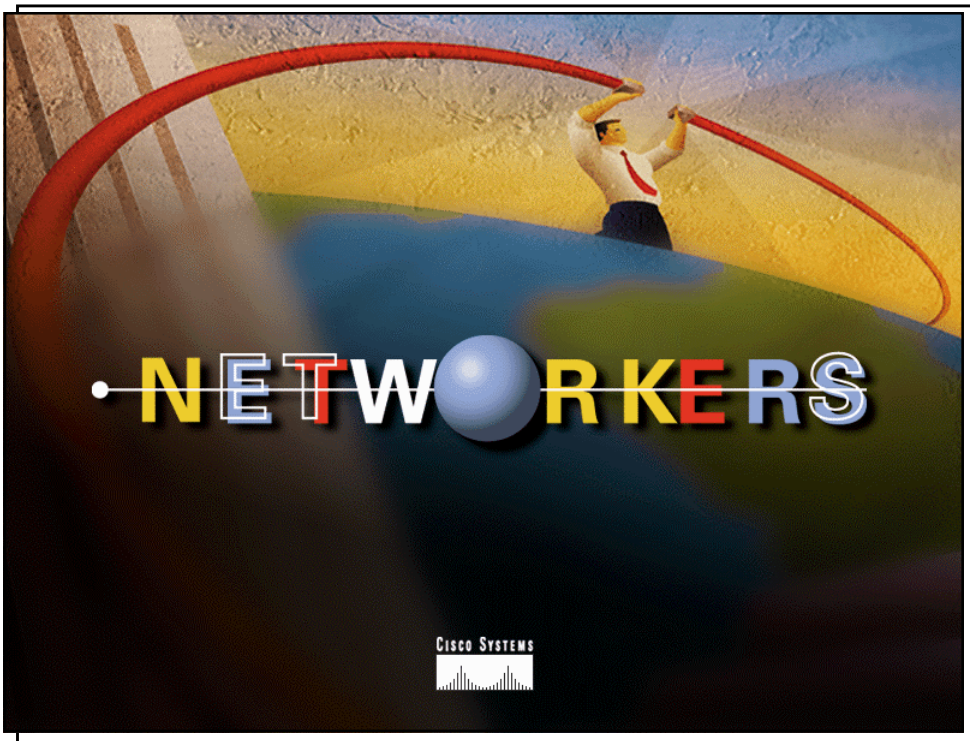

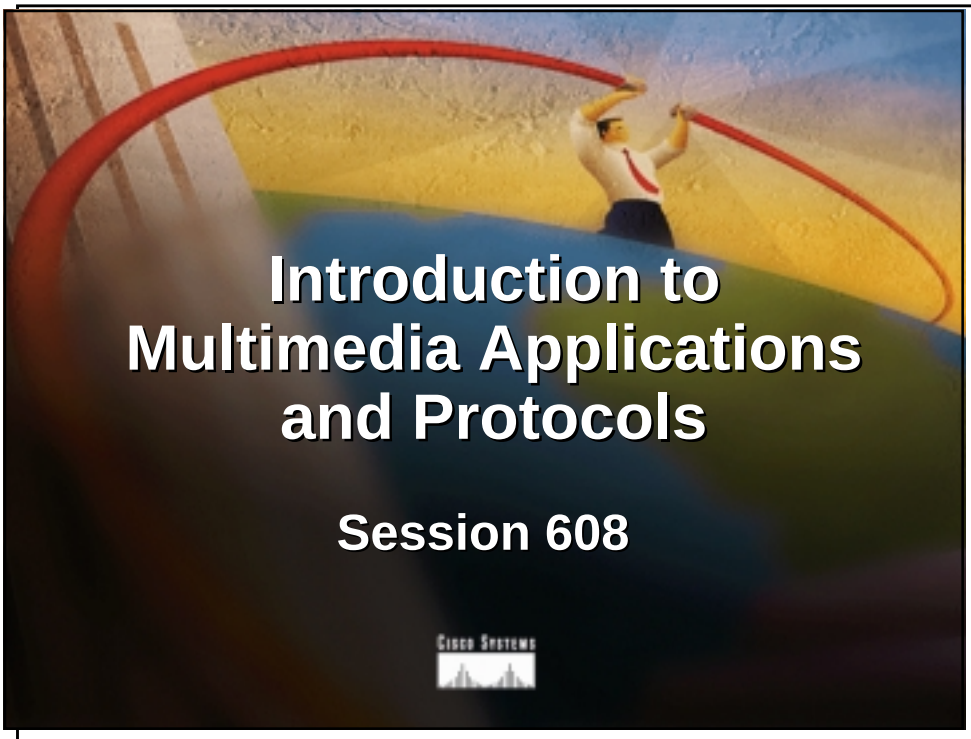

Agenda

- Application Classes
- Common Technology
- Protocols and Architectures
- Network Planning

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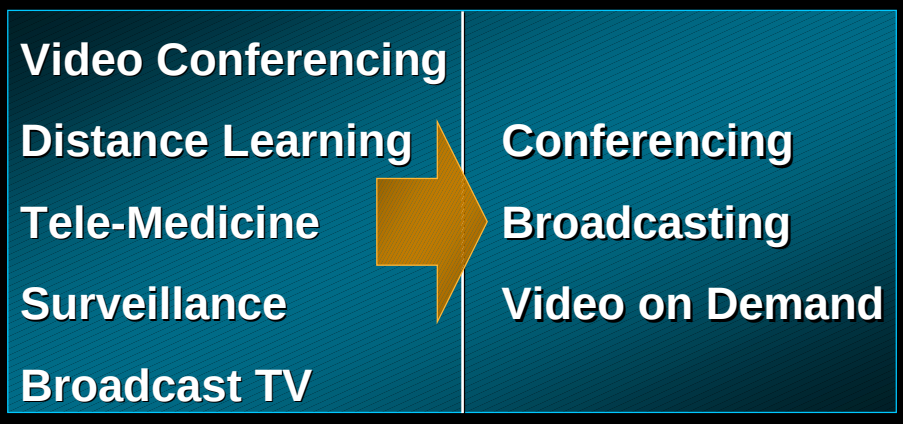
Video Applications



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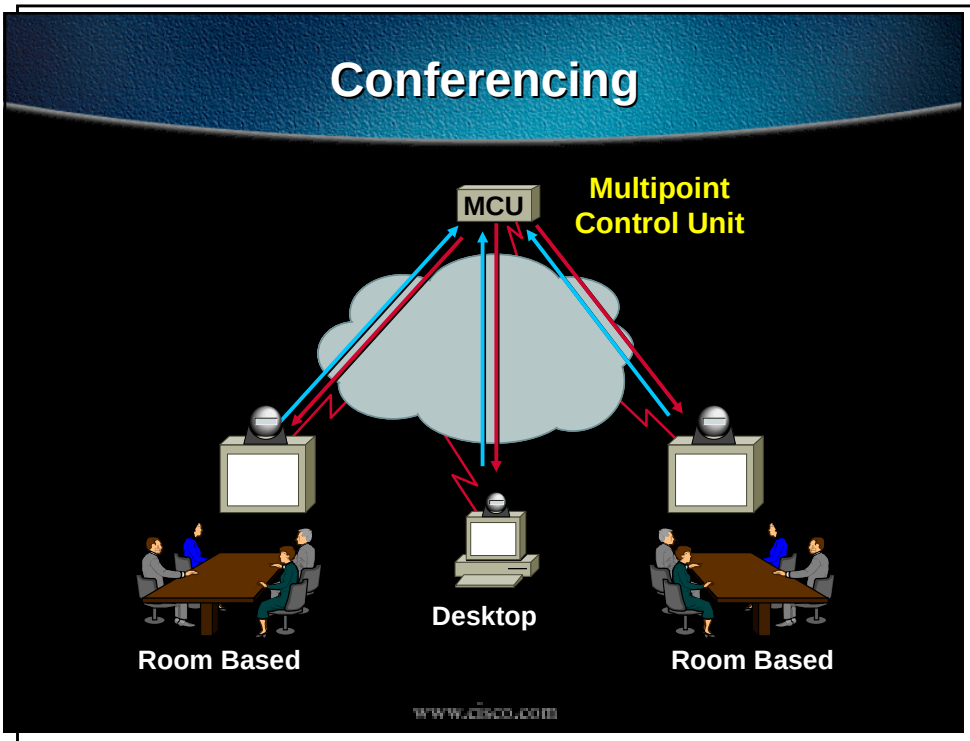
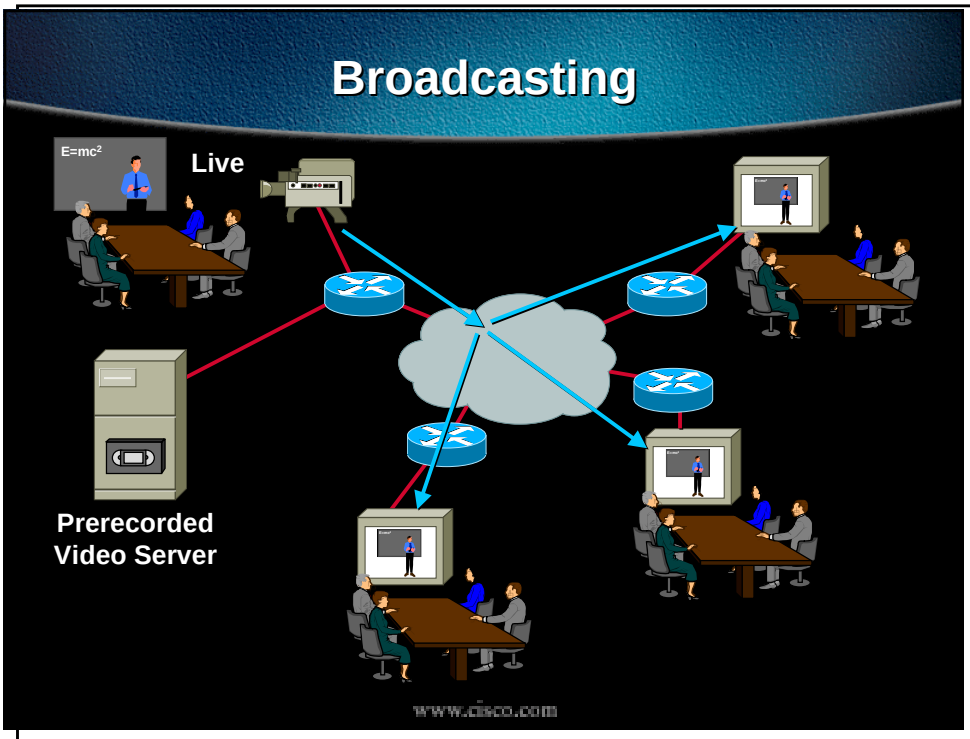
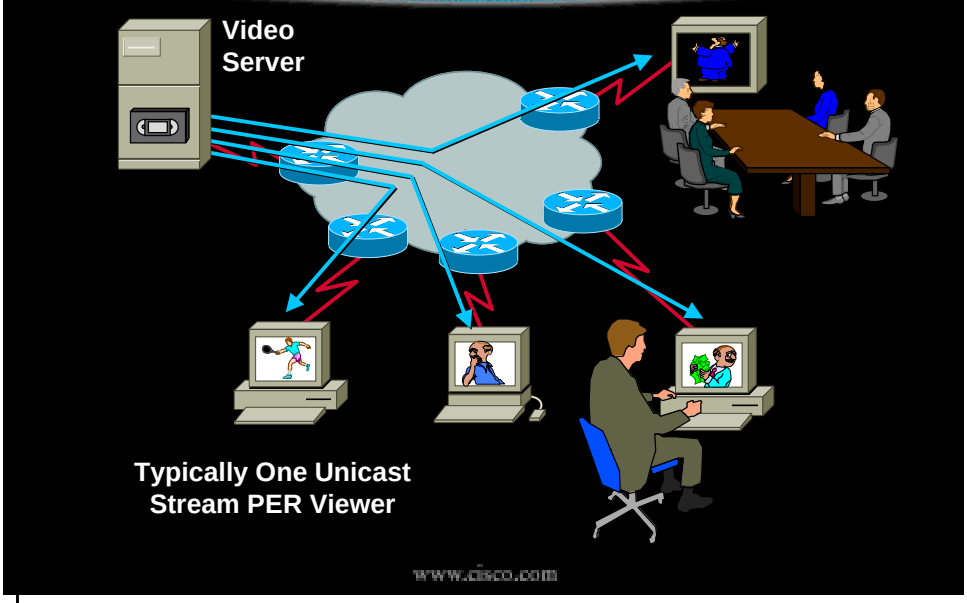
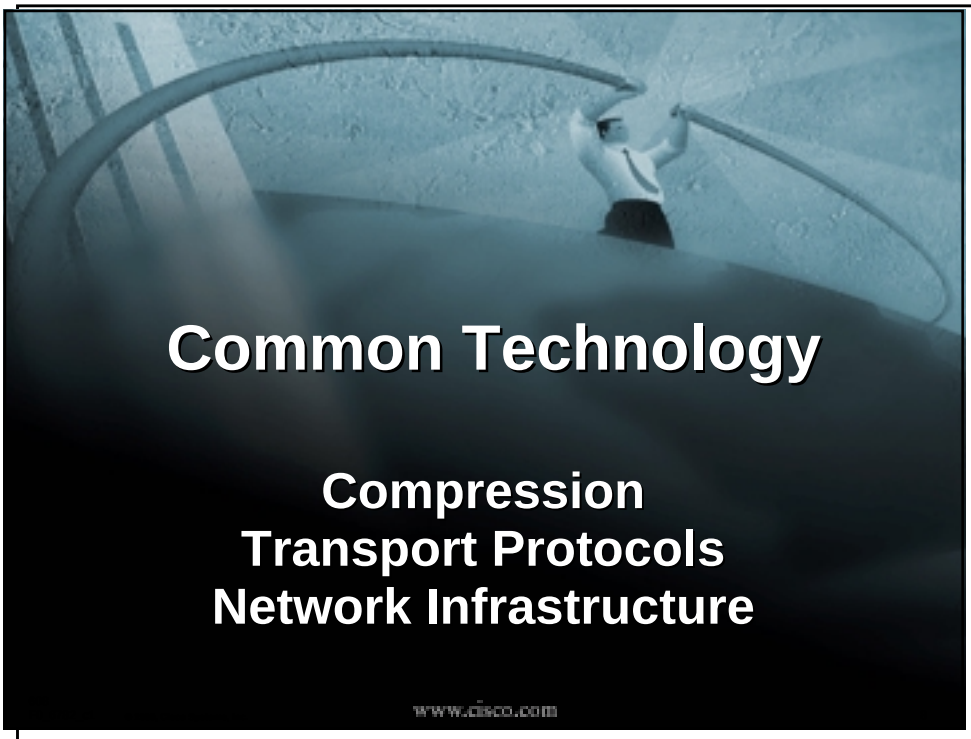




Video on Demand





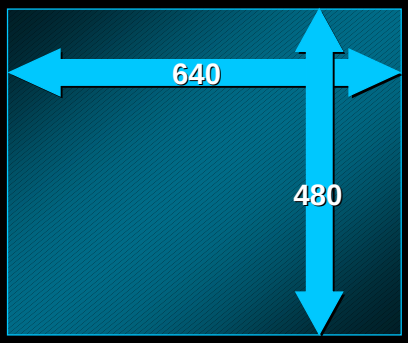
Video Data Requirements

640 x 480 pixels x

24 bits/pixel x

30 frames/second

= 221 Mbps



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Video Compression Standards

	Video Quality	Bandwidth (bits/sec)	Latency (ms)
Motion JPEG	Broadcast	10–26 M	<45
MPEG-2	Broadcast/HDTV	3–16 M	200–500
MPEG-1	VCR/Business	.5–1.5 M	200–500
H.261/H.263	Video Conf.	64 K–2 M	150–250
MPEG-4	Internet/Business	< 64 K–4 M	150–500

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Audio Compression Standards

Method	Source BW	Compress Ratio	Bandwidth Requirement
G.723.1	64 Kbps	10:1	6.4 Kbps
G.729	64 Kbps	8:1	8 Kbps
G.721	64 Kbps	2 : 1	32 Kbps
G.722	224 Kbps	3.5–4.6 : 1	48–64 Kbps
MPEG	706 Kbps	3–11 : 1	64–256 Kbps

Real-Time Transport Protocols

- Proprietary protocols for streaming
  - Real Networks, Microsoft, others (primarily unicast)
- IETF standards track protocol: RTP/RTCP
  - Conferencing (H.323) and streaming (Cisco IP/TV® and Apple QuickTime)

RTP/RTCP

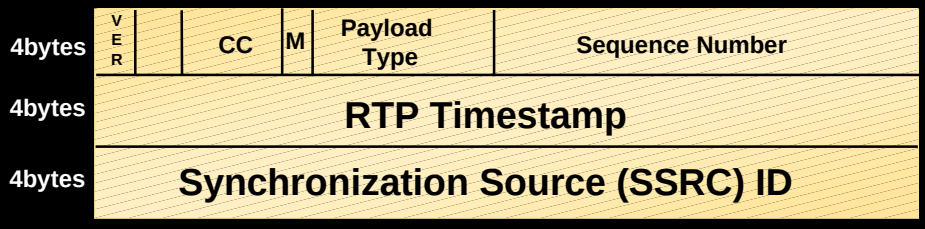
- Real-time transport protocol
  - Carries the data (media)
- Real-time transport control protocol
  - Carries control info among all session members
- Specified in RFC 1889

RTP/RTCP Features

- RTP and RTCP both based on UDP
  - Low delay is more important than 100% reliability
- Designed from the start to operate in multicast as well as unicast modes

UDP + RTP = Transport Layer

- UDP provides checksum and length
- RTP end-to-end network transport functions:
  - Payload type identification—voice, video, compression
  - Sequence numbering
  - Time stamping



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RTCP Functions

- Provides feedback on distribution quality (especially loss rate)
- Provides a uniform time reference for synchronization between separate RTP sessions
- Identifies all senders and receivers

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What Does Video Want from the Network?

- Sufficient bandwidth
- Low packet loss (avoid congestion)
- Low delay (jitter increases max delay)
- Multicast delivery for broadcast or large conferences

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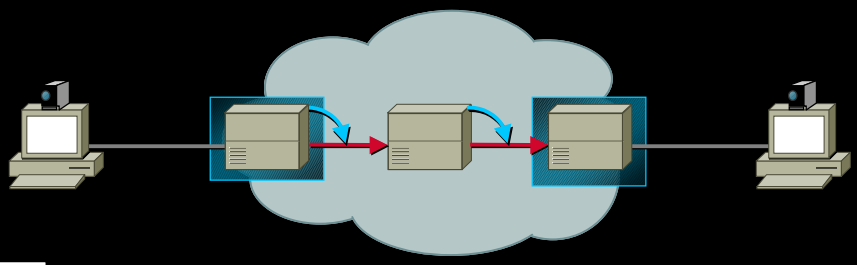
Mostly Fixed Delay Components



- Propagation delay—six microseconds per kilometer
- Serialization delay—buffer to serial link
- Processing delay
  - Coding/compression/decompression/decoding
  - Packetization

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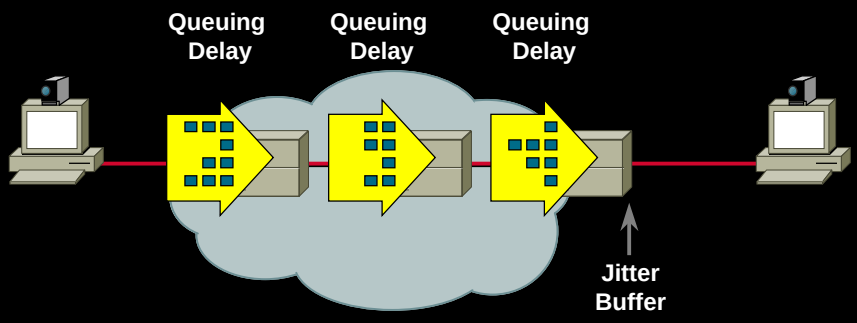
Variable Delay Components



- Variable packet sizes
- Queuing delay
- Jitter buffers

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What Do We Do About Queueing Delay?

- Smart scheduling
  - Priority queuing
  - Weighted fair queuing
  - Random Early Detection (RED)

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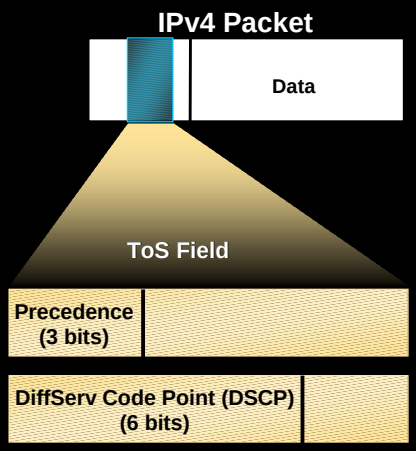
IP Precedence/DiffServ Marking



In Band QoS Signaling

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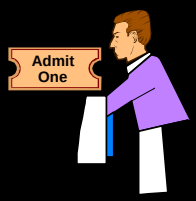
RSVP: Resource Reservation Protocol



- IETF proposed standard, RFCs 2205–2210
  - Reservation of bandwidth and delay
- Dynamic control of queuing policy
- Flow can be signaled by end station or proxied by router (static, CiscoAssure)
- RSVP and generic QoS APIs are in Winsock 2.0 on Windows 98 and 2000

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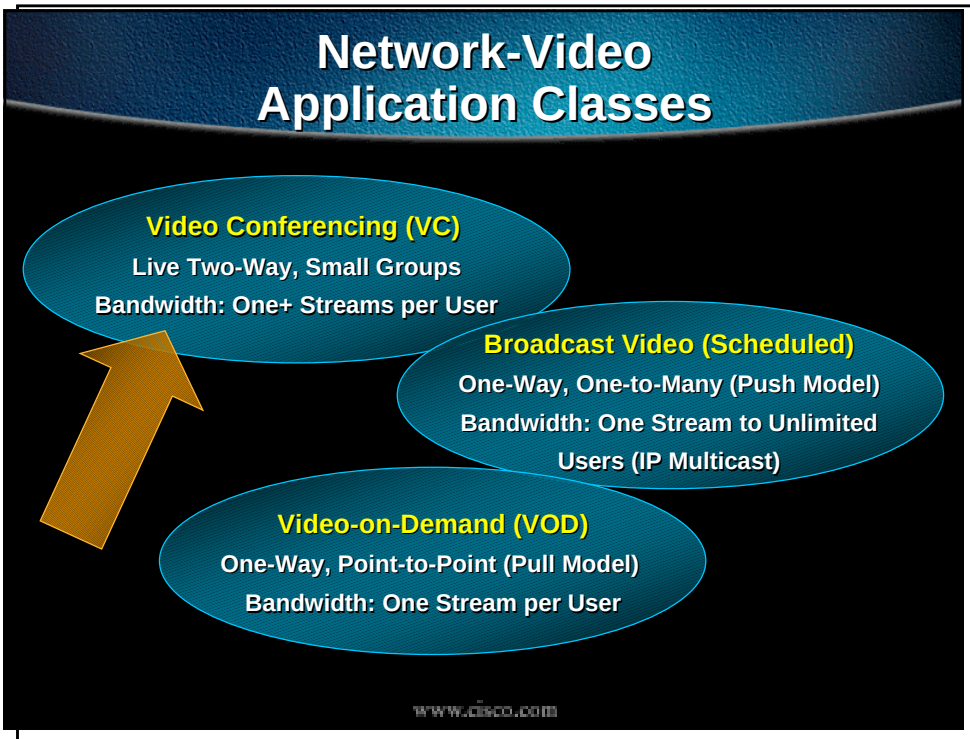

IP Conferencing Protocols

- **H.323**
  - ITU standard protocol
  - Evolved from H.320 ISDN standard
- **SIP—Session Initiation Protocol**
  - IETF proposed standard
  - Simpler, but less mature, than H.323

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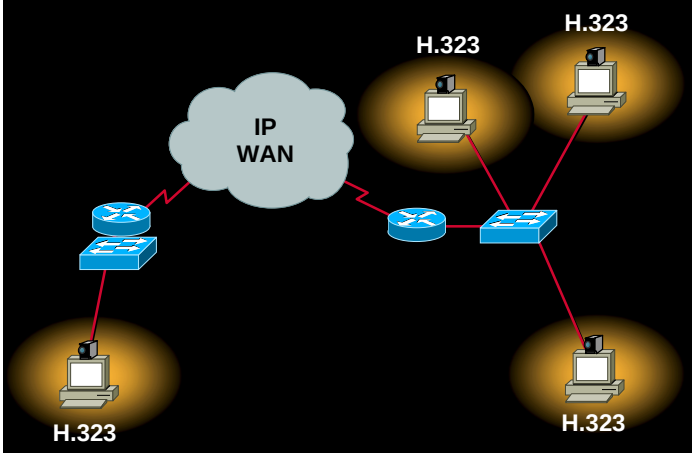
H.323 Architecture Endpoints



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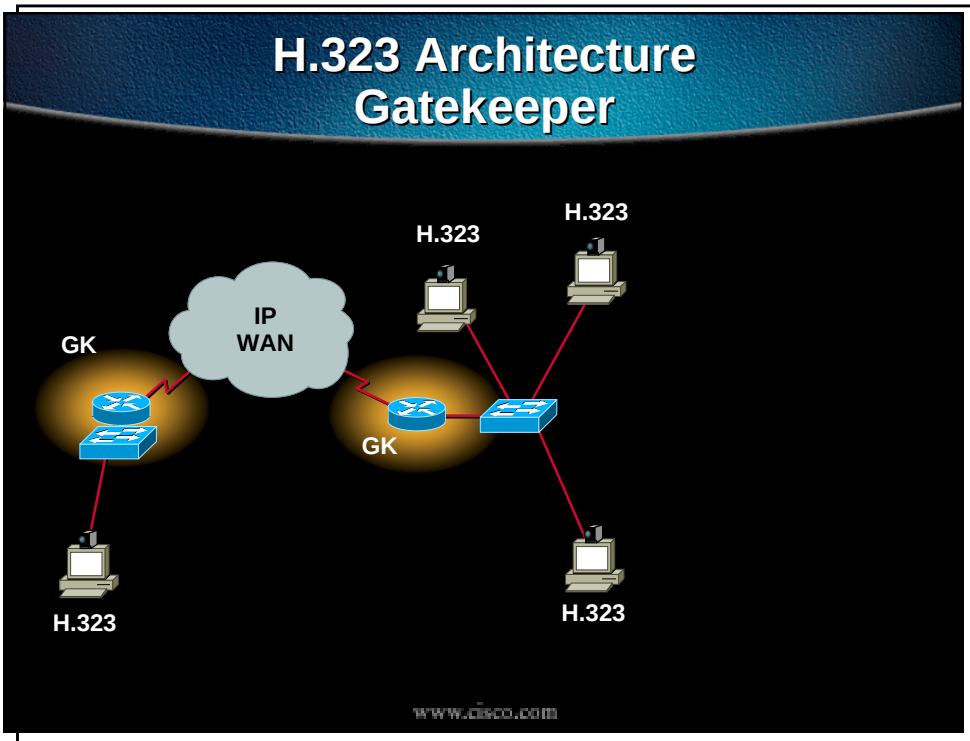

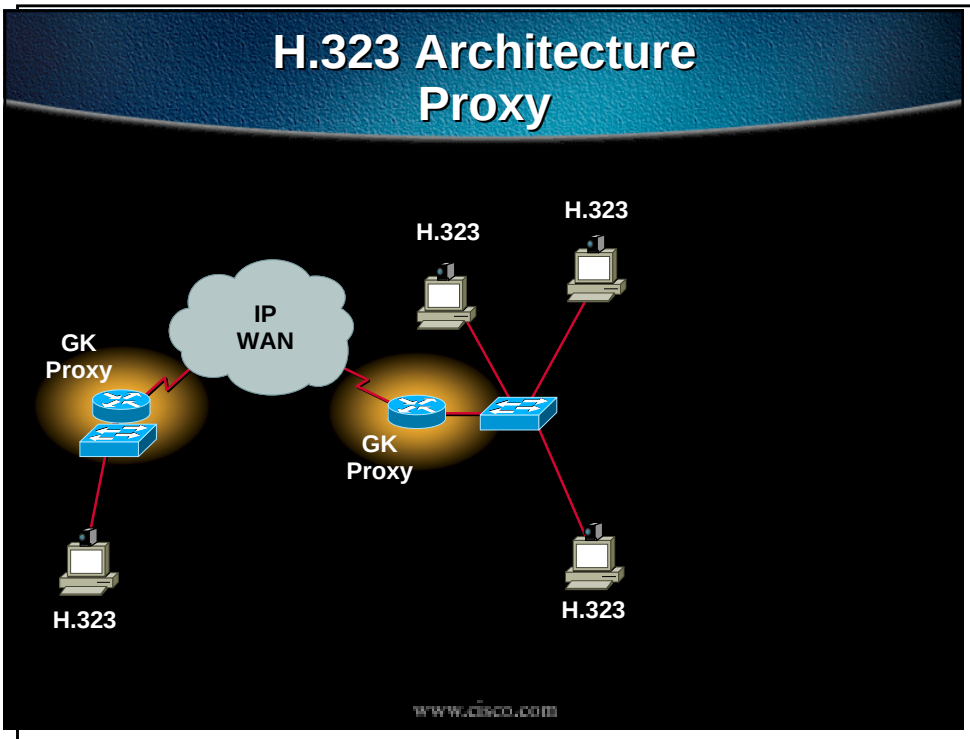

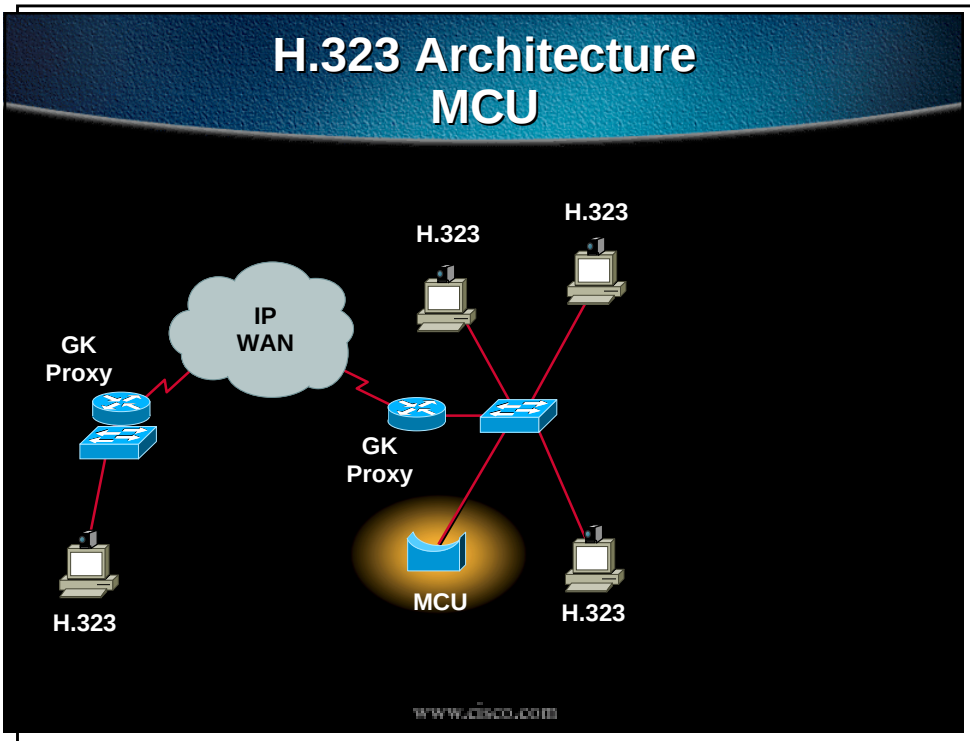

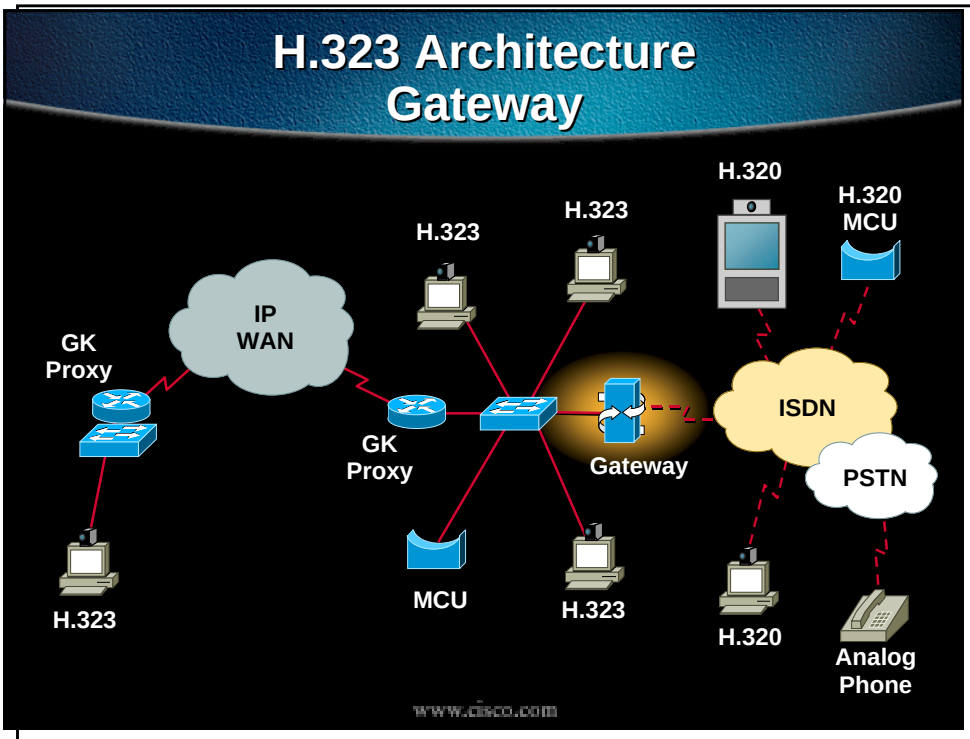

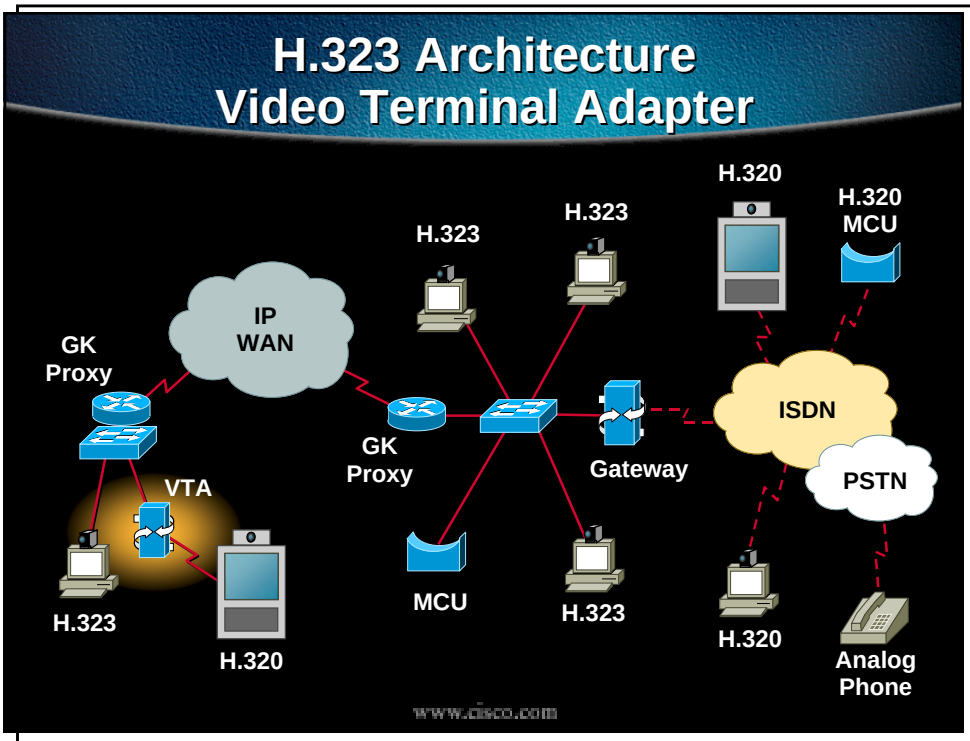

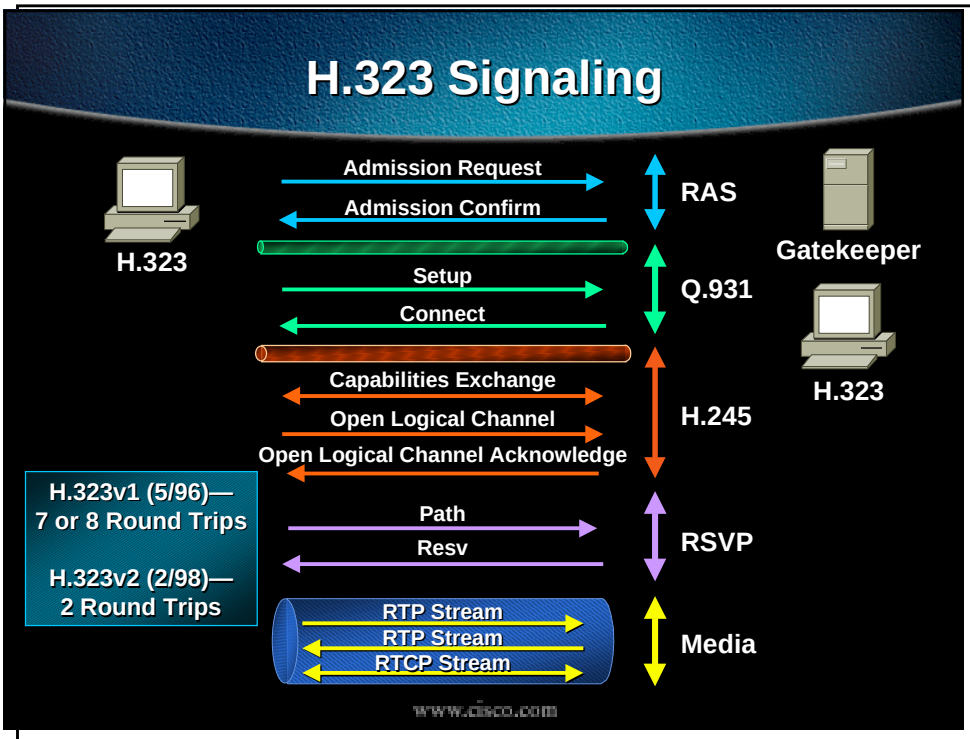

SIP: Session Initiation Protocol

- Lightweight signaling protocol, in part a reaction to complexity of H.323
- IETF Proposed Standard RFC 2543, March 1999
- SIP bake-offs April 1999, December 1999 with 26 organizations
  - Clients, proxy/redirect servers, PSTN gateways…

SIP Features

- Text-based in style of HTTP
  - → INVITE user@host.net
  - ← 200 OK
- Post-dial delay = 1.5 RTT
- Allows stateless servers for scalability
- Uses SDP to describe call parameters

Network-Video Application Classes

Video Conferencing (VC)
Live Two-Way, Small Groups
Bandwidth: One+ Streams per User

Broadcast Video (Scheduled)
One-Way, One-to-Many (Push Model)
Bandwidth: One Stream to Unlimited Users (IP Multicast)

Video-on-Demand (VOD)
One-Way, Point-to-Point (Pull Model)
Bandwidth: One Stream per User

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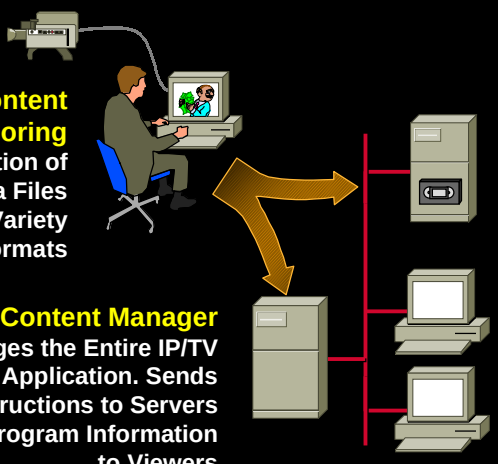
Video Broadcasting Infrastructure



Content Authoring
Creation of Media Files in a Variety of Formats

IP/TV Content Manager
Manages the Entire IP/TV Application. Sends Instructions to Servers and Program Information to Viewers

IP/TV Server(s)
Captures, Stores and Transmits Programs According to Content Manager's Instructions

IP/TV Viewers
Present Program Listings to Users and then Display Selected Programs

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Streaming File Formats

- Real Networks—Proprietary formats including multirate video
- Microsoft—AVI, ASF (advanced streaming format)
- Apple QuickTime—Basis for MPEG-4
- MPEG-1/2 Elementary and Systems Streams, “MP3” audio
- RTP file formats

Choosing a Format

- Depends upon what delivery system will be used
- Driven by what authoring systems produce
  - Editability
- Need multirate streaming?
  - Want scalable encoding or multistream file format

Control Protocols for Broadcasting

- Much simpler than conferencing
- Web interface
  - Link invokes player with necessary session parameters
- Announce/subscribe protocols
  - Session parameters distributed to potential receivers
  - Examples: SMIL (Real), SDP (IP/TV)

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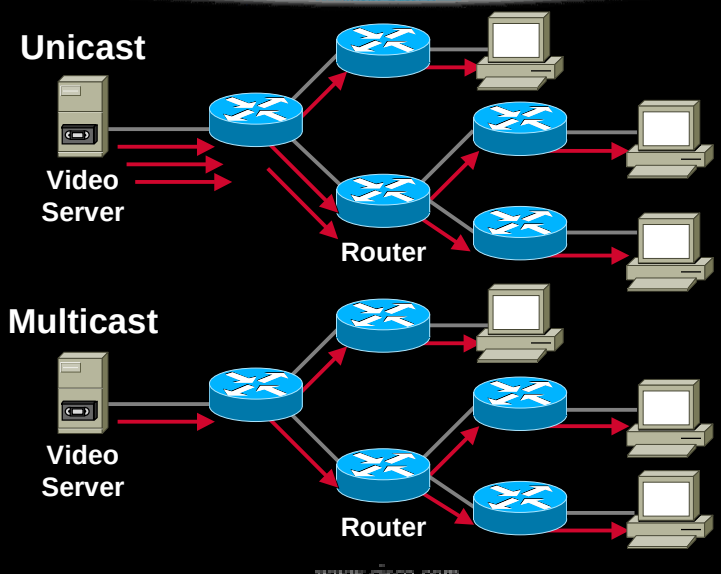
Need Multicast for Scalable Video Broadcast



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IP vs. Application Multicast

- Network-level IP multicast:
  - Builds a dynamic distribution tree using standard, multivendor protocols
  - Automatically reconfigures distribution tree as receivers come and go
- Application-specific schemes:
  - "Reflectors" and "splitters" form a rigid distribution tree (static routing)
  - Need new agents for each application

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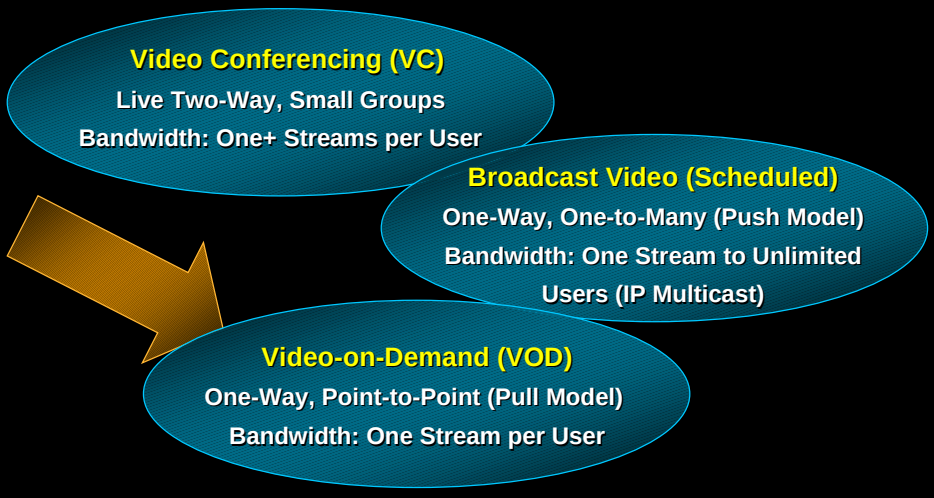
Network-Video Application Classes



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What Is Video on Demand?

- Architecture like video broadcasting:
  - Servers, viewers, content management
- But:
  - Video available “immediately” upon request
  - ⇒ Unicast stream per user
  - ⇒ Server and network capacity scaling is an issue

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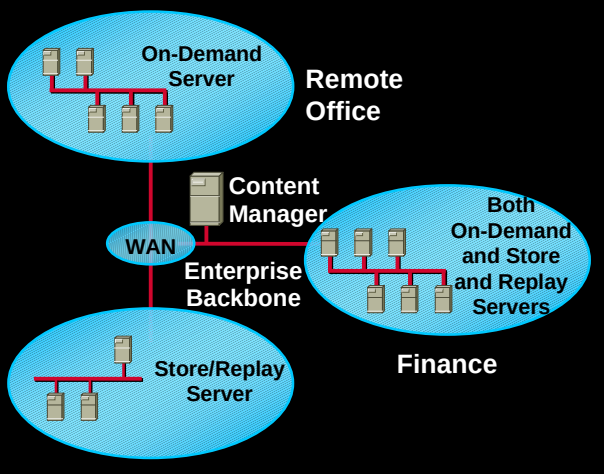
Scalable, Distributed Architecture

- Distribute content to local servers
- Balance load among servers
- Minimize and localize bandwidth consumption



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VOD Control Protocols

- Access via:
  - Web browser and plug-in
  - Application program listing
- Server session control protocol:
  - Usually TCP because point-to-point
  - Provides asset selection, VCR controls
- Proprietary protocol or RTSP

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RTSP: Real-Time Streaming Protocol

- IETF Proposed Standard RFC 2326
- Text-based in style of HTTP
  - → PLAY rtsp://foo.com/bar.file RTSP/1.0
  - ← RTSP/1.0 200 OK
- Uses SDP to describe media
- Uses RTP for media transport

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Domains for Scalability

- Conferencing applications
  - Gatekeeper zones
  - Proxies and firewalls at boundaries
- Streaming applications
  - Multicast administrative scopes
  - VOD clusters

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The Video Quality Conundrum

- **Video quality** is directly related to **bandwidth**
- Bandwidth is usually a fixed, limited resource
- All unicast solutions force a compromise between the number of users supported and video quality

  The more users, the lower the bandwidth per user must be, thereby lowering the video quality
- Delay also impacts quality for interactive video

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Bandwidth and Load

Video Conferencing	128 Kbps 384 Kbps	100 pps 100 pps
MPEG-1/MPEG-2	1 Mbps 6 Mbps	85 pps 500 pps
Video on Demand	128 Kbps 512 Kbps 1 Mbps	11 pps 44 pps 88 pps

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Choosing Quality/Bandwidth

- Know your target application
  - Example: Enterprise vs. Internet
- But don't aim too low
  - 28.8 video is a teaser, not a real solution
- Plan to increase network capacity
  - Compression won't improve 10X

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Business Quality Video

56 Kbits/second

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Business Quality Video

450 Kbits/second

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Business Quality Video

1000 Kbits/second

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IP Frames or ATM Cells?

	IP	ATM
Transport	Ethernet(s) FDDI ATM	ATM Only
QoS	RSVP IP Precedence	VBR, CBR
Bandwidth	Assured thru Routers	Guaranteed by Switches

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IP Quality of Service

- IP QoS maps onto any Layer 2 QoS
  - ATM
  - 802.1p
- Routers can do QoS for dumb links
  - Task is same for packets or cells

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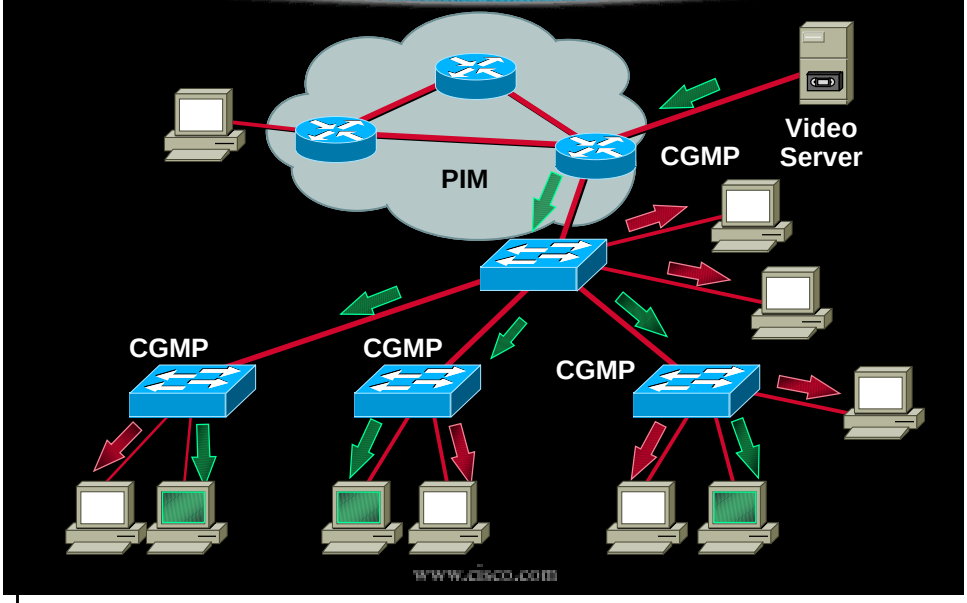
Deploying IP Multicast

- Use administrative scoping, RFC2365
  - Keeps traffic where you want it, e.g. multiple scopes for different bandwidths
  - Allows local multicast address allocation and address reuse
- Rendezvous Point (RP) placement
  - Consider splitting load on multiple RPs

Choose the Right Equipment

- Use devices that can handle high levels of multicast traffic well:
  - Replication at high-traffic levels
  - Large numbers of groups and sources
- Some potential problem areas:
  - ATM LANE broadcast unknown server
  - Some DSL devices
- Recommend switches, not hubs

Need Switches That Prune



Summary

- There are many different applications for packet video
- Supported by a well established body of technology
- Protocols and architectures have been developed to meet the needs of each class of applications
- Network infrastructure components are ready to be deployed

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