Cisco Canada Plus

IPTV, Internet Video and Adaptive Streaming Technologies

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Presenter Today – Ali C. Begen

- Have a Ph.D. degree from Georgia Tech
- With Cisco since 2007
  - Video and Content Platforms
  - Research & Advanced Development Group
- Works in the area of
  - Architectures for next-generation video transport and distribution over IP networks
- Interested in
  - Networked entertainment
  - Internet multimedia
  - Transport protocols
  - Content distribution
- Member of the IEEE and ACM
- Visit http://ali.begen.net for publications

Agenda

- Part I: IPTV
  - IPTV – Architecture, Protocols and SLAs
  - Video Transport in the Core Networks
  - Video Distribution in the Access Networks
  - Improving Viewer Quality of Experience
- Part II: Internet Video and Adaptive Streaming
  - Example Over-the-Top (OTT) Services
  - Media Delivery over the Internet
  - Adaptive Streaming over HTTP

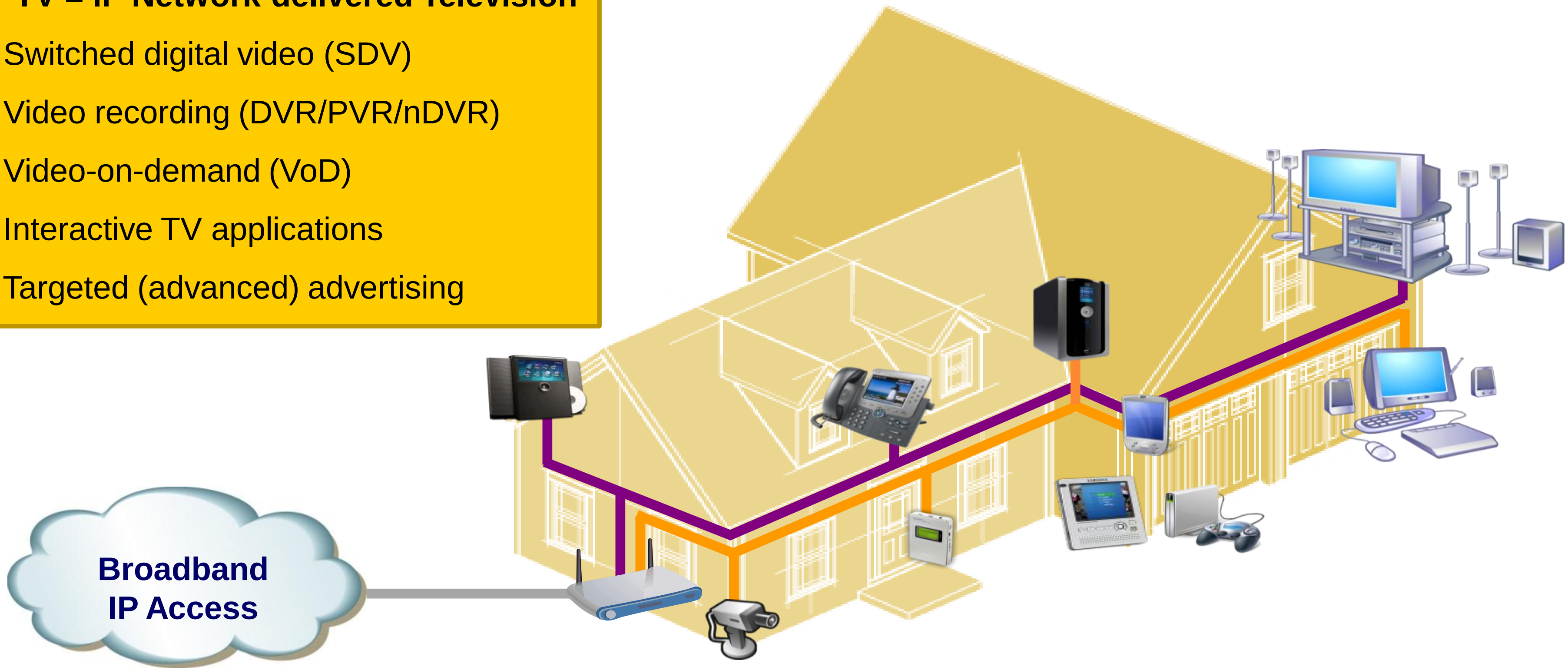
Part I: IPTV

Consumers Seek A Rich Media Experience

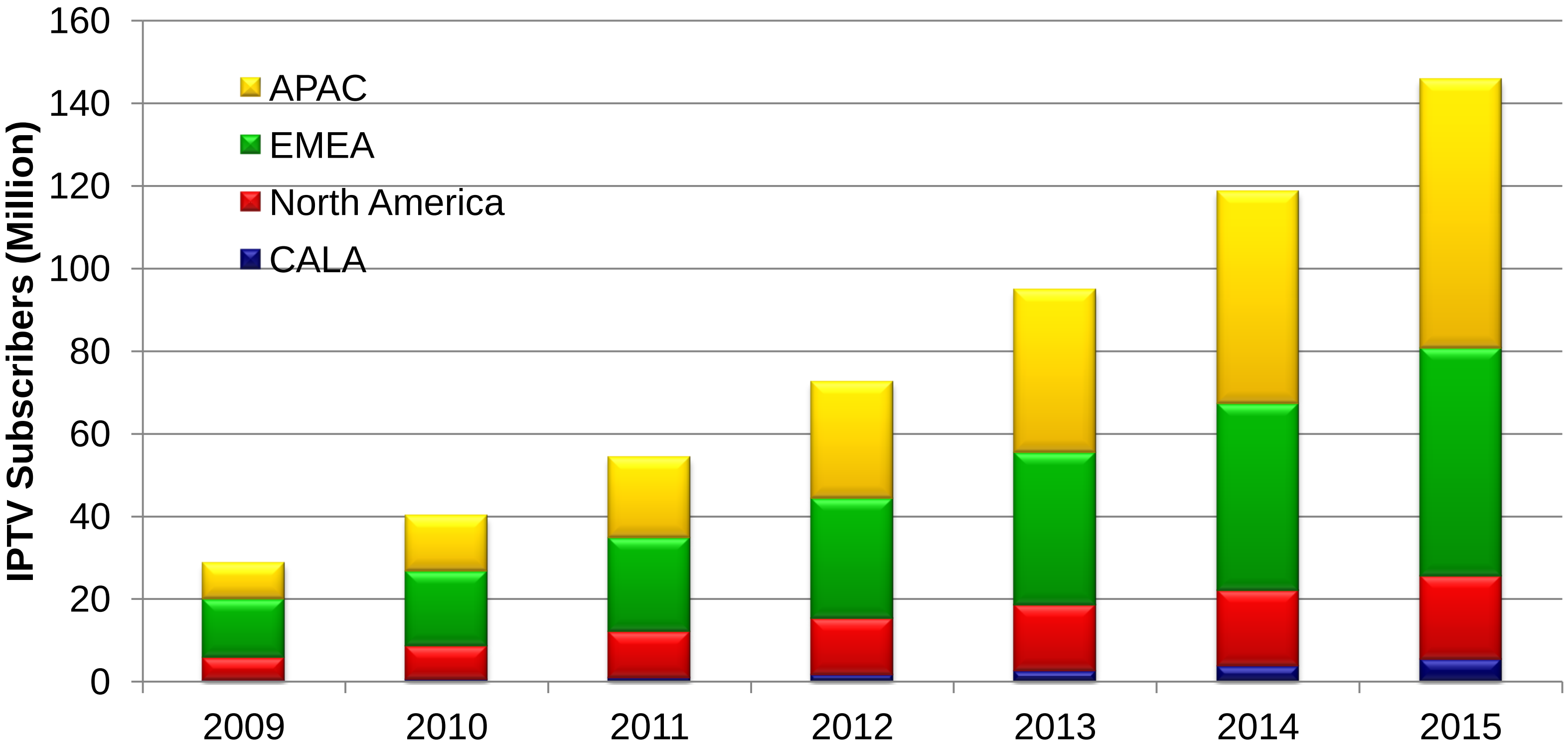
What Is IPTV?
The Fundamental Component for Connected Homes

IPTV = IP Network-delivered Television

- Switched digital video (SDV)
- Video recording (DVR/PVR/nDVR)
- Video-on-demand (VoD)
- Interactive TV applications
- Targeted (advanced) advertising



Growth for IPTV



Source: Infonetics Research, 2011

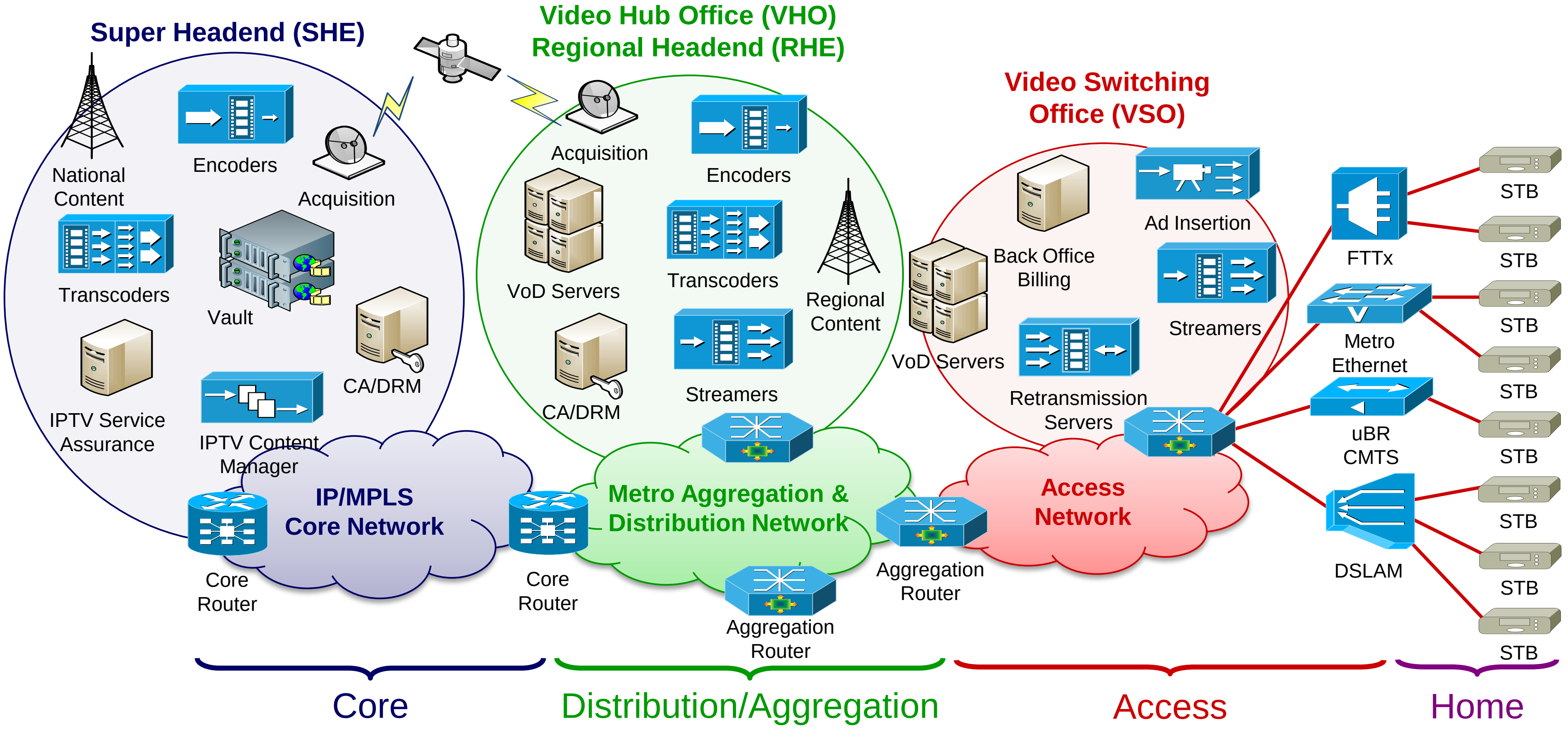
Trends Driving IPTV Adoption

- **Subscribers want more choice and control**
  - New generation grew up computer/Internet savvy
  - Customized for me – One bill, one provider, integrated services
- **Codec, access, server and CPE technologies are improving**
  - MPEG-4 AVC (H.264) improvements, new xDSL, FTTx, DOCSIS 3.0 access technologies
  - Moore's law advancements in processing and memory
- **Competition is increasing among service providers**
  - No longer limited by access
  - Traditional markets are going away, e.g., VoIP is almost free

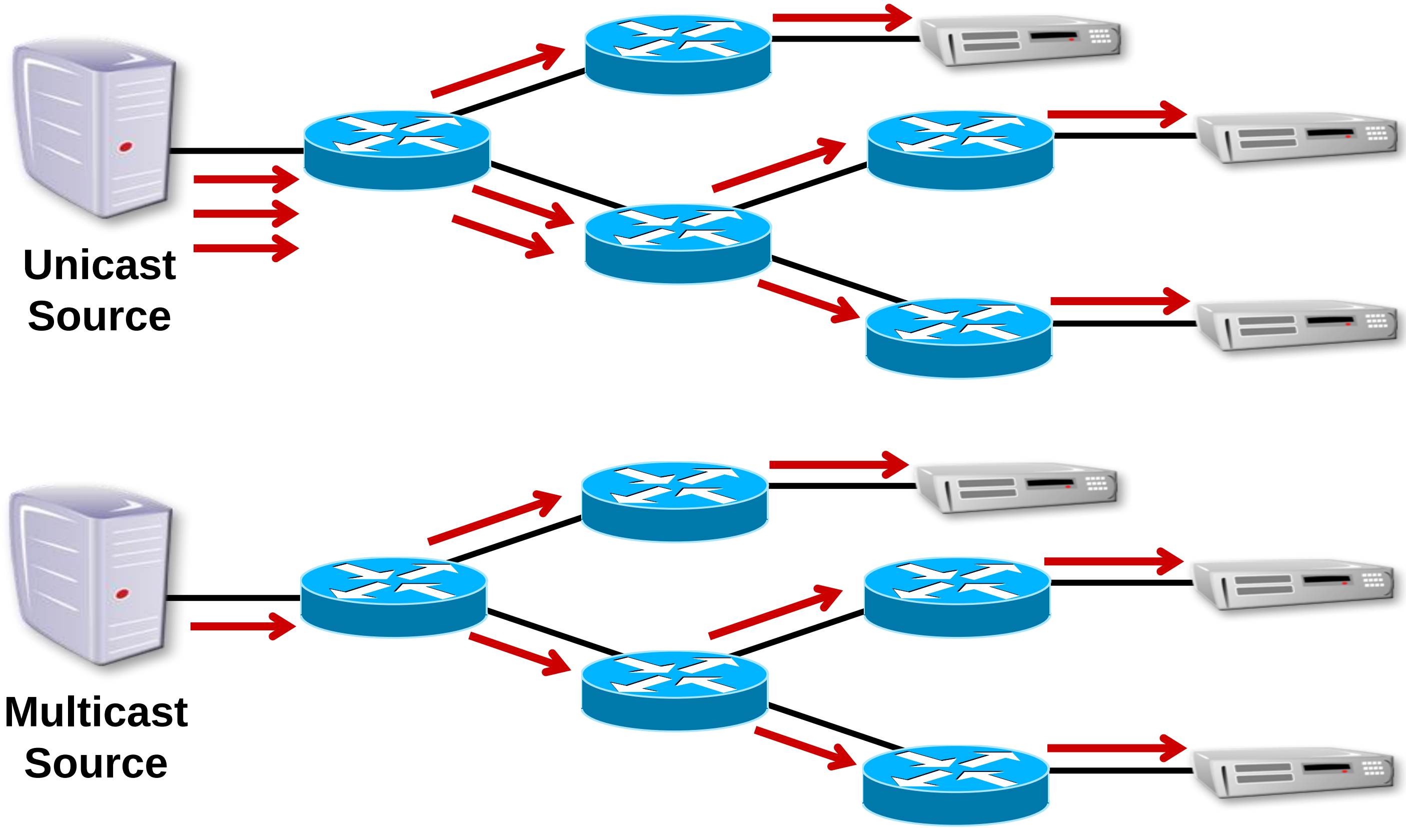
Video is driving next generation service provider network designs

IPTV – Architecture, Protocols and SLAs

End-to-End IPTV Network Architecture



Unicast vs. Multicast



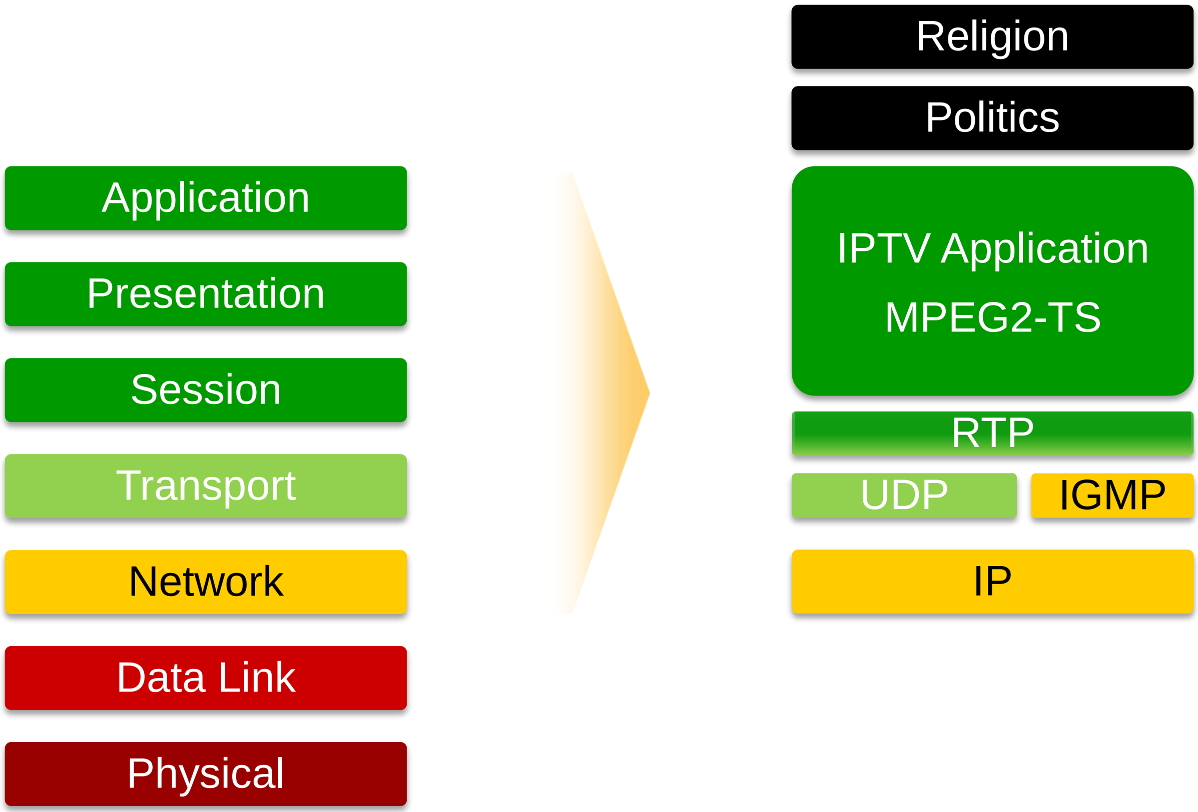
Broadcast IPTV = IP Multicast

- **Various Transports**
  - Native IP multicast, MPLS, L2, optical
- **SSM: Source-Specific Multicast (RFC 4604 and 4607)**
  - Receivers subscribe (S,G) channels to receive traffic only from source S sent to group G
  - Primarily introduced (by IETF) for IPTV-like services
- **IP Multicast Endpoints**
  - Sources: Encoder, transcoder, groomer, ad-splicer
  - Receivers: Transcoder, groomer, ad-splicer, eQAM, IP STB
- **IETF standardized**
  - Receiver-to-Router Protocols: IGMPv3 (IPv4) and MLDv2 (IPv6) with (S,G) signaling
  - Router-to-Router Protocols: PIM-SSM, IGMPv3 Proxy Routing, Snooping on HAG and L2 devices
- **Transport Challenges**
  - Packet loss, out-of-order delivery, packet duplication
  - (We cannot use TCP for IP multicast)

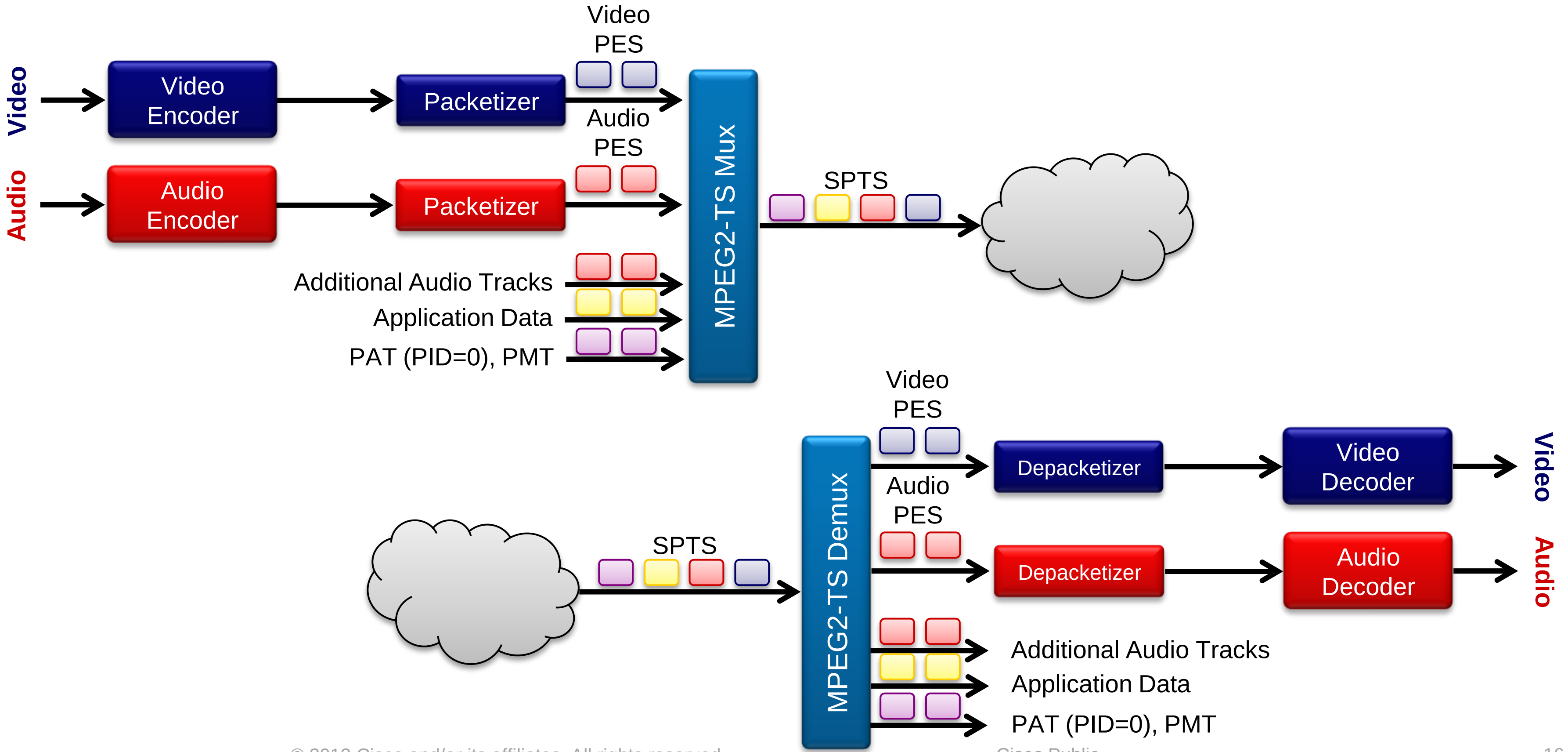
Real-Time Transport Protocol (RTP)
http://tools.ietf.org/html/rfc3550

- **Basics**
  - First specified by IETF in 1996, later updated in 2003 (RFC 3550)
  - Runs over any transport-layer protocol (Typically over UDP)
  - Runs over both unicast and multicast
  - No built-in reliability
- **Main Services**
  - Payload type identification
  - Sequence numbering
  - Timestamping
- **Extensions**
  - Basic RTP functionality uses a 12-byte header
  - RFC 5285 defines an RTP header extension mechanism
- **Control Plane – RTCP**
  - Provides minimal control and identification functionality
  - Enables a scalable monitoring functionality (Sender, receiver, extended reports)

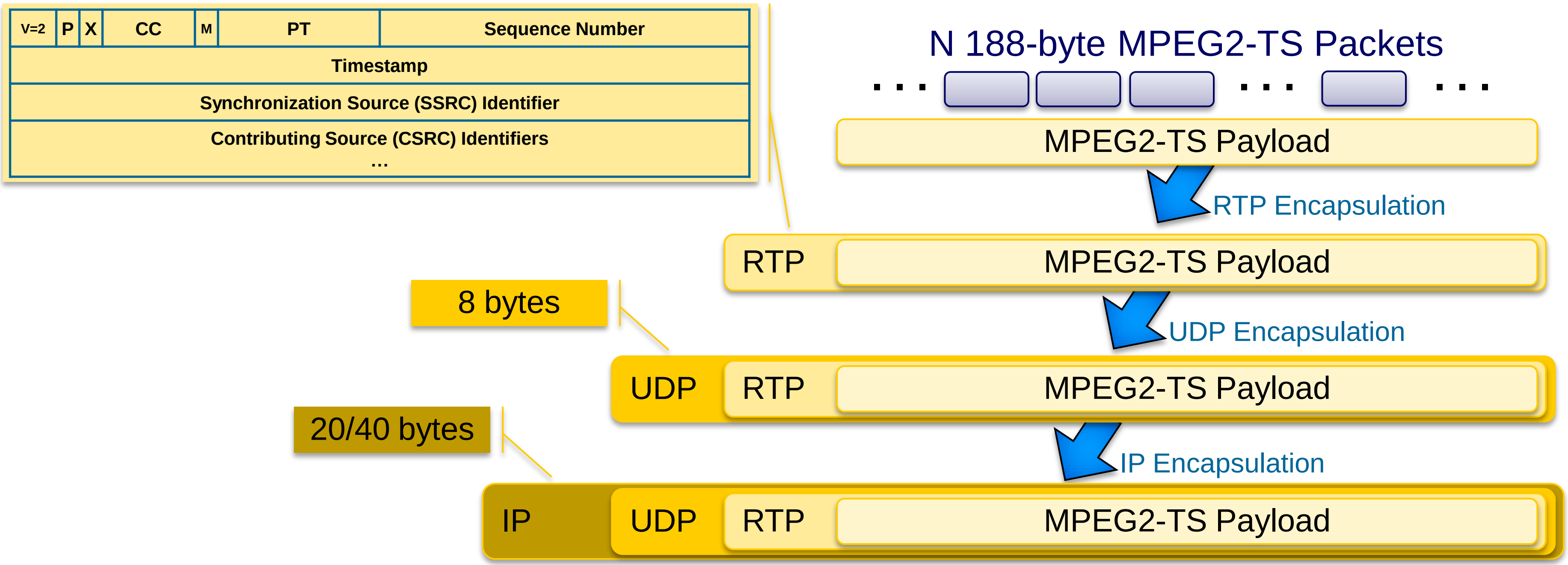
RTP Transport of MPEG2 Transport Streams



Packetization into MPEG2 Transport Streams
Single Program Transport Streams (SPTS)

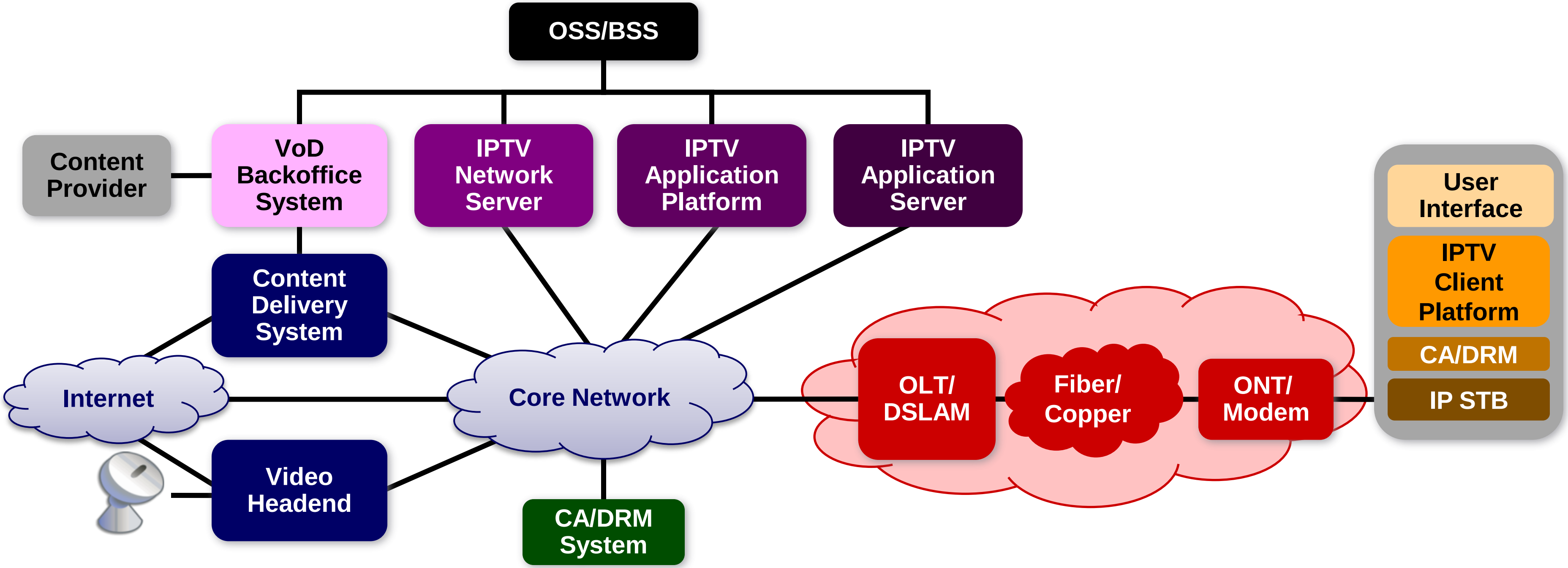


RTP Transport of MPEG2 Transport Streams
http://tools.ietf.org/html/rfc2250



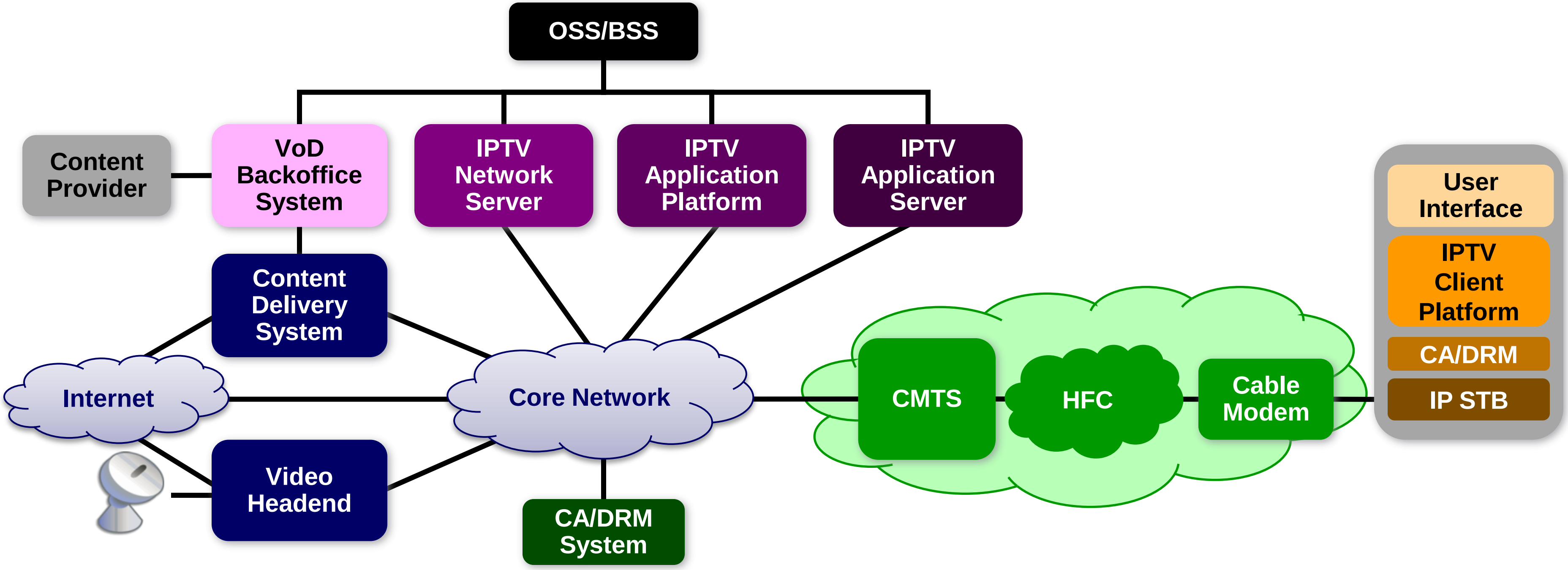
Default IP header size is 20 and 40 bytes for IPv4 and IPv6, respectively

Telco IPTV System Reference Architecture



IP Content and Delivery over Fiber/xDSL Access

Cable IPTV System Reference Architecture



IP Content and Delivery over DOCSIS (VDOC)

Efficiency Gains From IPTV in Cable Delivery

Variable Bitrate

- VBR provides a bandwidth savings of 40-60%
- IPTV is the best choice for narrowcast statmux and AVC statmux

Switched Video

- Switching is the way to offer unlimited channels
- IPTV provides built-in switching functionality

Advanced Coding

- AVC provides a bandwidth savings of 50% over MPEG2
- IPTV solves the problem of slow channel change

QAM Sharing

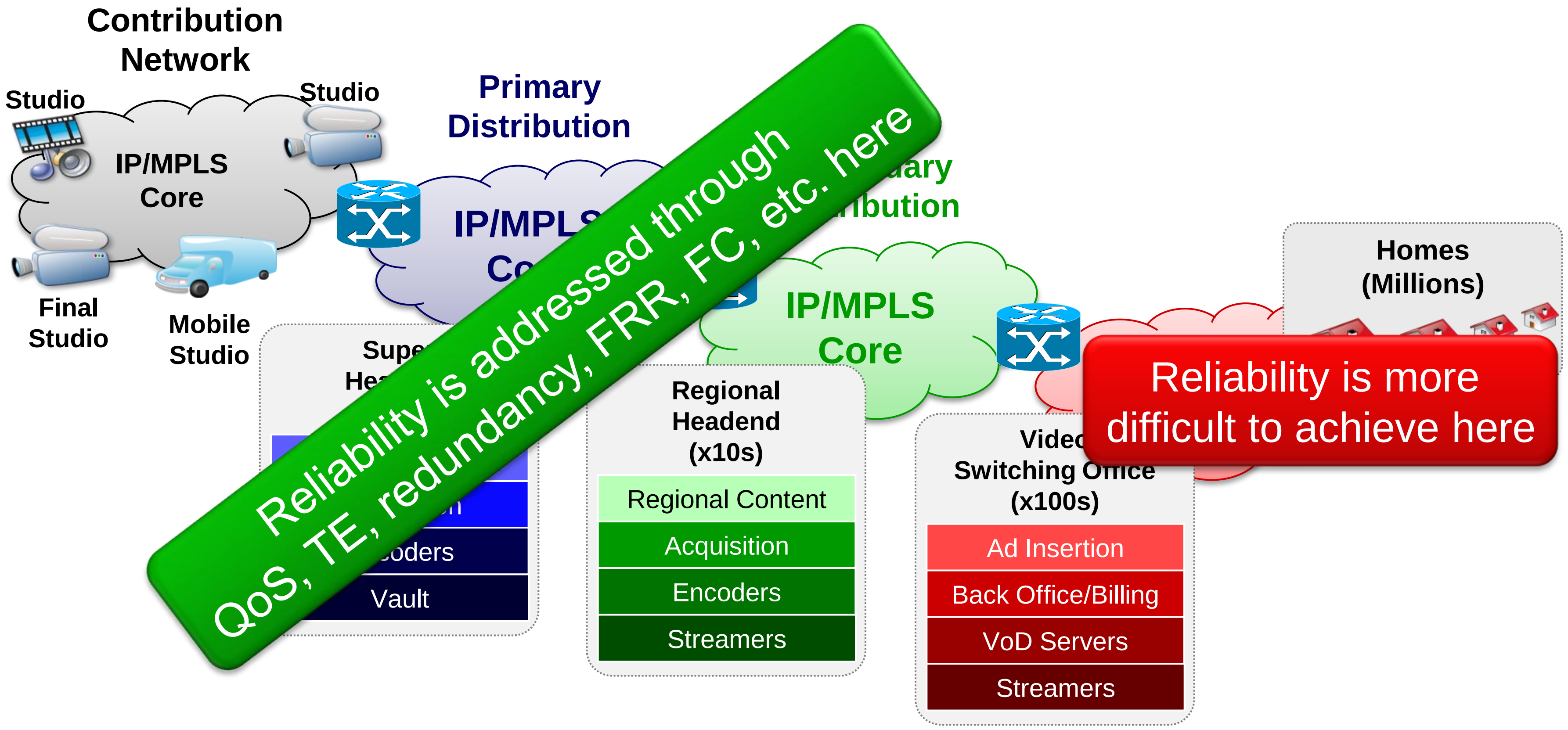
- Convergence provides further bandwidth savings
- We can share QAMs for VoD and SDV as well as for video and DOCSIS

Types of Video Services

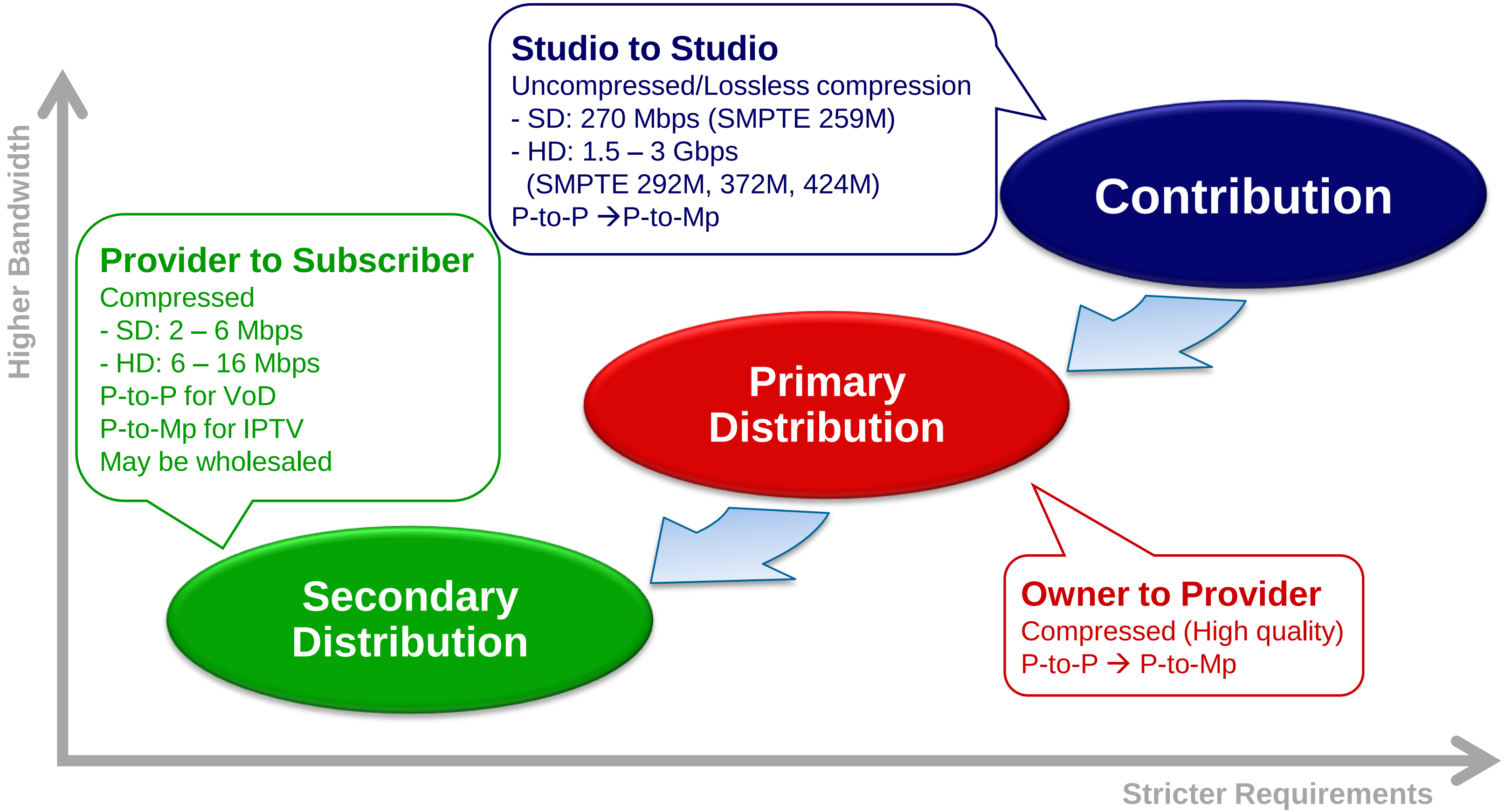
- **Transport (Contribution and Primary Distribution)**
- **IPTV /CATV (Secondary Distribution)**
  - IP multicast distribution from centralized super headends
    - Driving enhanced multicast features and functions
- **VoD (Secondary Distribution)**
  - Distributed architecture for better scalability
  - Non-real-time content distribution to caches
- **Enterprise**
  - mVPN based
  - Driving enhanced multicast features and functions
- **Over-the-Top (e.g., Hulu, Apple TV, Netflix)**
  - Adaptive streaming methods are quickly becoming ubiquitous

IPTV *must* Deliver Entertainment-Caliber Video

Tolerance is One Visible Artifact per Movie



Taxonomy of Video Service Providers



Video SLA Requirements

- **Throughput**
  - Addressed through capacity planning and QoS (i.e., Diffserv)
- **Delay/Jitter**
  - Controlled with QoS
  - Absorbed by de-jittering buffer at IP STB
    - We desire to minimize jitter buffer size to improve responsivity
    - Jitter originating in the core is rather insignificant
- **Packet Loss**
  - Controlling loss is the main challenge
- **Service Availability**
  - Proportion of time for which the specified throughput is available within the bounds of the defined delay and loss

Video Transport in the Core Networks

Four Primary Causes for Packet Loss

- **Excess Delay**
  Renders media packets essentially lost beyond an acceptable bound
  Can be prevented with appropriate QoS (i.e., Diffserv)
- **Congestion**
  Considered as a catastrophic case, i.e., fundamental failure of service
  Must be prevented with appropriate QoS and admission control
- **PHY-Layer Errors**
  Apply to core and access – Occurrence in core is far less
  Considered insignificant compared to losses due to network failures
- **Network Reconvergence Events**
  Occur at different scales based on topology, components and traffic
  Can be eliminated with high availability (HA) techniques

What are the Core Impairment Contributors?

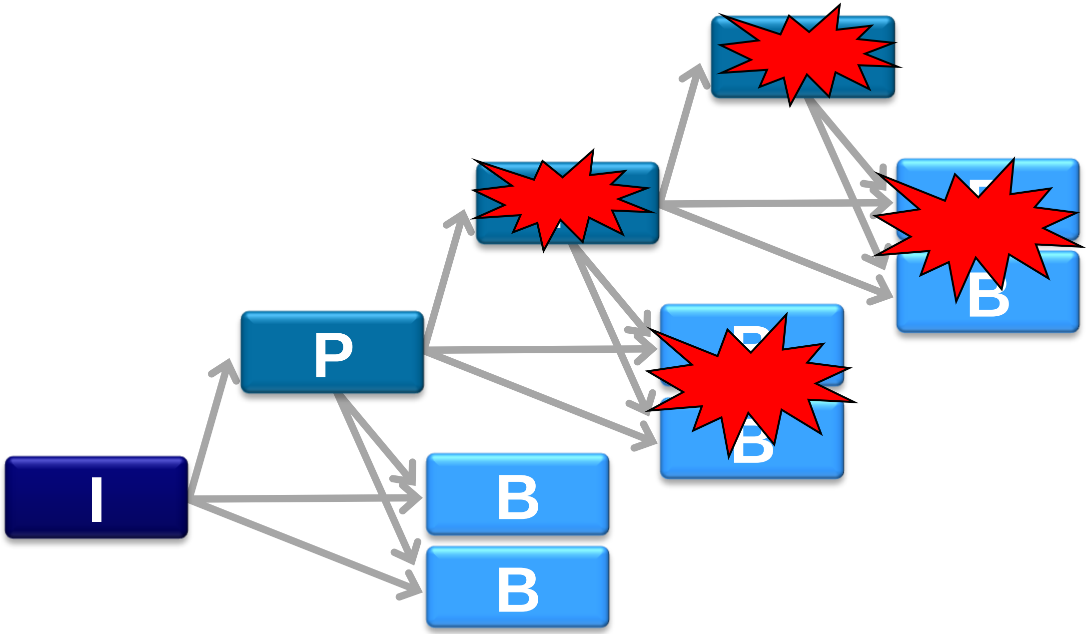
	Impairment Rate
Trunk failures	.0010 /2h
Hardware failures	.0003 /2h
Software failures	.0012 /2h
Non-stop forwarding (NSF) and Stateful switch-over (SSO) help here	
Software upgrades (Maintenance)	.0037 /2h
Modular code (IOS-XR) helps here	
Total	.0062 /2h (One every two weeks)
Note that average mean time between errors on a DSL line is in the order of minutes when no protection is applied	

Back of envelope calculations across several SPs show
mean time between core failures affecting video is > 100 hours

Source: Data from industry standards, customers and assumptions

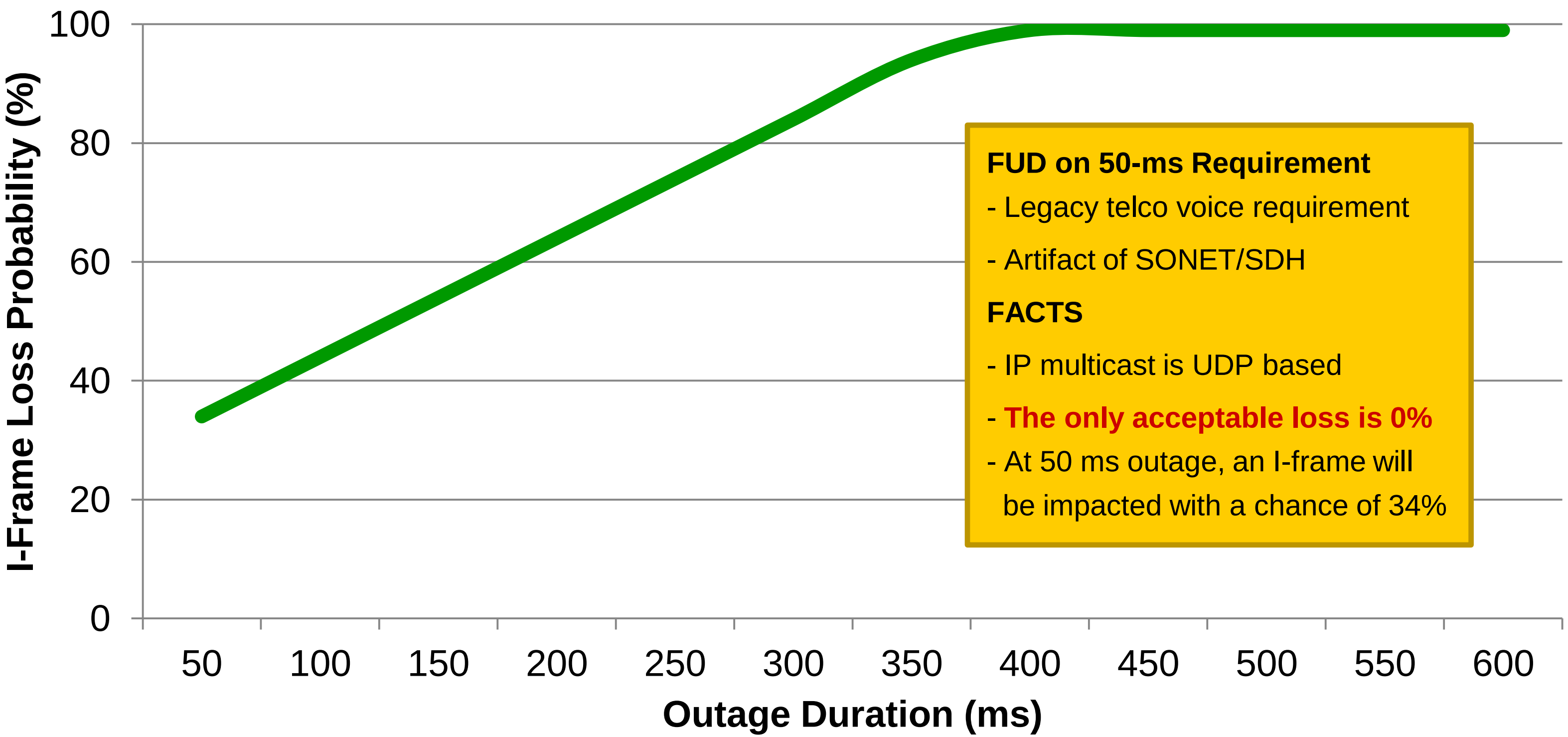
Unequal Importance of Video Packets

IPBBPBBPBB – MPEG GoP



MPEG Frame Impact from Packet Loss

GoP Size: 500 ms (I:P:B = 7:3:1)



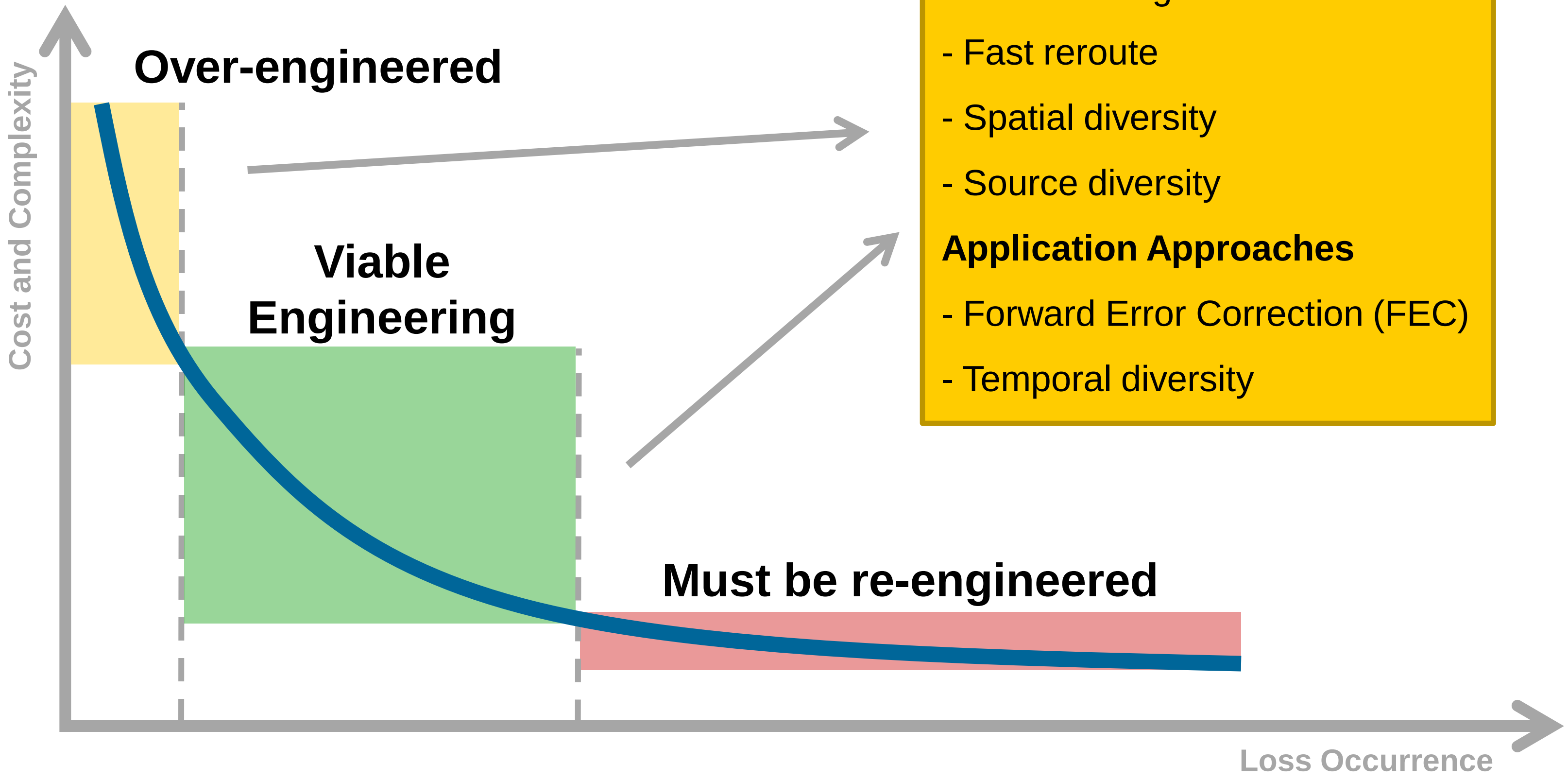
FUD on 50-ms Requirement

- Legacy telco voice requirement
- Artifact of SONET/SDH

FACTS

- IP multicast is UDP based
- **The only acceptable loss is 0%**
- At 50 ms outage, an I-frame will be impacted with a chance of 34%

Video SLA Requirements



Network Approaches

- Fast convergence
- Fast reroute
- Spatial diversity
- Source diversity

Application Approaches

- Forward Error Correction (FEC)
- Temporal diversity

Towards Lossless IPTV Transport

Reading

“Toward lossless video transport,”
IEEE Internet Computing, Nov./Dec. 2011

“Designing a reliable IPTV network,”
IEEE Internet Computing, May/June 2009

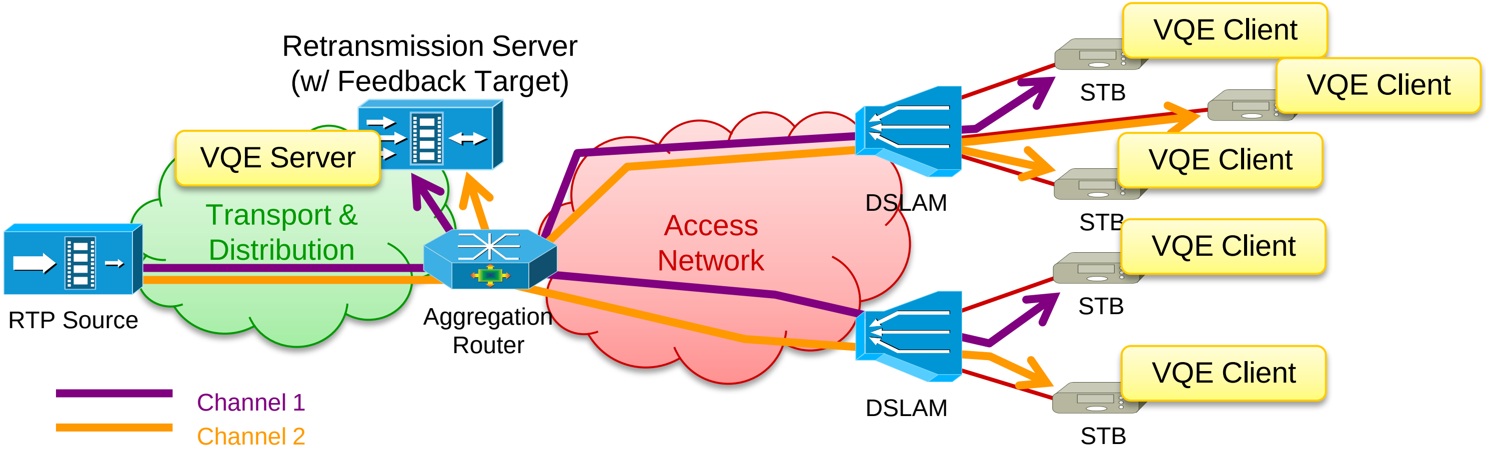
Video Distribution in the Access Networks

VQE – A Unified QoE Solution

Glitch-Free Audiovisual Quality, Short and Consistent Zapping

- **IPTV viewers have two criteria to judge their service**
  - Artifact-free audiovisual quality
    - Loss may be correlated in spatial and/or temporal domain, must be recovered quickly
    - Loss-repair methods must be multicast friendly
  - Short and consistent zapping times
    - Compression and encryption used in digital TV increase the zapping times
    - Multicasting in IPTV increases the zapping times
- **Service providers need a scalable unified solution that**
  - Is standards-based and interoperable with their infrastructure
  - Enables versatility, quick deployment and visibility into the network
  - Extends the service coverage area, and keeps CapEx and OpEx low

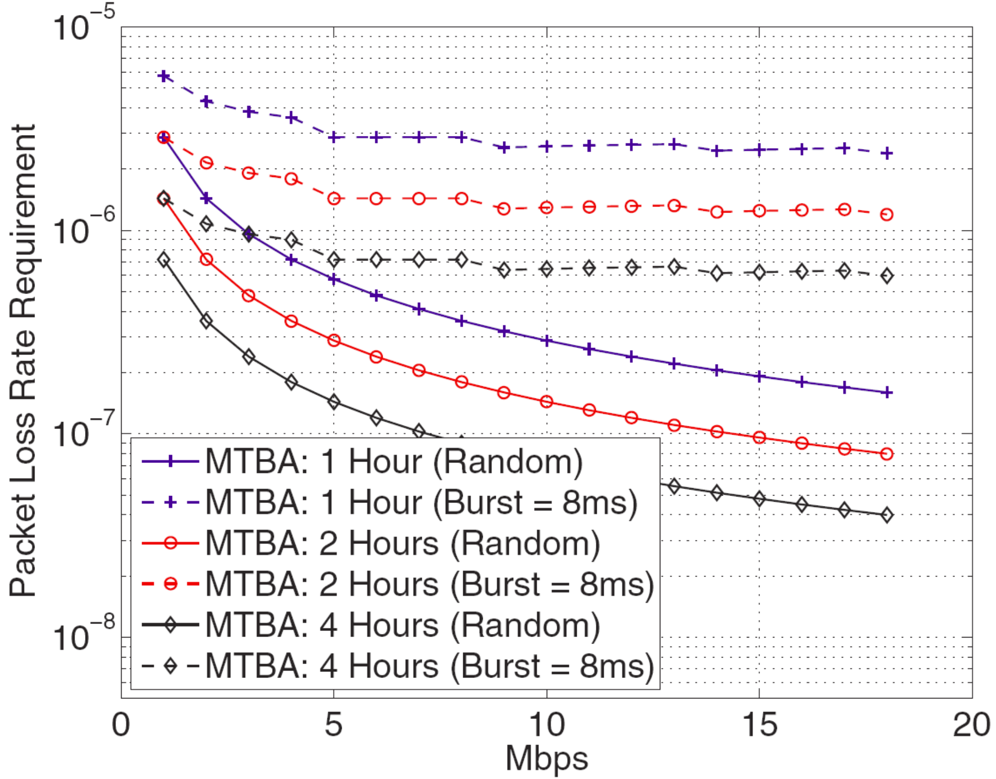
A Simplified Model



- **Each TV channel is served in a unique (SSM) multicast session**
  - IP STBs join the respective multicast session for the desired TV channel
  - Retransmission servers join all multicast sessions
- **Unicast feedback from IP STBs are collected by the feedback target**
  - NACK messages reporting missing packets, rapid channel change requests
  - RTCP receiver and extended reports reporting reception quality

Packet Loss Rate Tolerance Limits

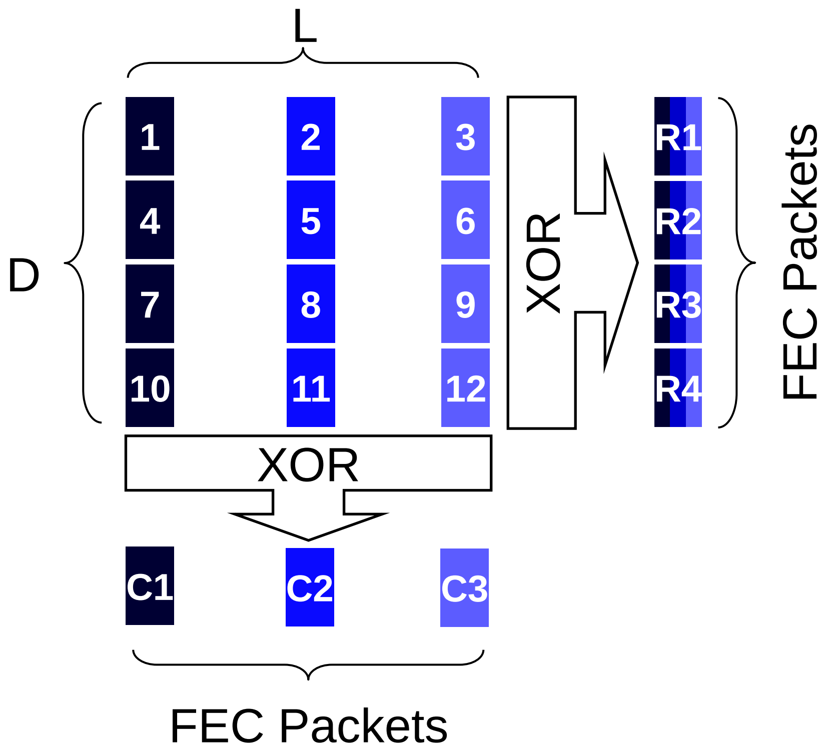
Each Random or Bursty Loss Counts for One Artifact



Impairments in xDSL Networks

- **Twisted pair is subject to**
  - Signal attenuation: Use shorter loops
  - Cross talk: Use Trellis Coding and RS-based FEC
  - Impulse noise: Use RS-based FEC with interleaving
- **There are three types of DSL impulse noise**
  - REIN: Short burst of noises (< 1 ms)
  - PEIN: Individual impulse noise (> 1 ms, < 10 ms)
  - SHINE: Individual impulse noise (> 10 ms)
- **We observe different noise characteristics**
  - Among different SP networks
  - Among different loops in the same SP network

First-Line of Defense in Loss Repair
1-D/2-D Parity Forward Error Correction



- **Source Block Size: D x L**
- **1-D Column FEC (for Bursty Losses)**

  Each column produces a single packet

  Overhead = 1 / D

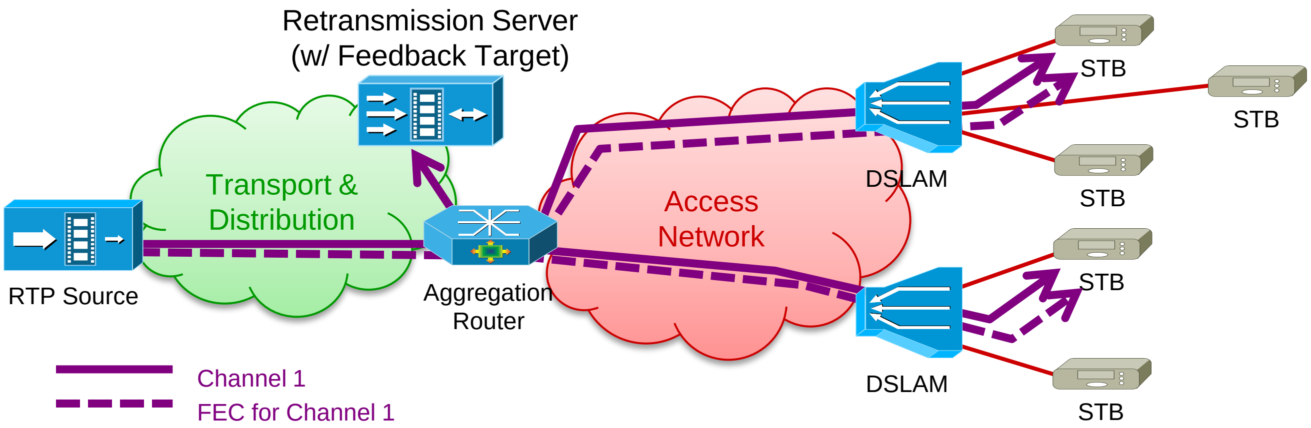
  L-packet duration should be larger than the (target) burst duration
- **1-D Row FEC (for Random Losses)**

  Each row produces a single packet

  Overhead = 1 / L
- **2-D Column + Row FEC**

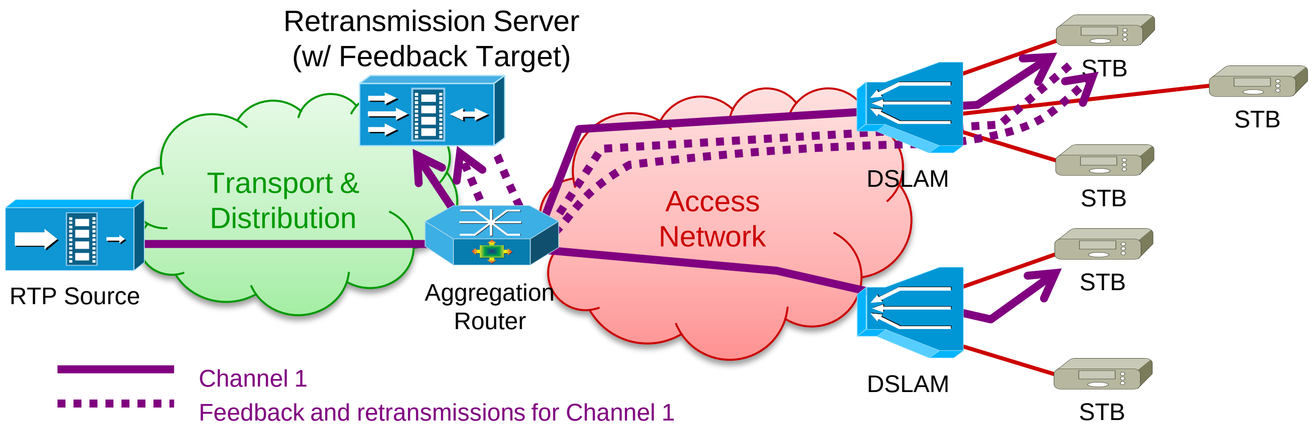
  Overhead = (D+L)/(DxL)

First-Line of Defense in Loss Repair
1-D/2-D Parity Forward Error Correction



- **Each TV channel may be associated with one or more FEC streams**
  - FEC streams may have different repair capabilities
  - IP STBs may join the respective multicast sessions to receive FEC stream(s)
- **General Remarks**
  - ✓ FEC scales extremely well with upfront planning, easily repairs spatially correlated losses
  - × Longer outages require larger overhead or larger block sizes (More delay)
  - × FEC requires encoding/decoding operations

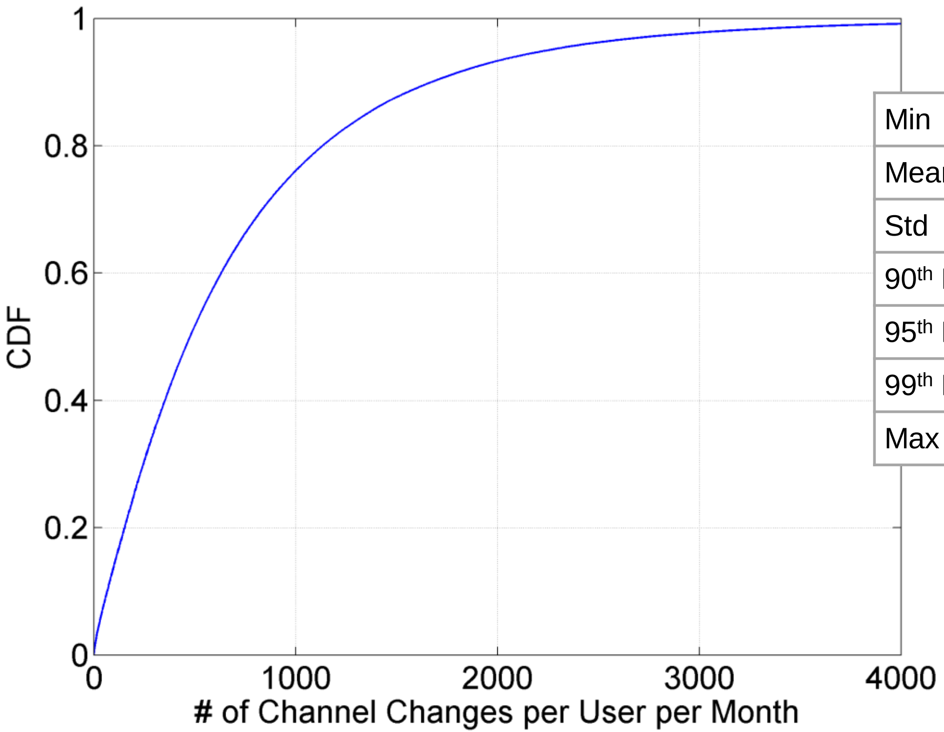
Second-Line of Defense in Loss Repair
RTP Retransmissions



- **There is a (logical) feedback target for each TV channel on the retransmission server**
  - If optional FEC cannot repair missing packets, IP STB sends an RTCP NACK to report missing packets
  - Retransmission server pulls the requested packets out of the cache and retransmits them
- **General Remarks**
  - ✓ Retransmission recovers only the lost packets, so no bandwidth is wasted
  - ✗ Retransmission adds a delay of destination-to-source-to-destination
- **Protocol suite comprises RFCs 3550, 4585, 4588 and 5760**

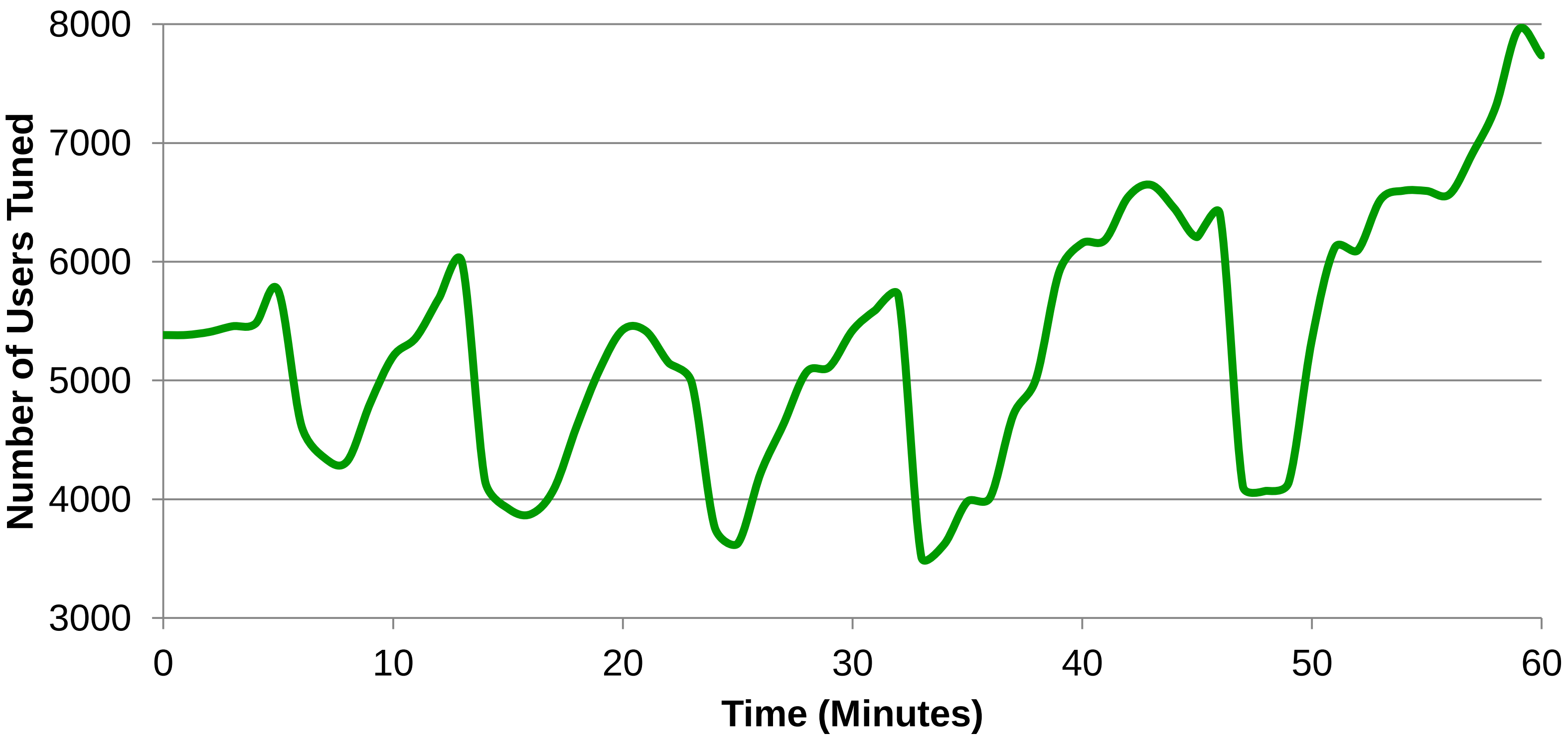
Improving Viewer Quality of Experience

TV Viewers Love Zapping
Results are Based on 227K+ Users in NA



Min	1
Mean	726
Std	814
90th Percentile	1672
95th Percentile	2250
99th Percentile	3798
Max	24186

Zappings are Correlated in Temporal Domain
On a Sunday between 8:00 – 9:00 PM



Delay Elements in Multicast MPEG2-TS Video

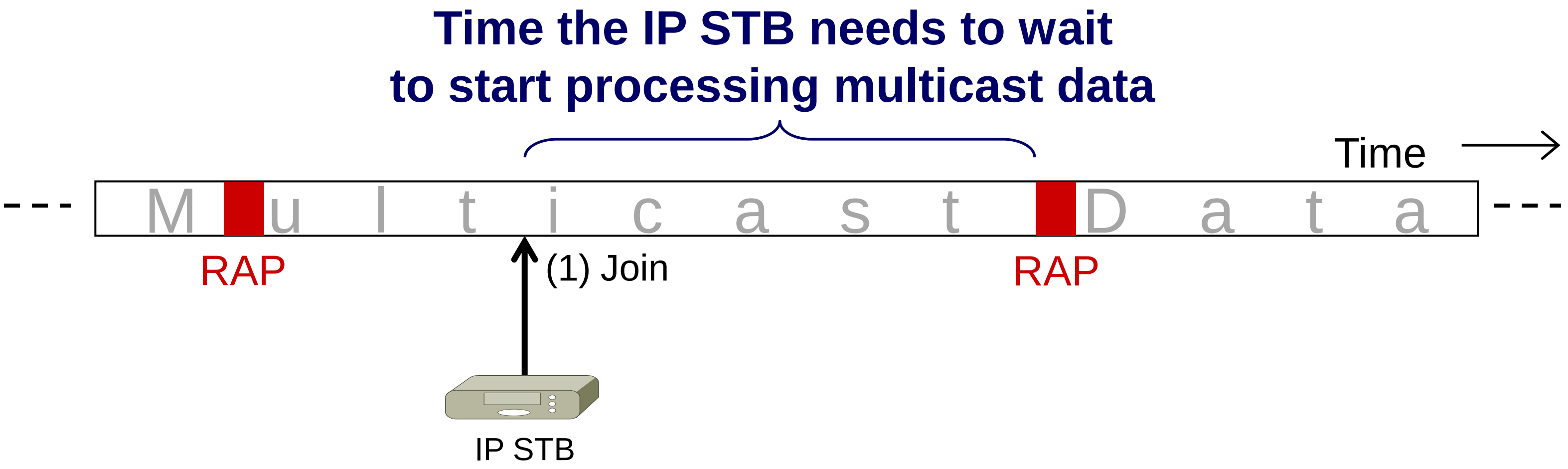
- **Multicast Switching Delay**
  - IGMP joins and leaves
  - Route establishment (Generally well-bounded)
- **Reference Information Latency**
  - PSI (PAT/CAT/PMT) acquisition delay
  - CAS (ECM) delay
  - RAP acquisition delay
- **Buffering Delays**
  - Loss-repair, de-jittering, application buffering
  - MPEG decoder buffering

Reference information latency and buffering delays are more critical in MPEG-based AV applications

Typical Zapping Times on DSL IPTV

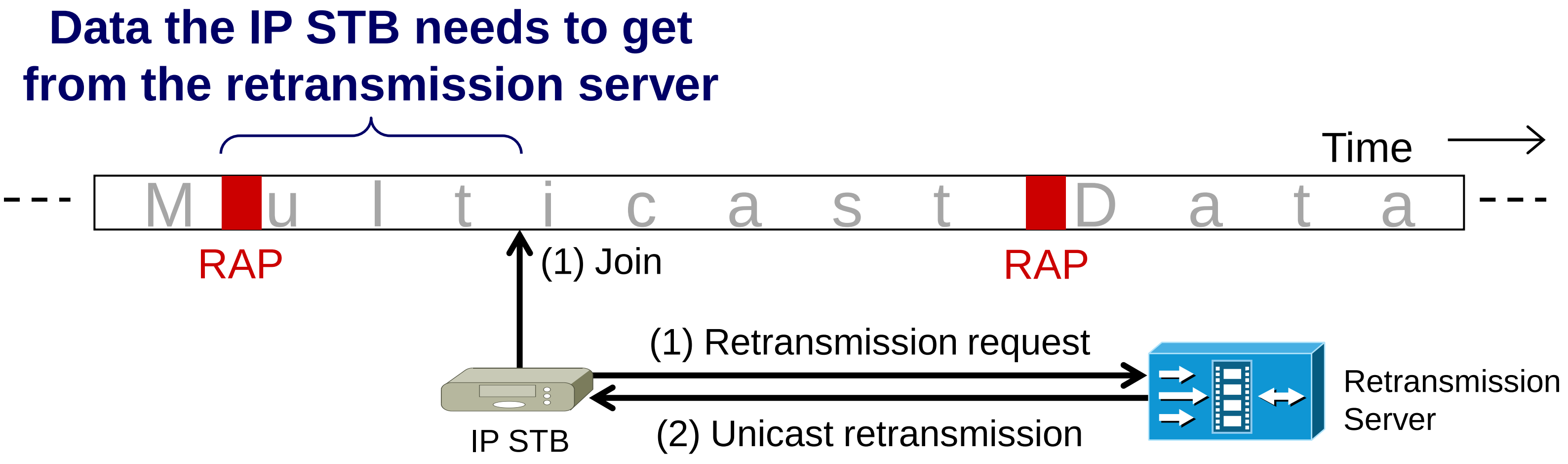
	Unit Time	Total Time
IP STB sends IGMP Leave	< 100 ms	
IP STB sends IGMP Join	< 100 ms	
DSLAM gets IGMP Leave	< 100 ms	
DSLAM gets IGMP Join	< 100 ms	~ 200 ms
DSLAM switches streams	50 ms	~ 250 ms
Latency on DSL line	~ 10 ms	~ 260 ms
IP STB receives PAT/PMT	~ 150 ms	~ 400 ms
Buffering		
De-jittering buffer	~ 150 ms	~ 550 ms
Wait for CA	< 50 ms	~ 600 ms
Wait for I-frame	0 – 3 s	0.5 – 3.5 s
MPEG decoding buffer	1 – 2 s	1.5 – 5.5 s
Decoding	**< 50 ms**	**1.5 – 5.5 s**

A Typical Multicast Join



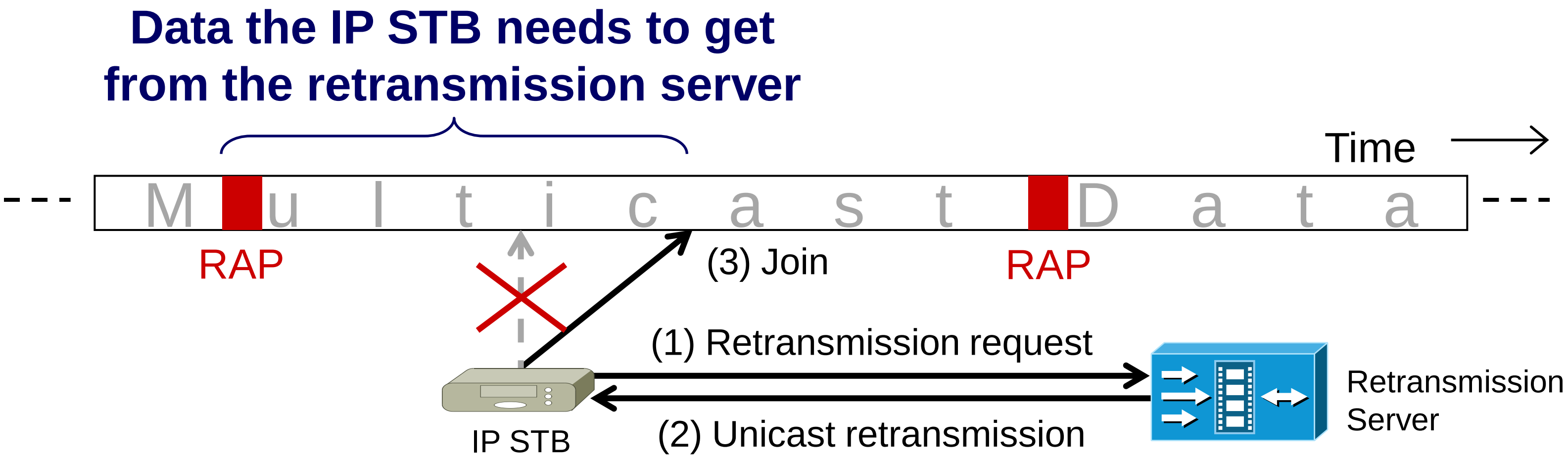
RAPs might be far away from each other
RAP data might be large in size and non-contiguous

Concurrent Multicast Join and Retransmission



If the residual bandwidth remaining from the multicast stream is small, retransmission may not be able to provide any acceleration

Retransmission Followed by Multicast Join



More data are retransmitted due to deferred multicast join
However, IP STB ultimately achieves a faster acquisition

Proposed Solution
Unicast-Based Rapid Acquisition

- **IP STB says to the retransmission server:**

  "I have no synch with the stream. Send me a repair burst that will get me back on the track with the multicast session"

- **Retransmission server**

  Parses data from earlier in the stream and bursts faster than real time

  Coordinates the time for multicast join and ending the burst

- **This solution uses the existing toolkit for repairing packet losses**

  RFC 3550 (RTP/RTCP)

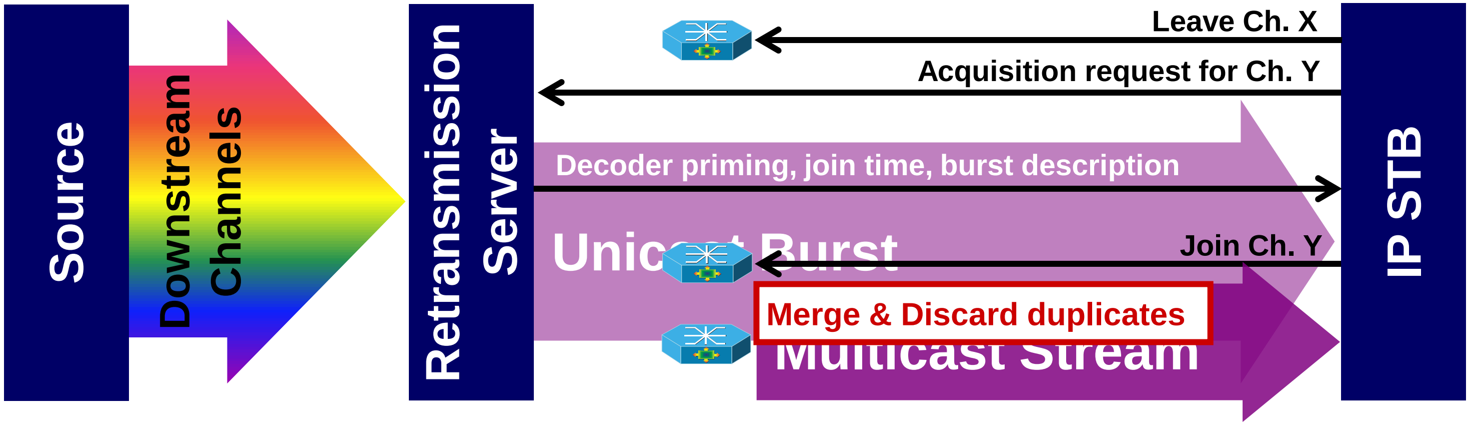
  RFC 4585 (RTP AVPF)

  RFC 4588 (RTP Retransmissions)

  RFC 5760 (RTCP Extensions for SSM)

Unicast-Based Rapid Acquisition

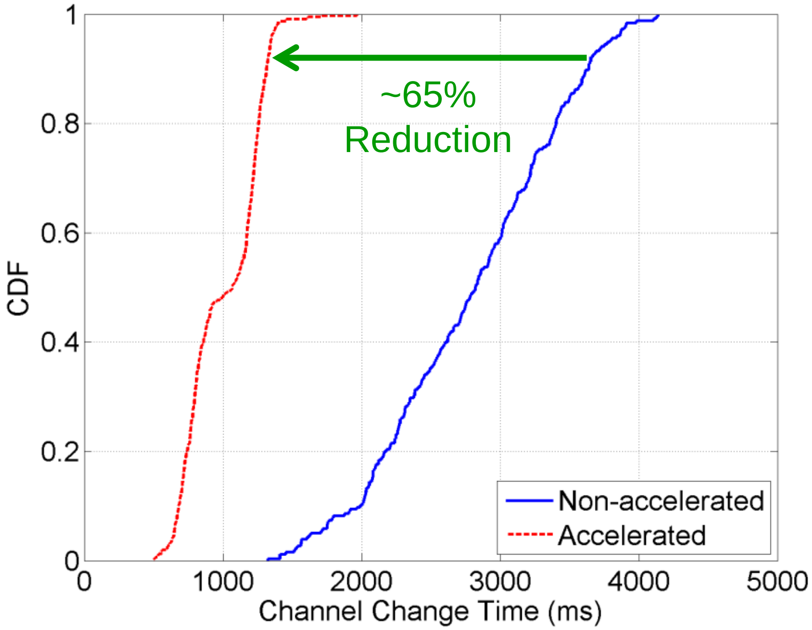
http://tools.ietf.org/html/rfc6285



Experimental Setup

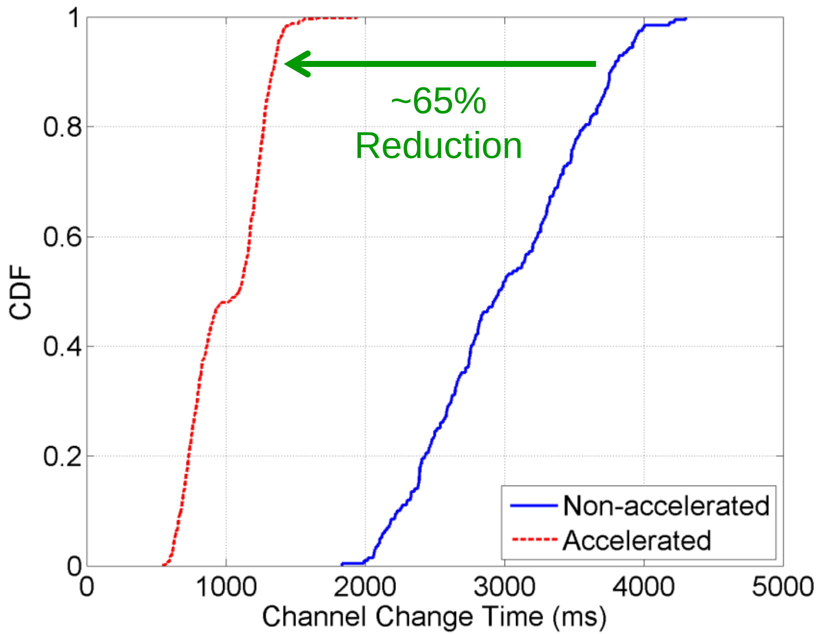
- **Comparison**
  - One IP STB with non-accelerated channel changes
  - One IP STB with accelerated channel changes
- **Video Streams**
  - Encoded with AVC at 2 Mbps and 30 fps
    - One stream with 15 frames per GoP (Short-GoP)
    - One stream with 60 frames per GoP (Long-GoP)
- **Transport**
  - 1356-byte RTP packets (7 TS packets plus RTP/UDP/IPv4 headers)
  - 20% additional bandwidth consumption for bursting
  - 500 ms loss-repair buffer in each IP STB

Short-GoP Results



	Min	Mean	Std	95th	99th	Max
Non-accelerated	1323	2785	645	3788	4101	4140
Accelerated	501	1009	260	1345	1457	1965

Long-GoP Results

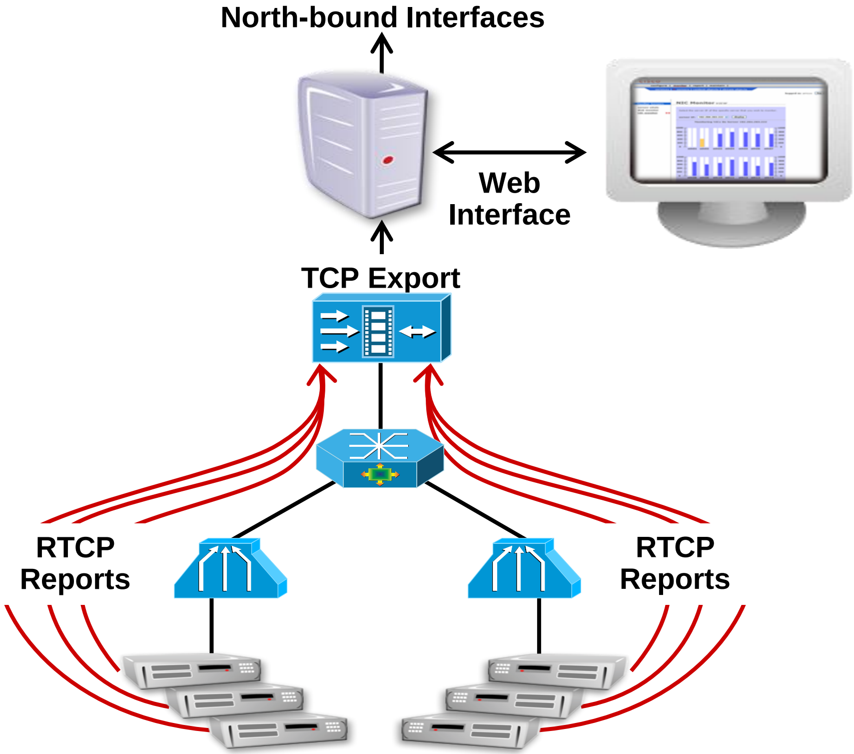


	Min	Mean	Std	95th	99th	Max
Non-accelerated	1831	3005	575	3920	4201	4300
Accelerated	536	1013	265	1377	1521	1937

VQE QoS/QoE Monitoring

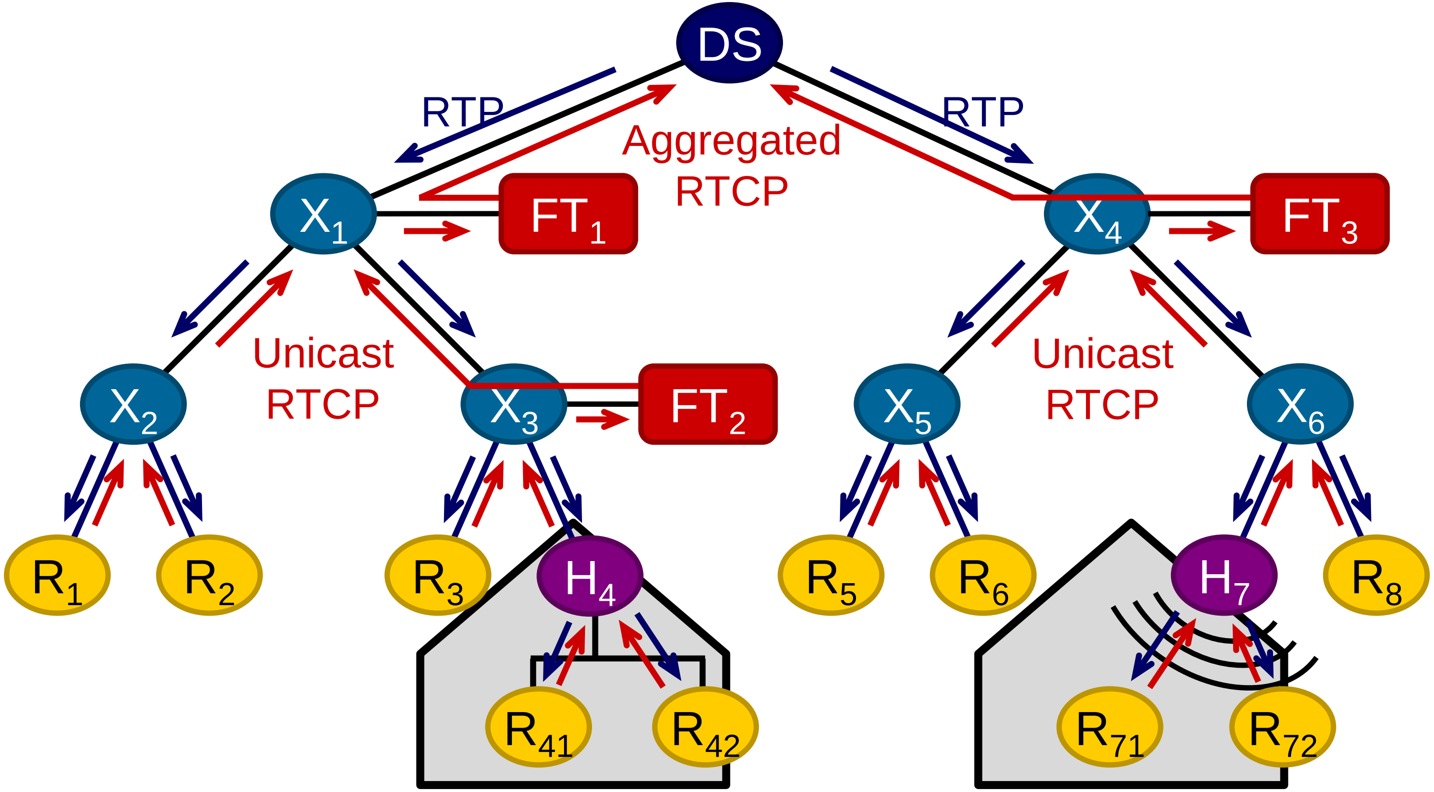
Tools to Isolate and Pinpoint the Problematic Locations

- VQE-S collects RTCP reports and outputs them to the management application
- Management application
  - Collects raw data from exporter
  - Organizes database
  - Conducts data analysis, trends
  - Create alerts
- Management application supports standards-based north-bound interfaces
- Reports and analysis can be granular to
  - Regions, edge routers
  - DSLAMs, access lines
  - Home gateways
  - Set-tops
- Set-tops can support RTCP reporting and TR-069 (or TR-135) concurrently



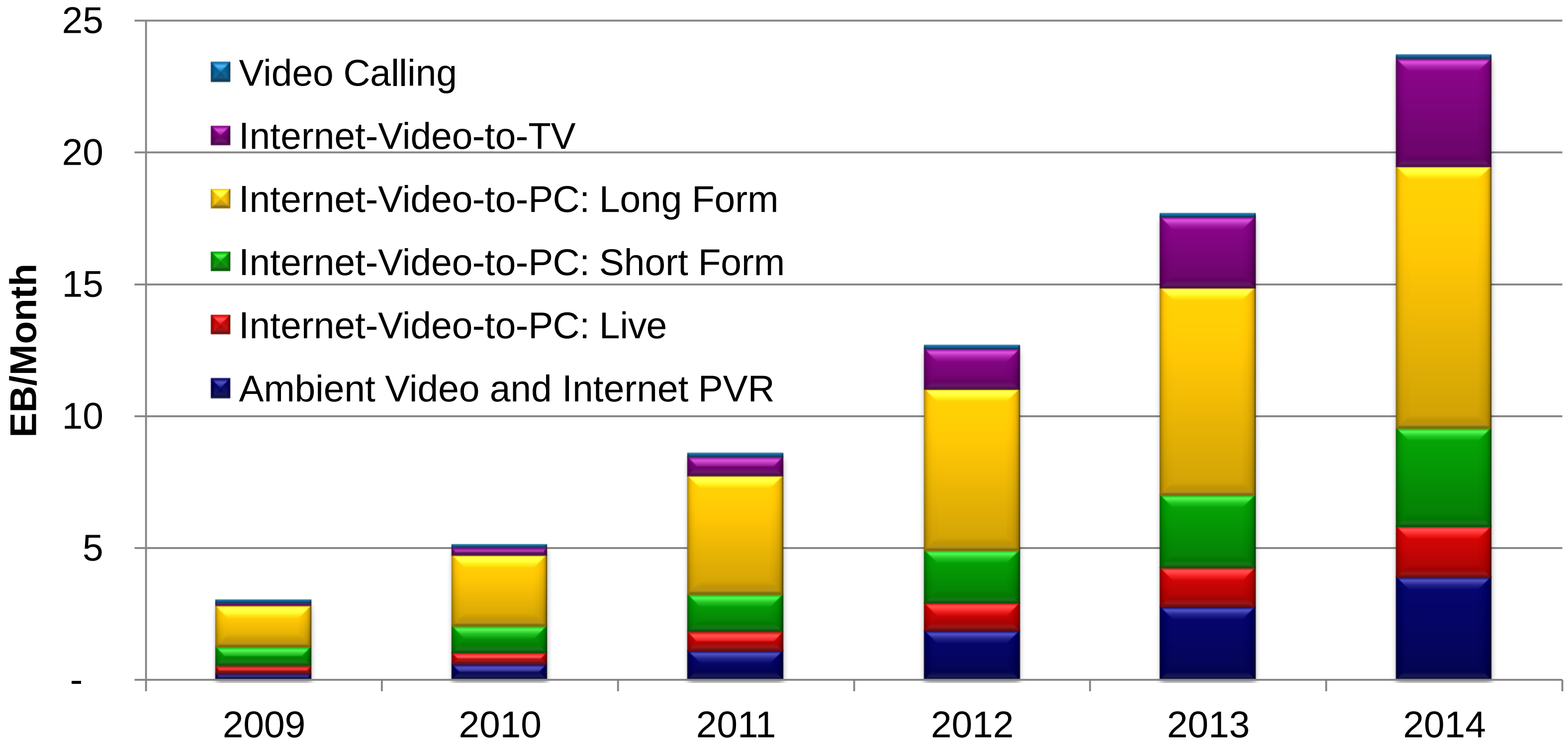
Fault Isolation through Network Tomography

Monitoring Viewer QoE with No Human Assistance



Part II: Internet Video and Adaptive Streaming

Consumer Internet Video Composition



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Experiences Consumers Want Now

Yet Service Providers Struggle to Deliver

Online Content on TV/STB

Intuitive Unified Navigation for All Content

Multi-screen TV Experience

Web 2.0 Experiences on TV/STB

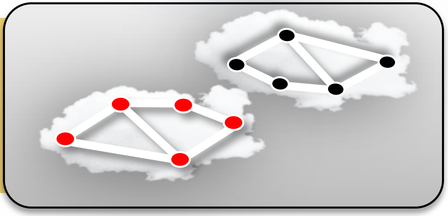
Support an increasing variety of services on an any device and deliver a common experience everywhere

Three Dimensions of the Problem

Content, Transport and Devices

Managed and Unmanaged Content

Managed and Unmanaged Transport



Managed and Unmanaged Devices

From Totally Best-Effort to Fully-Managed Offerings

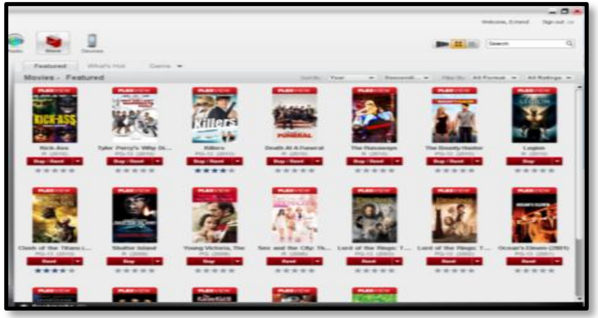
Challenge is to Provide a Solution that Covers All

Design to the most general case
Optimize where appropriate

Example Over-the-Top (OTT) Services

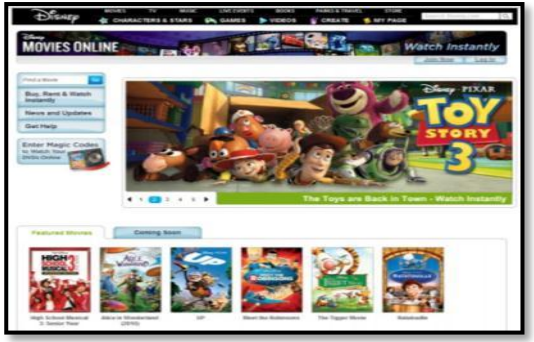
The Lines are *Blurring* between TV and the Web

AT&T U-verse Online



Verizon FlexView

Bell TV Online



Disney Movies Online

Paramount Media Store

Onet TV Catch-Up

Netflix

Content

Over 100K titles

Shipped 1 billionth DVD in 02/07

Shipped 2 billionth DVD in 04/09

Revenue

$875M in Q4 2011

$3.2B in 2011 and $2.1B in 2010

Subscribers

24.4M in the US by Q4 2011 (1.86M elsewhere)

Less than 6% churn

Competitors

Hulu Plus, Amazon Prime, TV Everywhere

Difficulties

ISP data caps (Most notably in Canada)

ISP/CDN throughput limitations

The Power of Recommendation

41% of DVD spending is on films with < $30M box-office

- Licensing fees are based on box-office revenues

Top-rented movies (2007) were not top 20 box-office hits

- Subscribers chose specialty films against all new releases

Plans

Unlimited streaming (only) for $7.99 (US and Canada)

1 DVD out at-a-time for $7.99 (US)

2 DVDs out at-a-time for $11.99 (US)

~1% of subscribers change plan after signup

Hulu

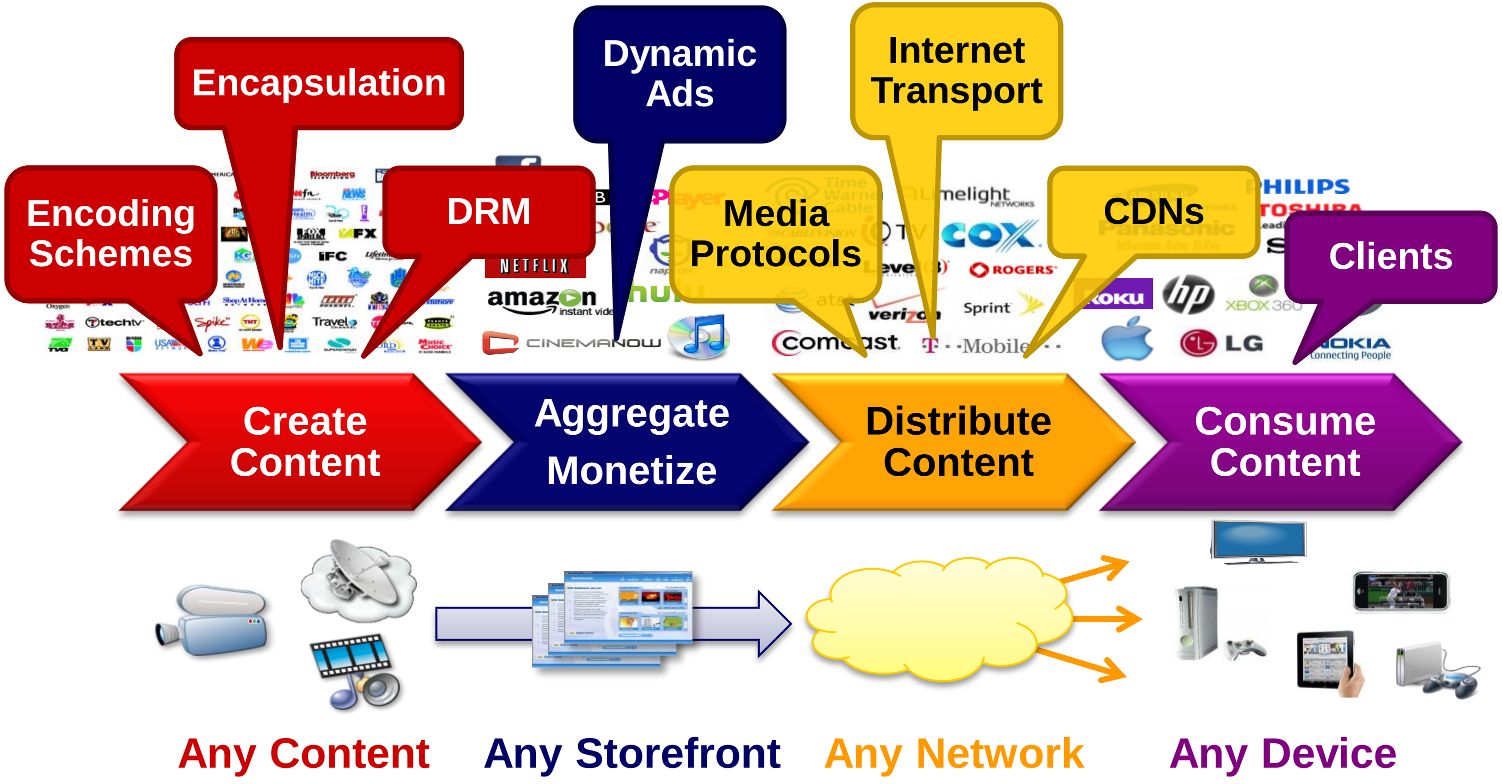
- **Summary**
  - Available in the US and Japan
  - Ad-supported subscription service business model
    - 1.5M Hulu Plus subscribers in 2011
  - Revenue of $420M (2011), $263M (2010), $108M (2009) and $25M (2008)
- **Content**
  - Catch-up TV (30000+ episodes)
  - 900+ movies
  - 350+ content partners
  - Encoded at 480, 700, 1000, 2500 and 3200 Kbps
- **Devices**
  - Primarily PC and Mac
  - Smartphones and tables (only w/ Hulu Plus)
  - Internet-connected TV (only w/ Hulu Plus)

Internet Video in the US
January 2012

	Unique Viewers (x1000)	Videos (x1000)	Minutes per Viewer
Google Sites	151,989	18,633,743	448.7
VEVO	51,499	716,608	62.2
Yahoo! Sites	49,215	538,260	57.4
Viacom Digital	48,104	507,046	58.0
Facebook.com	45,135	248,941	22.0
Microsoft Sites	41,491	558,017	51.3
AOL, Inc.	40,991	419,783	51.4
Hulu	31,383	877,388	189.0
Amazon Sites	27,906	86,705	19.7
NBC Universal	27,096	95,034	17.2
Total	**181,115**	**39,995,849**	**1,354.7**

Source: comScore Video Metrix

Open Digital Media Value Chain



Media Delivery over the Internet

Push and Pull-Based Video Delivery

	Push-Based Delivery	Pull-Based Delivery
Source	Broadcasters/servers like Windows Media Apple QuickTime, RealNetworks Helix Cisco CDS/DCM	Web/FTP servers such as LAMP Microsoft IIS Adobe Flash RealNetworks Helix Cisco CDS
Protocols	RTSP, RTP, UDP	HTTP, RTMPx, FTP
Video Monitoring and User Tracking	RTCP for RTP transport	(Currently) Proprietary
Multicast Support	Yes	No
Cacheability	No	Yes for HTTP

Pull-Based Video Delivery over HTTP

Progressive Download vs. Pseudo and Full Streaming

Progressive Download

- Server sends a file as fast as possible
- Client starts playout after a certain initial buffering

Pseudo Streaming

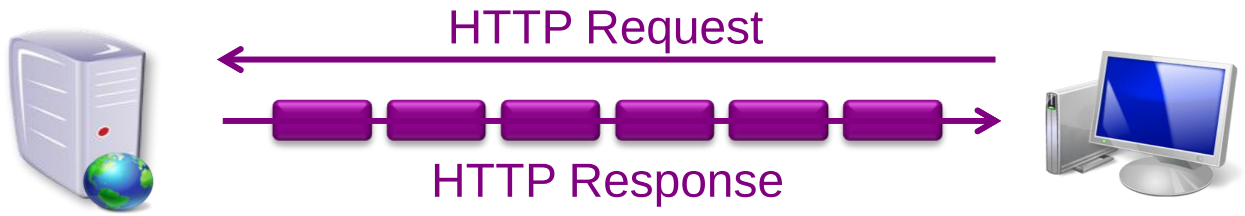
- Server paces file transmission
- Client can seek
- Some metadata is required

(Full) Streaming

- Client requests smaller chunks of a content individually
- Live and on-demand content is supported

Progressive Download

One Request, One Response (Possibly with Many Packets)



What is Streaming?

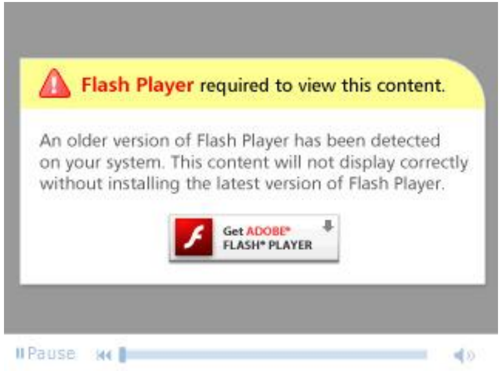
Streaming is transmission of a continuous content from a server to a client and its simultaneous consumption by the client

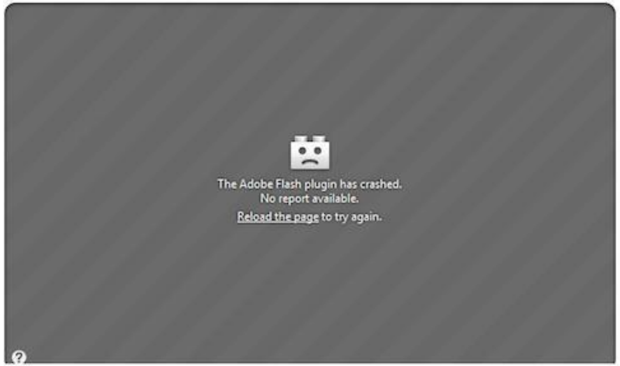
Two Main Characteristics

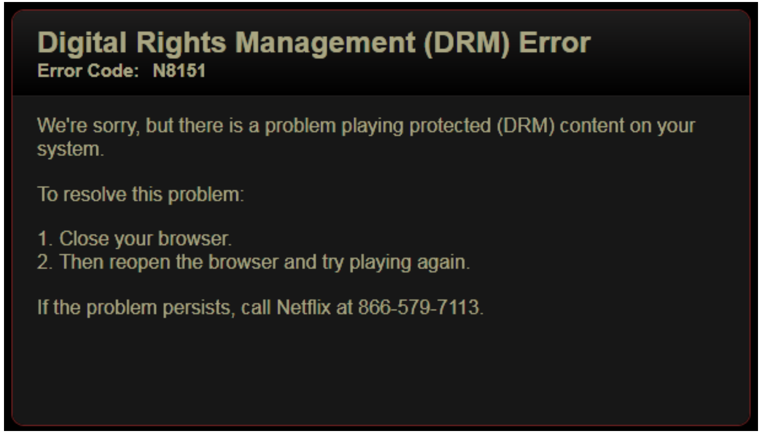
1. Client consumption rate may be limited by real-time constraints as opposed to just bandwidth availability
2. Server transmission rate (loosely or tightly) matches to client consumption rate

Common Annoyances in Streaming

Stalls, Slow Start-Up, Plug-In and DRM Issues





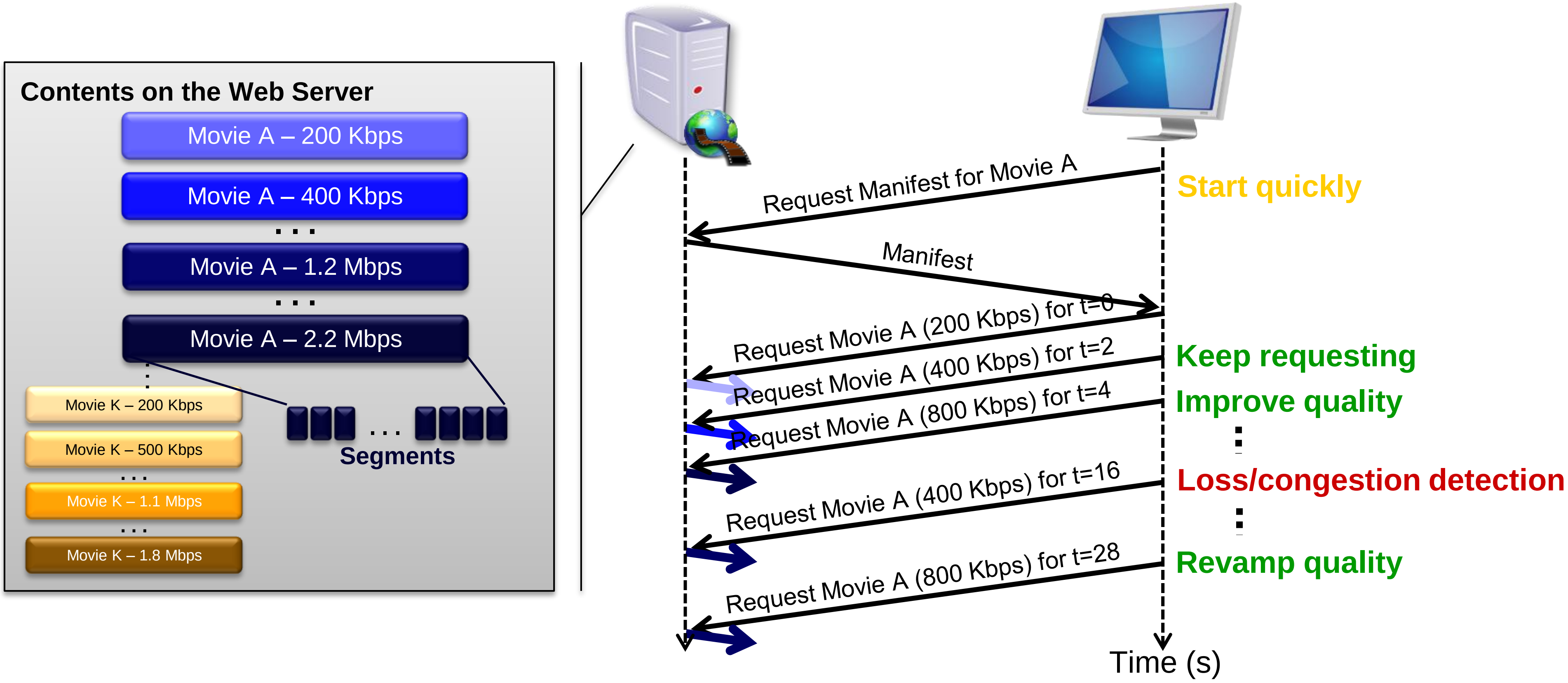


Adaptive Streaming over HTTP

Adaptive Streaming over HTTP
Adapt Video to Web Rather than Changing the Web

- **Imitation of Streaming via Short Downloads**
  - Downloads desired portion in small chunks to minimize bandwidth waste
  - Enables monitoring consumption and tracking clients
- **Adaptation to Dynamic Conditions and Device Capabilities**
  - Adapts to dynamic conditions anywhere on the path through the Internet and/or home network
  - Adapts to display resolution, CPU and memory resources of the client
  - Facilitates "any device, anywhere, anytime" paradigm
- **Improved Quality of Experience**
  - Enables faster start-up and seeking (compared to progressive download), and quicker buffer fills
  - Reduces skips, freezes and stutters
- **Use of HTTP**
  - Well-understood naming/addressing approach, and authentication/authorization infrastructure
  - Provides easy traversal for all kinds of middleboxes (e.g., NATs, firewalls)
  - Enables cloud access, leverages existing HTTP caching infrastructure (Cheaper CDN costs)

Multi-Bitrate Encoding and Representation Shifting



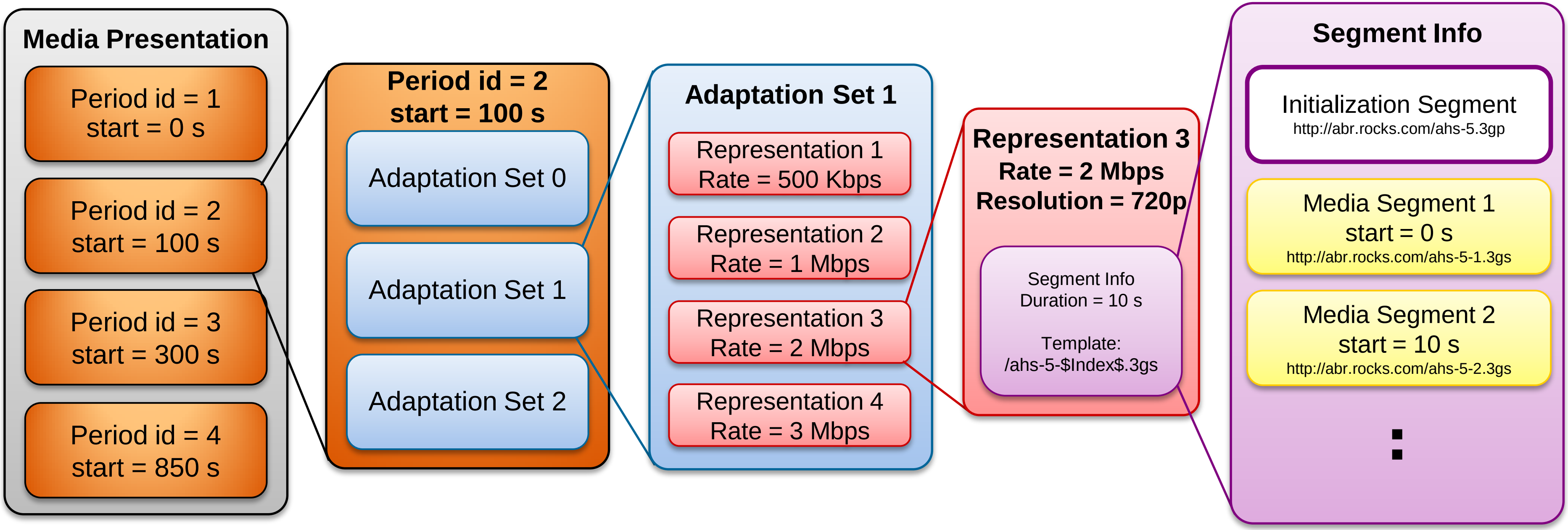
Example Representations
From Vancouver 2010 Winter Olympics

	Target Encoding Bitrate	Resolution	Frame Rate
Representation #1	3.45 Mbps	1280 x 720	30 fps
Representation #2	1.95 Mbps	848 x 480	30 fps
Representation #3	1.25 Mbps	640 x 360	30 fps
Representation #4	900 Kbps	512 x 288	30 fps
Representation #5	600 Kbps	400 x 224	30 fps
Representation #6	400 Kbps	312 x 176	30 fps

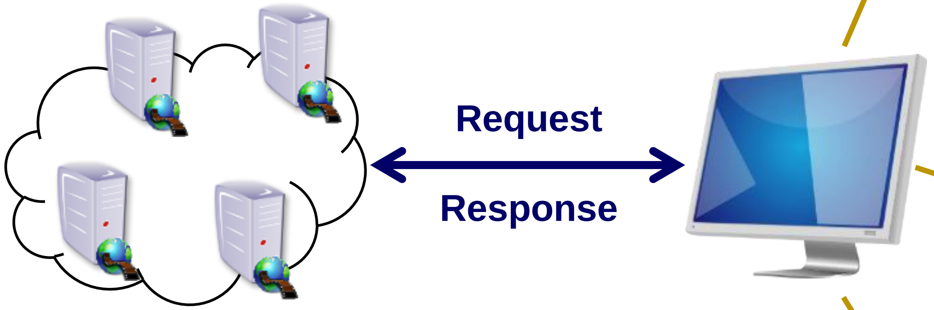
Source: Vertigo MIX10

DASH Media Presentation Description

List of Accessible Segments and Their Timings



Smart Clients



Client manages

- Manifest(s)

- HTTP transport

- TCP connection(s)

Client monitors/measures

- Playout buffer

- Download times and throughput

- Local resources (CPU, memory, screen, etc.)

- Dropped frames

Client performs adaptation

Major Players in the Market

- **Microsoft Smooth Streaming**

  http://www.iis.net/expand/SmoothStreaming
- **Apple HTTP Live Streaming**

  http://tools.ietf.org/html/draft-pantos-http-live-streaming

  http://developer.apple.com/library/ios/#documentation/networkinginternet/conceptual/streamingmediagui
- **Netflix**

  http://www.netflix.com/NetflixReadyDevices
- **Adobe HTTP Dynamic Streaming**

  http://www.adobe.com/products/httpdynamicstreaming/
- **Move Adaptive Stream (Acquired by Echostar)**

  http://www.movenetworks.com
- **Others**

  Octoshape Infinite Edge

  Widevine Adaptive Streaming (Acquired by Google)

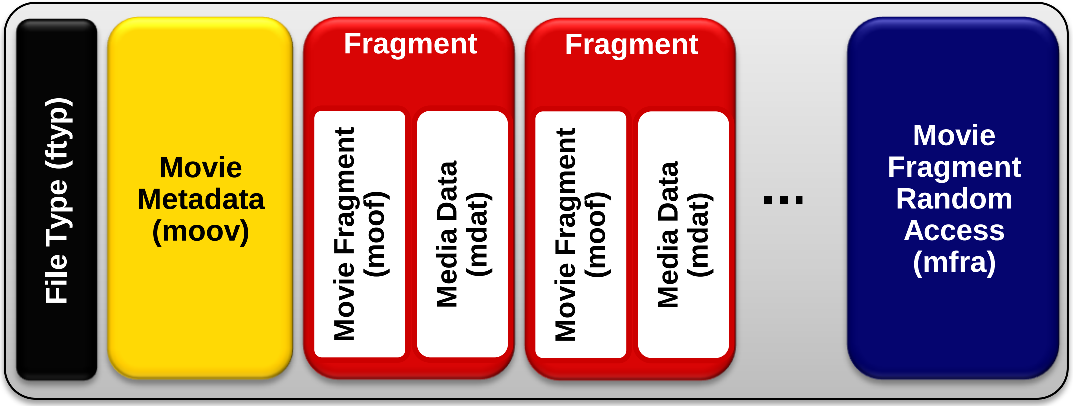
  Vidiator Dynamic Bitrate Adaptation

Example Request and Response
Microsoft Smooth Streaming

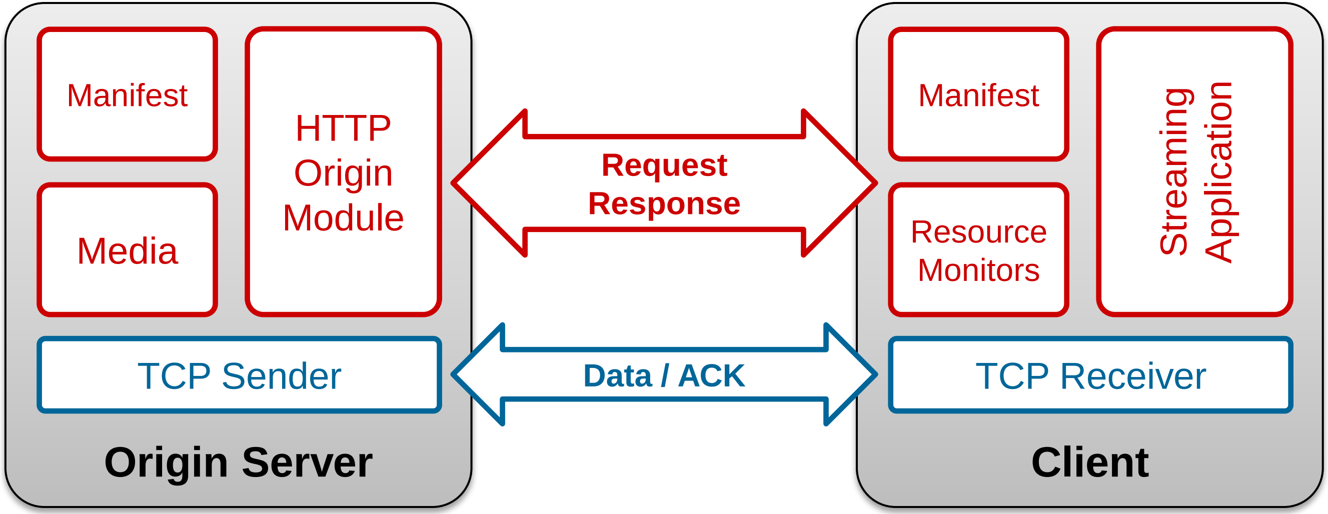
- **Client sends an HTTP request**

  GET 720p.ism/QualityLevels(572000)/Fragments(video=160577243) HTTP/1.1

- **Server**
  1. Finds the MP4 file corresponding to the requested bitrate
  2. Locates the fragment corresponding to the requested timestamp
  3. Extracts the fragment and sends it in an HTTP response



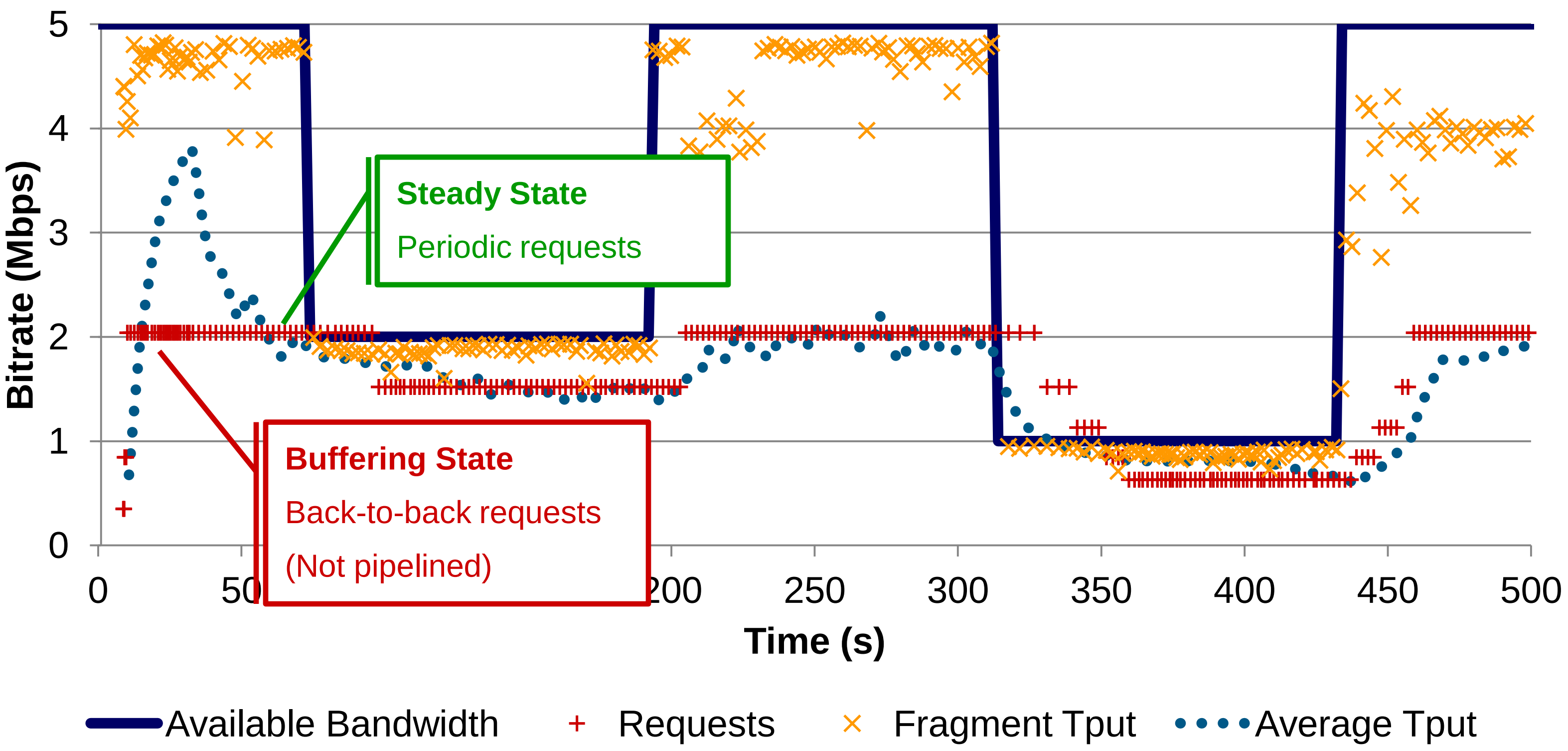
Inner and Outer Control Loops



There could be multiple TCPs destined to potentially different servers

Interaction of Inner and Outer Control Loops

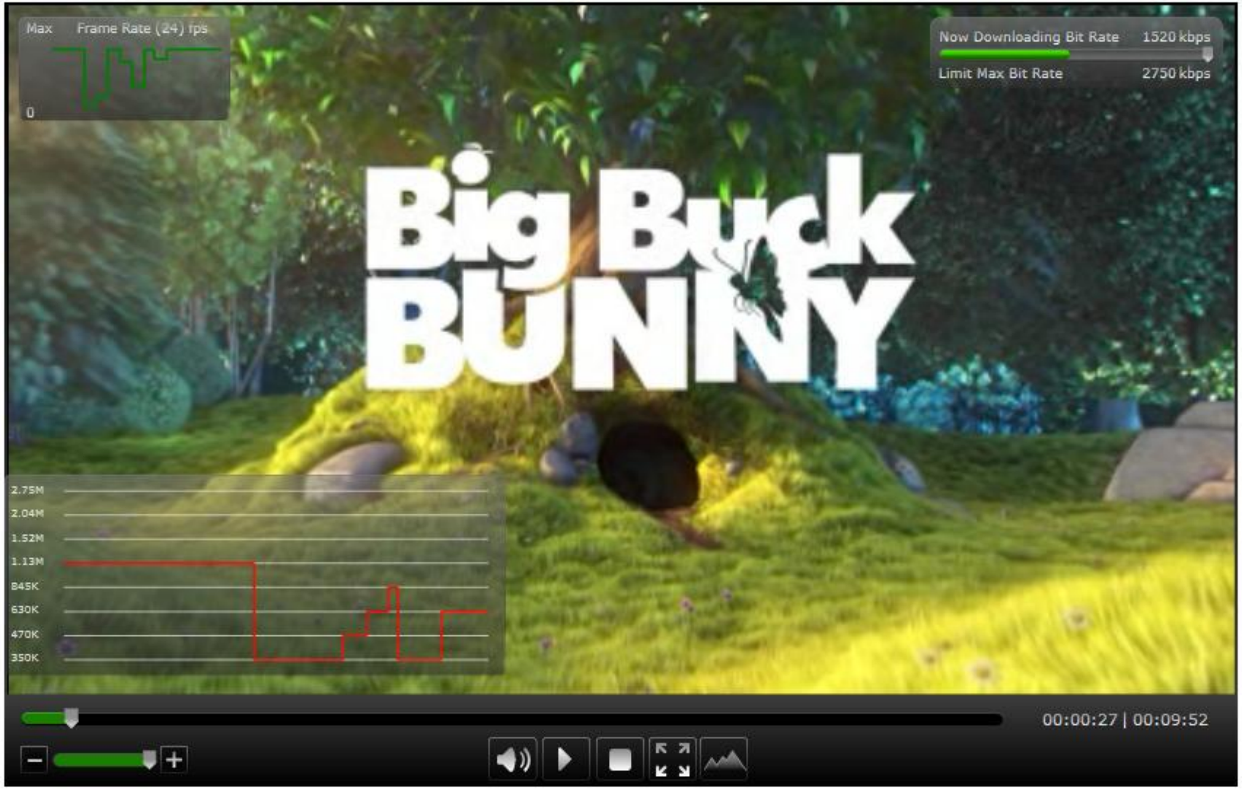
Microsoft Smooth Streaming Experiments



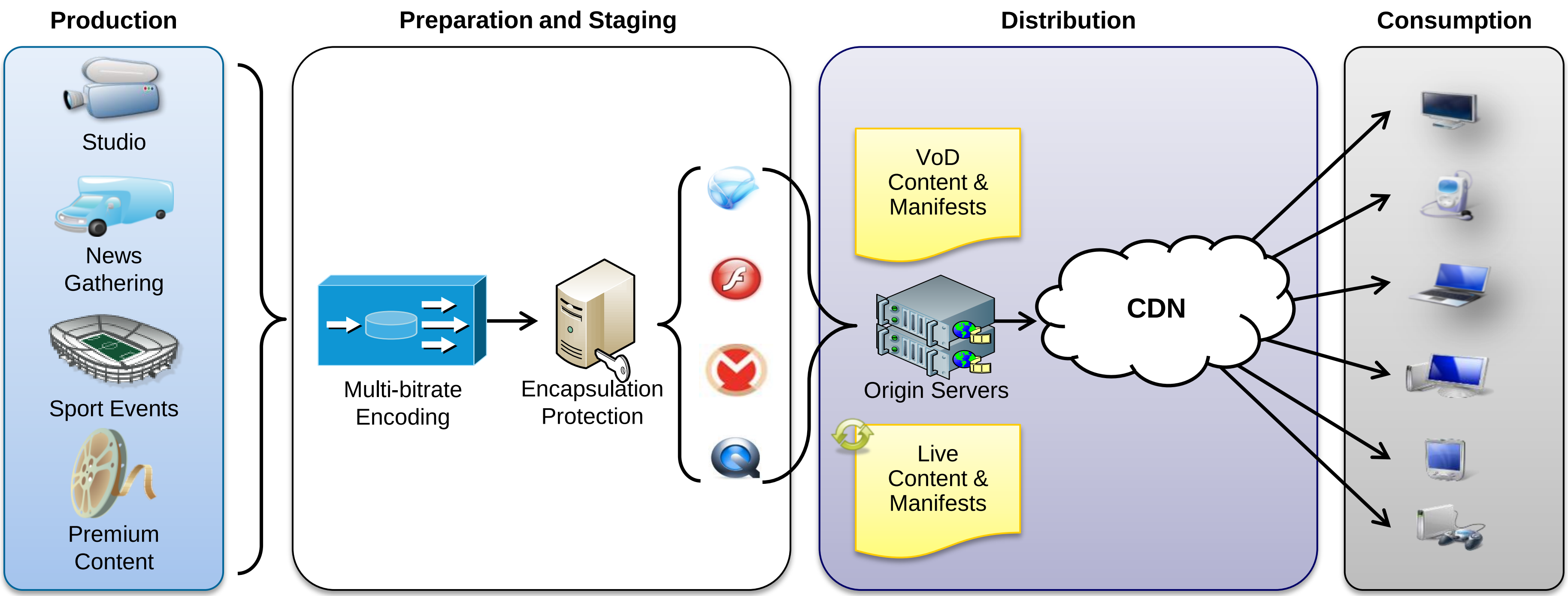
Reading: "An experimental evaluation of rate-adaptation algorithms in adaptive streaming over HTTP," ACM MMSys 2011

Microsoft Smooth Player Showing Adaptation

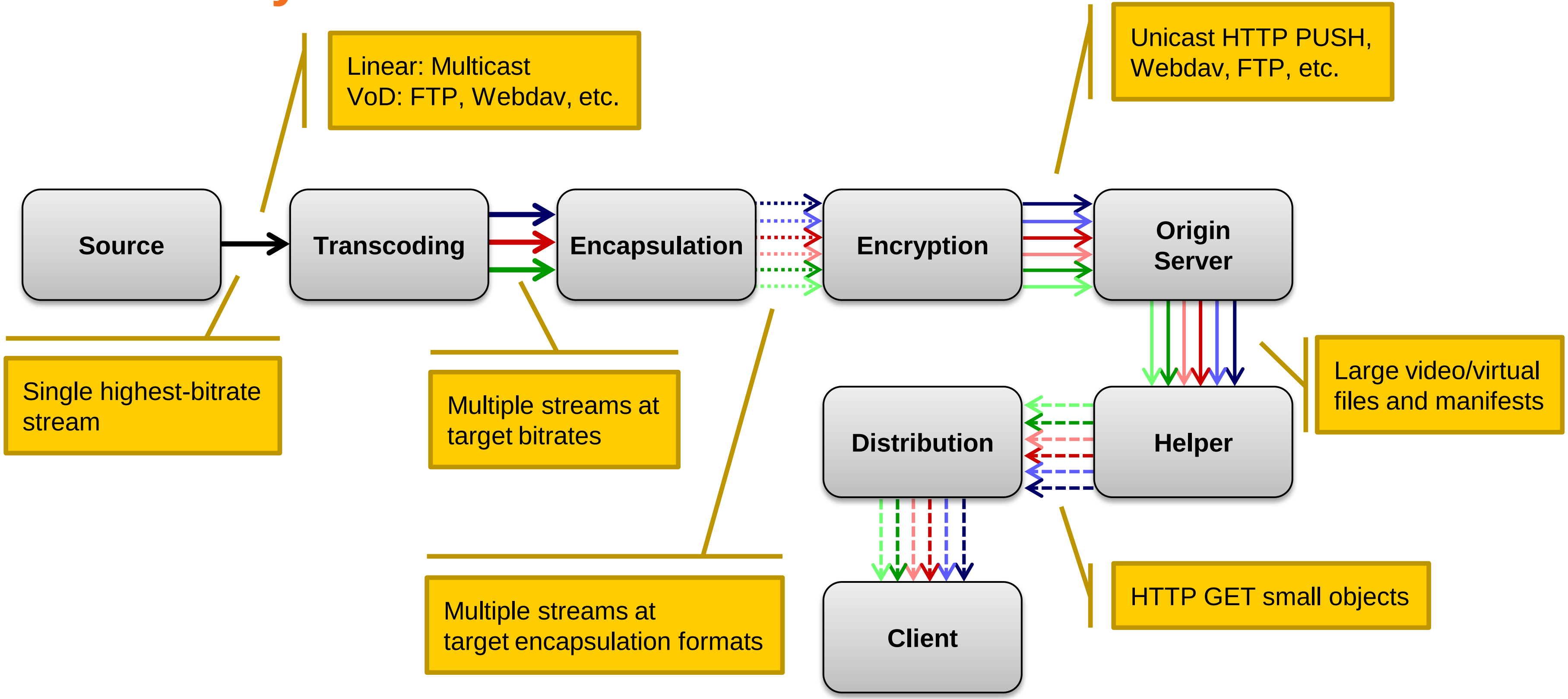
http://www.iis.net/media/experiencesmoothstreaming



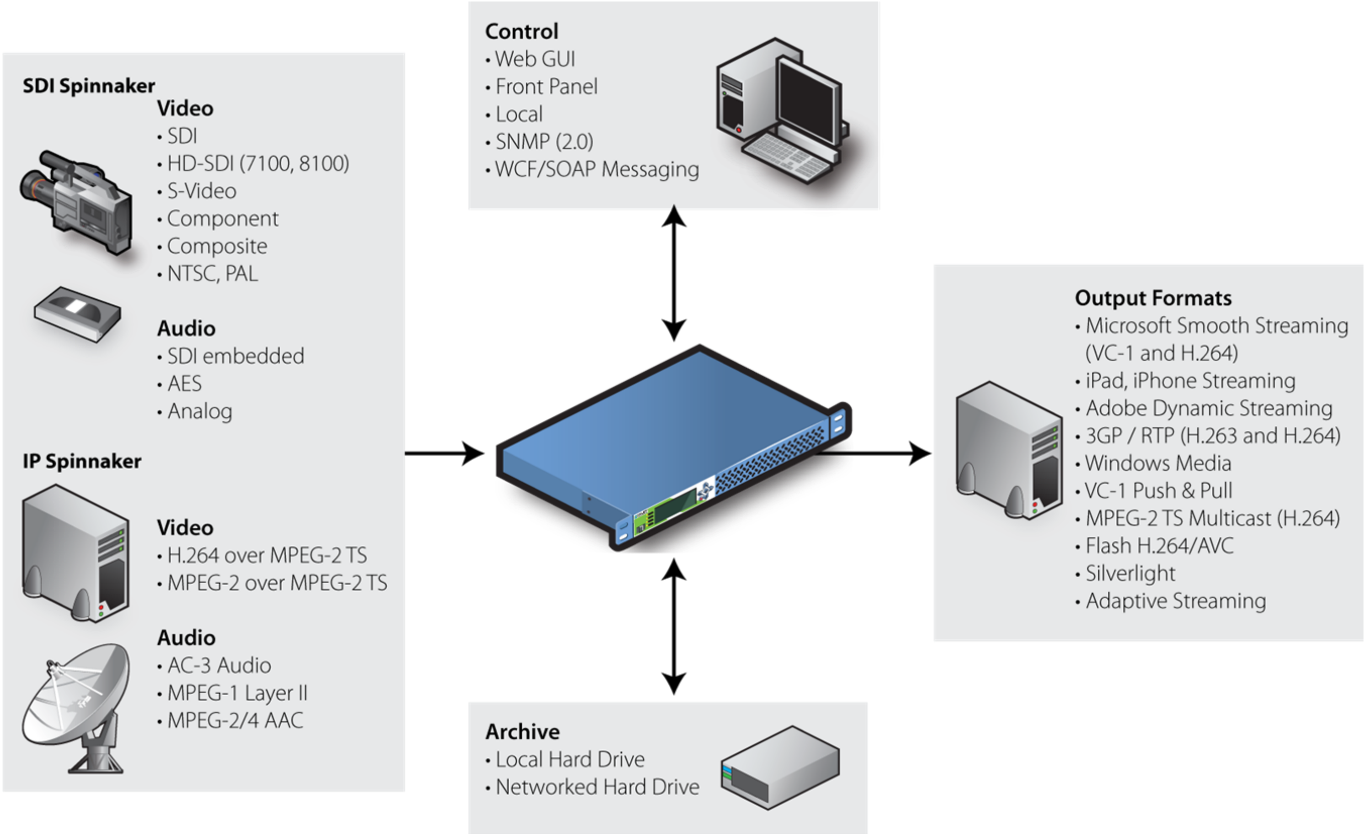
End-to-End Over-the-Top Adaptive Streaming Delivery



Adaptive Streaming Content Workflow
Today



Overview of Cisco Media Processors
Encode Once, Encapsulate for Many Formats



Source Representation

	Container	Manifest	Packaging Tools
Move	2-s chunks (.qss)	Binary (.qmx)	Proprietary
Apple HLS	Fixed-duration MPEG2-TS segments (.ts)	Text (.m3u8)	Popular encoders
Adobe Zeri	Aggregated MP4 fragments (.f4f – a/v interleaved)	Client: XML + Binary (.fmf) Server: Binary (.f4x)	Adobe Packager
Microsoft Smooth	Aggregated MP4 fragments (.isma, .ismv – a/v non-interleaved)	Client: XML (.ismc) Server: SMIL (.ism)	Popular encoders MS Expression
MPEG DASH	MPEG2-TS and MP4 segments	Client/Server: XML	Under development

- **Source containers and manifest files are output as part of the packaging process**
  - These files are staged on to origin servers
  - Some origin server implementations could have integrated packagers
- **Adobe/Microsoft allow to convert aggregated containers into individual fragments on the fly**
  - In Adobe Zeri , this function is called a Helper
  - In Microsoft Smooth, this function is tightly integrated as part of the IIS
- **Server manifest is used by Helper modules to convert the large file into individual fragments**

Staging and Distribution

	Origin Server	Packager → OS Interface	Distribution
Move	Any HTTP server	DFTP, HTTP, FTP	Plain Web caches
Apple HLS	Any HTTP server	HTTP, FTP, CIFS	Plain Web caches
Adobe Zeri	HTTP server with Helper	Integrated packager for live and JIT VoD Offline packager for VoD (HTTP, FTP, CIFS, etc.)	Plain Web caches → Helper running in OS Intelligent caches → Helper running in the delivery edge
Microsoft Smooth	IIS	WebDAV	Plain Web caches Intelligent IIS servers configured in cache mode
MPEG DASH	Any HTTP server	HTTP, FTP, CIFS	Plain Web caches

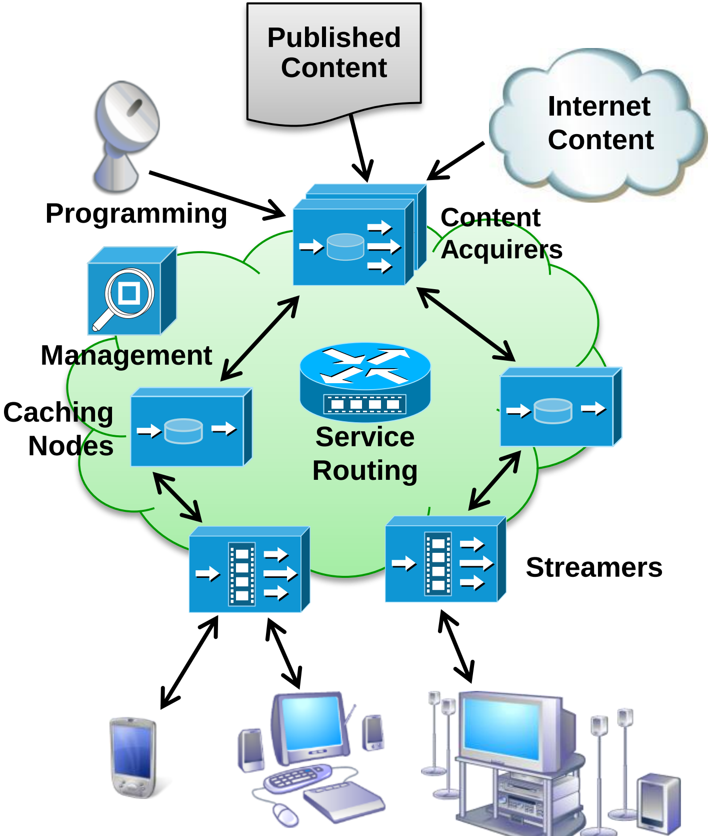
Delivery

	Client	# of TCP Connections	Transaction Type
Move	Proprietary Move player	3-5	Byte-range requests
Apple HLS	QuickTime X	1 (interleaved)	Whole-segment requests Byte-range requests (iOS5)
Adobe Zeri	OSMF client on top Flash player	Implementation dependent	Whole-fragment access Byte-range access
Microsoft Smooth	Built on top of Silverlight	2 (One for audio and video)	Whole-fragment requests
MPEG DASH	DASH client	Configurable	Whole-segment requests Byte-range requests

- **In Smooth, fragments are augmented to contain timestamps of future fragments in linear delivery**
  - Thus, clients fetch the manifest only once
- **In HLS, manifest is continuously updated**
  - Thus, clients constantly request the manifest

Cisco Content Delivery System

The Network is the Platform



- **Extensible Architecture**
  - Independent scalability of storage, caching and streaming
  - Non-stop service availability
  - Convergence of live and on-demand content
- **Distributed Network**
  - Multi-protocol centralized ingest
  - Popularity-based multi-tier caching
  - Multi-protocol decentralized streaming
- **Service Routing Functionality**
  - Service routing at the edge or headend
  - Global and local load balancing

Summary

- Part I: IPTV
  - IPTV – Architecture, Protocols and SLAs
  - Video Transport in the Core Networks
  - Video Distribution in the Access Networks
  - Improving Viewer Quality of Experience
- Part II: Internet Video and Adaptive Streaming
  - Example Over-the-Top (OTT) Services
  - Media Delivery over the Internet
  - Adaptive Streaming over HTTP

Q&A

Further Reading and References

Further Reading and References
IPTV Basics – Architecture, Protocols and SLAs

- **Articles**

“Not all packets are equal, part I: streaming video coding and SLA requirements,” IEEE Internet Computing, Jan./Feb. 2009

“Not all packets are equal, part II: the impact of network packet loss on video quality,” IEEE Internet Computing, Mar./Apr. 2009

“Deploying diffserv in backbone networks for tight SLA control,” IEEE Internet Computing, Jan./Feb., 2005

- **Special Issues**

IEEE Network (March 2010)

IEEE Transactions on Broadcasting (June 2009)

IEEE Internet Computing (May/June 2009)

IEEE Communications Magazine (Multiple issues in 2008)

Further Reading and References
Video Transport in the Core Networks

- **Articles**

  “Toward lossless video transport,” IEEE Internet Computing, Nov./Dec. 2011

  “Designing a reliable IPTV network,” IEEE Internet Computing, May/June 2009

- **Standards**

  http://tools.ietf.org/html/rfc2475

  http://tools.ietf.org/html/rfc2205

  http://tools.ietf.org/html/rfc3209

  http://tools.ietf.org/html/rfc4090

Further Reading and References
Video Distribution in the Access Networks

- **Articles**
  - "Error control for IPTV over xDSL networks," IEEE CCNC 2008
  - "IPTV service assurance," IEEE Communications Magazine, Sept. 2006
  - "DSL spectrum management standard," IEEE Communications Magazine, Nov. 2002
- **Standards and Specifications**
  - "Asymmetric digital subscriber line (ADSL) transceivers," ITU-T Rec. G.992.1, 1999
  - http://www.dvb.org/technology/standards/index.xml#internet
  - http://tools.ietf.org/html/rfc5760
  - http://tools.ietf.org/html/rfc5740
  - http://tools.ietf.org/html/rfc4588
  - http://tools.ietf.org/html/rfc4585
  - http://tools.ietf.org/html/rfc3550

Further Reading and References
Improving Viewer Quality of Experience

- **Articles**
  - "Reducing channel-change times with the real-time transport protocol," IEEE Internet Computing, May/June 2009
  - "On the scalability of RTCP-based network tomography for IPTV services," IEEE CCNC 2010
  - "On the use of RTP for monitoring and fault isolation in IPTV," IEEE Network, Mar./Apr. 2010
- **Standards and Specifications**
  - http://www.broadband-forum.org/technical/download/TR-126.pdf
  - https://www.atis.org/docstore/product.aspx?id=22659
- **Open Source Implementation for VQE Clients**
  - Documentation
    - http://www.cisco.com/en/US/docs/video/cds/cda/vqe/3_5/user/guide/ch1_over.html
  - FTP Access
    - ftp://ftpeng.cisco.com/ftp/vqec/

Further Reading and References

Industry Tests

- **Light Reading: Cisco Put to the Video Test**

  http://www.lightreading.com/document.asp?doc_id=177692&site=cdn

- **EANTC Experience Provider Mega Test**

  http://www.cisco.com/en/US/solutions/ns341/eantc_megatest_results.html

- **IPTV & Digital Video QoE: Test & Measurement Update**

  http://www.heavyreading.com/insider/details.asp?sku_id=2382&skuitem_itemid=1181

Further Reading and References
Adaptive Streaming

- **Articles**

  "Watching video over the Web, part 2: applications, standardization, and open issues," IEEE Internet Computing, May/June 2011

  "Watching video over the Web, part 1: streaming protocols," IEEE Internet Computing, Mar./Apr. 2011

  "Mobile video delivery with HTTP," IEEE Communications Mag., Apr. 2011

- **Special Sessions in ACM MMSys 2011**

  Technical Program and slides: at http://www.mmsys.org/?q=node/43

  VoDs of the sessions are available in ACM Digital Library

  http://tinyurl.com/mmsys11-proc

  (Requires ACM membership)

- **W3C Web and TV Workshops**

  http://www.w3.org/2010/11/web-and-tv/

  http://www.w3.org/2011/09/webtv

Further Reading and References
Source Code

- **Microsoft Media Platform: Player Framework**

  http://smf.codeplex.com/

- **Adobe OSMF**

  http://www.opensourcemediaframework.com/

- **OVP**

  http://openvideoplayer.sourceforge.net

- **LongTail Video JW Player**

  http://www.longtailvideo.com/players/jw-flv-player

Further Reading and References

Demos

- **Akamai HD Network**

  http://wwwns.akamai.com/hdnetwork/demo/index.html

  http://bit.ly/testzeri

  Also watch http://2010.max.adobe.com/online/2010/MAX137_1288195885796UHEZ

- **Microsoft Smooth Streaming**

  http://www.iis.net/media/experiencesmoothstreaming

  http://www.smoothhd.com/

- **Adobe OSMF**

  http://www.osmf.org/configurator/fmp/

  http://osmf.org/dev/1.5gm/debug.html

- **Apple HTTP Live Streaming (Requires QuickTime X or iOS)**

  http://devimages.apple.com/iphone/samples/bipbopall.html

- **OVP**

  http://openvideoplayer.sourceforge.net/samples

  http://openvideoplayer.sourceforge.net/ovpfl/samples/as3/index.html

- **Octoshape Infinite Edge**

  http://www.octoshape.com/?page=showcase/showcase

Further Reading and References
Links for Organizations and Specs

- **3GPP PSS and DASH**
  - http://ftp.3gpp.org/specs/html-info/26234.htm
  - http://ftp.3gpp.org/specs/html-info/26247.htm
- **MPEG DASH**
  - ISO/IEC 23001-6 and ISO/IEC 14496-12:2008/DAM 3 available at
  - http://mpeg.chiariglione.org/working_documents.php
  - Mailing List: http://lists.uni-klu.ac.at/mailman/listinfo/dash
- **W3C Web and TV Interest Group**
  - http://www.w3.org/2011/webtv/
- **DECE UltraViolet**
  - http://www.uvvu.com/
- **IETF httpstreaming Discussion List**
  - https://www.ietf.org/mailman/listinfo/httpstreaming
- **OIPF Volume 2a - HTTP Adaptive Streaming**
  - http://www.openiptvforum.org/specifications.html