling endpoint should contact the other endpoint directly or use the gatekeeper as an intermediary
- Gatekeeper may reduce the bandwidth in the ACF message

RAS Messages

- Gatekeeper request (GRQ)
- Gatekeeper confirm (GCF)
- Gatekeeper reject (GRJ)
- Registration Request (RRQ)
- Registration Confirm (RCF)
- Registration Reject (RRJ)
- Unregistration Request (URQ)
- Unregistration Confirm (UCF)
- Unregistration Reject (URJ)
- Location Request (LRQ)
- Location Confirm (LCF)
- Location Reject (LRJ)
- Admission Request (ARQ)
- Admission Confirm (ACF)
- Admission Reject (ARJ)
- Bandwidth Request (BRQ)
- Bandwidth Confirm (BCF)
- Bandwidth Reject (BRJ)
- Information Request (IRQ)
- Information Request Response (IRR)

RAS Message Exchange



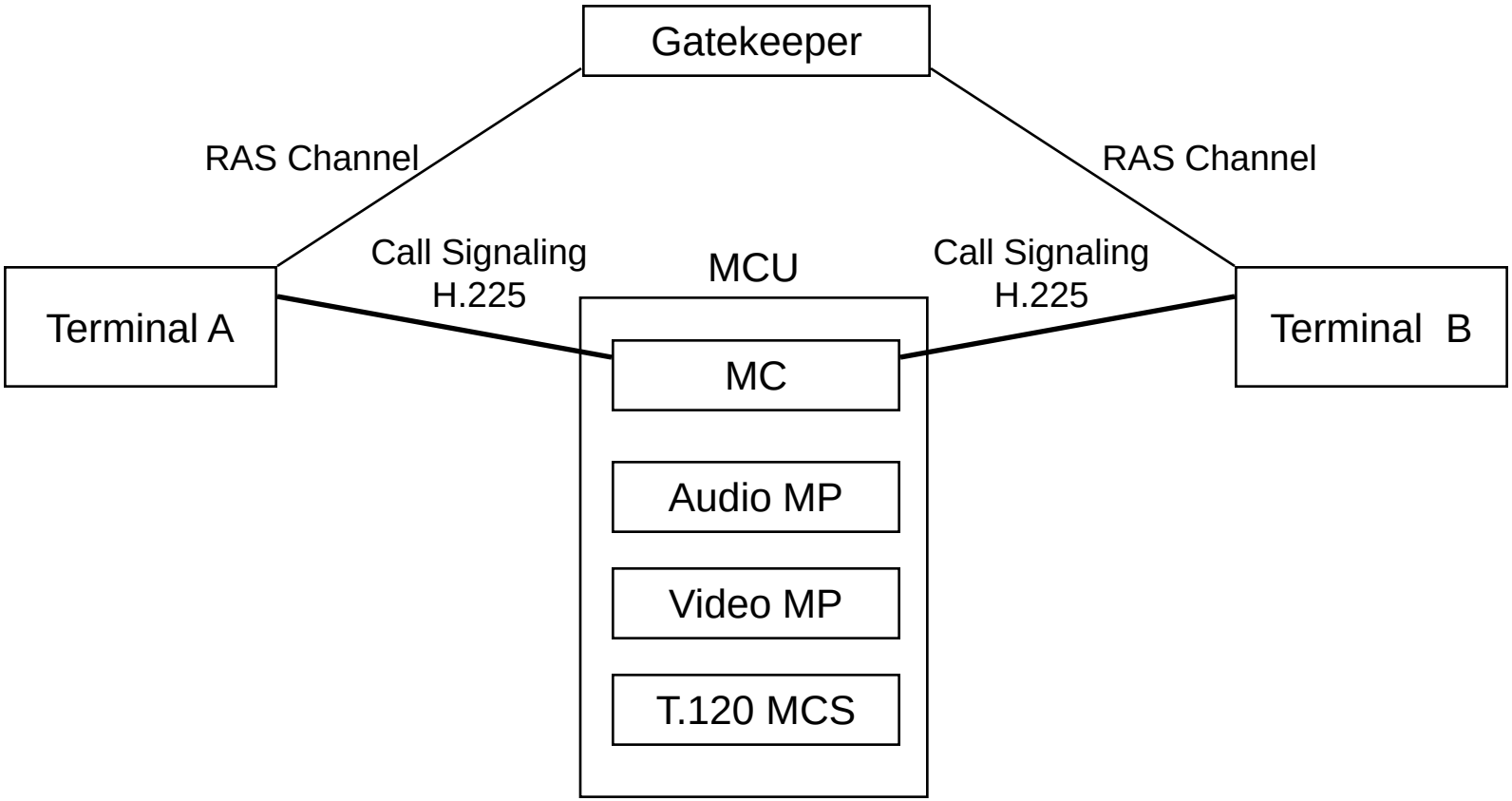
Bandwidth Change

- Used to dynamically change the bandwidth requirements during a conference
- May be initiated by gatekeeper or endpoint

Status Request

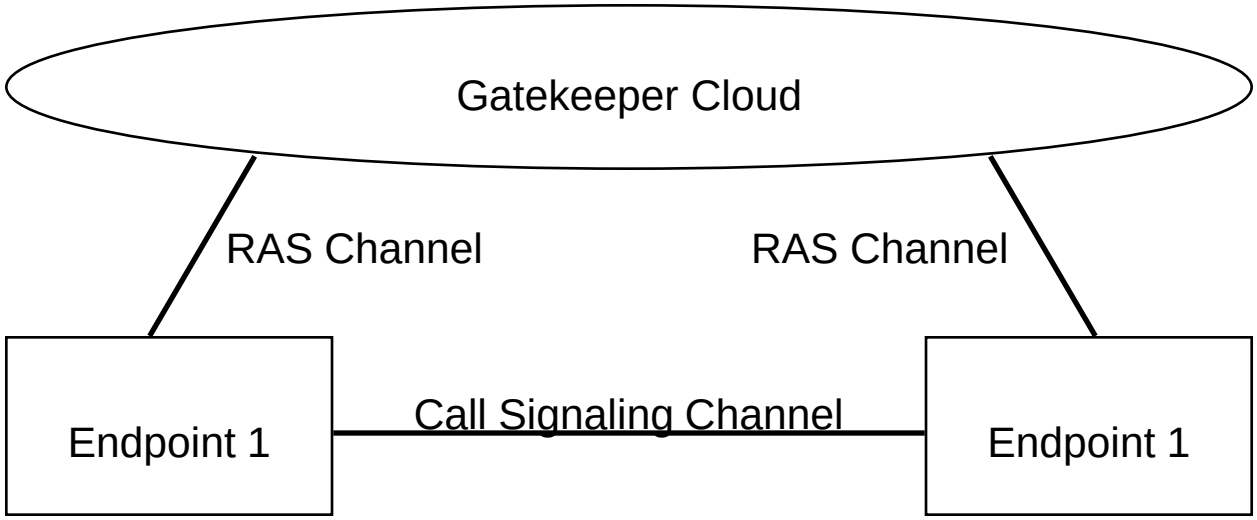
- IRQ (Information Request) message used by the gatekeeper to poll endpoints in a conference to determine if call is still active
- Endpoints respond with IRR (Information Request Response) message containing information about the current call state

Step 2: Call Signaling Channel



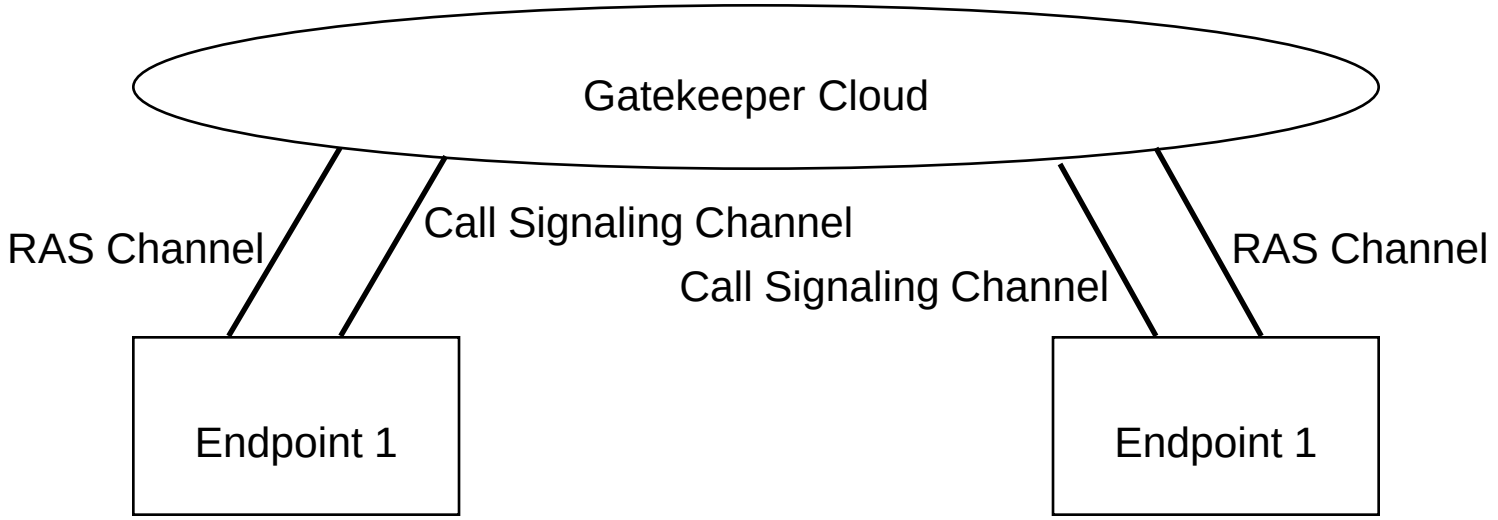
Call Signaling
Channel Routing (1)

- Direct Endpoint Call Signaling
  - Endpoints directly exchange call signaling messages



Call Signaling
Channel Routing (2)

- Gatekeeper Routed Call Signaling
  - Endpoints send call signaling messages to the gatekeeper which forwards the messages to the destination

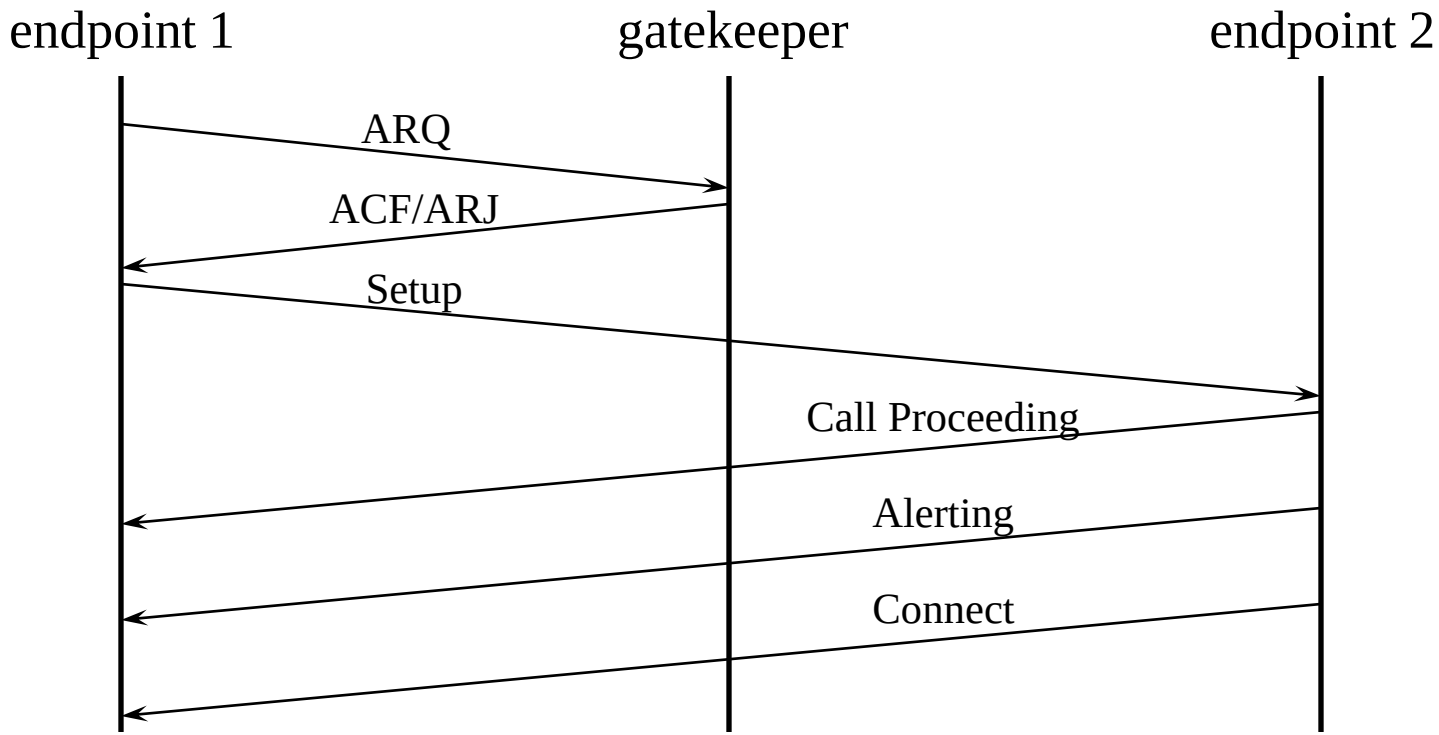


Call Signaling Channel

- Q.931/Q.932 messages are exchanged using the transport addresses discovered through the RAS admission procedure
- Messages supported
  - Setup - caller requests connection
  - Call Proceeding - callee or intermediate node indicates connection request is being processed
  - Alerting - callee indicates it has received the Setup message
  - Connect - callee indicates the call has been accepted
  - Facility - Request terminal use a gatekeeper
  - Release Complete - terminal signals the end of a connection
  - Status Inquiry / Status - request call status (similar to IIR message on RAS channel)

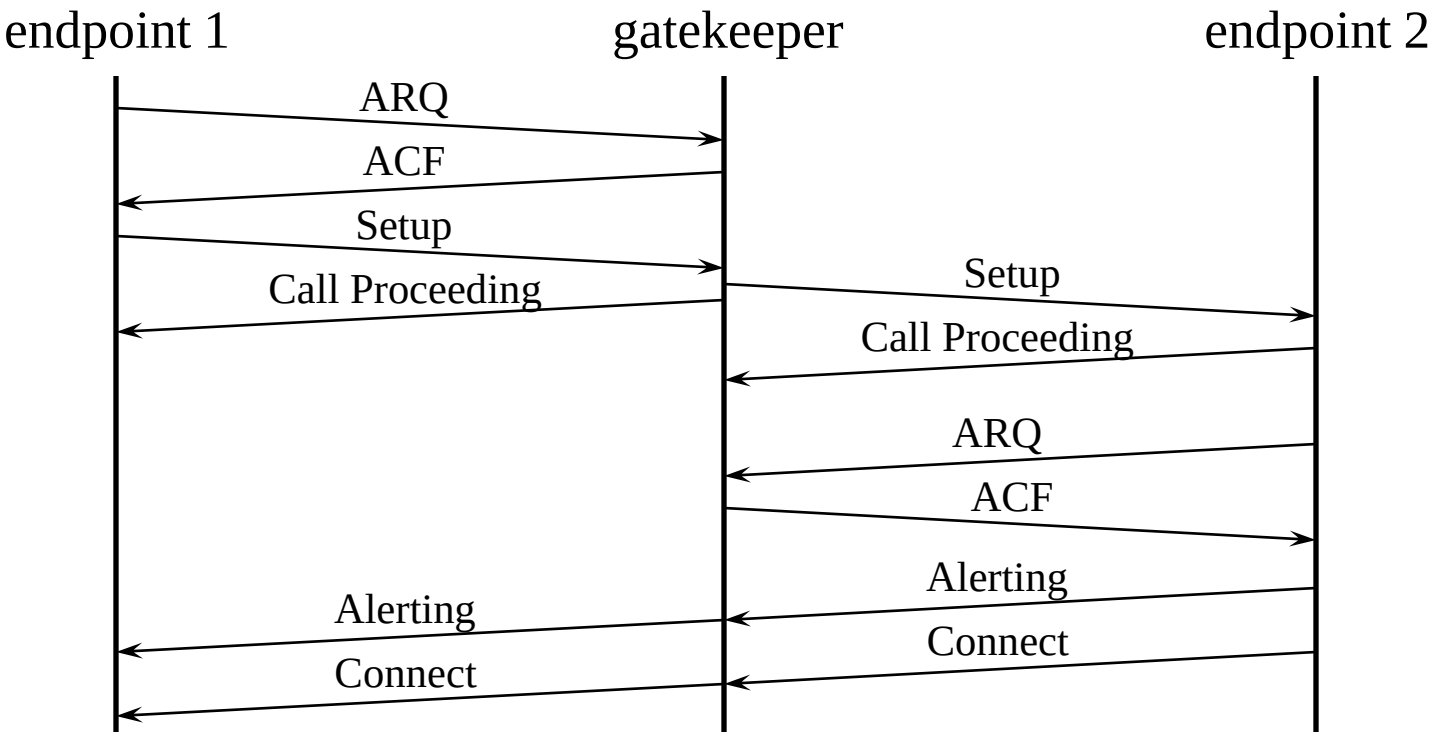
Call Setup Example 1

- Both endpoints use the same gatekeeper
- Direct call signaling



Call Setup Example 2

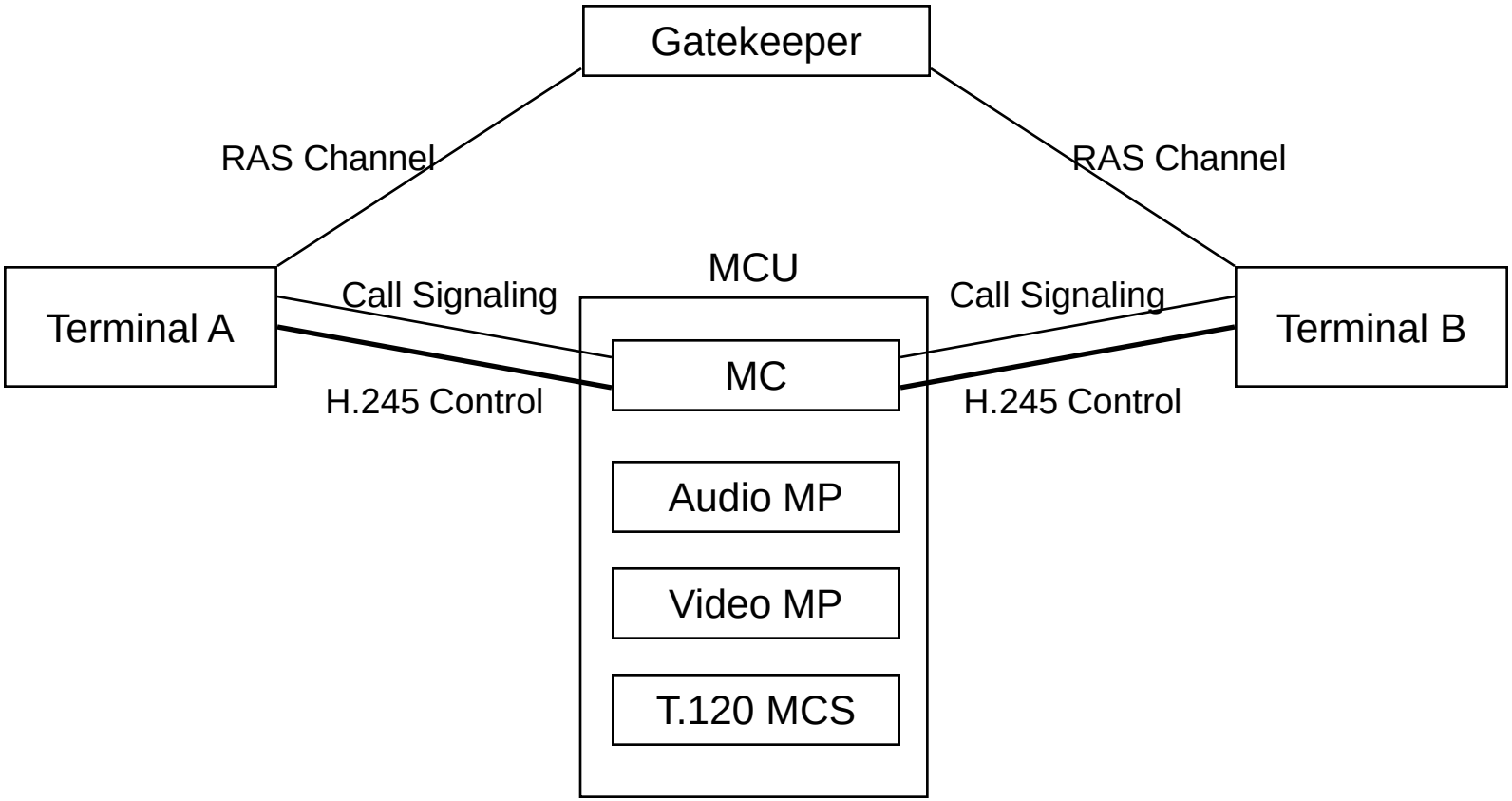
- Both endpoints use the same gatekeeper
- Gatekeeper routed call signaling



Additional Call Signaling Messages

- Setup Acknowledge
- Notify
- Progress
- Status
- User Information
- Hold / Hold ACK / Hold REJ

Step 3: H.245 Control Channel



H.245 Control Channel

- Transport address for the H.245 Control Channel is exchanged on the Call Signaling Channel
- May be routed directly or through gatekeeper (just like Call Signaling Channel)
- Used to exchange capabilities, create logical channels, and exchange multipoint commands

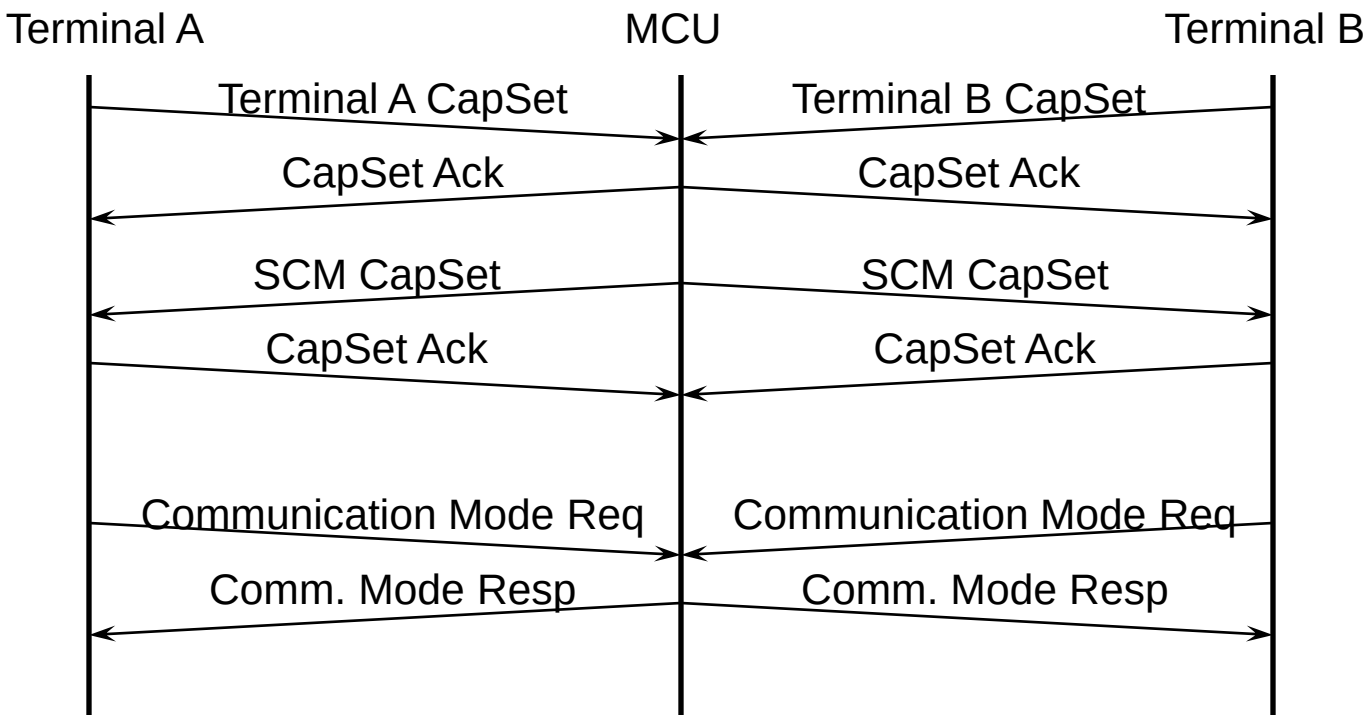
H.245 Capability Exchange

- All endpoints transmit a Terminal Capability Set
  - List of all audio, video, and data capabilities supported by the endpoint
  - Separate set for transmit and receive capabilities
- MCU receives the capabilities and determines the Selected Communication Mode (SCM)
- MCU transmits a capability set based on the SCM

H.245 Communication Mode

- Terminals send Communication Mode Requests to indicate the preference for centralized or decentralized conference
- MCU selects a mode and transmits Communication Mode Response or Communication Mode Command
  - Communication Mode Command contains multicast addresses to use in distributed conference

H.245 Control Channel Message Exchange

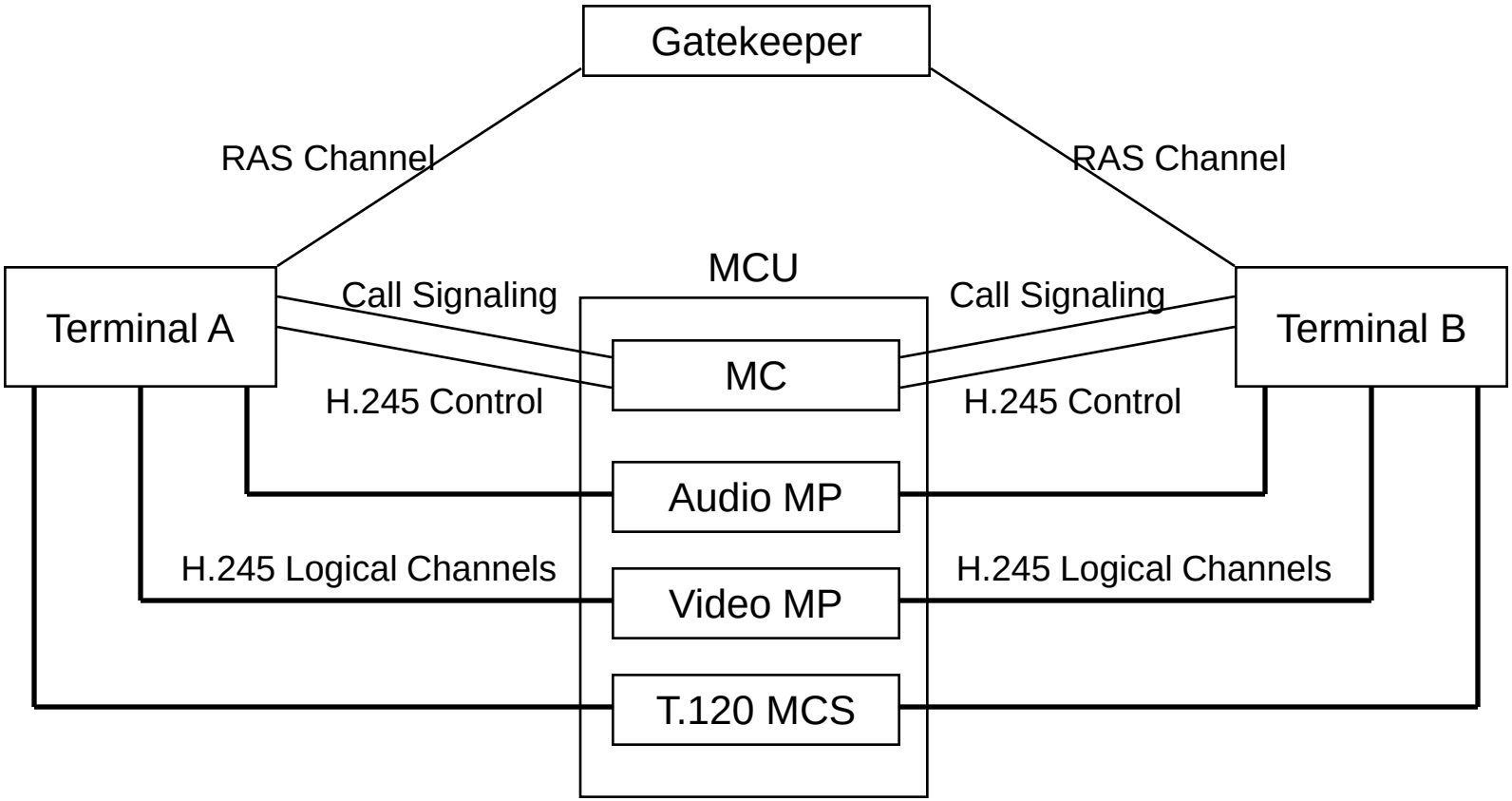


SCM: Selected Communications Mode

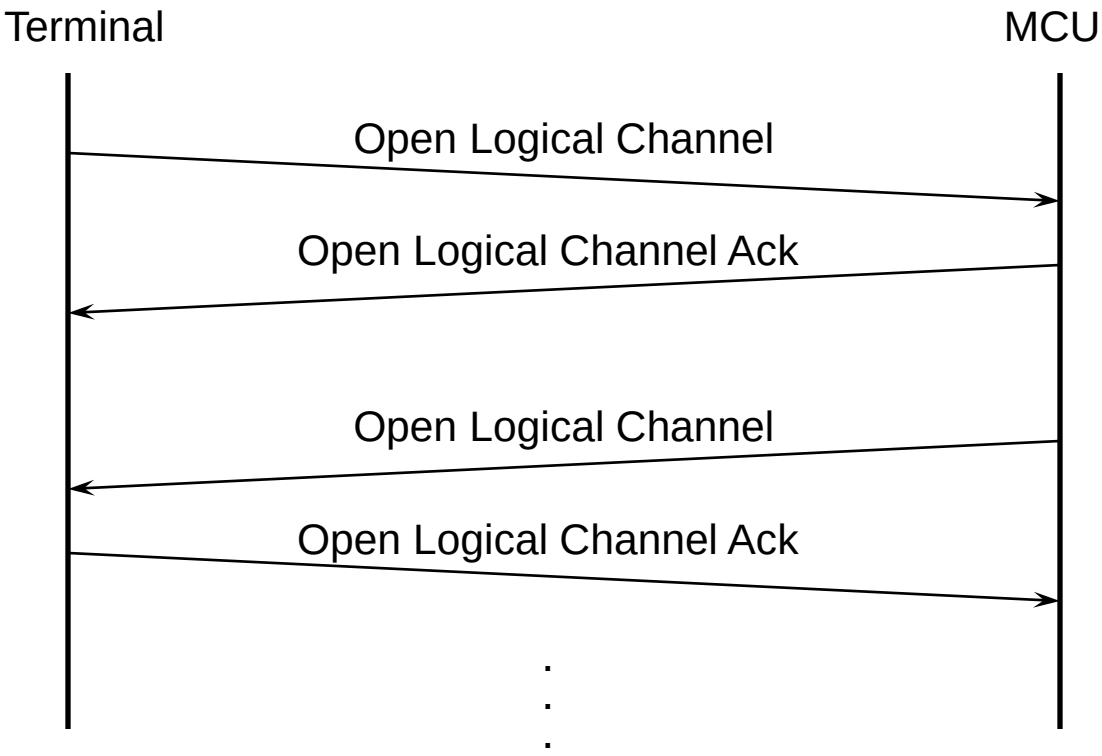
Other H.245 Procedures

- Master/Slave Determination
  - ex. Select a single MC to use for a conference
- Request Mode
  - After the capability exchange, a terminal may request the other terminals use a specific mode (e.g. H.263, two channel stereo G.723, encryption mode)
  - Other terminals do not have to comply
- Commands and Indication
- Round Trip Delay Determination
- Maintenance Functions

Step 4: Logical Channels



Logical Channel Message Exchange



Logical Channels

- H.245 is used to exchange Open Logical Channel and Open Logical Channel Ack messages
- Each terminal requests a unidirectional logical channel for every type of media it wants to transmit
- For Centralized Multipoint Conference
  - The MCU responds with the OLC Ack message indicating the Transport Address to use for the channel
  - The MCU requests corresponding unidirectional logical channel
- For Decentralized Multipoint Conference
  - MCU forwards the OLC to all other stations
- Uses RTP to encapsulate audio and video streams