

A photograph of an offshore wind farm with numerous white wind turbines on a blue sea under a clear sky. The text is overlaid on the right side of the image.

IPTV over Cable

Ariel Szternberg

Agenda

- Market Drivers for Cable IPTV
- Technical Enablers for Cable IPTV
- Deployment Strategies

The background of the slide features a dark blue-to-black gradient. Overlaid on this gradient are several sets of concentric circles in various shades of blue, creating a ripple effect. The circles are of different sizes and are scattered across the upper and middle portions of the slide.

Why are Cable Operators interested in IPTV?

What is Driving Cable to Look at IPTV?

1. Adjacent Market Opportunities

Deliver services where there is no HFC (MDUs, college campuses, new fiber-based residential communities, etc.)

2. Multi-Network Video Delivery

Deploy the same service, same CPE, in cable, wireline, FTTx, WiMax, etc.

3. Cheaper, more varied CPE

IP-based client devices eliminate tuner costs and enable delivery to a wider range of CE devices

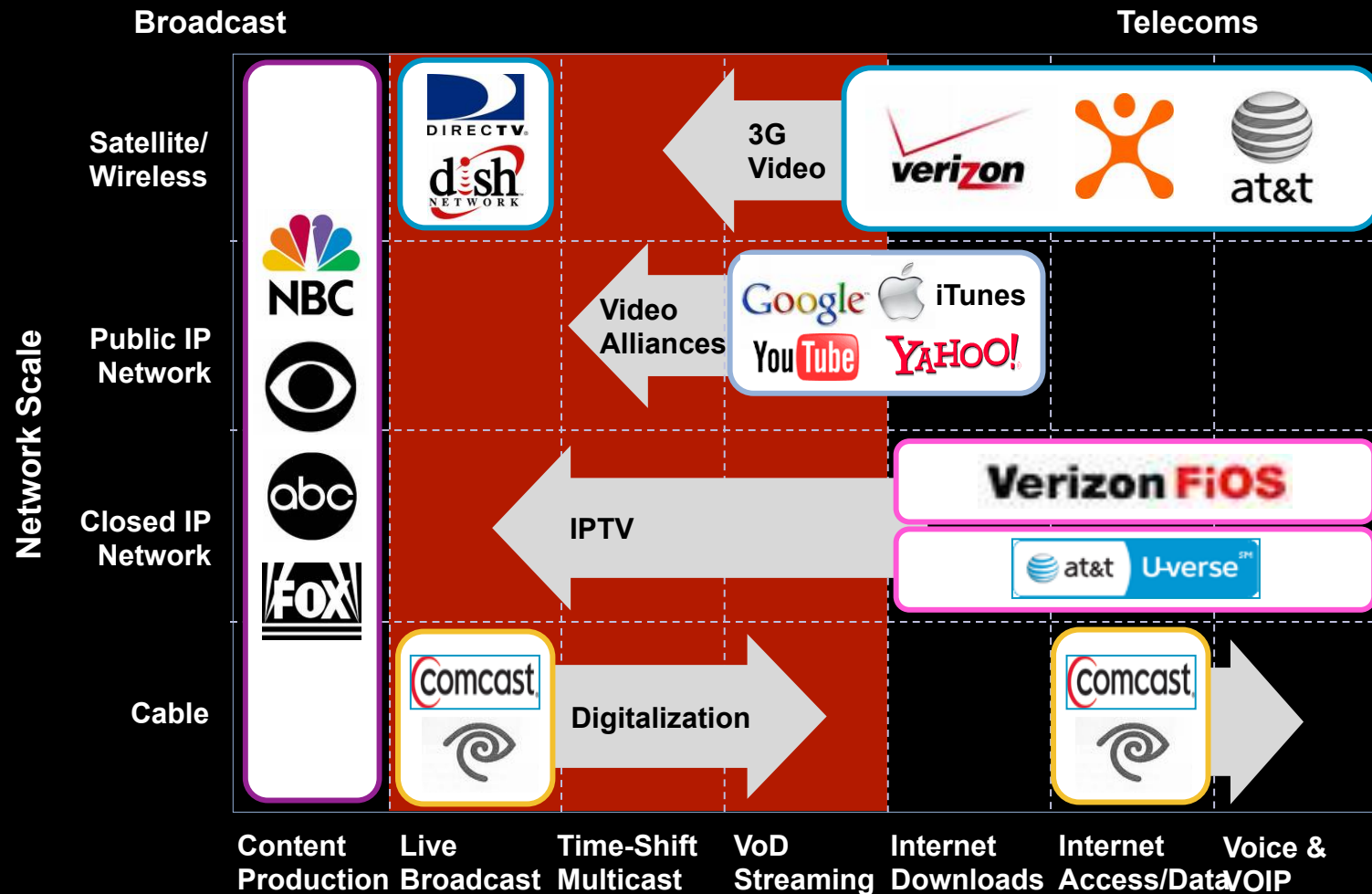
4. Overlay Deployment

An IPTV Video Service can be deployed alongside an existing legacy service with modest incremental spectrum demands

5. Service Velocity

IPTV systems leverage Web 2.0 technologies, enabling rapid application/service development

The competitive environment is only getting more challenging...



Satellite Weapon of Choice - HD



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 - CNN HD
 - Comedy Central HD
 - Country Music TV HD
 - Discovery Channel HD
 - DISH Network ON DEMAND¹
 - DISH Network PAY PER VIEW¹
 - Disney Channel HD
 - Disney XD HD
- Encore**
 - ESPN HD
 - ESPN2 HD
 - ESPNNEWS HD
 - Food Network HD
 - Golf Channel HD
- Hallmark Movie Channel**
 - HD Theater
 - HDNet
 - HGTV HD
 - History Channel HD
 - Lifetime
 - Lifetime Movie Network
- National Geographic**
 - NFL Network HD
 - Palladia
- Planet Green**
- Science Channel HD**

with your local channels, plus a 3-year DVR service and Free Standard Professional Installation.

TLC HD
TNT HD
Travel Channel HD

Telco Weapon of Choice - Innovation

The image shows a screenshot of the AT&T U-Verse website's 'Features' page. The page is displayed on a computer monitor within a virtual environment. The website's navigation bar includes 'HOME', 'WHAT IS U-VERSE', 'HARDWARE', 'FEATURES', 'AVAILABILITY', 'GET U-VERSE', and 'VIDEO GALLERY'. The 'FEATURES' section lists several items: 'Total Home DVR', 'Remote Access', 'HD Channel Line-Up', 'Electronic Program Guide', 'U-bar', 'Flickr', 'Exclusive Content', and 'Other Cool Stuff'. Red callout boxes with arrows point from these items to descriptive text boxes on the right side of the screen. The callouts are: 'Multi-room DVR' (pointing to 'Total Home DVR'), 'Remote Programming' (pointing to 'Remote Access'), 'HD' (pointing to 'HD Channel Line-Up'), 'PIP, Fast Channel Change' (pointing to 'Electronic Program Guide'), 'Personalized Weather/Sports/Traffic/etc.' (pointing to 'U-bar'), 'Photos' (pointing to 'Flickr'), 'VOD, Clips' (pointing to 'Exclusive Content'), and 'Other Cool Stuff' (pointing to 'Other Cool Stuff'). The top right of the page says 'online experience store'. A 'HOME' button is visible in the bottom left corner of the monitor, and a 'sound on' icon is at the bottom center.

online experience store

WIRELESS AT&T U-VERSE CUSTOMER SERVICE

HOME WHAT IS U-VERSE HARDWARE FEATURES AVAILABILITY GET U-VERSE VIDEO GALLERY

Features

- Total Home DVR
- Remote Access
- HD Channel Line-Up
- Electronic Program Guide
- U-bar
- Flickr
- Exclusive Content
- Other Cool Stuff

Multi-room DVR

Remote Programming

HD

PIP, Fast Channel Change

Personalized Weather/Sports/Traffic/etc.

Photos

VOD, Clips

“Other Cool Stuff”

HOME

sound on

IPTV = Service Velocity

Application development much easier when "direct IP" connection present



Instant Channel Change

Feature Velocity

One platform for all applications

Cross Platform Applications

Ubiquitous connectivity

Web service interface

Slideshow on TV



Caller ID on TV

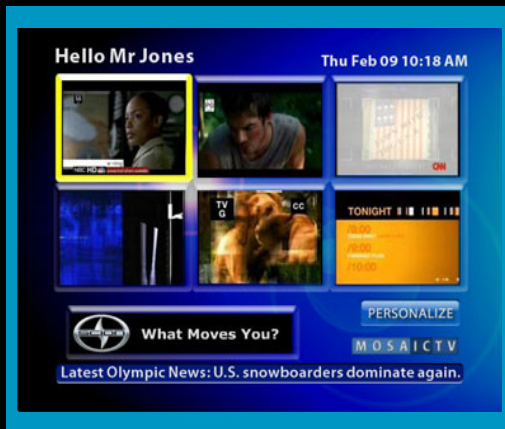


Video/voice mail on TV



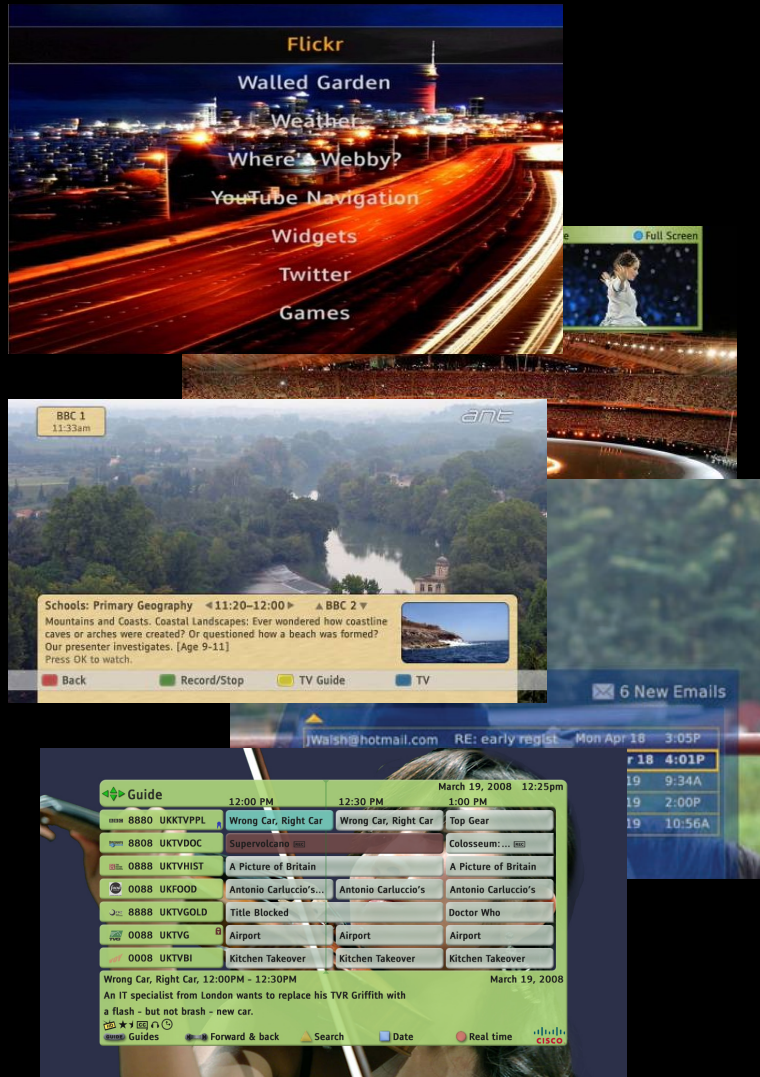
Remote DVR programming

And more...



Video Mosaic

Multi-Vendor, Multi-Device Application Framework

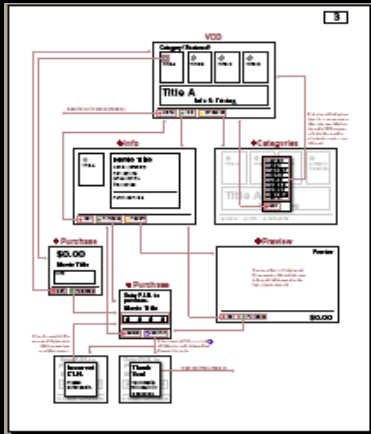


- Compact, highly optimized and reliable
- The latest Internet standards
 - HTML4.01, XHTML, DHTML, DVB-HTML, AJAX
 - CSS 2.1, CSS TV, CSS 3
 - DOM 2, JavaScript 1.5, SSL 2 and 3
- Compatible with latest Access Gateway technologies and protocols
- Full control over style
 - Easy branding and theme changes
 - Quickly change style sheet for new look on demand
 - Opportunity to personalize
- Rapid prototyping environment

Enables Fast Service Authoring

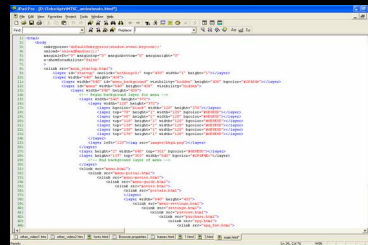
For Rapid Prototyping and Launch of Advanced Services

UI Design & Layout



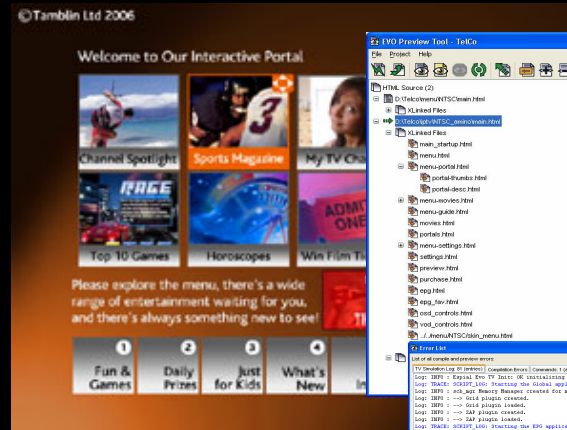
Wire-frame for look and usability analysis

Authoring Tools



HTML/Web tools used to develop UI and input into previewing

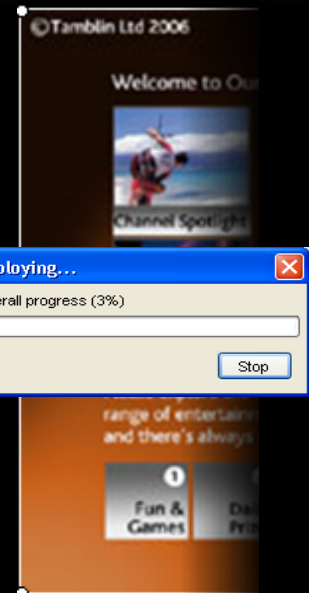
HTML Output



Debug Tools Refine & Debug

Preview

Deployment

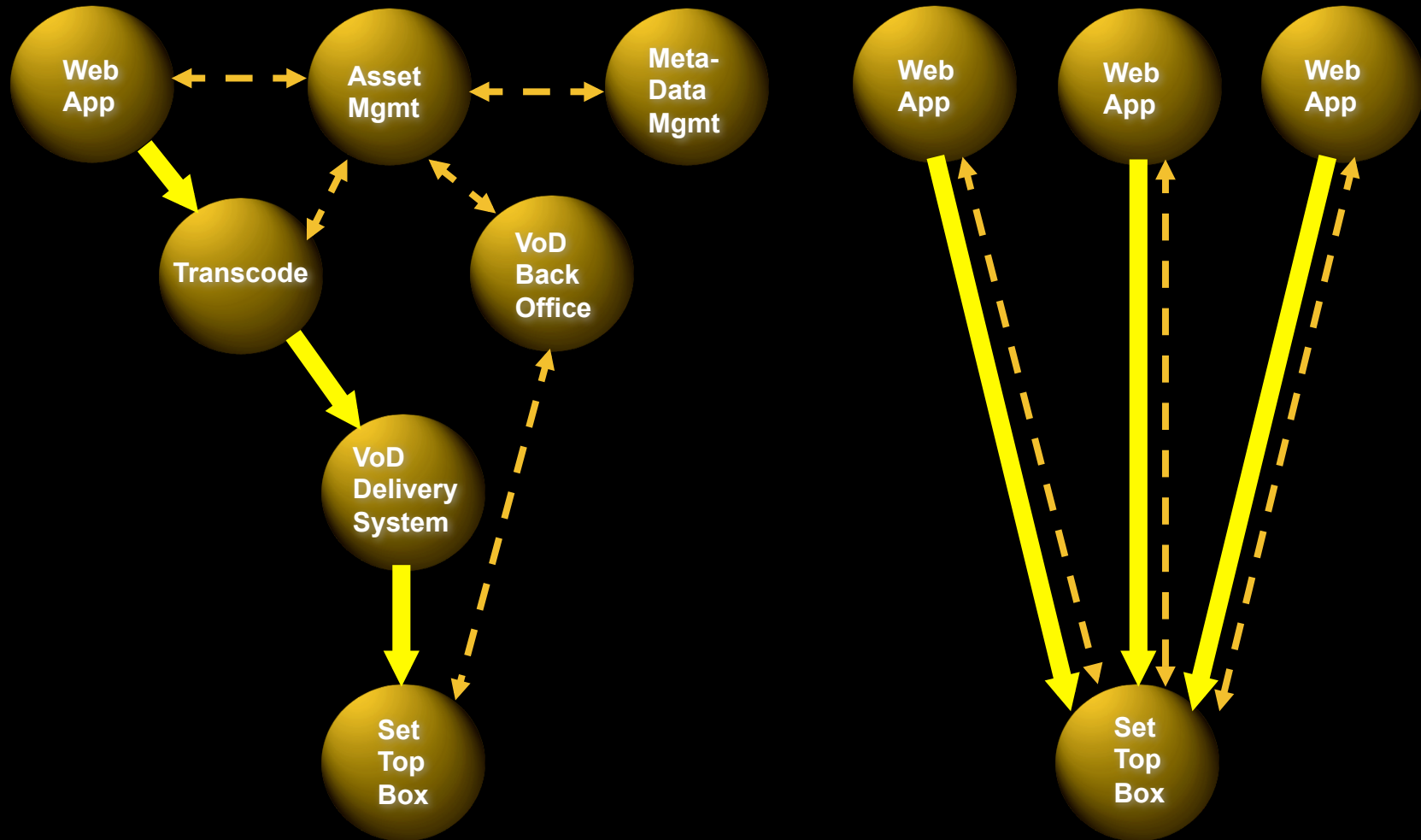


Package for deployment

Low skill set needed, Faster turn around, Easy deployment

Native IP Delivery of Set-Top Applications

Reduces Complexity and Increasing Service Velocity



Traditional Cable Set-Top
Complex Ecosystem
for Existing Set-Tops

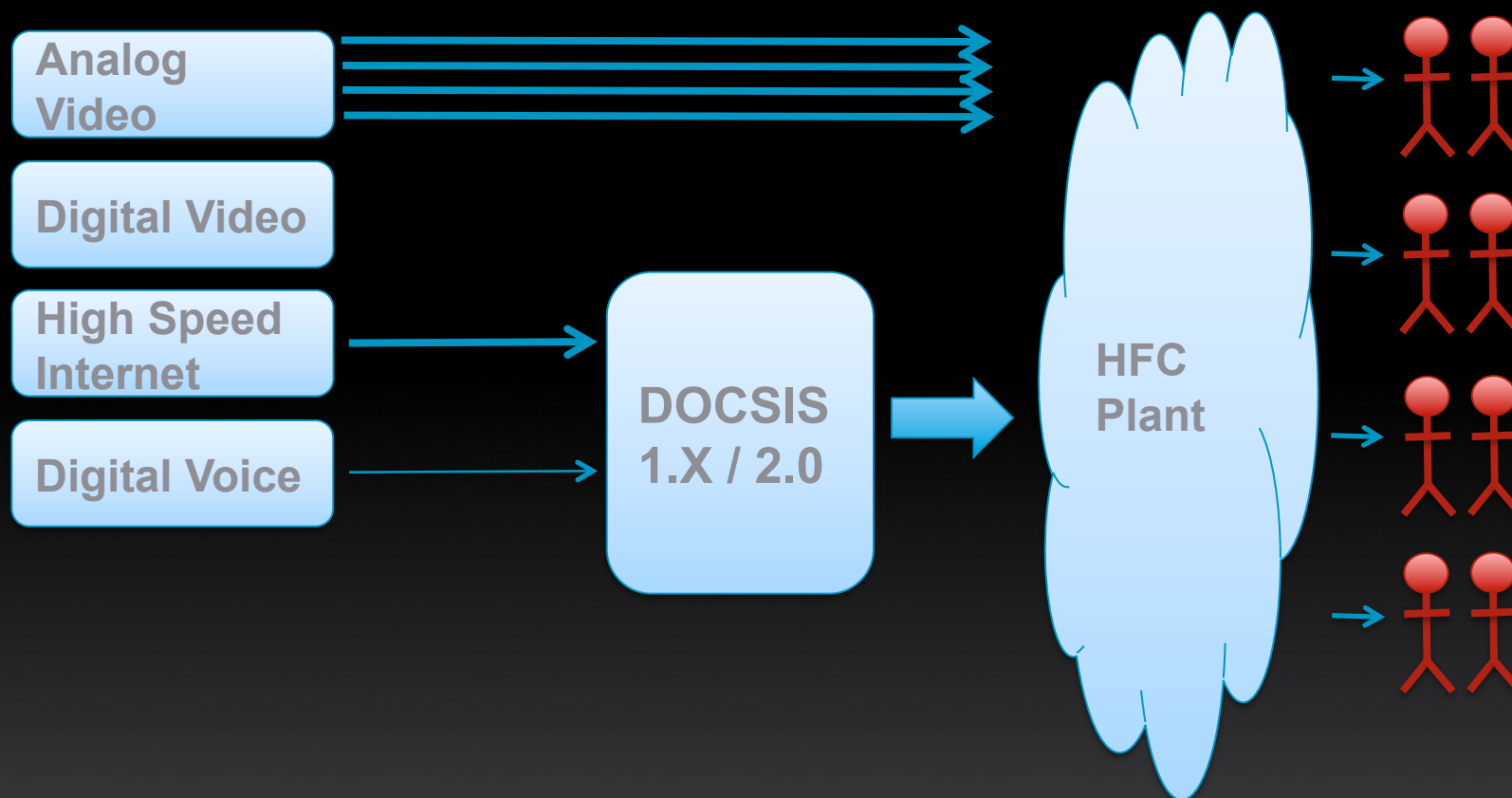
IP or Hybrid Set-Top
Simple Ecosystem
Utilizes IP capabilities

The background features a dark blue gradient that transitions from black at the top to a medium blue at the bottom. Overlaid on this gradient are several concentric circles of varying sizes and shades of blue, creating a ripple effect. The circles are semi-transparent and overlap each other, with some appearing more prominent than others.

Value Proposition

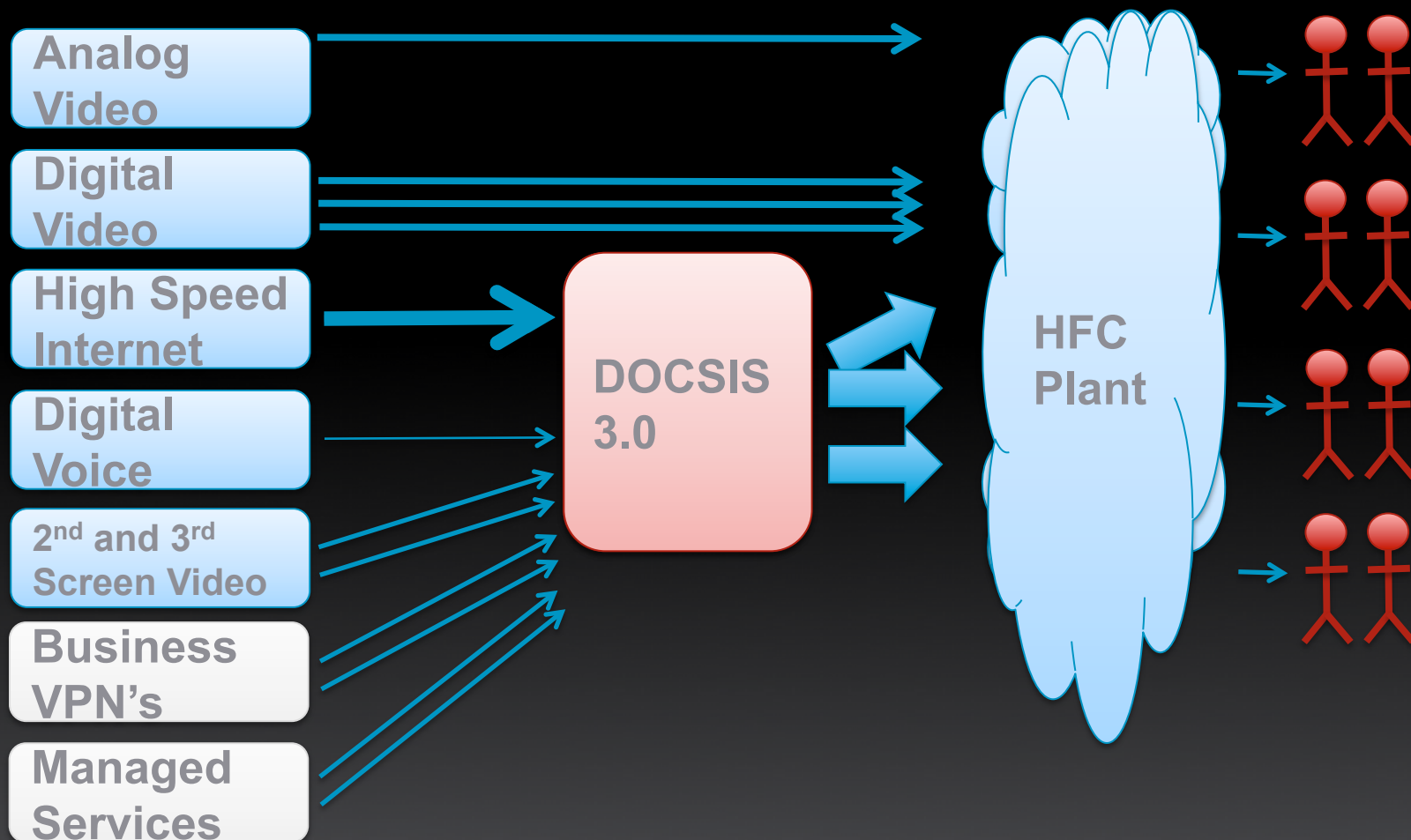
Delivery of services is changing...

Yesterday – Analog channels moved to digital



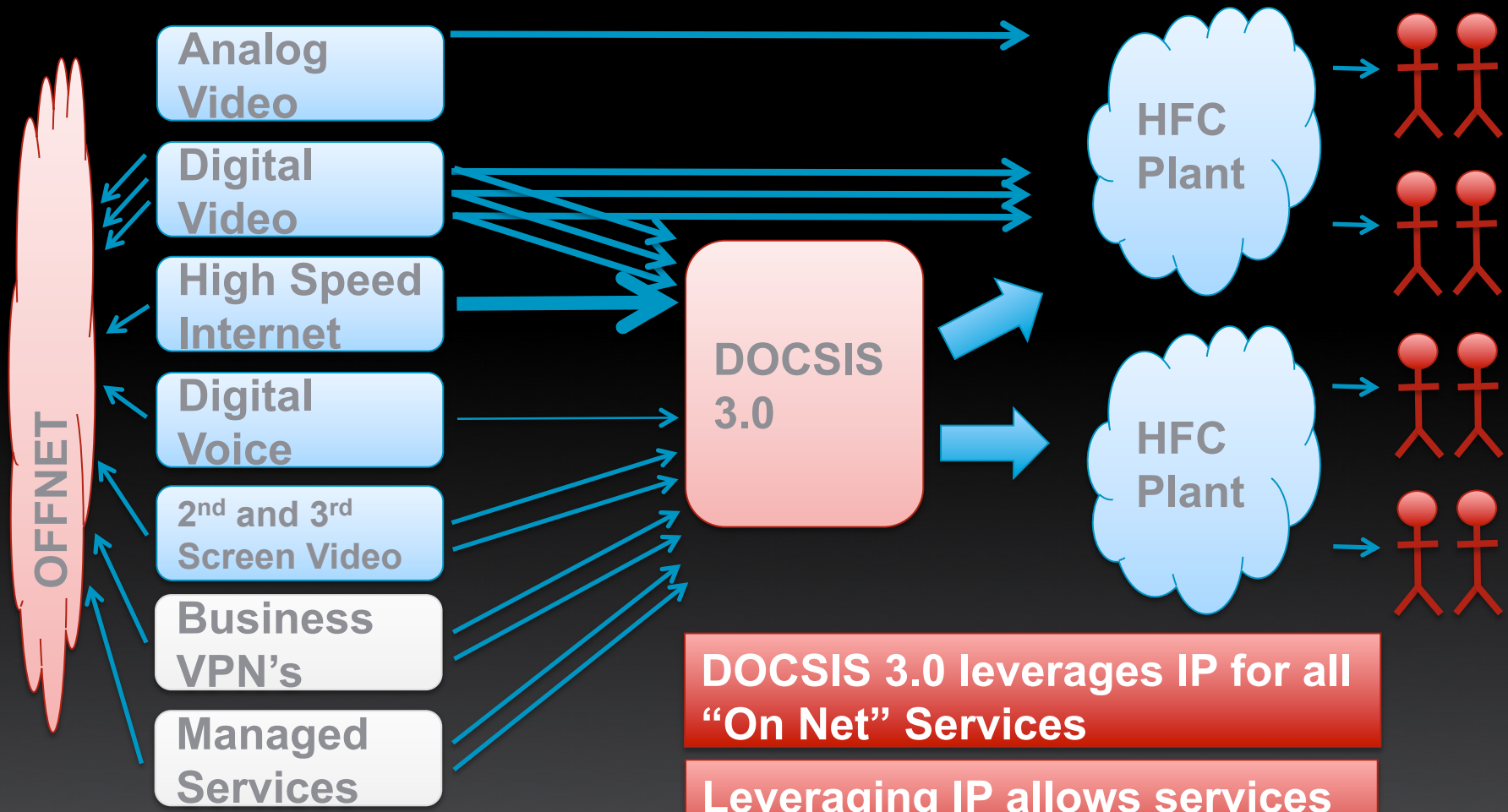
Delivery of services is changing...

Today – Further HFC Plant Segmentation



Changing Delivery of Services

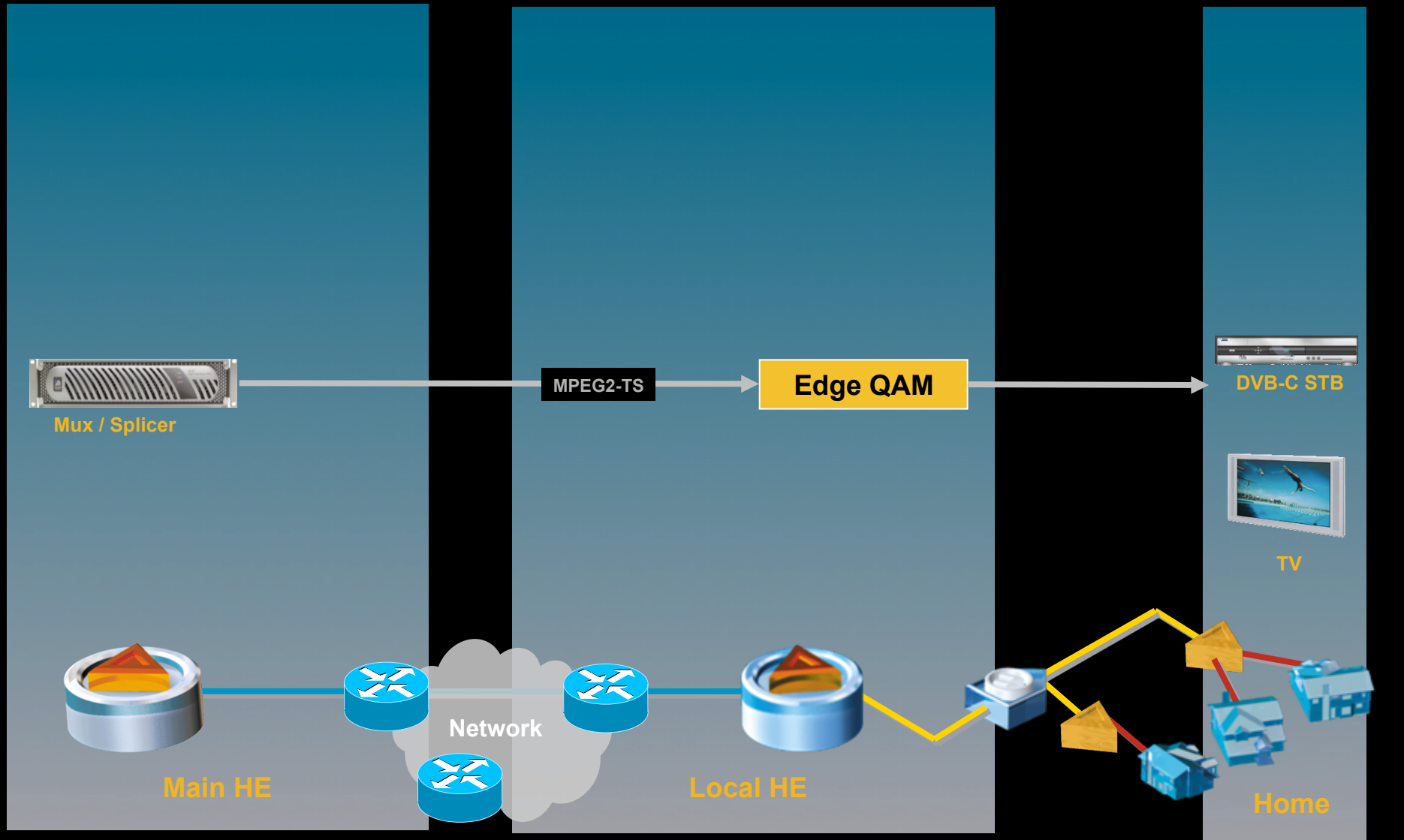
Tomorrow – Digital channels moving to IPTV



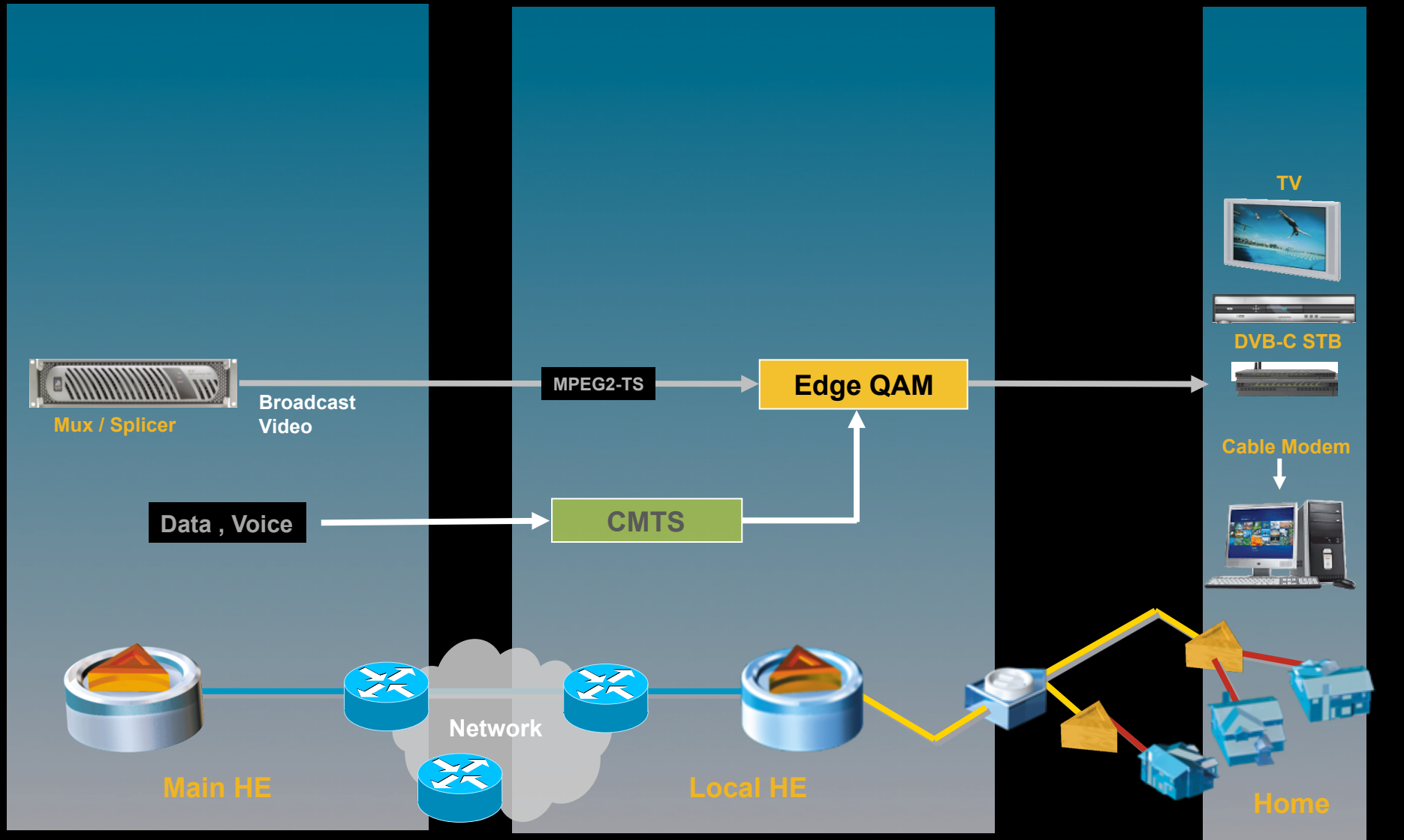
DOCSIS 3.0 leverages IP for all "On Net" Services

Leveraging IP allows services to also go "Off Net"

IP Centric Headend Broadcast Video

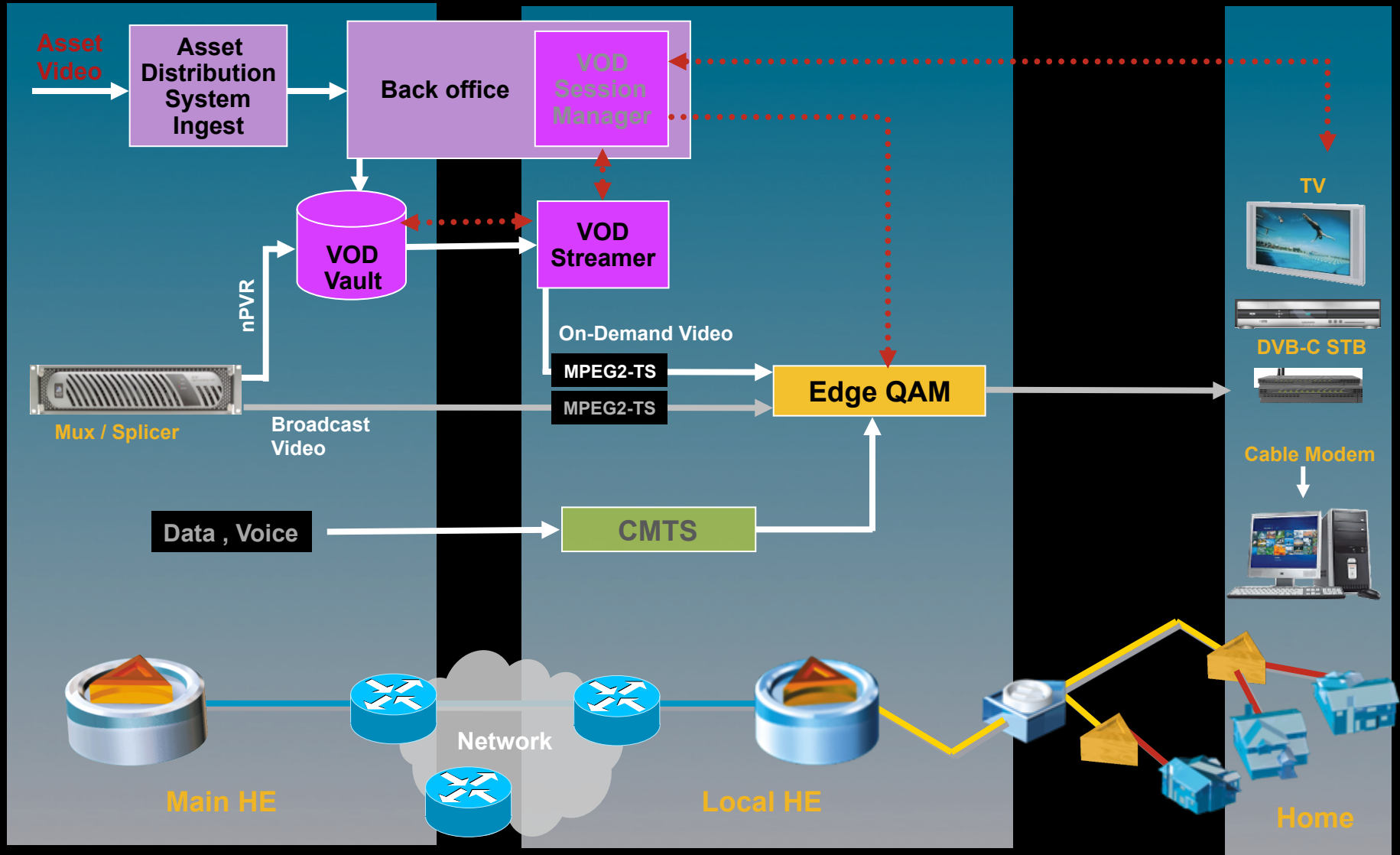


IP Centric Headend Broadcast Video + HS Data



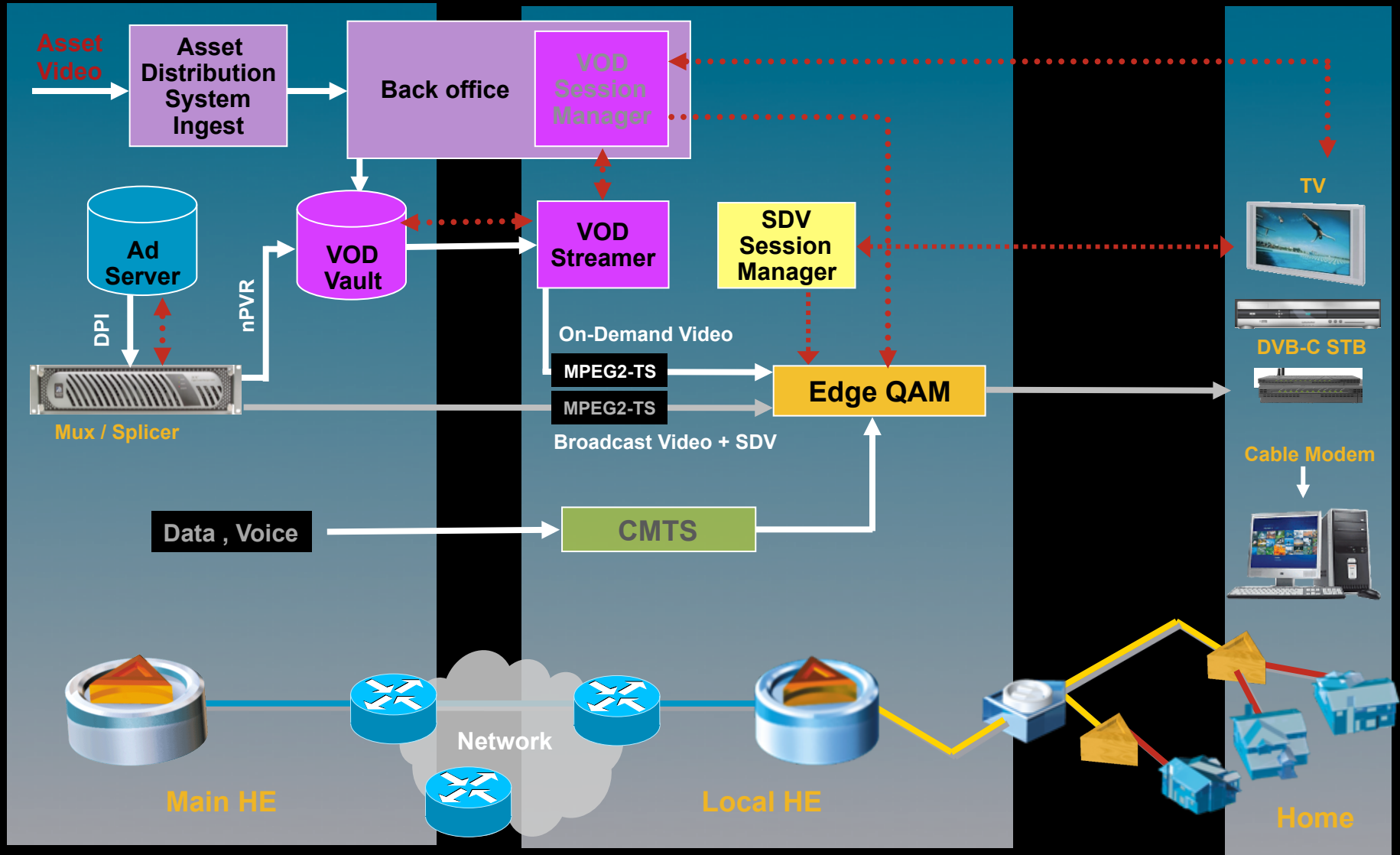
IP Centric Headend

Broadcast Video + HS Data + VoD



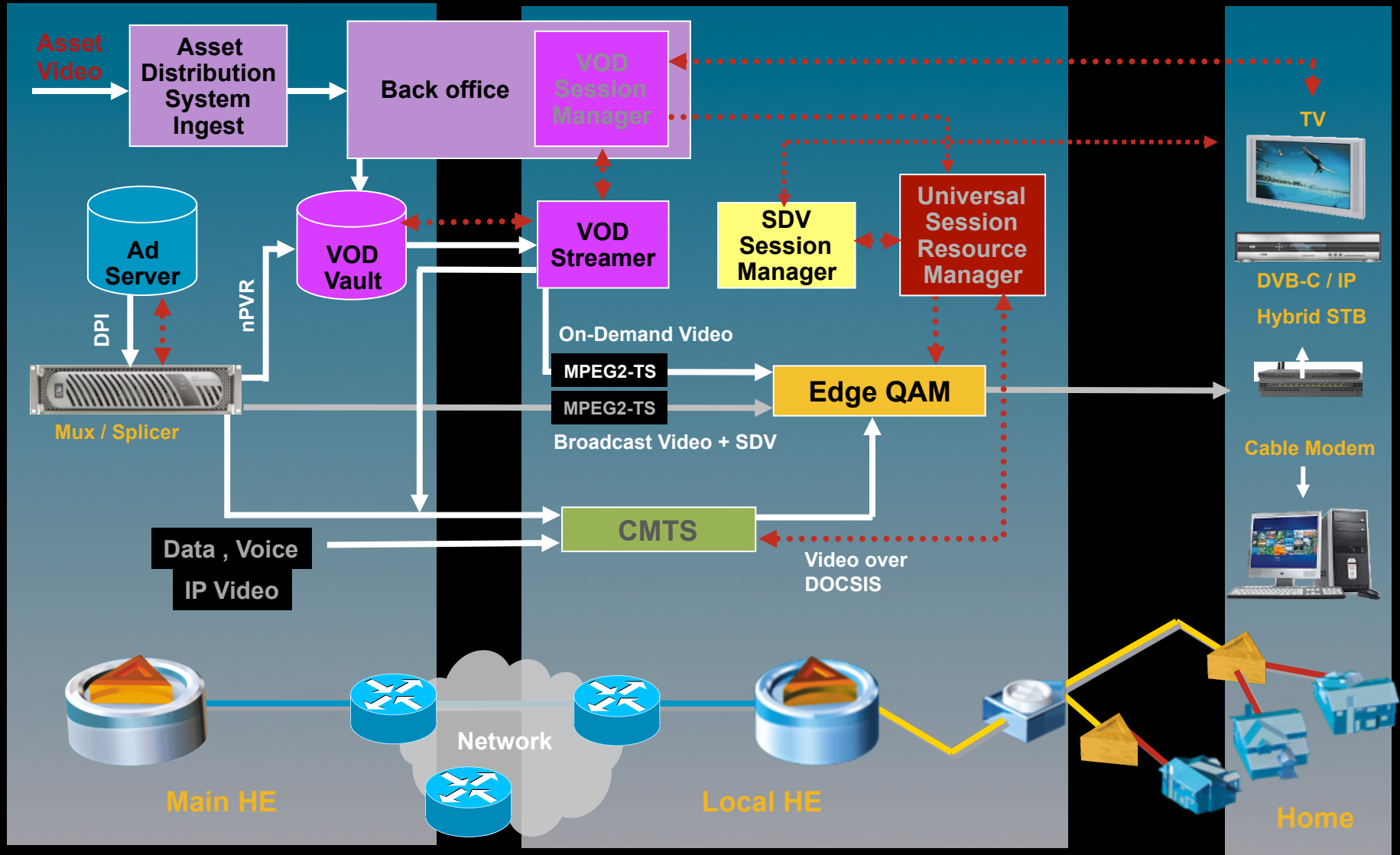
IP Centric Headend

Broadcast Video + HS Data + VoD + DPI + SDV



IP Centric Headend

BC Video + HS Data + VoD + DPI + SDV + VDOC

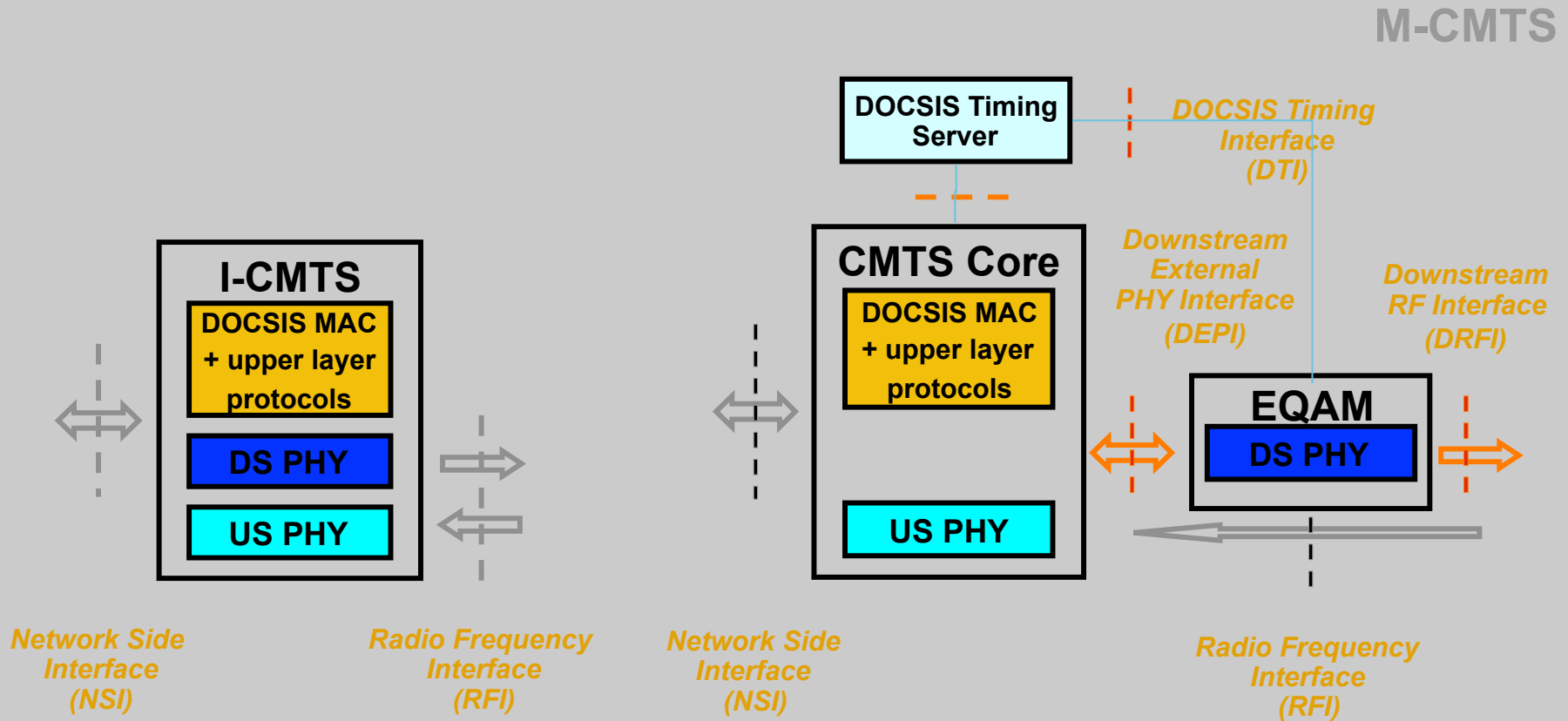


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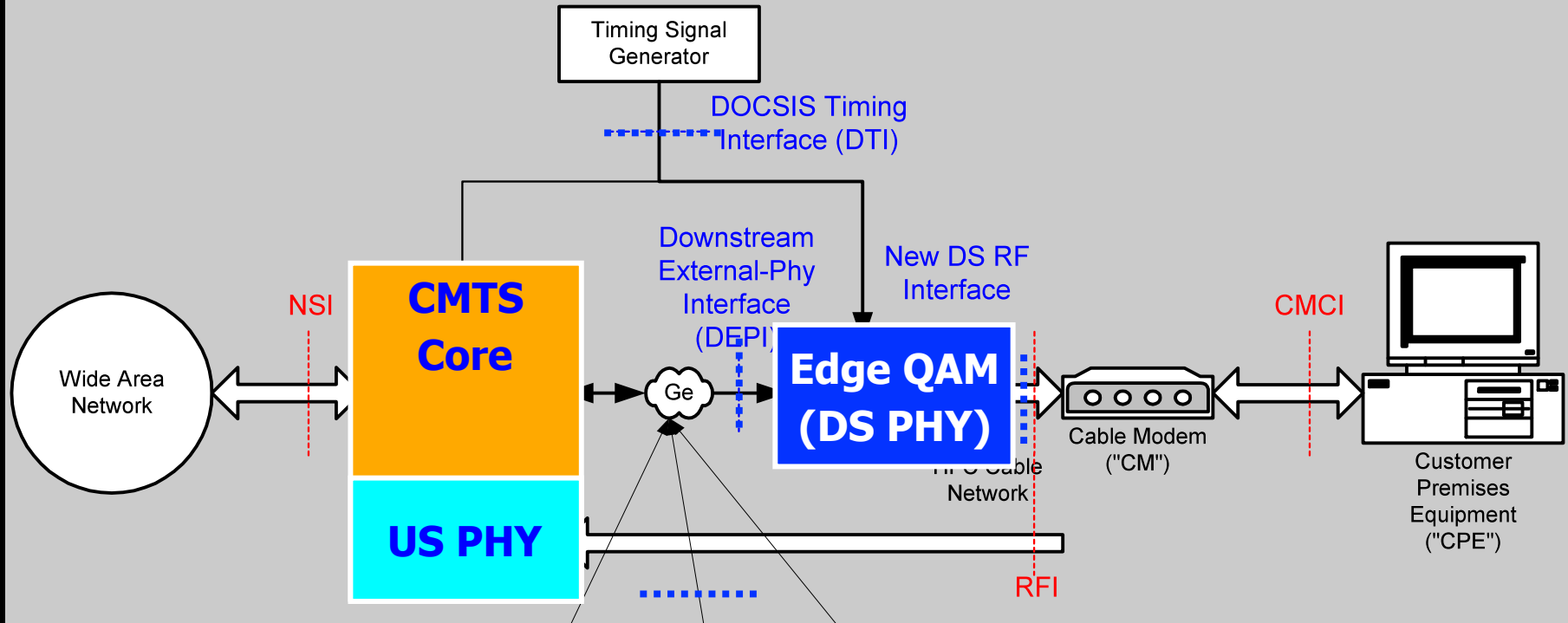
What makes Docsis 3.0 suitable for IPTV

Integrated and Modular CMTS Architecture

- MAC, DS PHY and US PHY functions are co-located on the same Line Card
- Fixed ratio between DS and US Ports
- External DS PHY (separate MAC and PHY)
- Flexible ratio between DS and US Ports
- Timing server to keep the two boxes in synch



Cable Labs M-CMTS Architecture



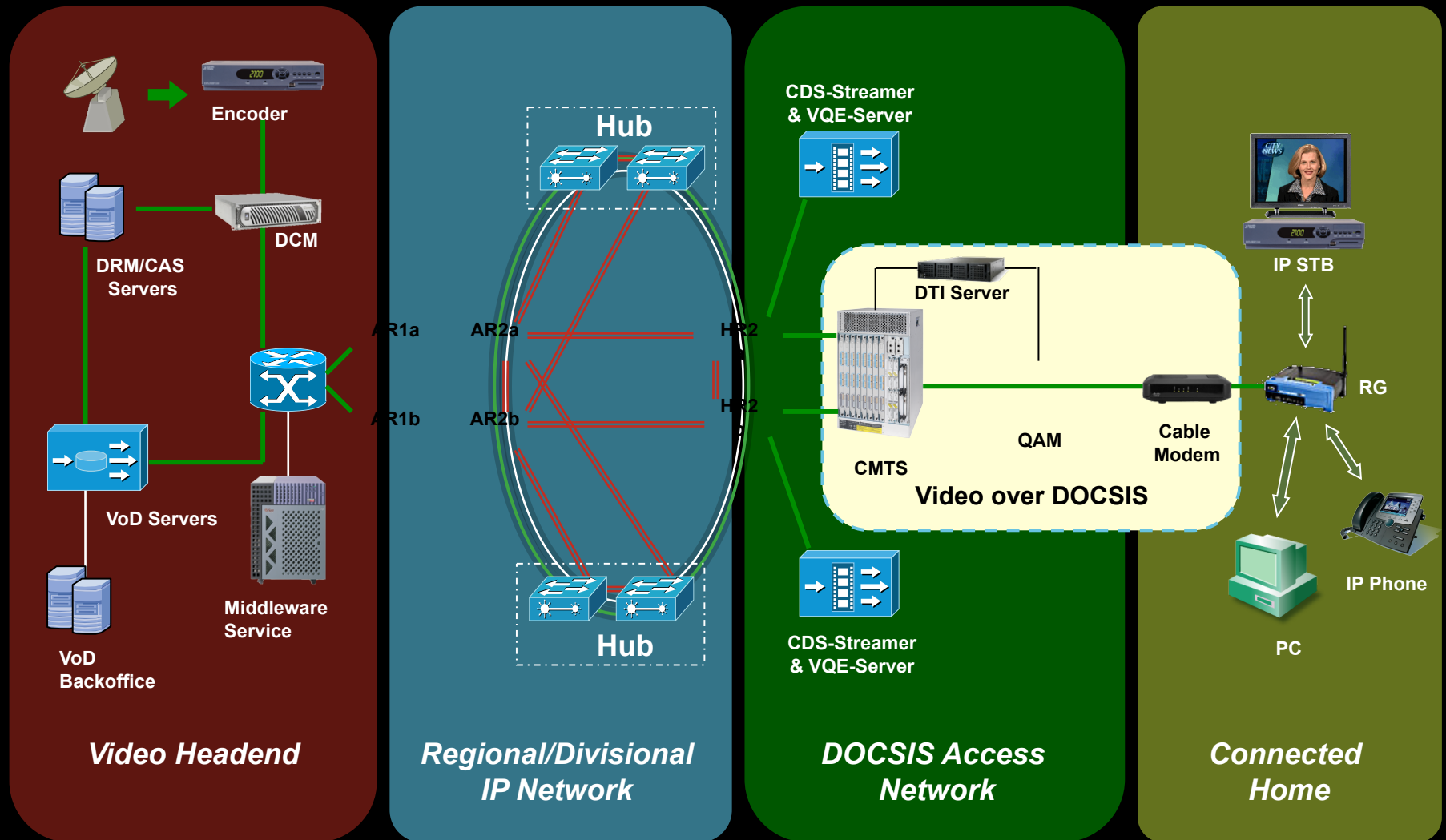
Downstream External Phy Interface: DEPI

DOCSIS Timing Interface: DTI

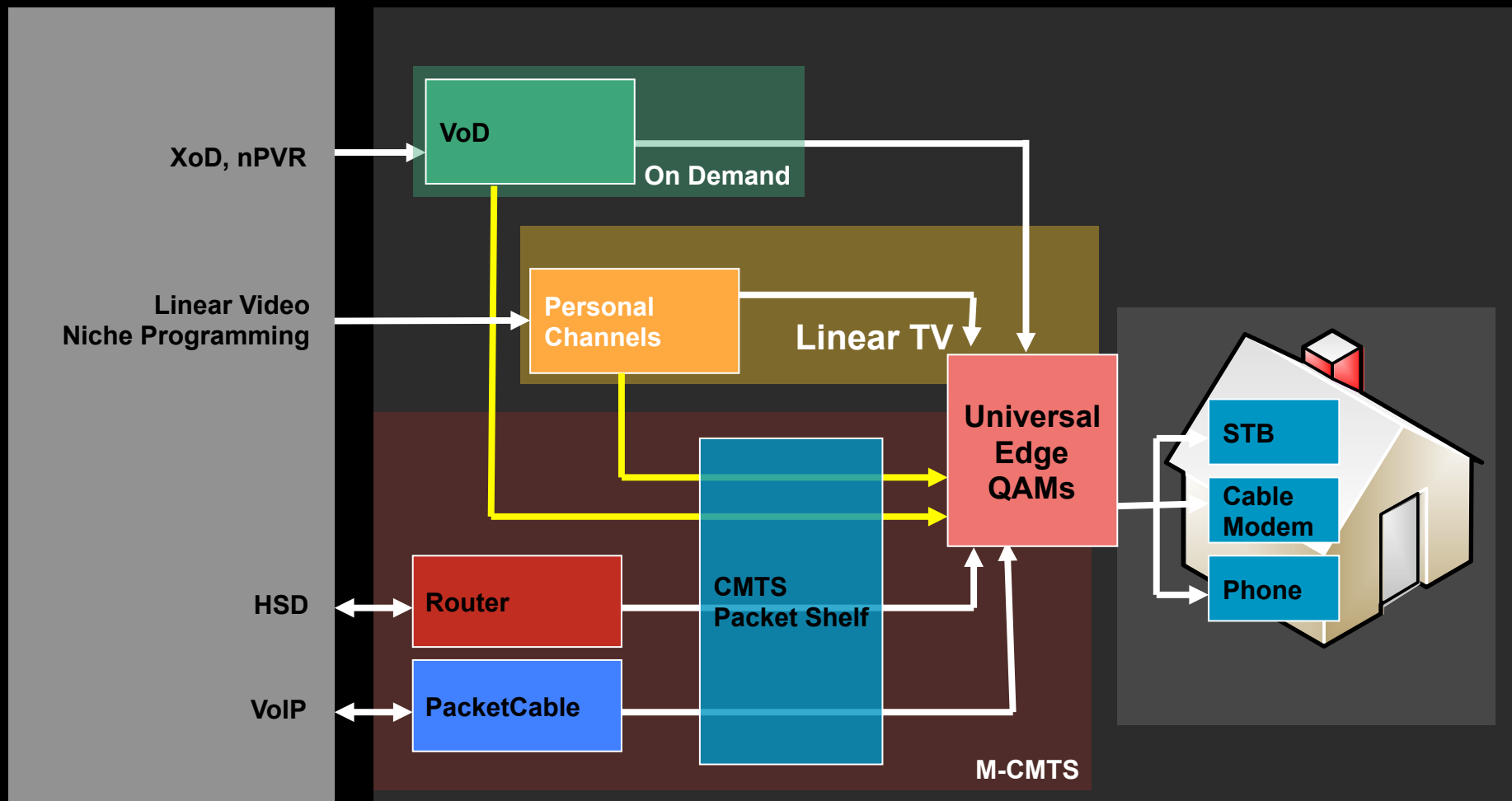
Downstream RF Interface: DRFI

Edge Resource Management Interface: ERMI

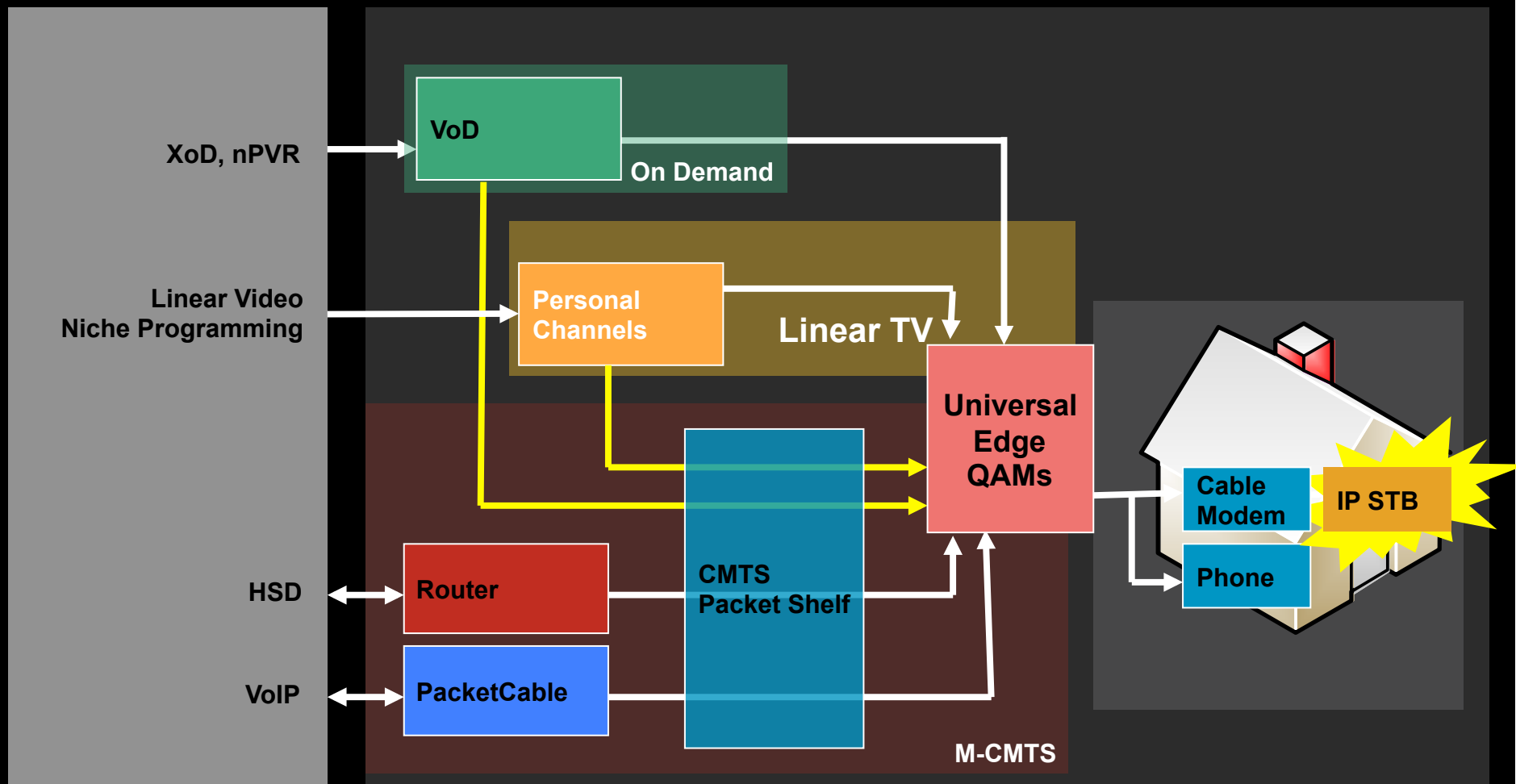
Cable IPTV System Reference Architecture



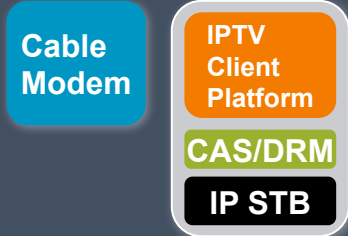
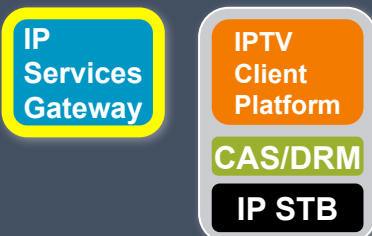
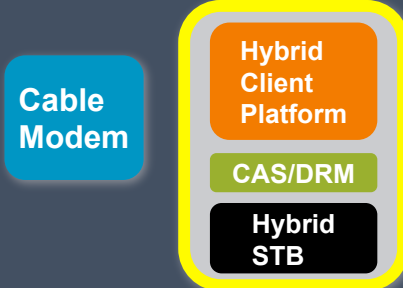
Making the Transition to Cable IPTV



Making the Transition to Cable IPTV



IPTV CPE Options

Pure IP STB	IP Video Gateway + IP STB	Hybrid STB
<p>Maximum STB cost savings</p> <p>One CM is shared among all IP capable devices</p> <p>Easy to upgrade to latest in CM bonding capability</p> <p>Spectrum utilization is not optimal – duplication of broadcast</p>	<p>Nominal STB cost savings</p> <p>One IP service gateway is shared among all IP capable devices</p> <p>Easy to upgrade to latest in CM bonding capability</p> <p>Improved broadcast spectrum utilization</p>	<p>Higher STB cost</p> <p>One CM is shared among all IP capable devices</p> <p>Easy to upgrade to latest in CM bonding capability</p> <p>Improved broadcast spectrum utilization</p>
 <p>The diagram shows a Cable Modem connected to an IPTV Client Platform. The IPTV Client Platform includes CAS/DRM and an IP STB.</p>	 <p>The diagram shows an IP Services Gateway connected to an IPTV Client Platform. The IPTV Client Platform includes CAS/DRM and an IP STB.</p>	 <p>The diagram shows a Cable Modem connected to a Hybrid Client Platform. The Hybrid Client Platform includes CAS/DRM and a Hybrid STB.</p>

Compounding Efficiency Gains From IPTV

Variable Bitrate

VBR improves bandwidth 40-60% percent

- Use VBR for all broadcast content
- The only bandwidth solution for MPEG2 only box
- 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

Advanced encoding improves bandwidth by 50%

- The solution for HD channels
- Even better when combined with VBR and statmux
- IPTV solves the problem of slow channel change with AVC

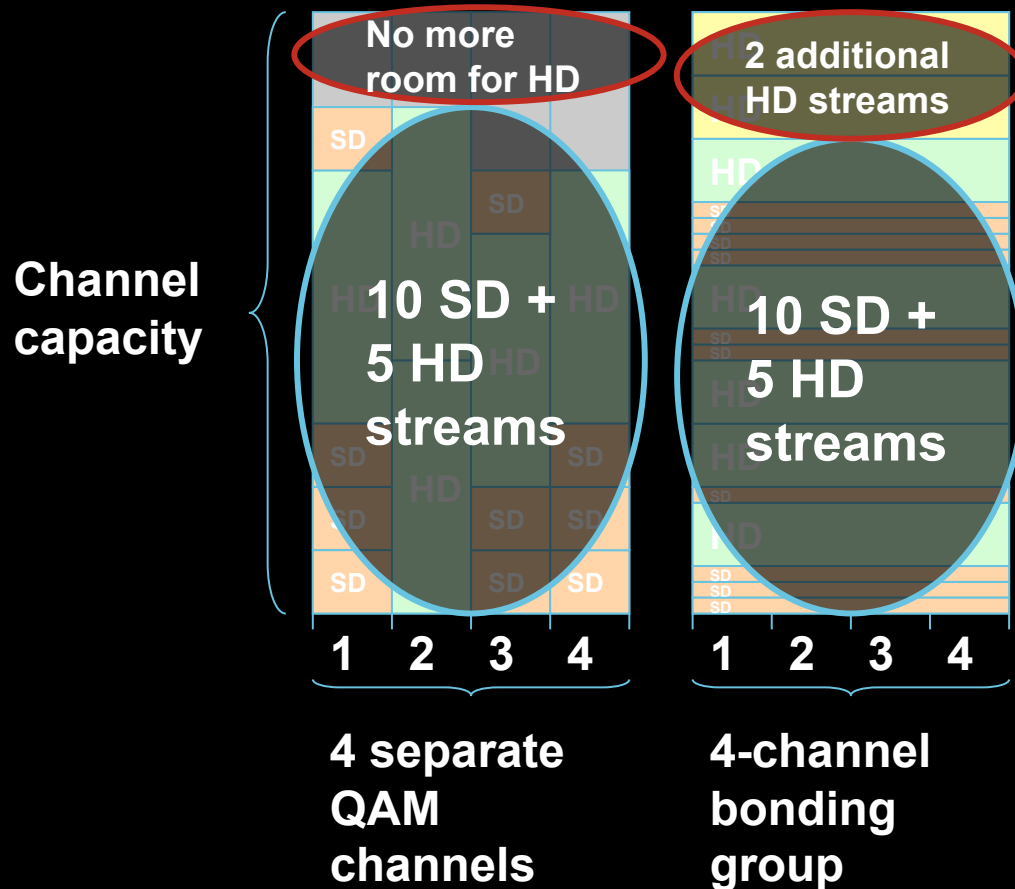
QAM Sharing

Convergence provides further bandwidth savings

- QAM sharing for VoD and SDV
- QAM sharing for video and DOCSIS
- IPTV provides the convergence of data, voice and video

Channel Bonding creates efficiency gains

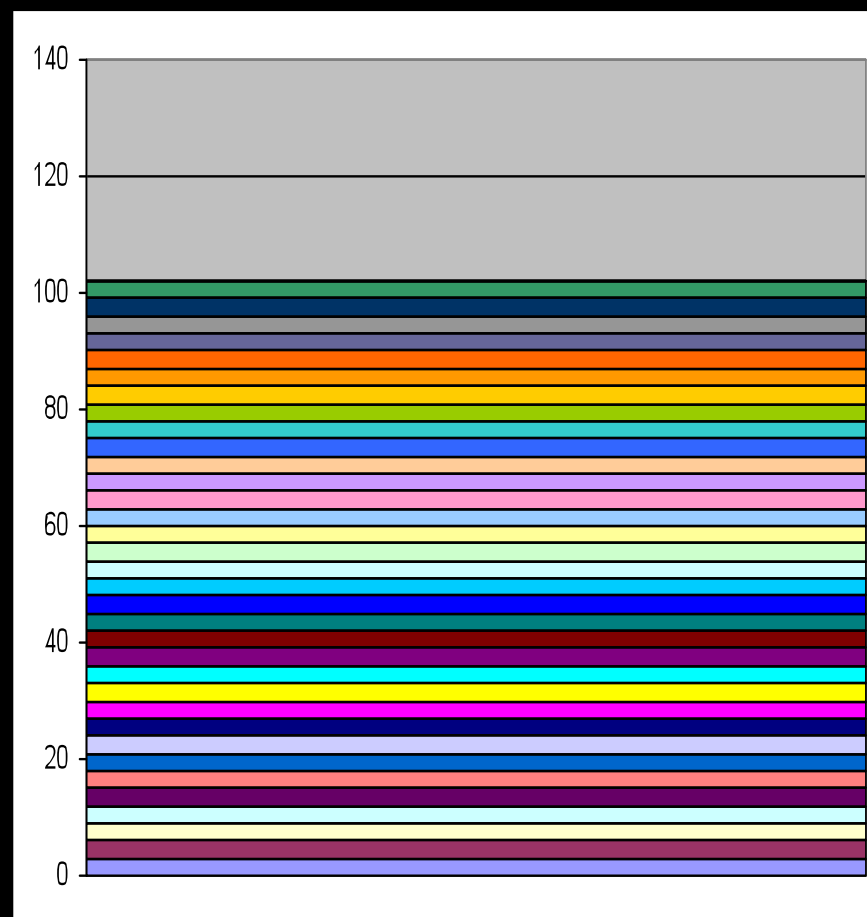
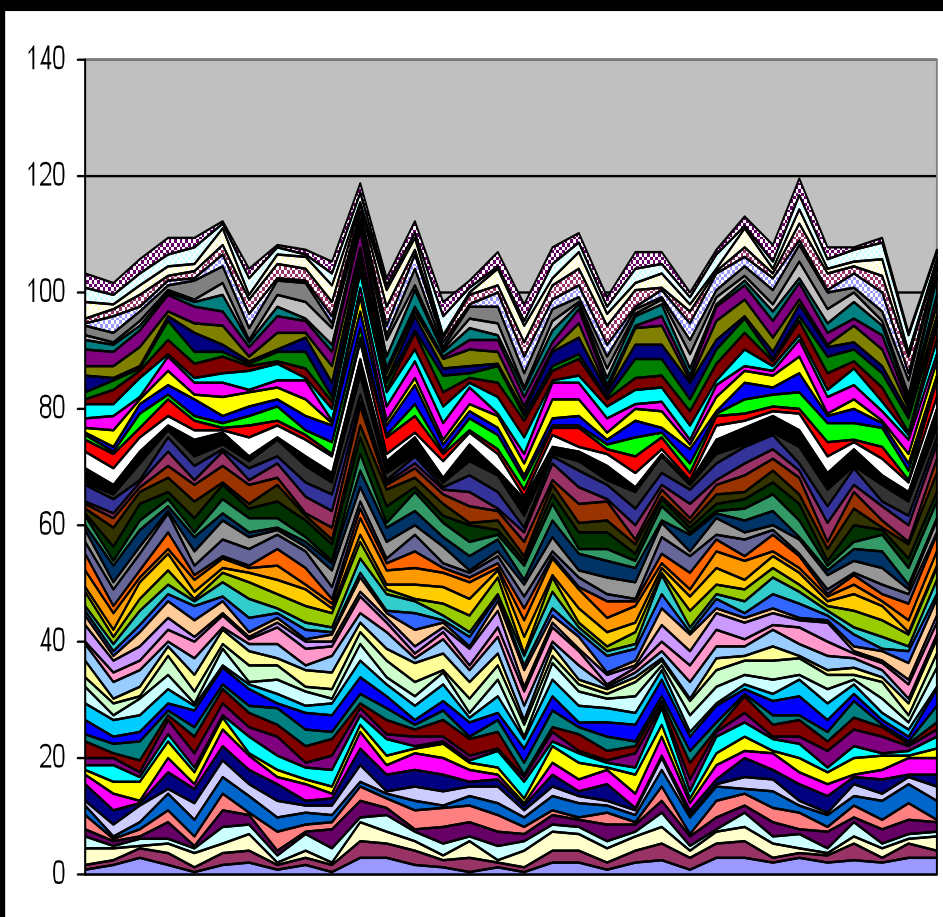
Big Channel “Packing Advantage”



- Unbonded channels create inefficient boundaries
- Bonding drives efficient “Packing”
- Benefit varies
 - MPEG2/4 HD/SD mix
 - Bonding group size

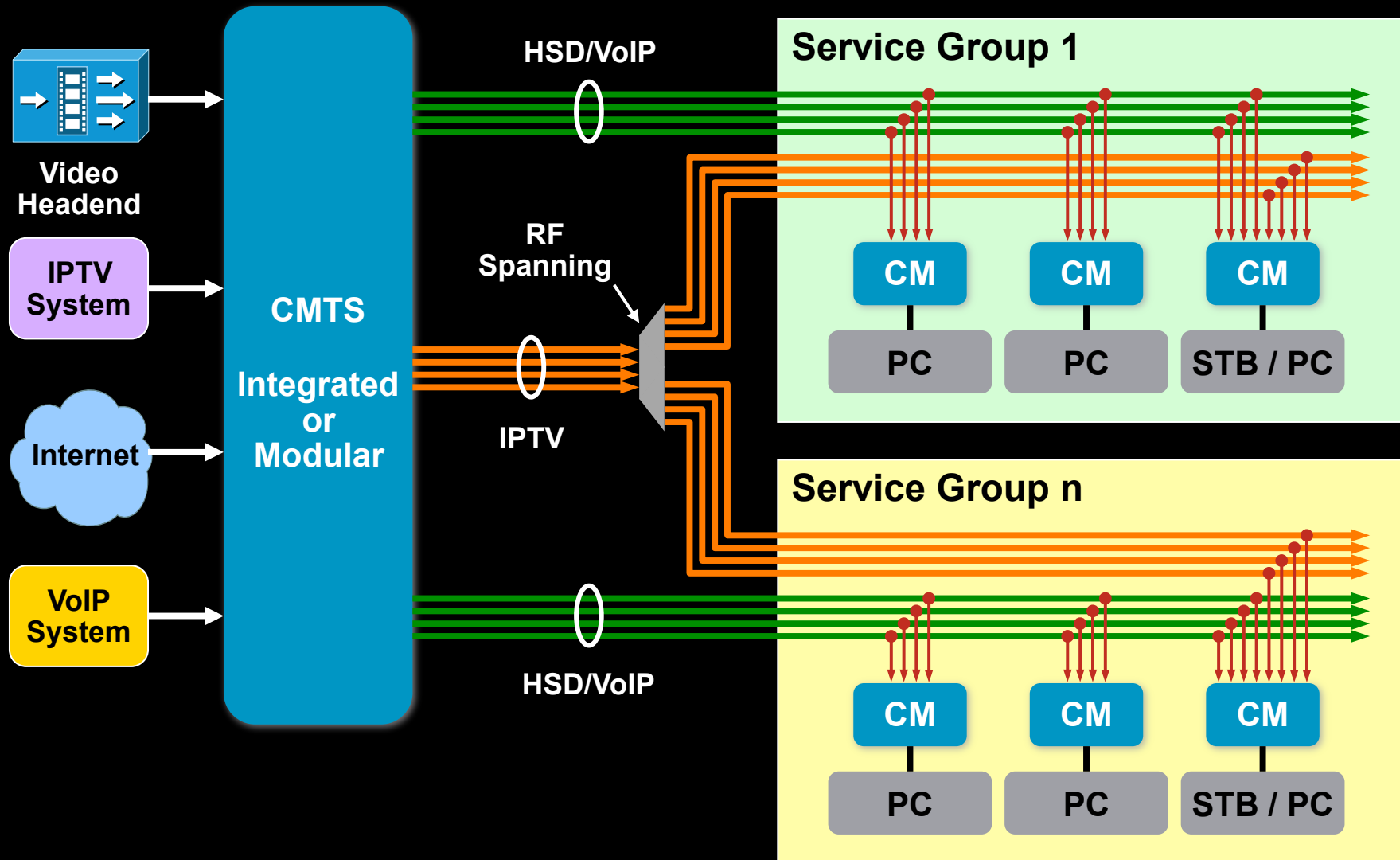
Efficiency Gains from VBR Video – 40-60%

- VBR streams provide equivalent/better quality at lower avg BR
- Law of large numbers favors simple VBR multiplexing in large pipe



Cable IPTV Network

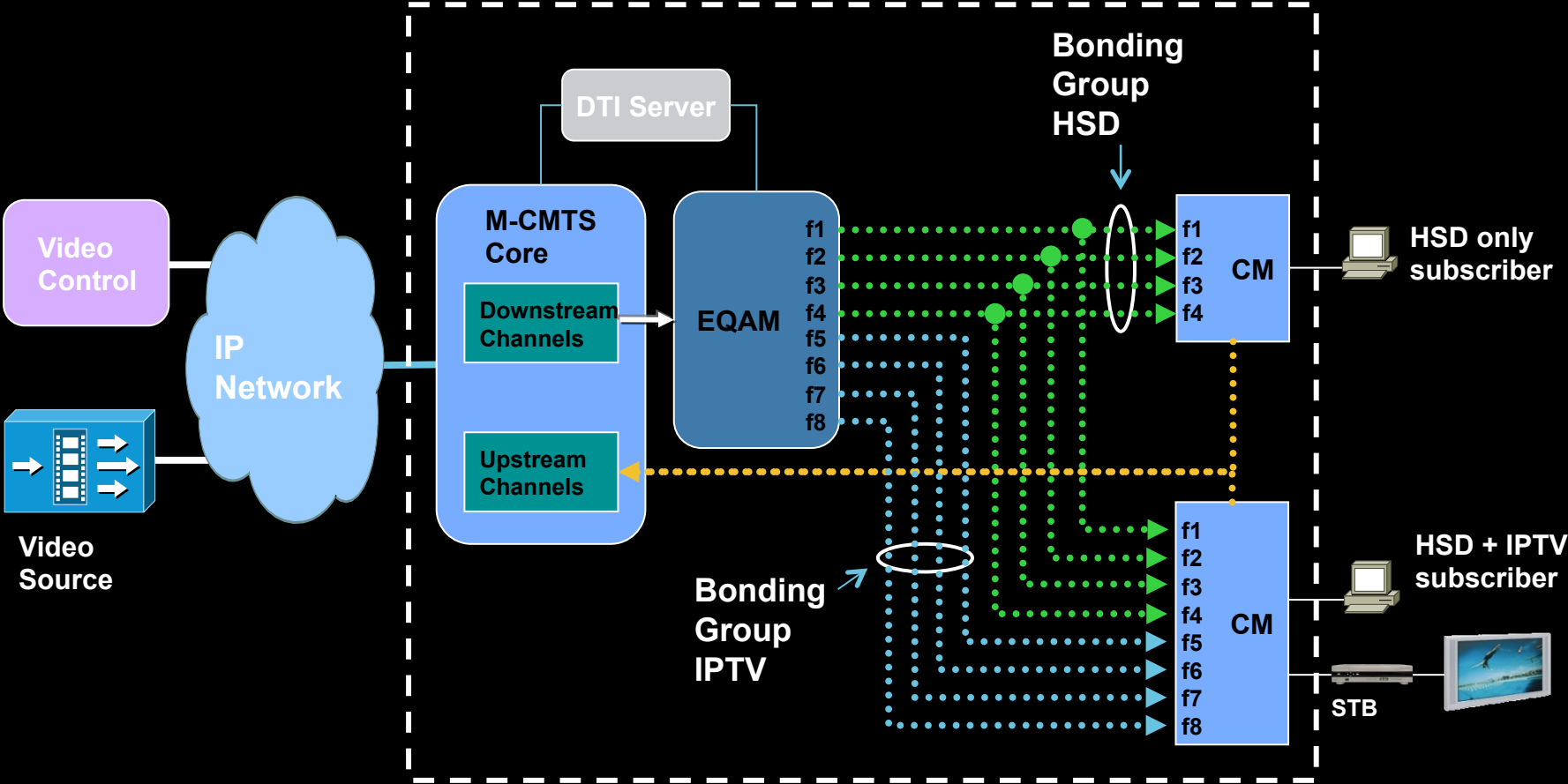
Multiple Bonding Groups for Video/Data/Voice



The background features a dark blue gradient that transitions from black at the top to a medium blue at the bottom. Overlaid on this gradient are several overlapping circles of varying sizes and shades of blue, creating a ripple effect. The circles are semi-transparent and overlap each other, with some appearing more prominent than others.

DOCSIS Access

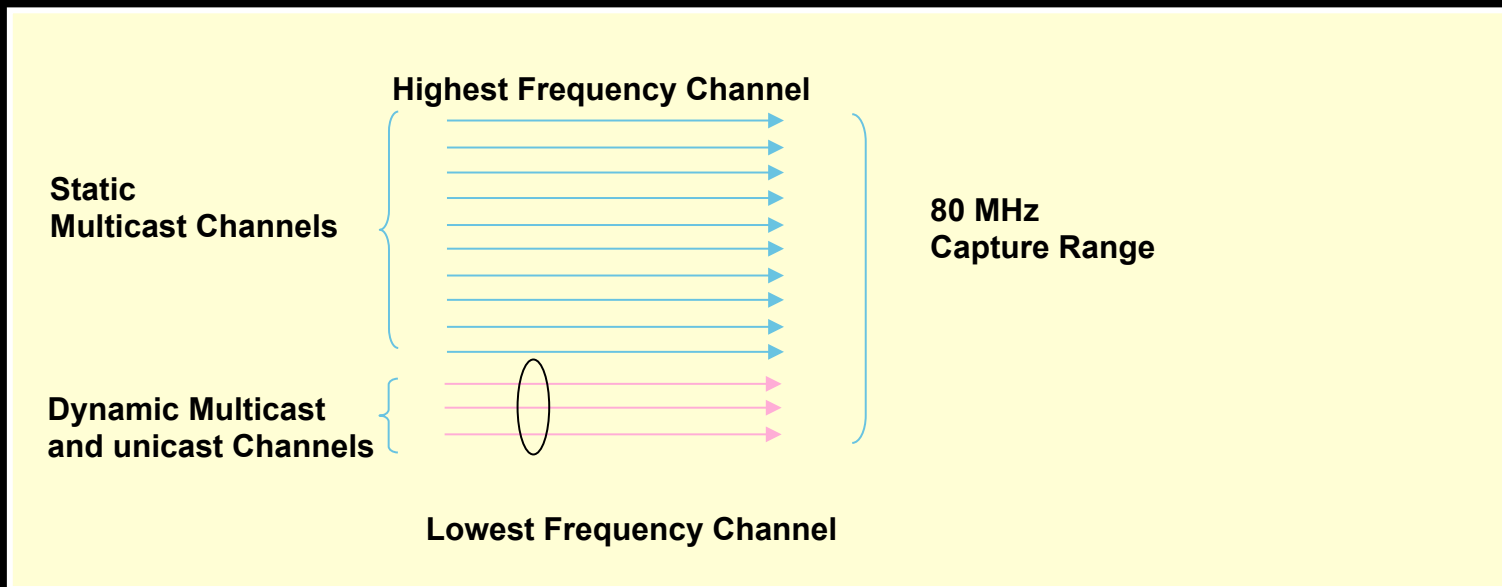
DOCSIS Transport Design



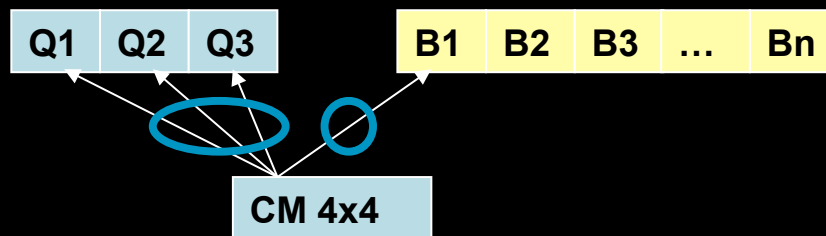
-▶ DOCSIS DS (HSD)
-▶ DOCSIS DS (IPTV)
-◀ DOCSIS US

Spectrum Design with 4x4 CM

- Multicast and unicast service flows must fit modem tuner capture window
 - One tuner block with 80MHz tuning range
- 10 unbonded multicast channels and 3 bonded unicast channels max (Annex B)
 - 87 CBR streams (2Mbps SD and 8Mbps HD with 33% HD percentage)
 - assume 10% DOCSIS overhead
- Dynamic Bonding Change (DBC) is used to tune to different multicast channels



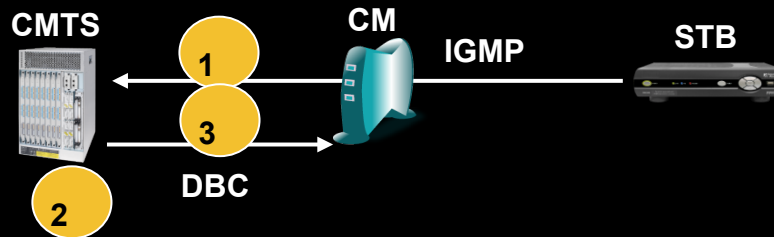
Dynamic Bonding Change (DBC)



Receiving Channel Configuration (RCC) for CM

- Q1/Q2/Q3/B1
- Q1/Q2/Q3/B2

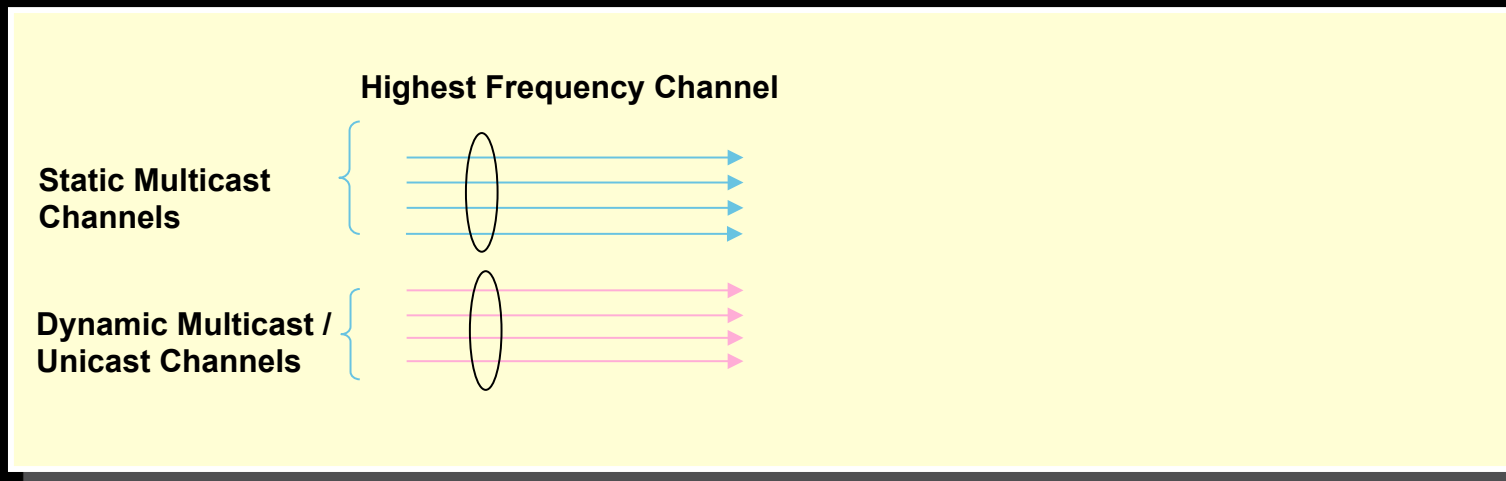
...



- Broadcast channels are delivered by the CMTS to broadcast QAMs B1... Bn via static multicast
- The STB sends IGMP to the CMTS to tune to a broadcast channel
- The CMTS looks up the multicast address and finds out the broadcast QAM that carries the channel
- The CMTS sends the DBC message to CM and gives the RCC for tuning
- The CM tunes to the RCC and the media flows to the STB

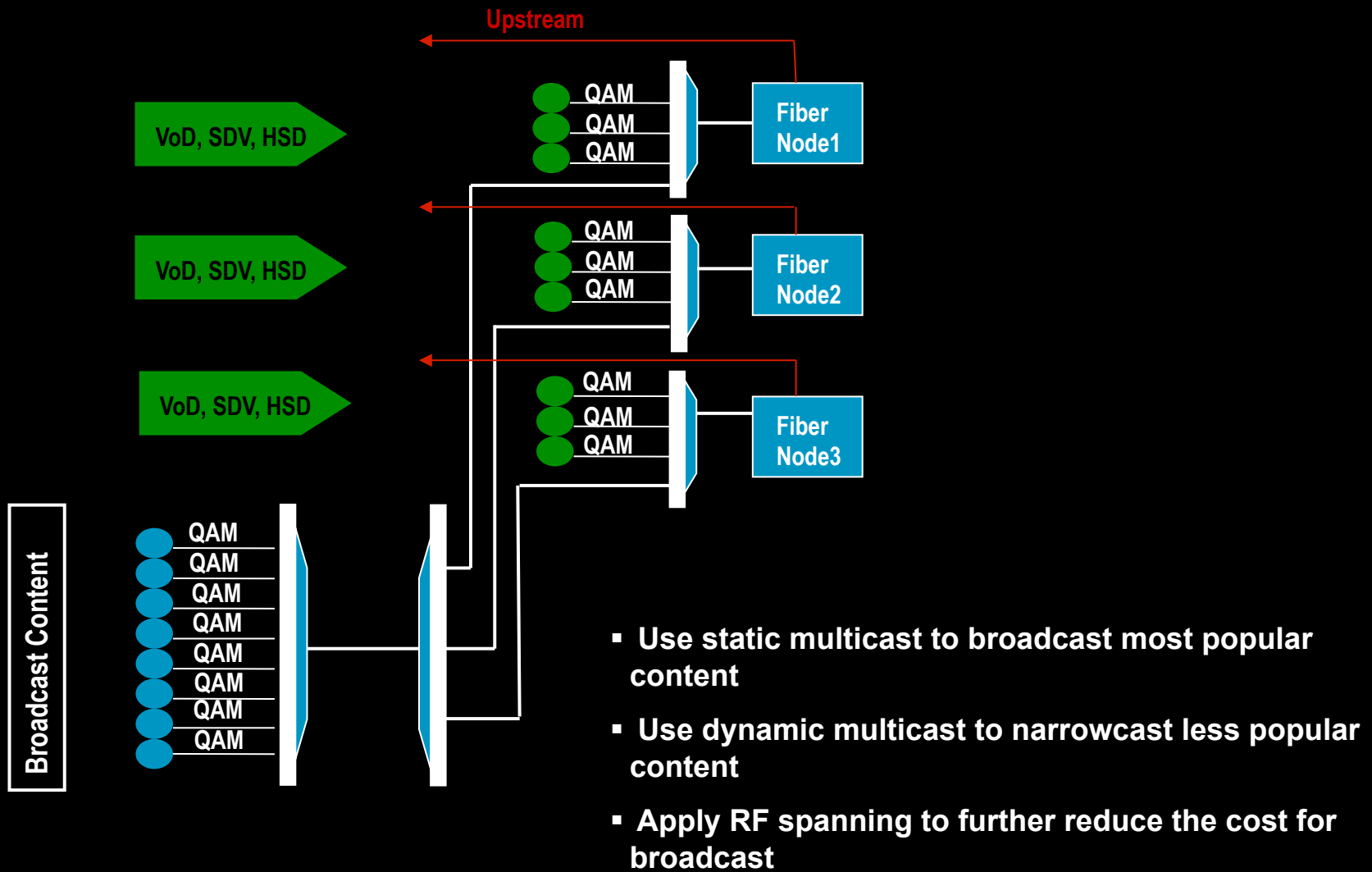
Spectrum Design with 8x4 CM

- 4 channel bonded multicast and 4 channel bonded unicast
 - static multicast and RF spanning
 - two independent tuner blocks, 32MHz each

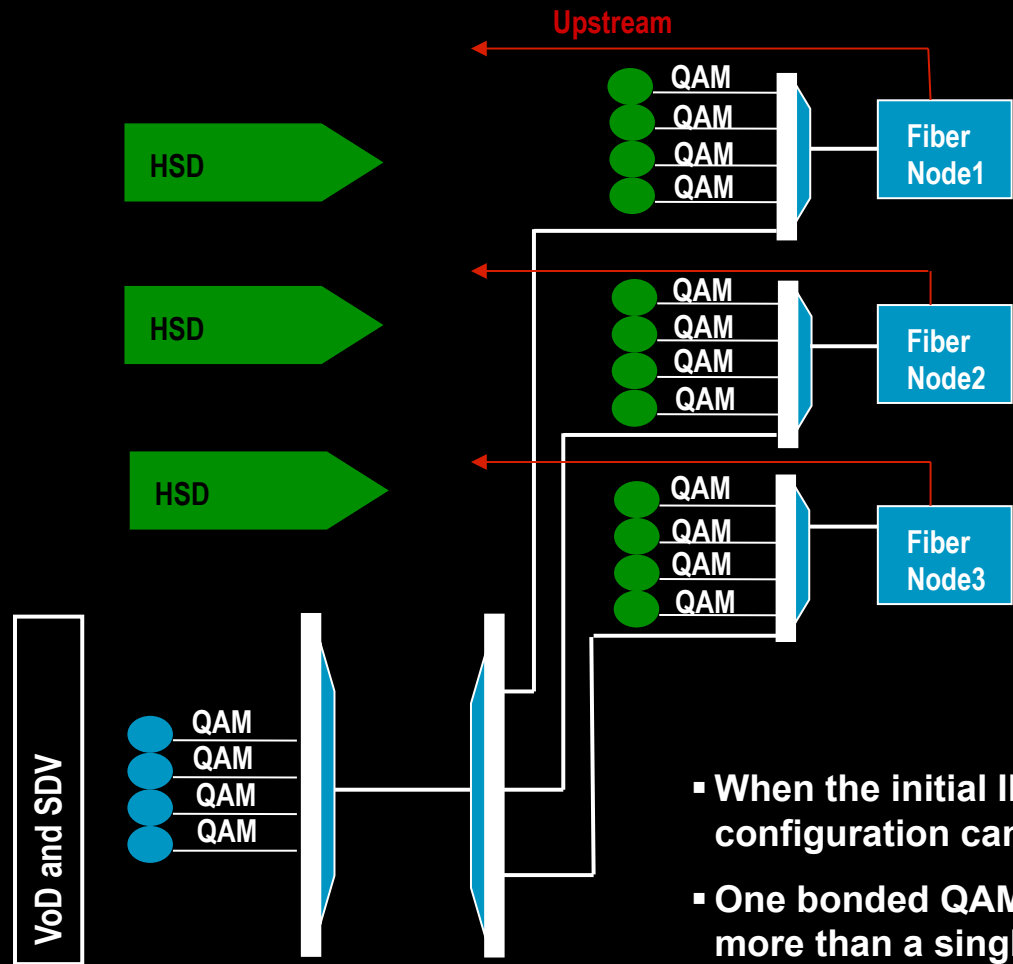


- One 4-channel bonding group for static multicast (Annex B)
 - 35 CBR streams (2Mbps SD, 8Mbps HD at 33% HD percentage)
 - 56 VBR streams with 40% VBR encoding gain and 87% VBR statmux efficiency
- One 4-channel bonding group for dynamic multicast and unicast

RF Spanning

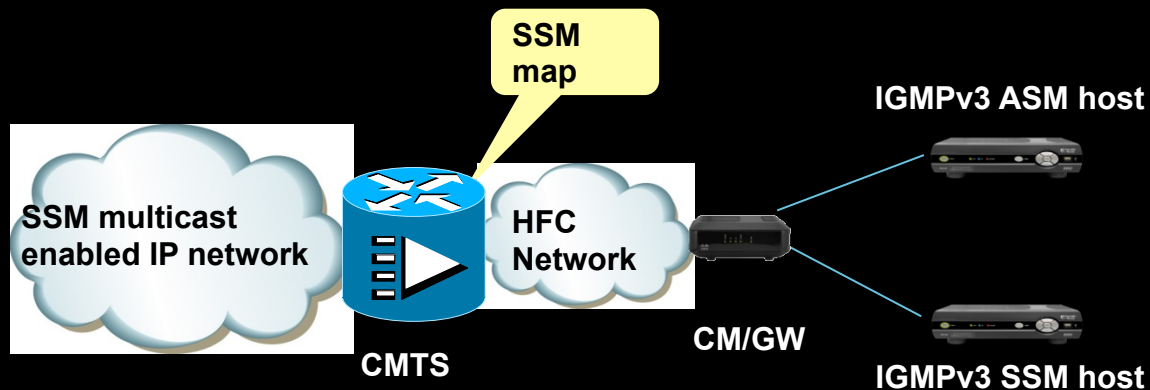


RF Spanning for Very Low IPTV Penetration



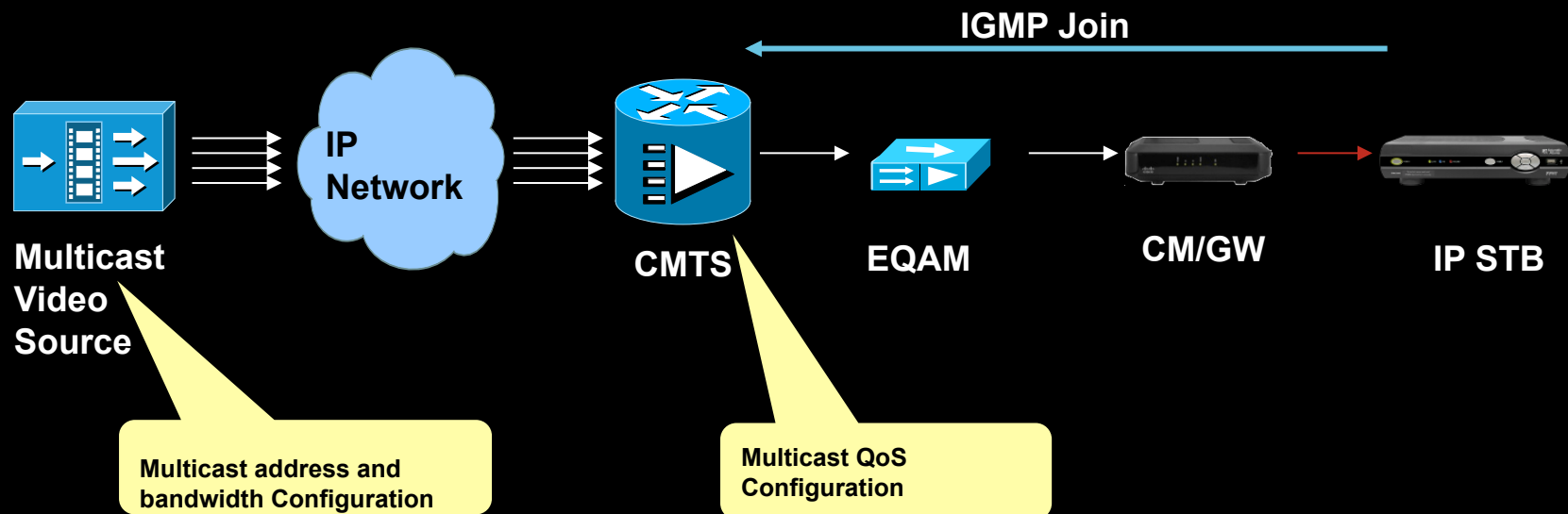
- When the initial IPTV penetration is extremely low, this configuration can further reduce the startup cost
- One bonded QAM channel group can feed CMs from more than a single fiber node
- Fully switched linear content

DOCSIS 3.0 Multicast



- The critical multicast features for IPTV: multicast QoS, multicast fast leave, SSM
- The regional network is SSM network, the CMTS needs to support SSM mapping to support migration from ASM to SSM on the CPE side
- The SSM mapping should support both single sender and multiple senders
- Multicast fast leave is needed to support basic IPTV channel change and rapid channel change
- In DOCSIS 3.0 multicast, the fast leave is achieved by CMTS explicit CPE tracking. IGMPv3 on the CPE side is the requirement for fast leave
- IGMP join latency and latency variation are critical for VQE RCC operation
- DOCSIS 3.0 CM will NOT do IGMP snooping, the forwarding is fully controlled by the CMTS

DOCSIS Multicast Admission Control



- Dynamic multicast with QoS is subjected to admission control
- Static multicast can be used for critical multicast flows
- Admission control is triggered by IGMP
- Bandwidth configuration at the source and CMTS must match
- STB must handle silent IGMP failure gracefully

DOCSIS Quality of Service

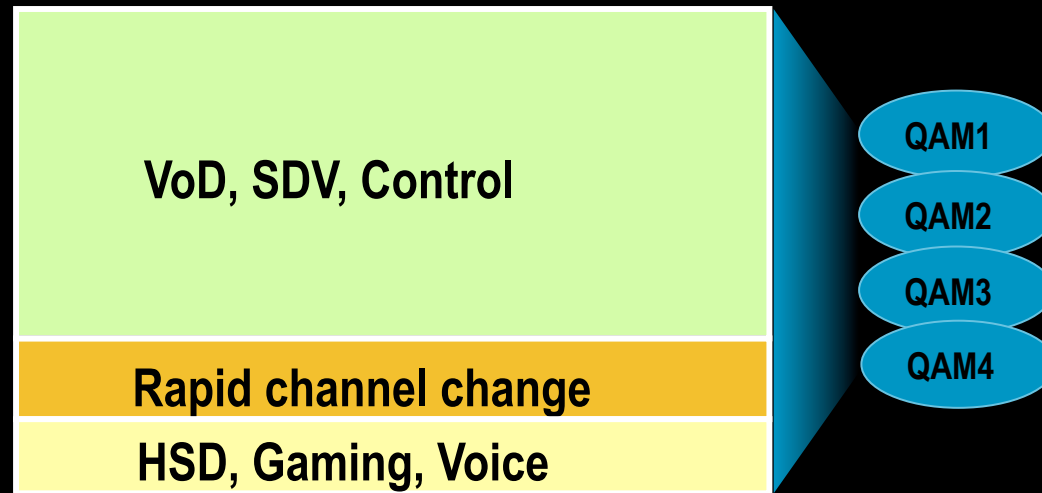
Traffic Type	DSCP Marking
Interactive Voice	EF 0b101110
Broadcast Video and dynamic multicast	AF41 0b100010
Interactive video (VoD)	AF42 0b100110
All control traffic	CS3 0b011000
VQE RCC	CS4 0b100000
Data (Internet Access)	BE 0b000000

Traffic Type	DOCSIS QoS Priority	Bonding Group	CIR
Interactive Voice	Any	HSD BD	CIR with PCMM signaling and low latency
Broadcast Video	Any	Broadcast BD	Separate bonding group
Interactive video (VoD)	Any	Video BD	CIR w. signaling for admission control Or non-CIR best effort
Dynamic Multicast Video	Any	Video BD	CIR with IGMP signaling for admission control
All control traffic	Any	Video BD	8Kbps per CM CIR
VQE RCC	Any	RCC BD	No CIR
Data (Internet Access)	Any	HSD BD	No CIR

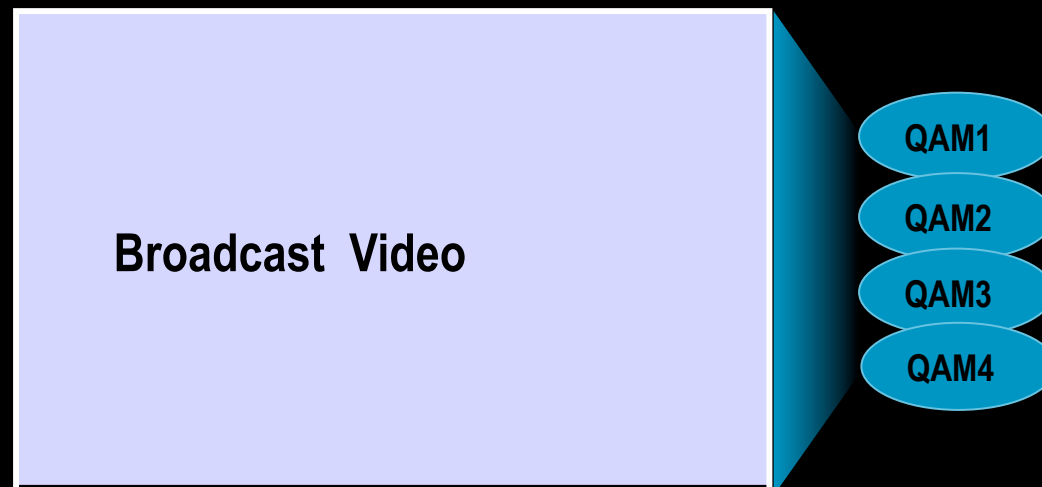
- **DSCP marking for various traffic type**
 - Downstream marking done at first hop routers closest to source
 - Upstream marking is done by the STB (configured on ISDS)
- **CIR admission control: SDV**

QoS with Overlapping Bonding Groups

Three overlapping bonding groups

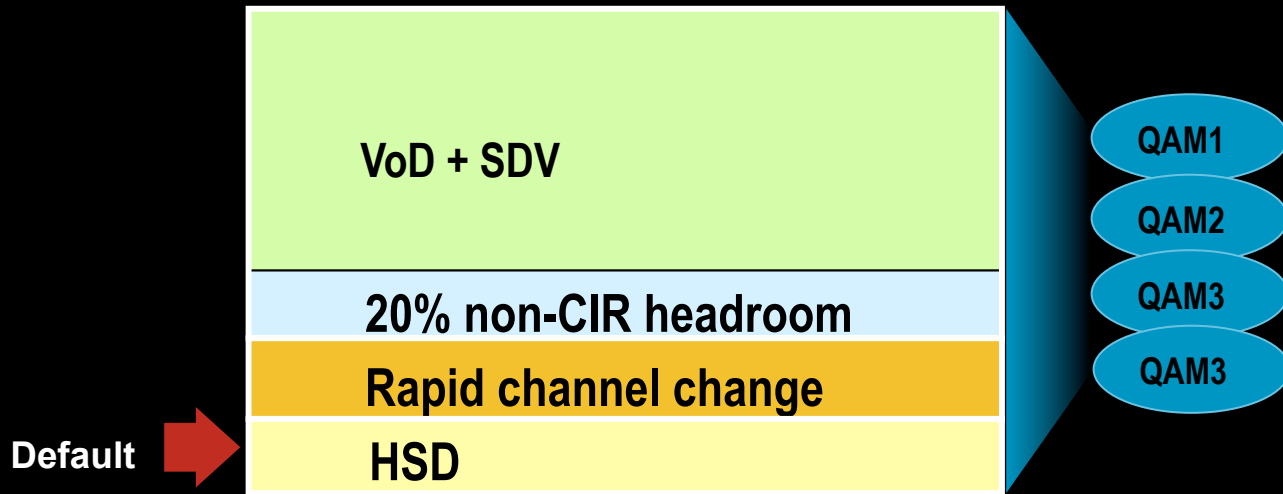


Non-overlapping broadcast bonding group

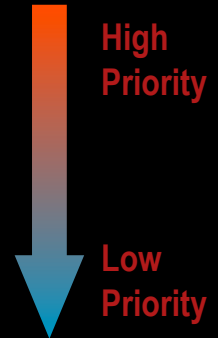


Dynamic Bandwidth Sharing

Dynamic bandwidth sharing among overlapping bonding groups



Bonding Group	Fixed BW (%)	Remaining ratio	Effective Guaranteed BW (%)
SDV & VoD & multicast control traffic	85	1	68% if VoD flows are CIR 85% if VoD flows are non-CIR
Rapid channel change	5	100	22% if VoD flows are CIR 5% if VoD flows are non-CIR
HSD	10	1	10%

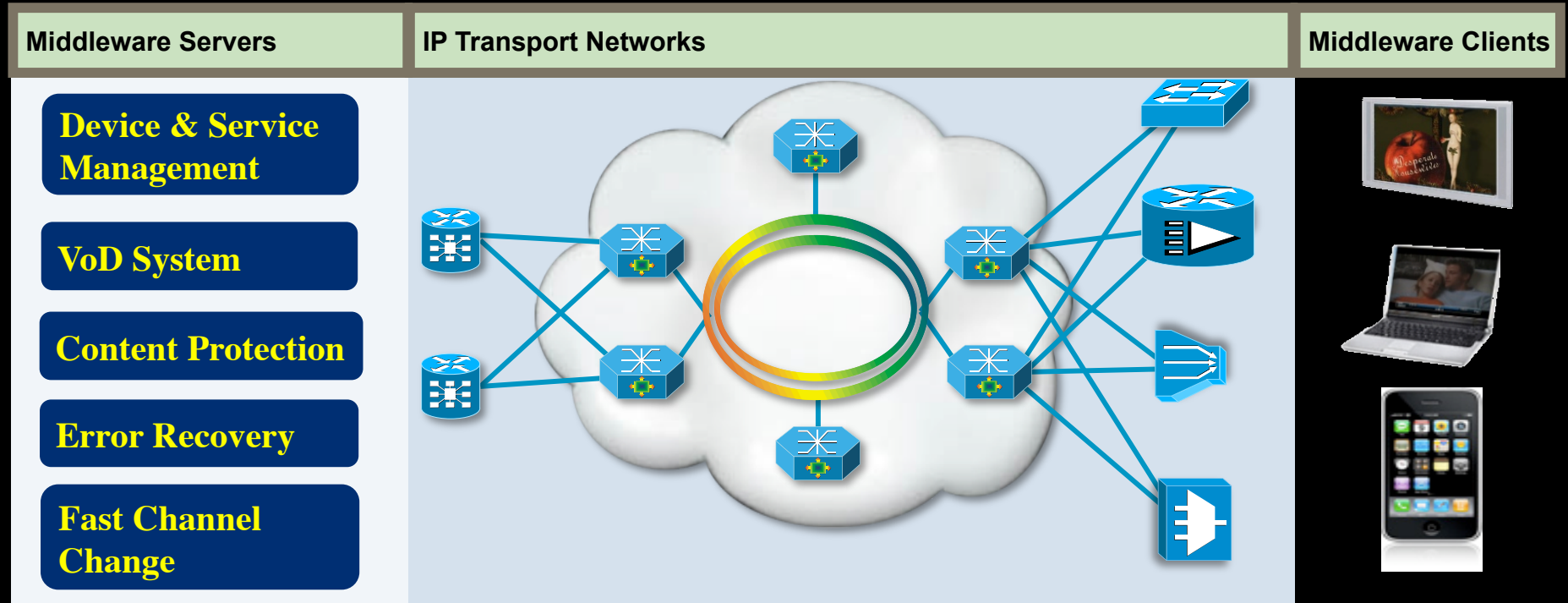


- Attributed based forwarding is used to direct traffic to different bonding group
- Bonding group is associated with attributes
- Service flow is configured with attributes
- CMTS matches the SF attributes with bonding group attributes when directing SF

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IPTV feature requirements

IPTV Middleware Systems



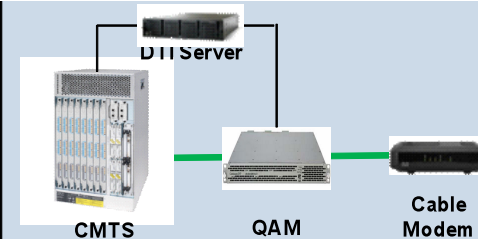
- **Middleware system enables the IPTV service**
 - linear video is delivered via multicast
 - on-demand video is delivered via unicast
- **Middleware is access independent**
- **Middleware can be optimized for cable access**

Middleware and Adaptation

Cable Access Characteristics

- Shared last mile*
- Wideband access*
- Low bit error rate*

Cable DOCSIS Access



Adaptation

Admission Control:

- Network based instead of subscriber based
- Middleware admission control signaling

Error Recovery:

- Avoid application level FEC, use error retransmission

Any Middleware

Fast Channel Change:

- Use high burst rate to optimize performance
- Network congestion and QoS

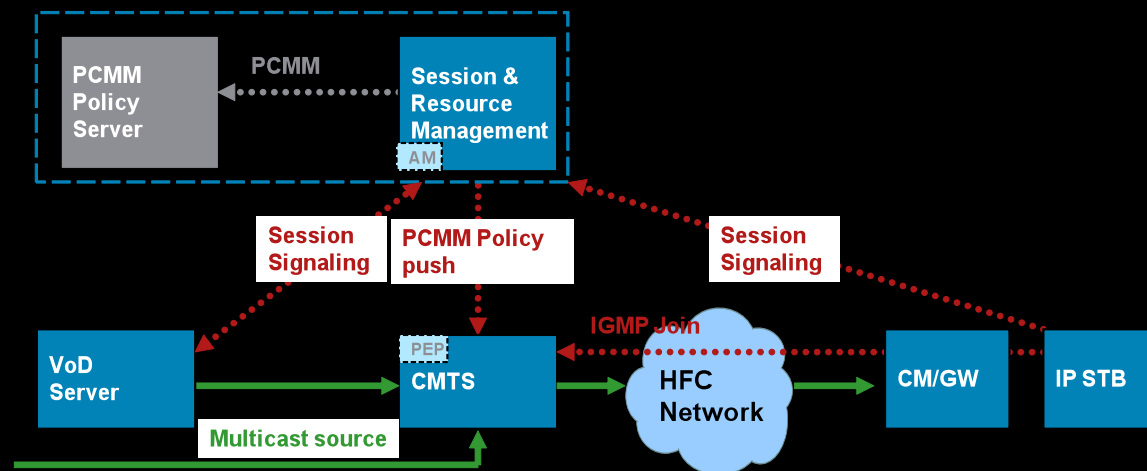
Multicast Control Flow:

- IGMPv3 and SSM
- Static vs. dynamic and broadcast vs. narrowcast

Optimization

Ensuring Video Quality w. Admission Control

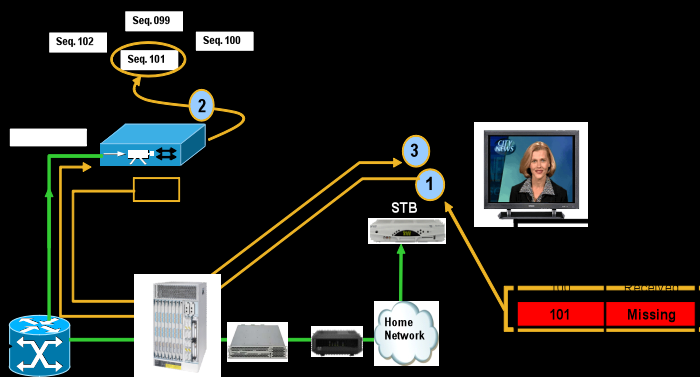
- What happens when demand exceeds design assumptions in shared access such as cable?
- Oversubscription leads to packet loss for many
- For shared cable access, admission control should be done at the access node instead of subscriber home
- DOCSIS access support admission control based on PCMM. For multicast, IGMP could also be leveraged for admission control
- Middleware must provide the signaling trigger for DOCSIS admission control



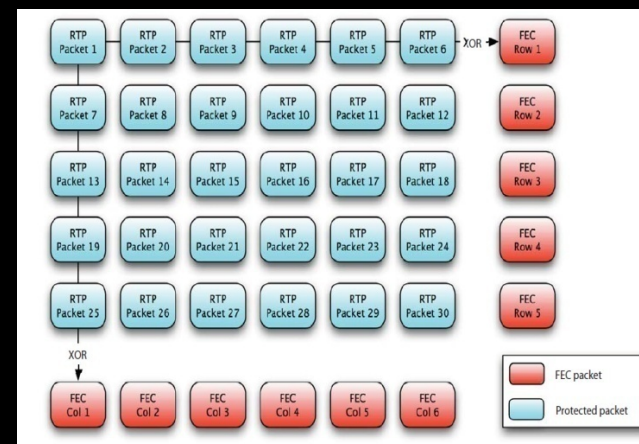
Error Concealment and Recovery

- Middleware error concealment and recover is divided into two categories
 - Error retransmission:** retransmitting lost packet to client
 - Application level forward error correction (FEC):** sending duplicate error repair packet
- DOCSIS access has FEC at QAM level using RS coding. This contributes to low BER, e.g. in the order of $1E-8$
- The low BER characteristics of DOCSIS does not justify the use of FEC at application level because of the higher bandwidth overhead
- Error retransmission covers packet loss in home network as well

Error Retransmission

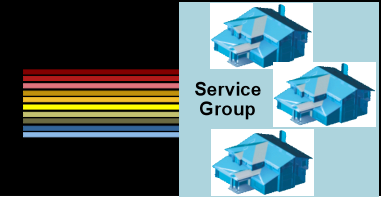
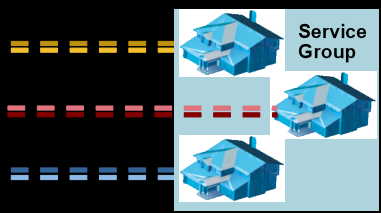
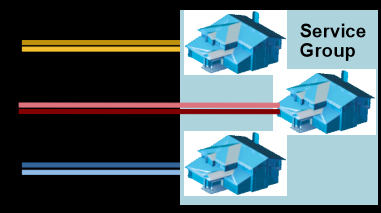


Application Level FEC

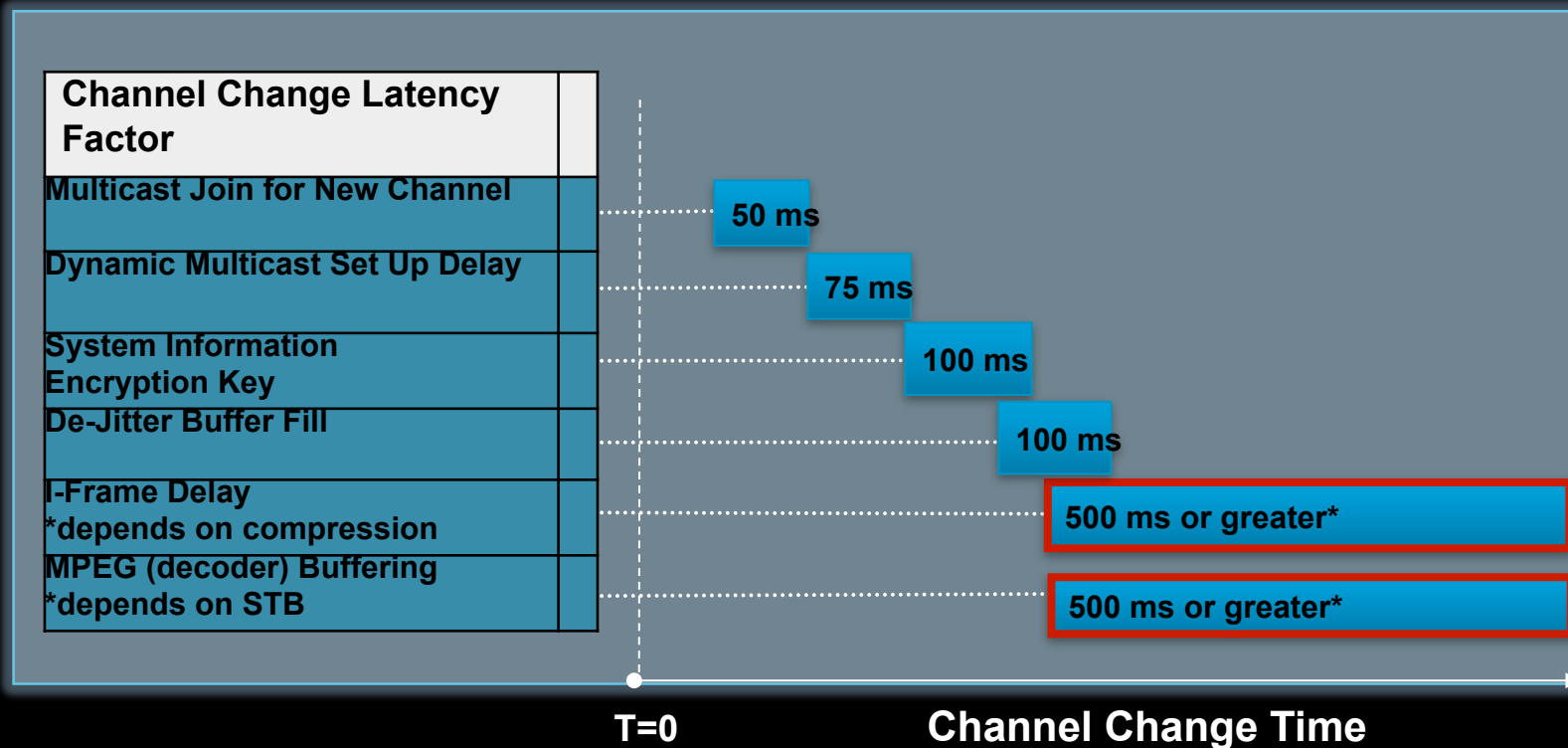


Middleware and Multicast

- SSM is the multicast choice of SP networks. If a middleware does not support SSM, the ASM to SSM conversion can be applied at the network edge (CMTS)
- Middleware needs to support IGMPv3 for IPTV channel change operation
- Middleware may apply multicast to control signaling. The multicast usage should be optimized in cable access with the following options

Delivery Methods	DOCSIS delivery	Multicast Method	Subject to Admission	Recommended Usage
	Broadcast	Static multicast	No	System wide scoping Low bandwidth control flow
	Narrowcast	Dynamic multicast	Yes	Per service group scoping Graceful handling of admission failure required
	Narrowcast	Static multicast	No	Per service group scoping Critical control flow Low bandwidth flow

Channel Change Delay Contributing Factors



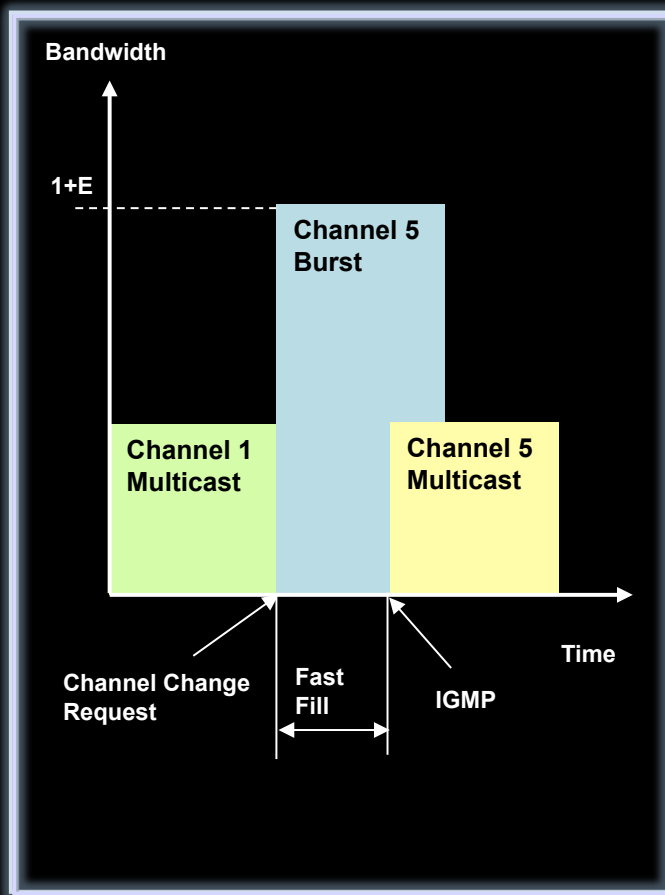
Main culprits

- I-frame delay and decoder buffer fill

Typical fast channel change technique

- Unicast bursting the I-frame at speed faster than nominal play speed
- Seamless switch back to multicast stream after channel change event

Fast Channel Change in Cable Access



- DOCSIS access has higher bandwidth in the access
- Bursting at a higher rate delivers better channel change performance in cable access than in DSL access

Example:

Bursting SD channel at 3 times the nominal rate

Bursting HD channel at 2 times the nominal rate

- In shared access as DOCSIS, fast channel change burst should be given high priority than BE data service via QoS design
- Middleware must gracefully handle network congestion and resort to un-accelerated channel change if congestion happens during the unicast burst

The background features a dark blue-to-black gradient. Overlaid on this are several concentric circles in various shades of blue, some overlapping each other, creating a ripple effect.

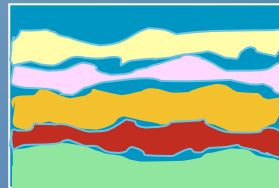
Summary

IPTV Service in Cable Networks

New Devices
New Content
New Access



Bandwidth
Efficiency



Enhanced User
Experience



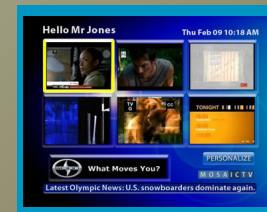
Capital Cost
Savings



Operational Cost
Savings



New Application
Service Velocity



Key IPTV Takeaways

- IPTV Technology/Innovation ecosystem is happening no matter what the cable industry does
 - Ignore vs. fight vs. adopt
- DOCSIS 3.0 rollout opens the window to port this ecosystem to cable industry
 - Multicast, Channel Bonding, M-CMTS
- Cable IPTV allows cable operators to access “innovation pool” developing in IPTV ecosystem
- Cable IPTV completes end-to-end IP connection from headend to home, enabling delivery to any IP-connected device



CISCO

Thank You