

Lots of Video on the Internet Random Thoughts

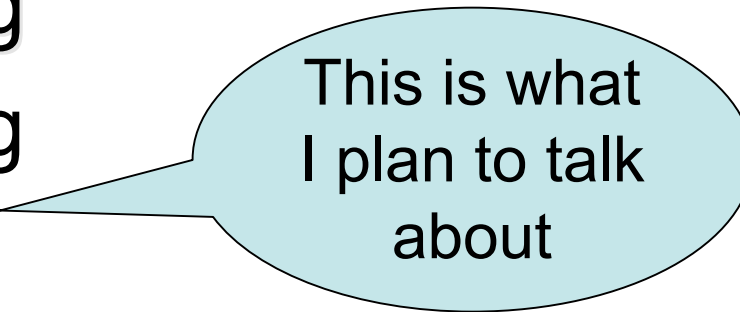
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Voice all over Again?

- In early 1996 Steve Deering said to me:
 - “This VoIP stuff is going to destroy the Internet...
...and it'll be *your fault!*”
- It didn't, but it did spawn a whole bunch of stuff, some good, some bad, some ugly.
 - SBCs, SIP universe, NAT complications, IMS in walled gardens
- Are we going to see the same phenomena recapitulated 10 years later?

Video Applications

- Video Conferencing
- Realtime Streaming
- Content download



This is what
I plan to talk
about

Why?

It's hard

It's where the \$\$\$ is

It's what I'm working on

∴ It's what I know something about

Voice compared (*naïvely*) to Realtime Video

Voice	Video
Isochronous	Isochronous
Congestion unresponsive	Congestion unresponsive
Low delay	Moderate Delay
Low bandwidth	High bandwidth
Moderately loss intolerant	Highly loss intolerant

These are the problem areas I want to concentrate on

Video Bandwidth

Typical Video Conference	300kbps
Current Internet Streaming	50-700kbps
MPEG2 Entertainment Video SD Broadcast SD DVD HD Broadcast	3.75Mbps 8Mbps 13-18Mbps
MPEG4/AVC Entertainment Video SD Broadcast HD Broadcast	1.5-2Mbps 8-10Mbps
CIR601 Uncompressed Video	270Mbps
Professional Sports Cameras: 1920x1080@180fps	10Gbps
Ultra HD (uncompressed) 7680 x 4320@60fps	12Gbps
3D Holographic (uncompressed - 200 slices) 1600x2900@60fps	6.3Tbps

Packet Loss in Video

- Each Packet Carries Multiple MPEG Frames
 - Any loss likely causes visible artifact for a varying amount of time
 - Not like voice - human visual system is much more sensitive to distortion than human auditory system
 - Error concealment technology for video not nearly as effective as for voice
- Rule of thumb: no more than one artifact per 2 hour movie
 - For MPEG-2 SD content @ 3.75 Mbps this translates to $< 0.390 \times 10^{-6}$ packet loss rate
 - MPEG-4 AVC High Definition requires at least 6 Mbps Which translates to $> 0.244 \times 10^{-6}$

What does this mean for Protocols? Quick Architectural tour

L1/L2

- Unidirectional Optics
 - Highly asymmetric bandwidth for broadcast and streaming
 - Peer-to-peer is a real problem here!
- Channel bonding (e.g. Etherchannel)
 - Large-scale video will nearly always exceed fastest economically/technically viable medium
 - 4x 10GigE per POP, 15 terabits/metro
- Mesh or overlaid rings for reliability

L3 (IP & MPLS)

- Heavy use of SSM
 - Also P2MP MPLS (for core distribution inside an AS)
 - Some people want to use MTR to put video on separate routing topology
- AMT (automatic multicast tunneling) for delivering to customers of other ISPs
 - no inter-ISP multicast cooperation
- Hitless failover critical:
 - Disjoint path routing, Redundant feeds
 - MPLS or IP FRR (need 400ms convergence to avoid delay or long FEC blocks)
- UDLR for the unidirectional Optical links

QoS

- Admission control needed for VoD
 - Match server capacity to network capacity and access link loading
- Diffserv for carrying media
 - Entertainment Video does not mix well with other classes, especially interactive voice
 - Now need extra queue(s) in core/edge routers to isolate video
 - BE, EF, Signaling, Business customers, video
- Access links are nearly always a bottleneck
 - Video on DSL is like VoIP on dialup - one stream sucks significant fraction of total link bandwidth

L4-7

- RTP, RTCPSSM
 - Switch from raw UDP transmission underway
 - RFC2250 is king today (MPEG-TS over RTP)
- TCP/SCTP problematic
 - Long buffer fill times
 - Trick Play (fast forward, reverse, etc.)
- FEC to cover random loss and short outages

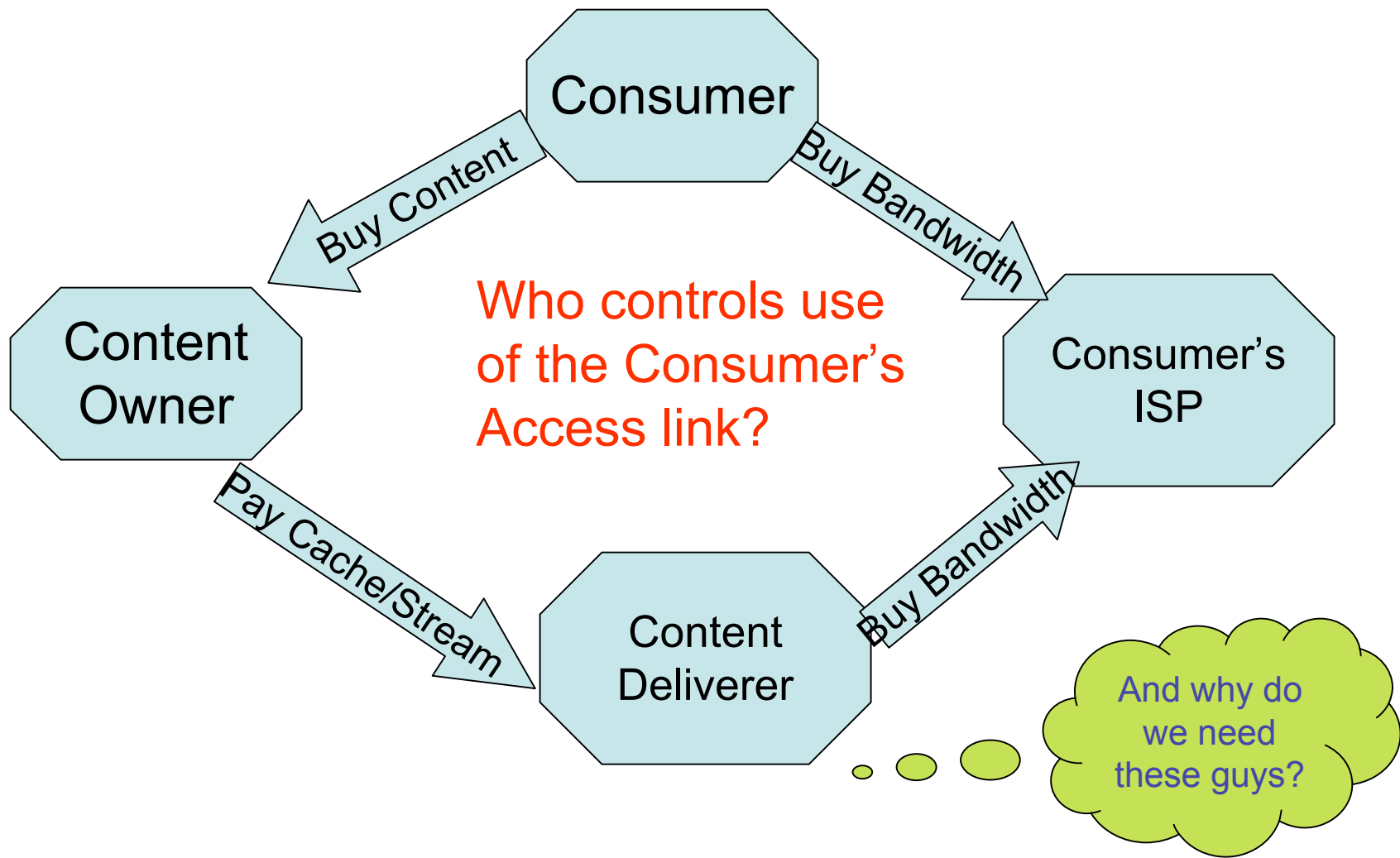
Security Considerations Section

- Little interest in IPSEC or TLS
 - Transport security not considered the problem
- Content protection is king
 - DRM drives nearly all design tradeoffs
 - Desire for tamperproof hardware
 - “Camera-to-eyeball protection”
 - Still arguments about closing the “analog hole”
 - High value broadcast and PPV use rapid key rotation (3-5 seconds)

Finally - we get to L8...

- Interests among players are mis-aligned:
 - Consumers
 - ISPs
 - Content aggregators
 - Content Owners
- Pure carriage uneconomical for ISPs
 - Price for voice or Web and video is unaffordable
 - Price for Video and everything else is “free”
 - Peer-to-peer has no known upper bound on bandwidth usage
- Which brings us right into the NetNeutrality swamp

Interaction diagram



Thank you!

Questions?