Lots of Video on the Internet

Random Thoughts

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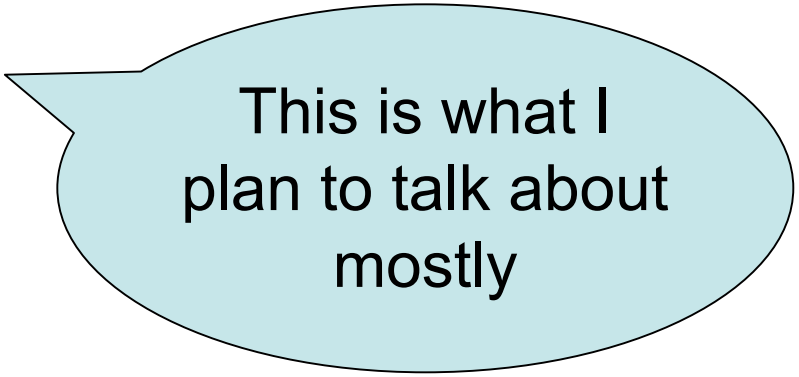
Voice all over Again?

- 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



Voice compared (*naïvely) to* Realtime Video

- Isochronous
- Congestion unresponsive
- Low delay
- Low bandwidth
- Moderately loss intolerant

- Isochronous
- Congestion unresponsive
- Moderate Delay
- High bandwidth
- 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:
  - 3.75Mbps SD, (8Mbps DVD) 13-18 Mbps HD
- MPEG4/AVC Entertainment Video
  - 1.5-2Mbps SD, ~8Mbps HD
- Professional Sports Cameras
  - 1920x1080@180fps uncompressed = 10Gbps
- 3D Holographic
  - 1600-2900@60fps uncompressed = 6.3 Tbps

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 x 10-6
  - MPEG-4 AVC HDefinition requires at least 6 Mbps Which translates to > 0.244 x 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)
  - 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 problematical
  - 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 bout 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