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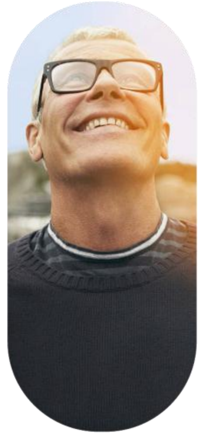
What You Make Possible

BRKSPG-2016

Architectures for new services over Cable

John Knox



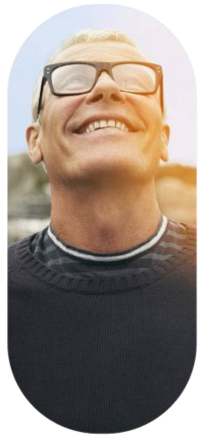
Abstract

- *The session describes the key aspects of CCAP (Converged Cable Access Platform) and will describe how Cable operators will migrate multiple silos of technology to a converged architecture whilst maintaining backward compatibility with current DOCSIS and Video deployments.*
- *The session will also describe the emerging standard for “Advance MAC /PHY” (AMP) in DOCSIS 3.1 and how this plays a pivotal technical development role in the future of an MSO’s architecture. A focus on some of the service-driven architectures enabled by DOCSIS will also be covered in this session.*

Agenda

- Overview of the key aspects of CCAP
- Cable MSO's Migration to CCAP – what will it bring me?
- DOCSIS 3.1 Introduction
- DOCSIS 3.0 vs IEEE EPOC
- Conclusions

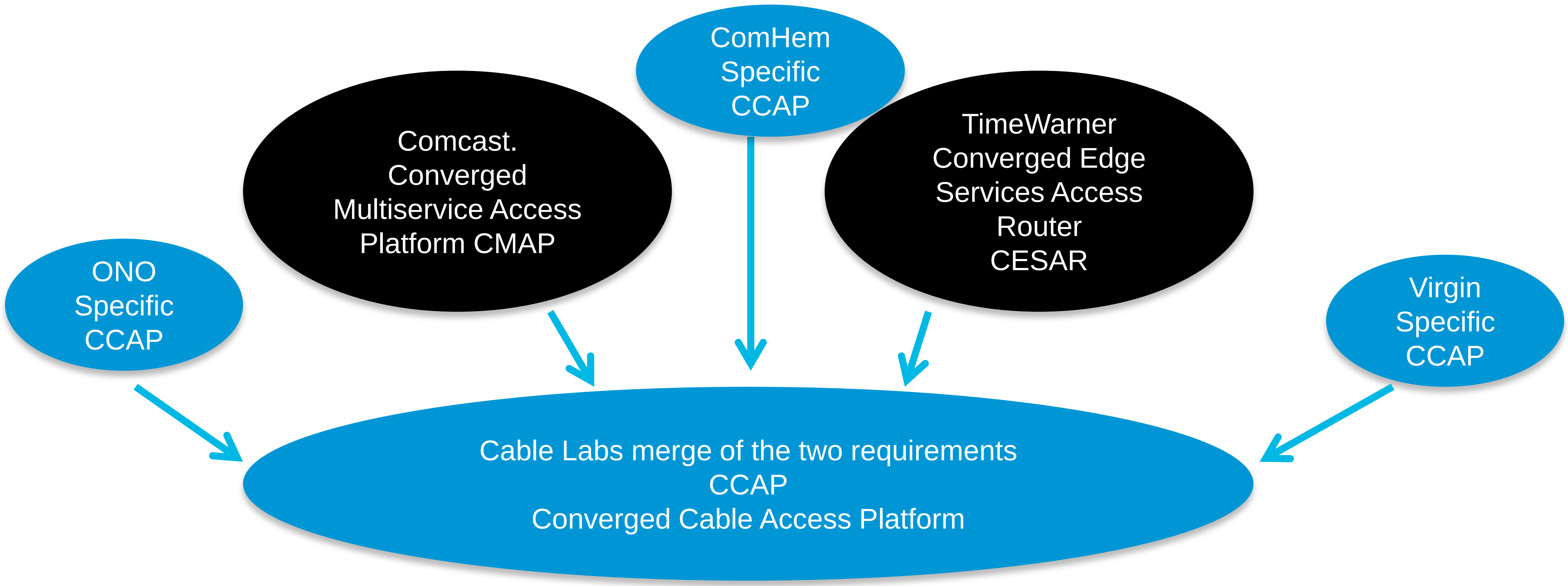
CCAP
Converged Cable Access Platform



Converged Cable Access Platform

- Scope
  - Reference :- CM-TR-CCAP-V03-120511.pdf (new document posted on docZone CL)
  - http://www.cablelabs.com/specifications/CM-TR-CCAP-V03-120511.pdf

CCAP “a specification or a recommendation”



CCAP Fundamentals

- The Converged Cable Access Platform (CCAP) is intended to provide a new equipment architecture option for manufacturers to achieve the **Edge QAM and CMTS** densities that MSOs require in order to address **the costs and environmental challenges** resulting from the success of narrowcast services.
- CCAP leverages existing technologies, DOCSIS3.0, MHA and can also include new technologies such as EoC /EPO
  – NOTE: MHA: Modular Headend Architecture also detailed and leveraged CMTS and EdgeQAM to provide “converged “Video and Data” services , however CCAP takes this a step further by allowing the “sharing of broadcast channels”
- The sharing of “narrowcast channels” in both MHA and CCAP is implied

Key Points CCAP- Goals

- Flexible use of QAMs, for services supported by MSO . eg modification to the No of QAMs using MPEG TS (VoD, SDV) Vs DOCSIS based services through a single point of configuration.
- Configuration of QAM channels to dedicated Service Groups
  – eg) a specific HSD/Voice service group, VOD Service Group and SDV service group
- QAM Replication. Implementation of separate sets of QAM channels for NC and BC so the NC (inc DOCSIS) can be configured on a unique basis and Broadcast Channels shared across ports in the Downstream line card DLC
- The simplification of the RF combining to enable all digital services from a single port
- An option to add content scrambling for both standards based and proprietary without any additional HW- as to aid “interoperability” between platform vendors and to minimise platform complexity.

Key Points CCAP- Goals-continued

- The CCAP architecture needs to be agnostic in as much to support new and emerging EPON technologies natively as well as scaling to higher capacity uplink interfaces in the future with pluggable or replaceable components.
- Modularisation of the software environment, allowing upgrades to be applied to specific services without impacting other services. This partitioning also helps to ensure that software issues in the implementation of a given service do not necessarily impact other partitioned services.
- Environmental efficiencies (eg reduced power consumption, reduced space ,heat dissipation)

CCAP V03 Major Changes

- **OLD VERSION**

CCAP can be implemented in a I-CCAP or M-CCAP- If M-CCAP the TR specifies it must be managed as a single entity.

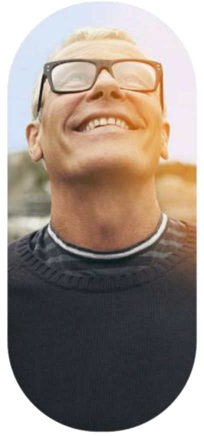
  – Modular CCAP is defined as two types of devices

    PS (Packet Shelf)- Supporting L3, Subscriber management, and packet processing functions

    AS Access Shelf)-Supporting the US and DS PHY functions and DOCSIS MAC

- **CCAP V03**
- M-CMTS and DTI are allowed
- The CCAP chassis may be deployed in a large chassis, designed to support a minimum of 40 downstream RF ports. The CCAP could also be implemented in a smaller chassis, supporting at least 16 downstream RF ports.

CCAP – Benefits Service Multiplexing Flexibilities



SG Combining Using RF Spanning

Converged QAM Network

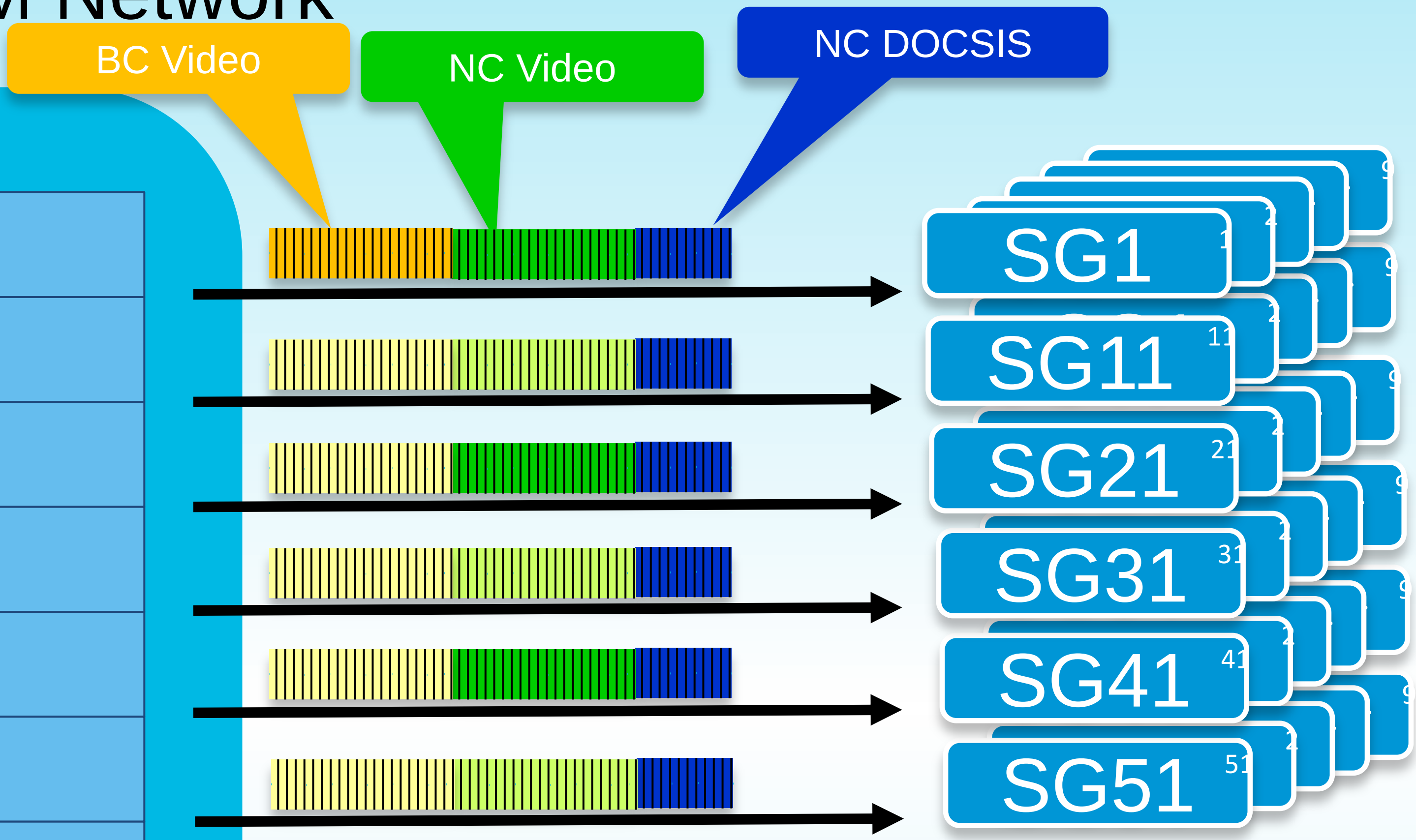
RFGW-10
Universal EQAM

RFGW-10

DS384/1-1	48BC, 48NC Video, 24 DOCSIS,
DS384/1-2	48BC, 48NC Video, 24 DOCSIS
DS384/1-3	48BC, 48NC Video, 24 DOCSIS
DS384/1-4	48BC, 48NC Video, 24 DOCSIS
DS384/1-5	48BC, 48NC Video, 24 DOCSIS
DS384/1-6	48BC, 48NC Video, 24 DOCSIS
DS384/1-7	Not Available
DS384/1-8	Not Available

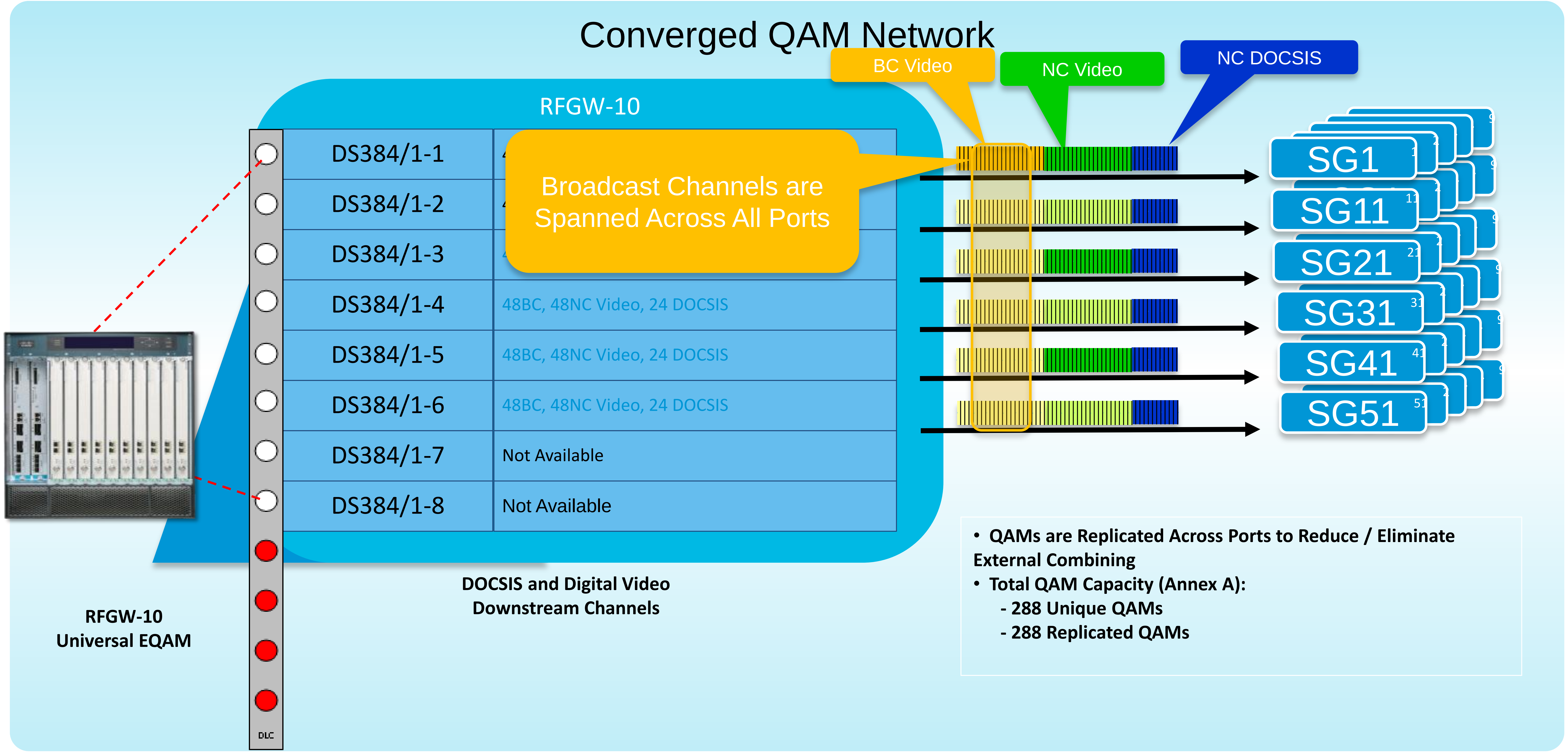
DLC

DOCSIS and Digital Video Downstream Channels



- **QAMs are Replicated Across Ports to Reduce / Eliminate External Combining**
- **Total QAM Capacity (Annex A):**
  - **- 288 Unique QAMs**
  - **- 288 Replicated QAMs**

SG Combining Using RF Spanning



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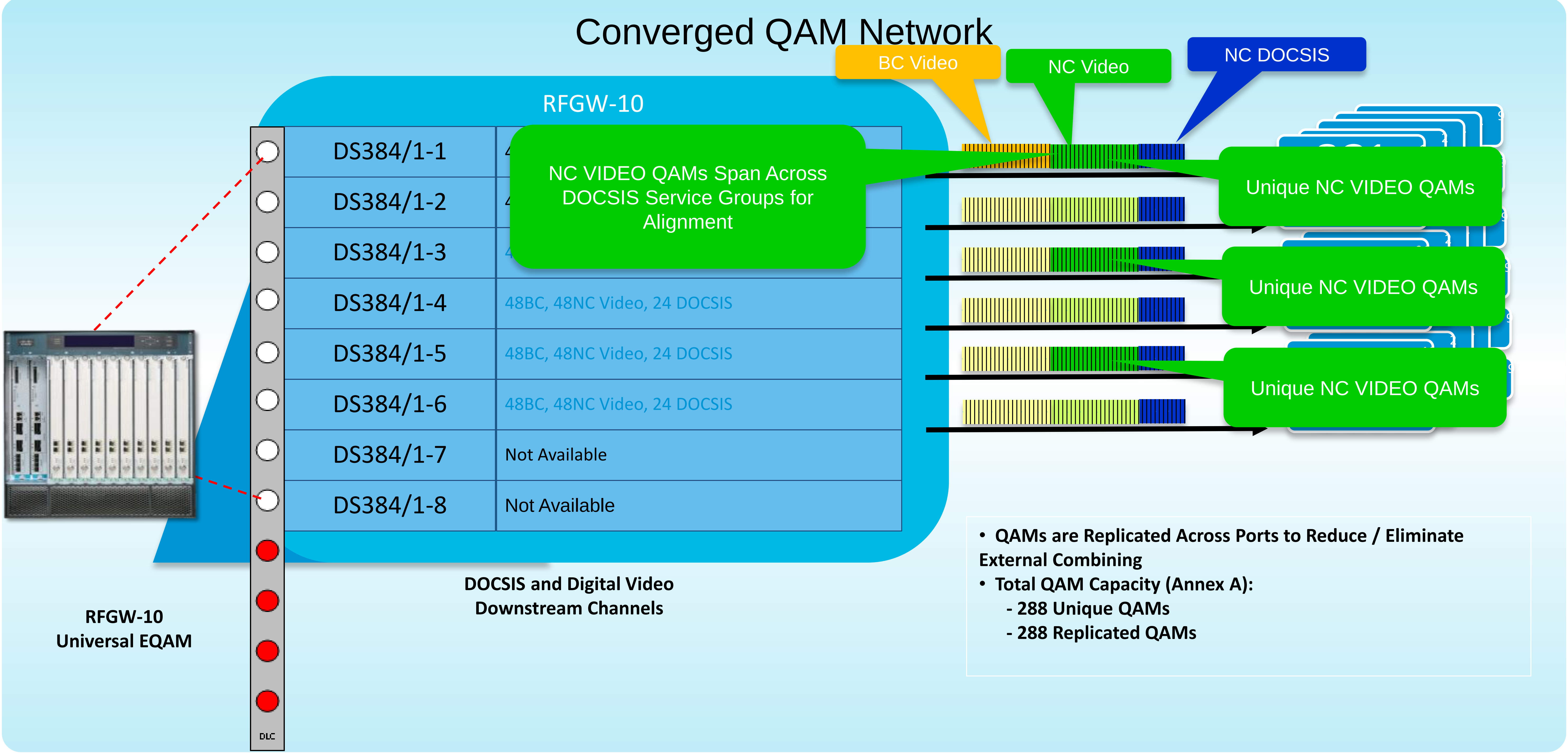

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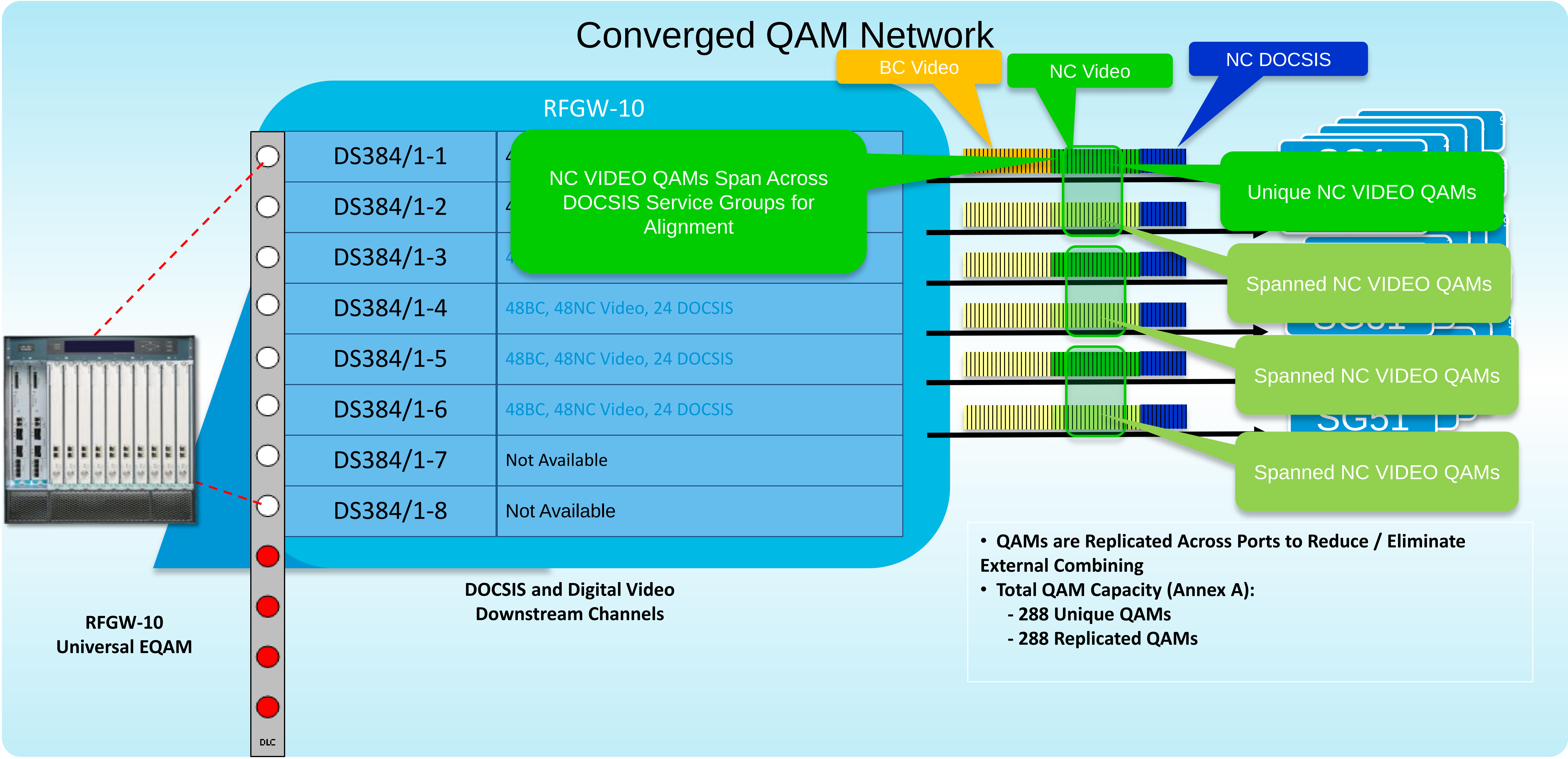
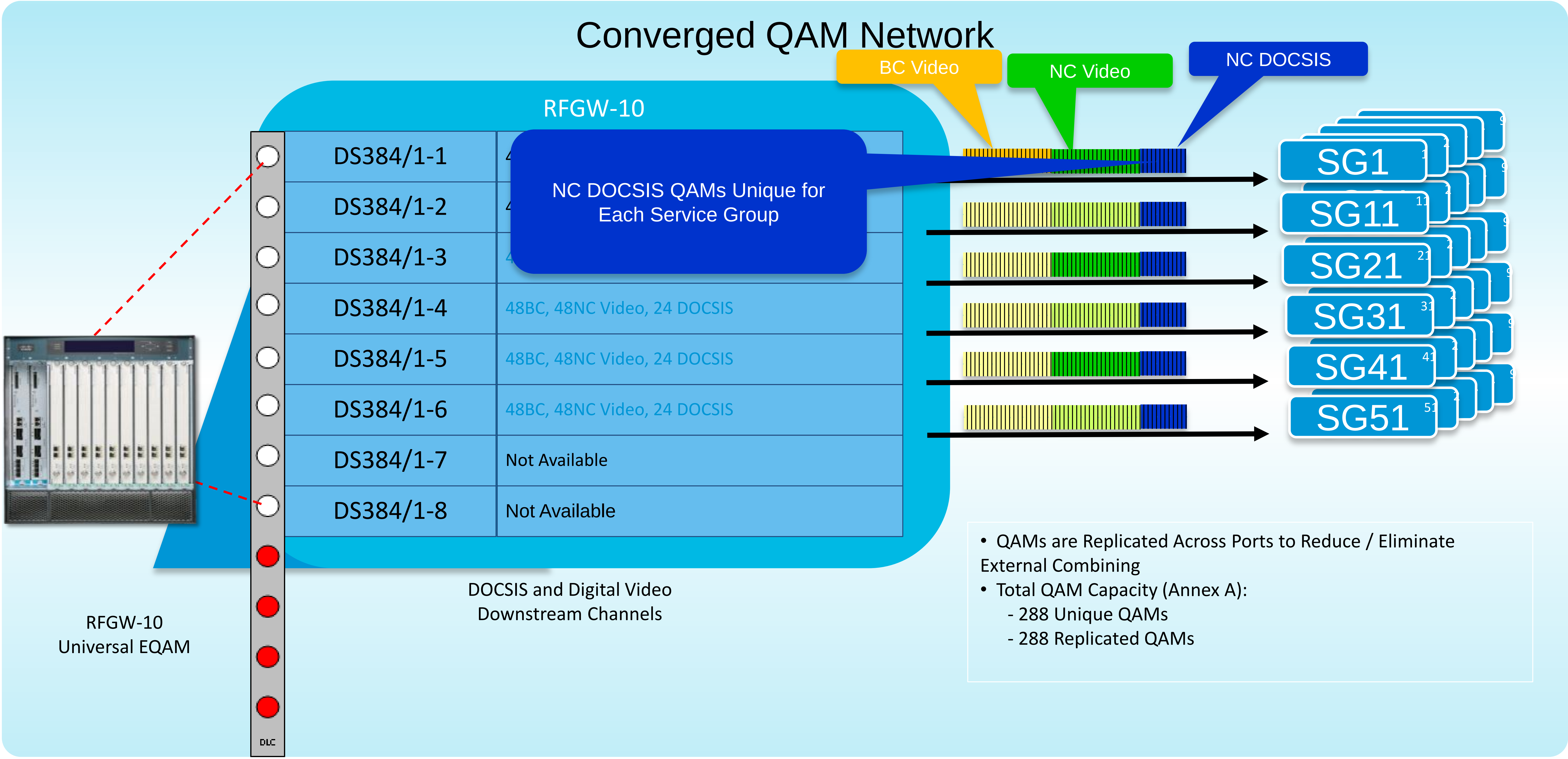


SG Combining Using RF Spanning



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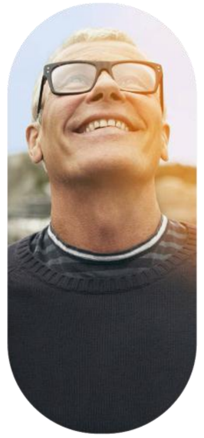
Bandwidth Capacity and Density Gains



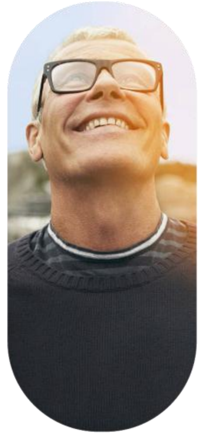
CCAP recommends

- 40-60 DS/RF ports on a large chassis per M-CMTS(no dimensions or RU as to determine a "large Chassis)
  – Cisco-72 DS ports with n+1)
- Support for 10,40 an
  – Cisco-PRE 5 will h DOCSIS QAM Channels
  – Cisco-K10 Calista insertion

The TR changed its position to state UP TO 12 DS RF ports in V03 from V02

- Support for Downstream of 100 Gbps using BCAST replication
- "DS Line cards to support **up to** 12 DS RF ports with support for 158 QAMs" (this will mean Annex B but 108-1002Mhz gives 112 Annex A QAM)
  – Cisco-DS384 will offer 36 QAMs unique per port if 8 ports used but also full spectrum
  – Cisco-NC and BC will be replicated to make up full spectrum over unique DOCSIS QAMs

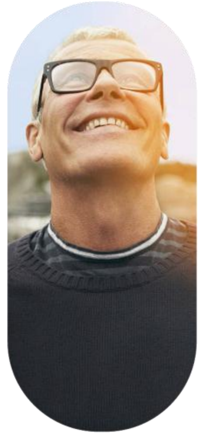
High reliability and redundancy capabilities



Features HA

- The CCAP is designed with a "wire once" approach: physical interface cards (PICs) implement the upstream and downstream physical interfaces, allowing replacement of line cards without impact to the cabling. N+1 redundancy allows line card replacement without impacting services for longer than the failover time and without the need to rewire upstream and downstream connections. This reduces mean time to recovery for the CCAP.
- Cisco uBR10012 and RFGW10 both support N+1, as will NG Chassis.
- Cisco have been promoting a “cable once” approach for many years .
- The use of the Cisco UCH- “Universal Cable Holder” for connection to RF ports has been adopted in CCAP
- The CCAP is designed such that software upgrades can be performed against a specific functional module, allowing an upgrade to a specific service that does not impact other services on the CCAP

Configuration and Management Simplifications



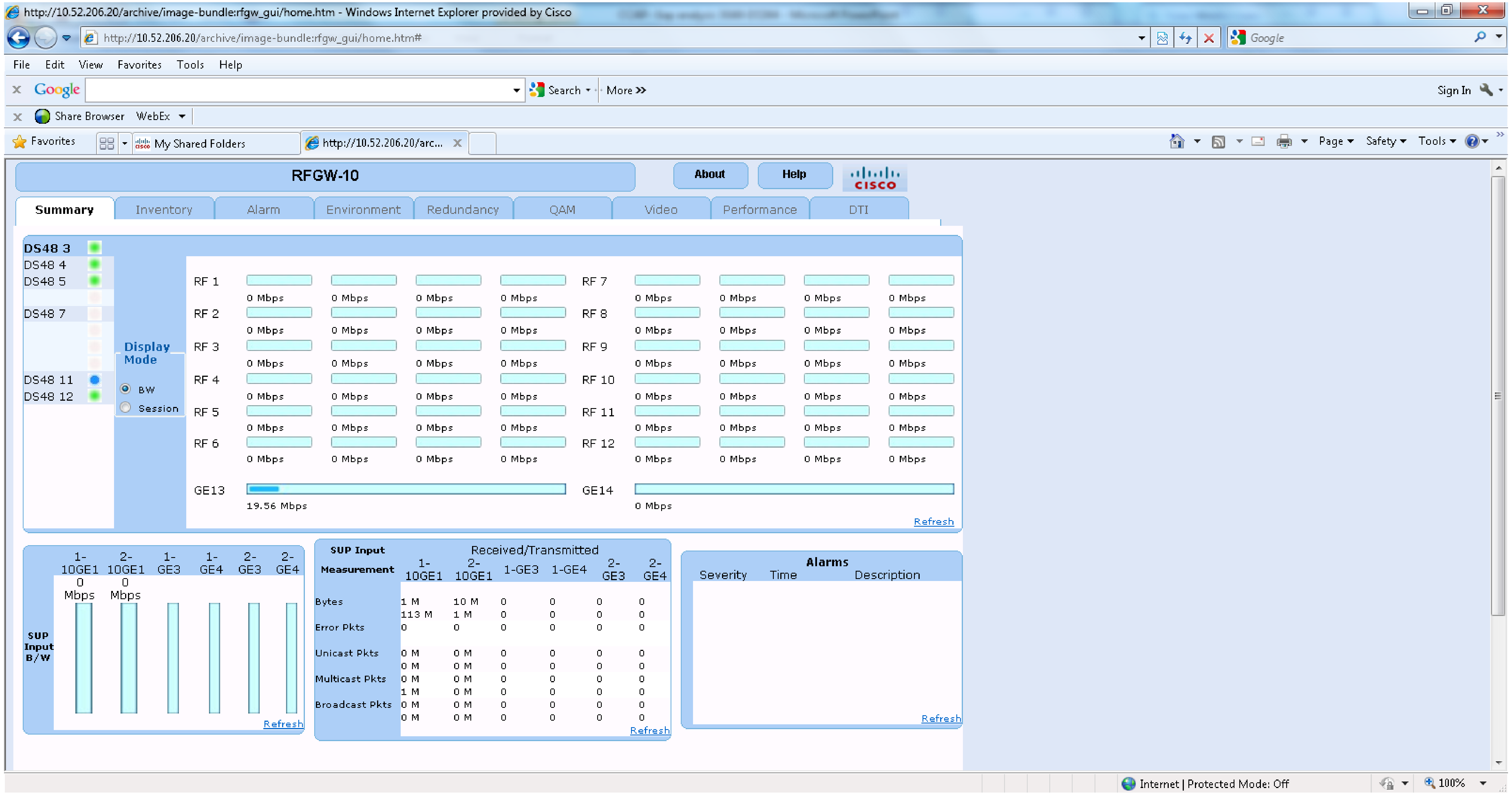
Configuration simplifications

- “The CCAP will allow configuration of both CMTS and EQAM functions from the same configuration interface”
- Cisco implemented DEPI (Downstream external phy interface) Control Plane
  - This meets requirements of a “single entity” for configuration for DOCSIS DS RF QAMS.

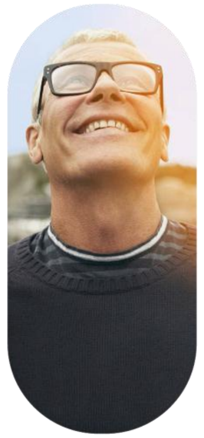
Video configuration in CCAP

- Key objective of CCAP is to merge/converge . The advantage of the Cisco uBR10k and RFGW-10 is that we can already offer a -
- “single RF port per Fiber Node for converged services at full spectrum”
- RFGW 10 will have an “active GUI” that will rest well with “video operations” (next slide)

Configuration simplifications

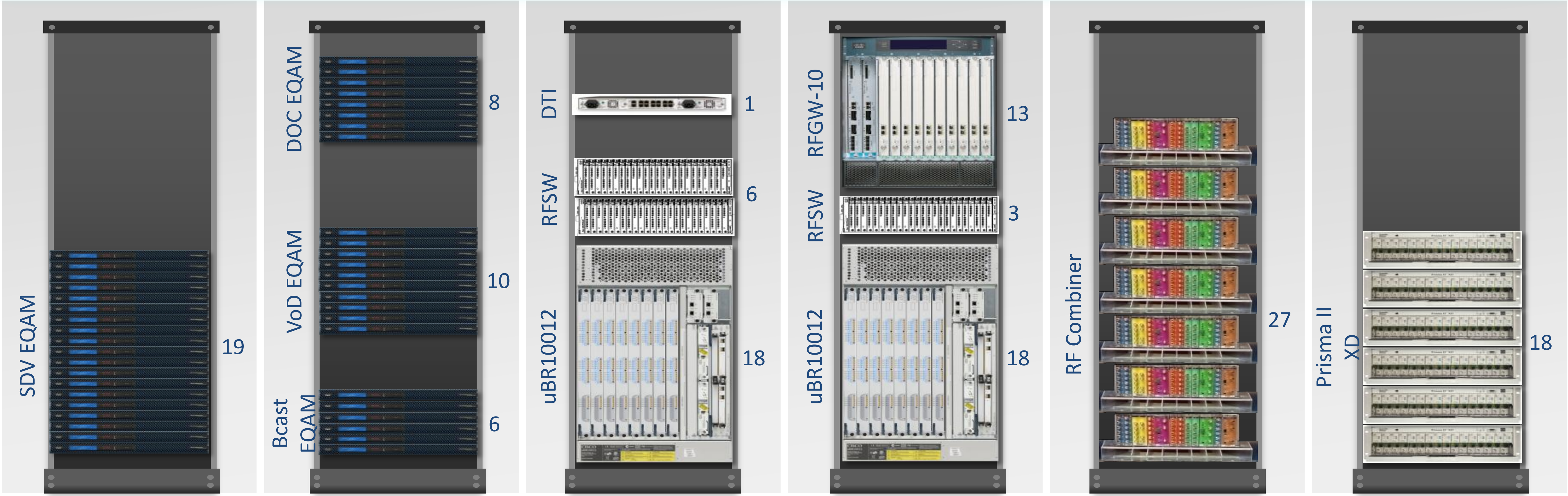


Rack Space and Power reduction



Scale DOCSIS downstream/SG on a high-density UEQAM

Total Rack Space	Total Power	BW per Sub
139 RU*	16.2 KW	1.8 Mbps



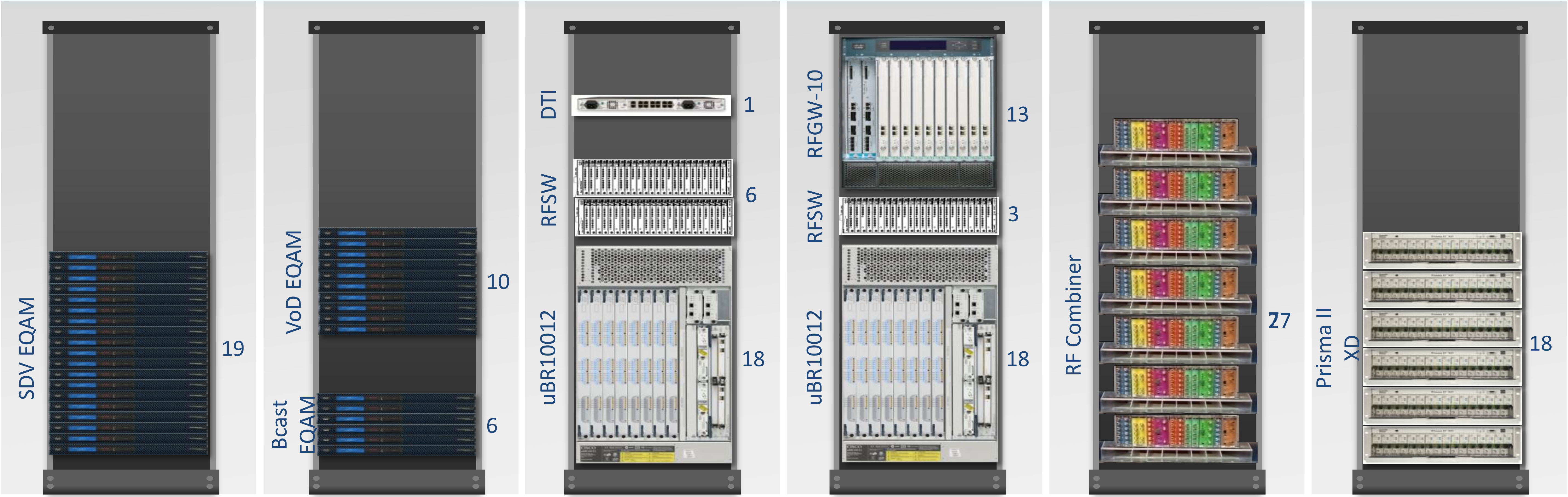
*Note: Calculation is based on 35K HHP / hub and 54 SGs, 1 RU = 1.75"

Add uBR10012 to increase

- Establish foundation for modular CCAP with uBR10012 & RFGW-10
- Increase DOCSIS downstream bandwidth-per-sub by 100%

Converge VoD & SDV QAMs on a High-Density UEQAM

Total Rack Space	Total Power	BW per Sub
90 RU* (-35%)	8.9 KW (-45%)	1.8 Mbps

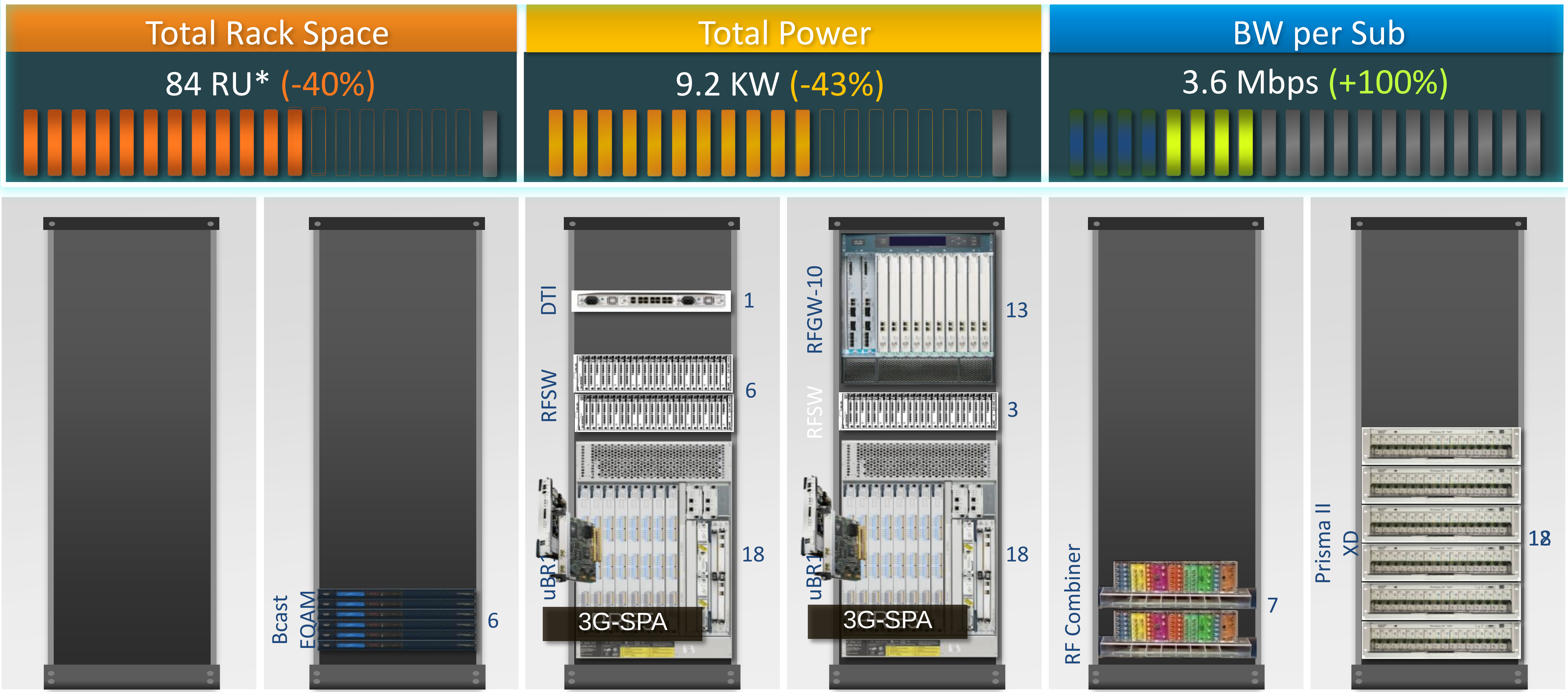


*Note: Calculation is based on 35K HHP / hub and 54 SGs, 1 RU = 1.75"

Reduce number of RF Combiners

- Converge legacy VoD & SDV QAMs into modular CCAP on RFGW-10
- Decrease rack space by 35% and power by 45%

Scale CMTS Downstream Capacity



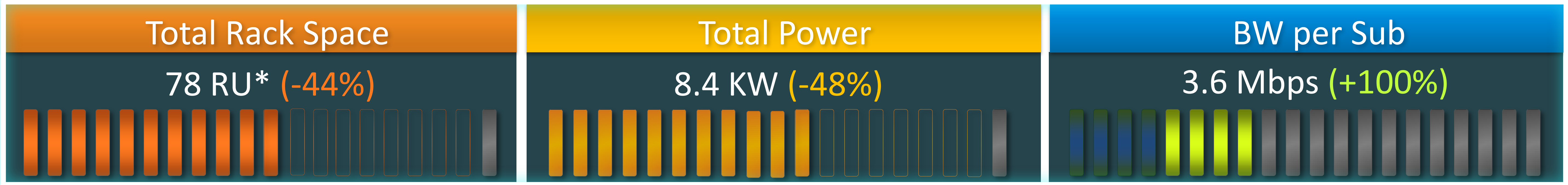
*Note: Calculation is based on 35K HHP / hub and 54 SGs, 1 R

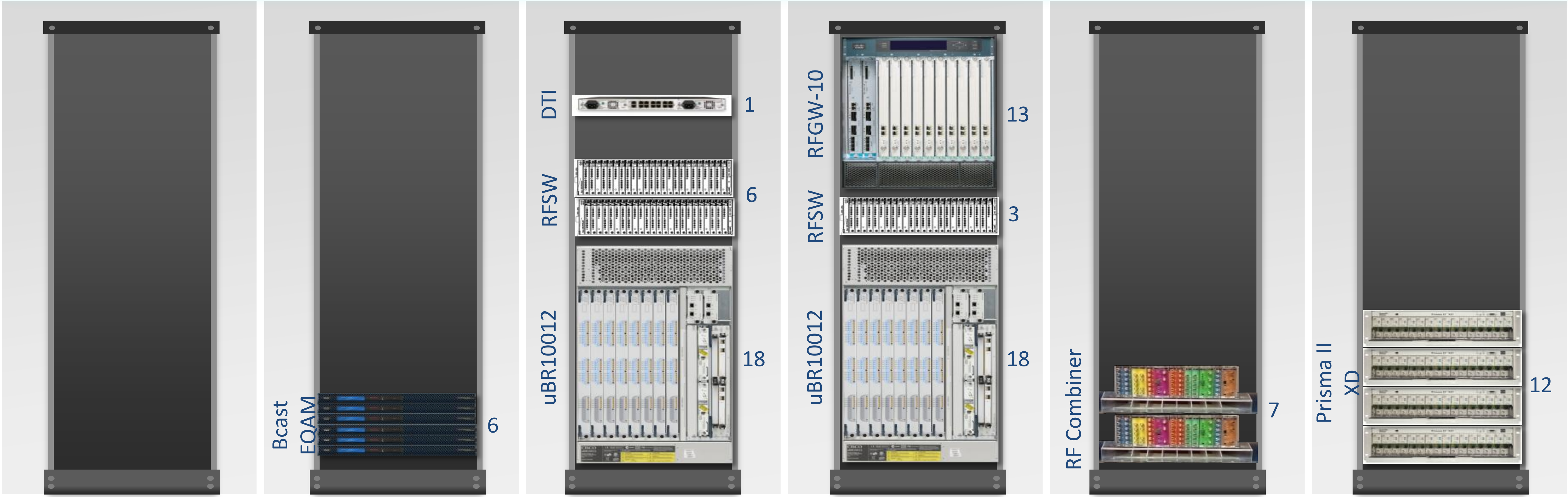
Add 3G-SPA to uBR10012

Reduce Prisma II XD

- Double the downstream capacity of uBR10012 with PRE5 & 3G-SPA
- Reduce Prisma rack space by 33% with double-density TX modules

Converge Broadcast Video on a High-Density UEQAM





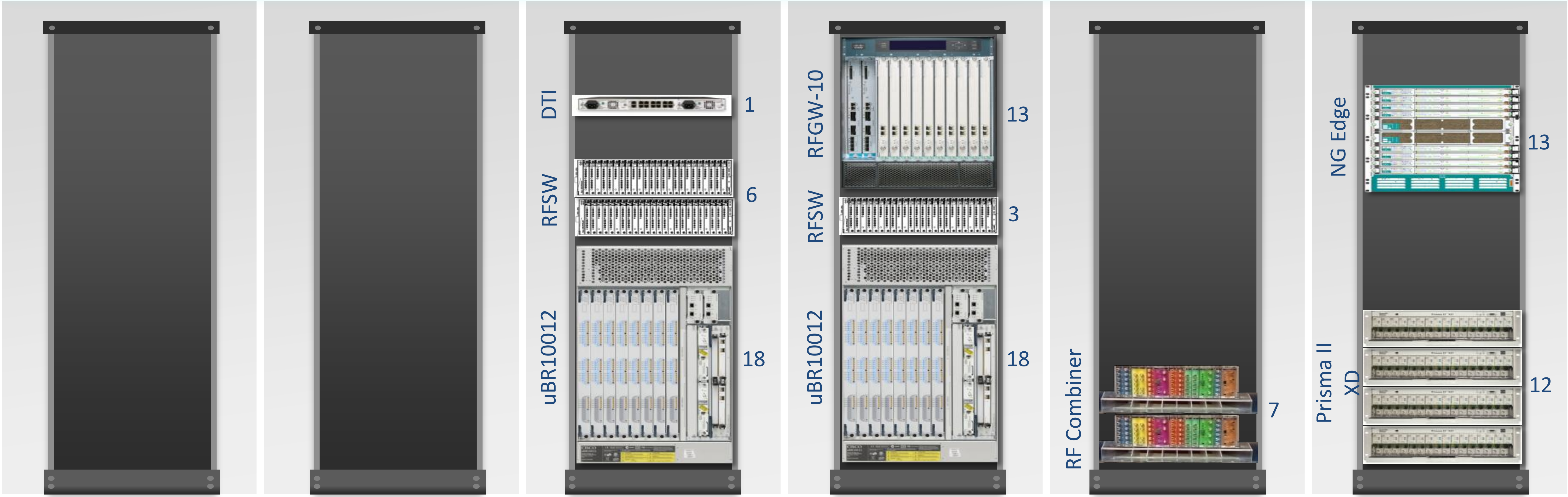
*Note: Calculation is based on 35K HHP / h

Migrate Bcast EQAM to RFGW-10

- Converge broadcast QAMs into modular CCAP on RFGW-10
- Decrease rack space by 8% and power by 9%

Scale DOCSIS to >1 Gbps per SG with NG Edge

Total Rack Space	Total Power	BW per Sub
29 RU* (-79%)	7.1 KW (-56%)	7.2 Mbps (+300%)



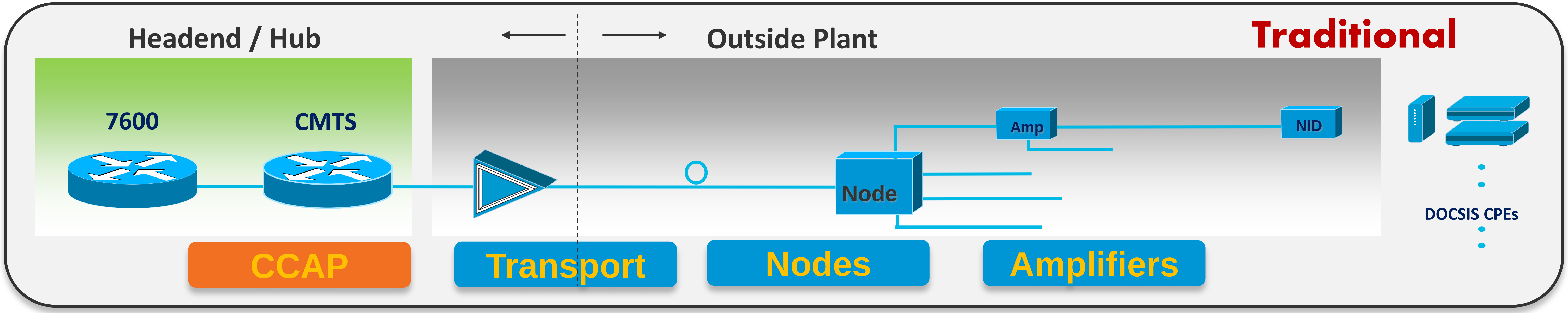
*Note: Calculation is based on 35K HHP / hub and 54 SGs, 1 RU = 1.75"

Migrate to NG Edge

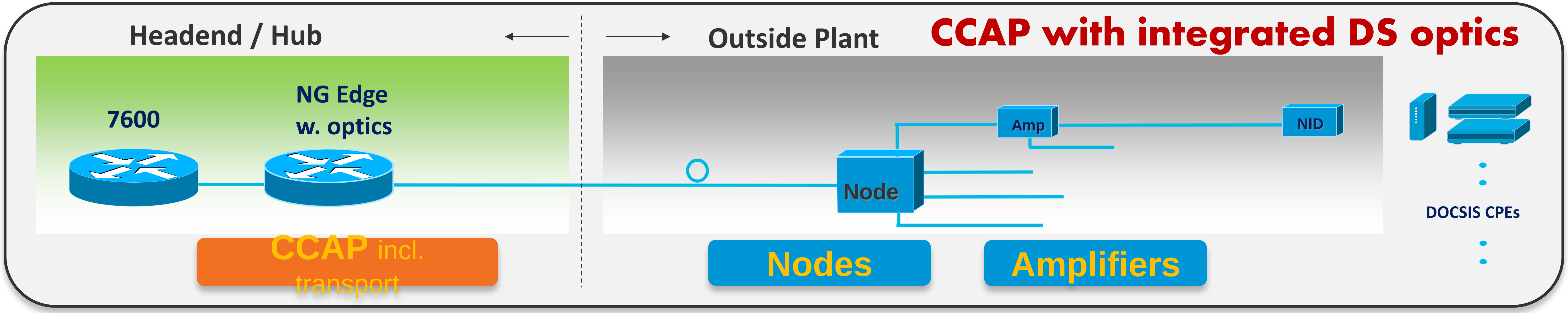
- Increase bandwidth-per-sub by another 100%
- Decrease rack space by 63% and power by 16%

CCAP, What is coming next?

Integrated Optics: Impact on HFC Architecture



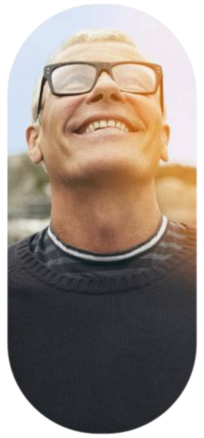
Reduction of actives & Interconnects!
Further CAPEX/OPEX Savings for Service provider



Meeting CCAP Objectives
With Both Current and Next Generation Products

CCAP Objectives	M-CCAP: uBR10012 + RFGW-10	I-CCAP: NG Edge
Increased scalability & capacity	✓	✓
Reduced cost-per-downstream	✓	✓
Converged multi-service	✓	✓
EPON support	✓	✓
Rack space per system	35 RU	16 RU
Downstream capacity per SG	Up to 1Gbps / SG	Above 1Gbps / SG
Deployment range	1 Gbps – 80 Gbps	40 Gbps – 1.2 Tbps

DOCSIS 3.1 – The story continues



The evolution of DOCSIS is bounded only by technology and imagination -- both of which themselves are unbounded.

JTC

What is DOCSIS 3.1?

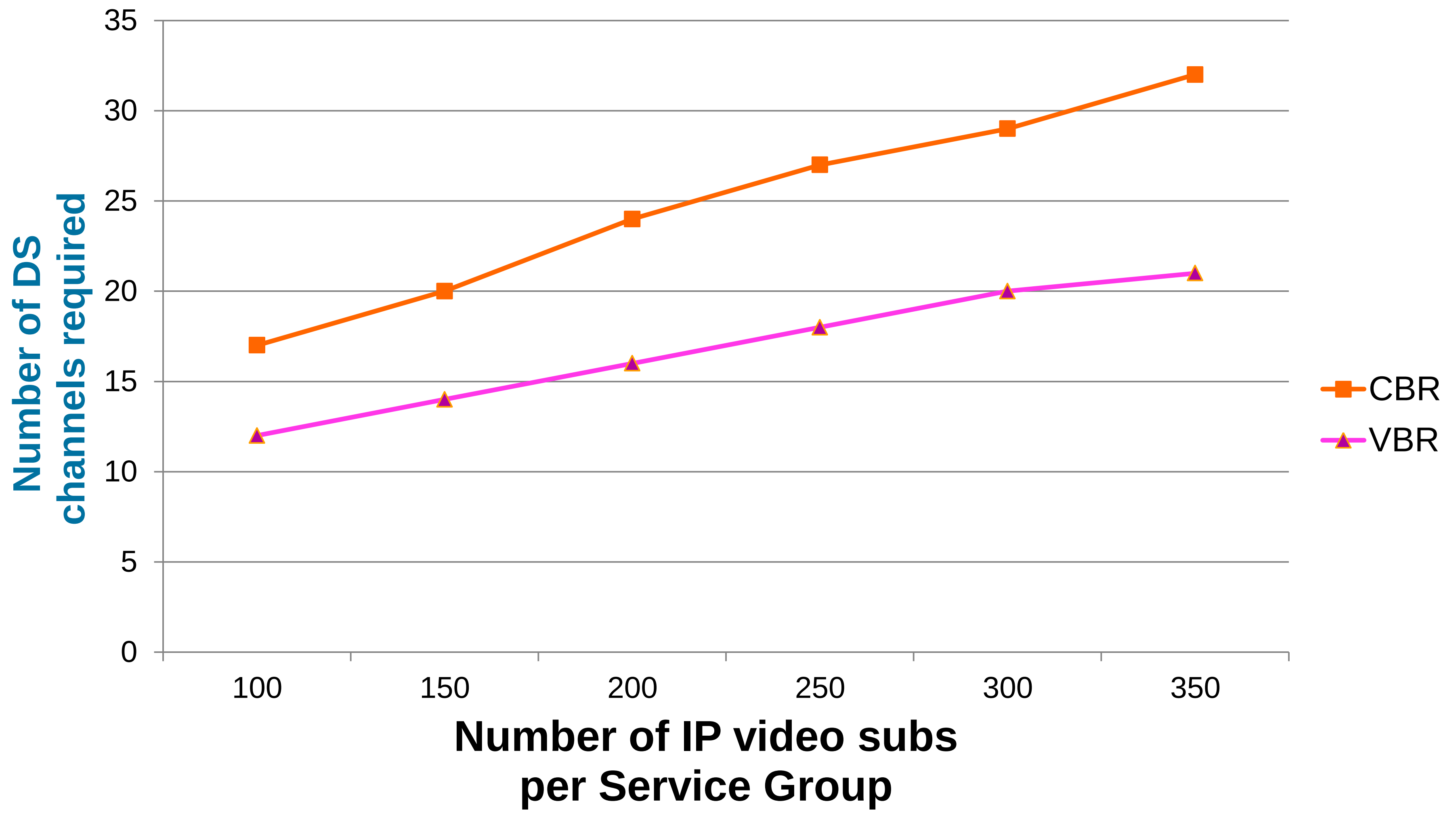
- Goals
  - Allow DOCSIS over HFC to compete with FTTH solutions.
  - Achieve 5+ Gbps in the downstream.
  - Achieve 1+ Gbps in the upstream
  - Backward compatibility story with DOCSIS 3.0, 2.0, & 1.1.
  - Better spectral efficiency.
- Technology
  - OFDM and LDPC
  - Re-use SCDMA MAC concepts

- Standardization is underway at CableLabs

IP Video Bandwidth

Example:

- 300 video subs per SG,
  - multicast for linear,
  - unicast for VoD,
  - 50% HD, 50% SD,
  - VBR, MPEG4,
  - 20 DOCSIS channels
- 150 ch collapsing to 20 ch (200 MHz). That is efficient!



- Video bandwidth will expand as new 4K and 8K formats are adopted.
- HSD will continue to grow and eventually may exceed SP video BW.

Source: "HFC Capacity Planning for IP Video" by Sangeeta Ramakrishnan, SCTE Expo 2011

Joint Supplier Team

1. Introduction
2. Cable Spectrum Analysis
3. Solving Legacy Issues
4. Coax Network Analysis
5. HFC Optical Transport Options
6. HFC Topology
7. DOCSIS PHY
   (ATDMA, SCDMA, OFDM)
8. DOCSIS MAC
9. Network Capacity Analysis
10. Network Capacity Migration
11. Recommendations

- Cisco, Arris, Motorola, and Intel teamed together to help define and drive DOCSIS 3.1.
- The first output of this joint effort was a landmark white paper at NCTA 2012, both in terms of size and in terms of collaboration.
  - 182 pages
  - 83 Figures
  - 43 Tables
  - 10 recommendations
  - 7 areas of further study

Technology Potential of DOCSIS 3.1

	DOCSIS 3.0		DOCSIS 3.1	
	Now	Phase 1	Phase 2	Phase 3
DS Range (MHz)	54 - 1002	108 - 1002	300 - 1152	500 - 1700
DS QAM Level	256	256	≥ 1024	≥ 1024
# DS Channels	8	24	“142”	“200”
DS Capacity (bps)	300M	1G	7G	10G
US Range (MHz)	5 - 42	5 - 85	5 - 230	5 - 400
US QAM Level	64	64	≥ 256	≥ 1024
# US Channels	4	12	“33”	“60”
US Capacity (bps)	100M	300M	1G	2.5G

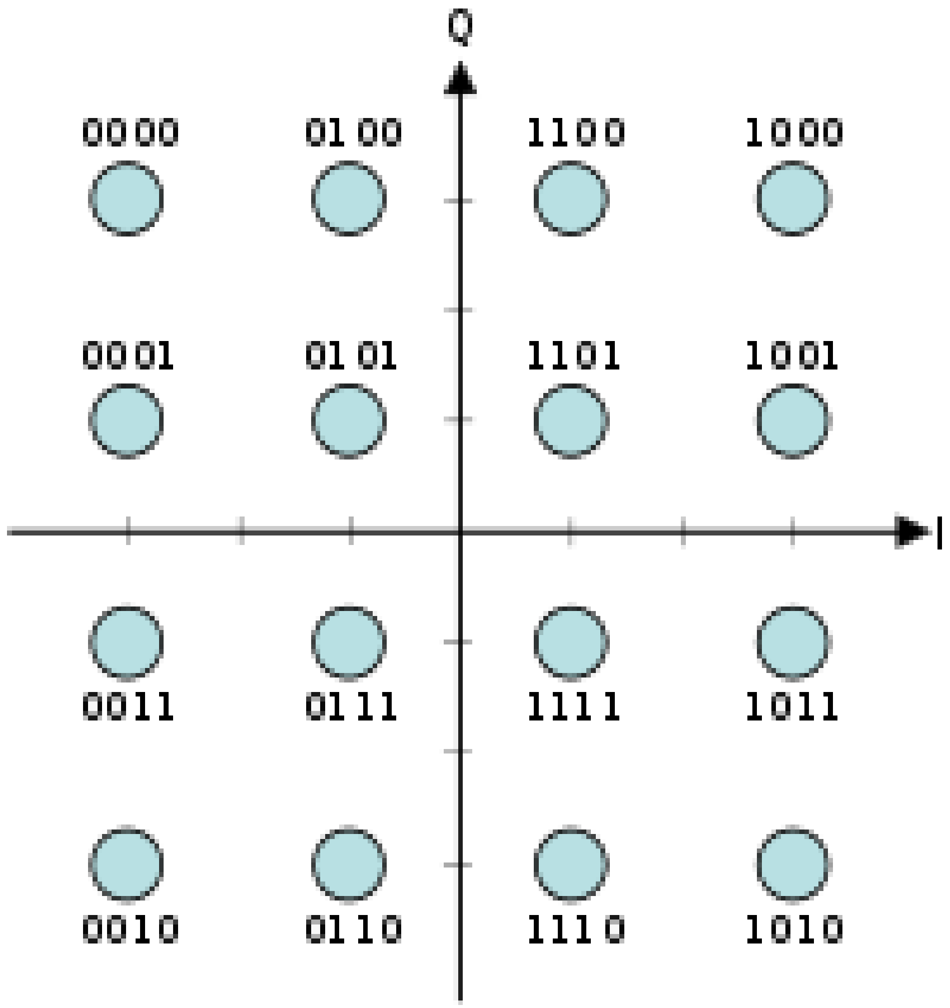
Note: TBD values are underlined, Channels in quotes = Equivalent # of SC-QAMs

Industry Proposed Schedule

✔	Date	Milestone
✔	2012 - 2012	AMP exploratory committee at CableLabs to determine technology options.
✔	2012-07	MSO CTO Meeting to determine D3.1 direction D3.1 Committee has its first meeting
	2013-02	PHY Spec W01 – Downstream only
	2013-03	MAC Spec W01 – Downstream only
	TBD	MAC and PHY Spec W02 – Upstream included
	2014	CM Silicon available. System integration and test.
	2015	DOCSIS 3.1 CM Product Availability
	2015+	DOCSIS 3.1 CMTS Product Availability

- NOTE: Final vendor schedules may differ.

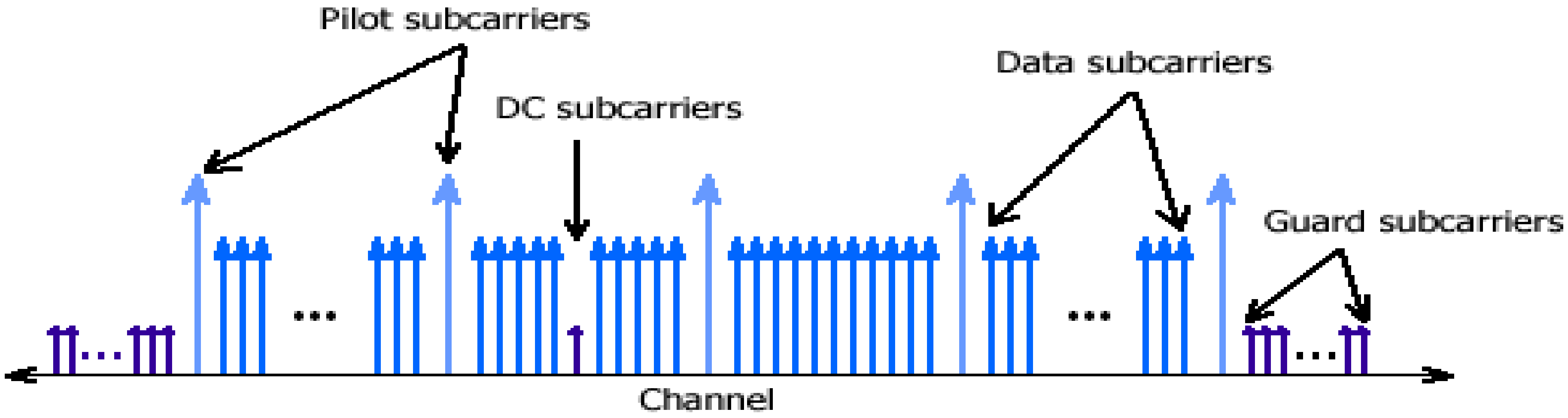
Quadrature Amplitude Modulation



Example: 16-QAM

- DOCSIS 3.0 uses single carrier QAM (SC-QAM) in the downstream and upstream.
  – Two sine waves, I and Q, each with separate amplitude and phase are added together to create symbol within a constellation.
- Each instance is referred to as a symbol.
  – 16-QAM is 4 bits per symbol
  – 256-QAM is 8 bits per symbol
  – 1024-QAM is 10 bits per symbol
  – 4096-QAM is 12 bits per symbol
  – 16384-QAM is 16 bits per symbol

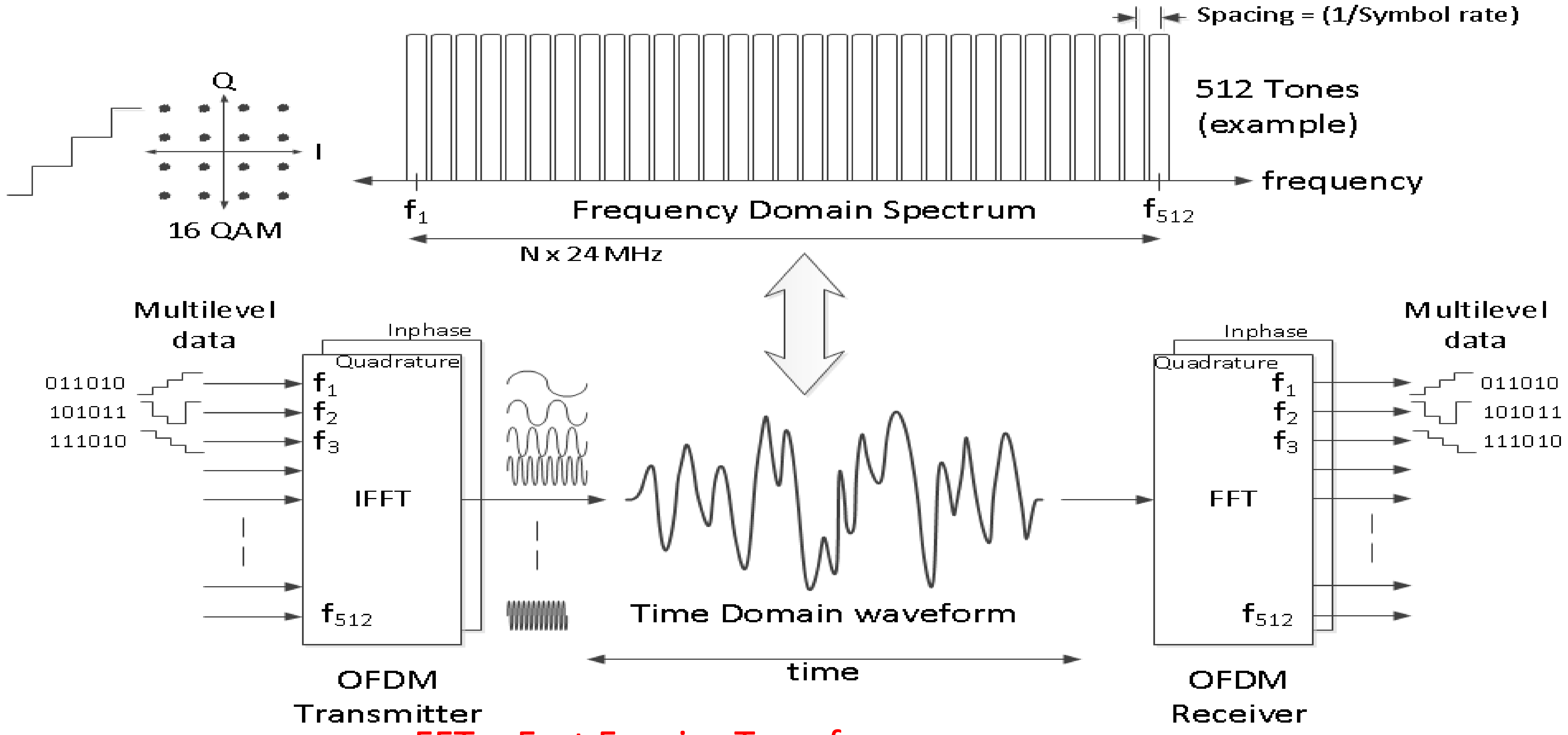
OFDM



- Orthogonal Frequency Division Multiplexing is a large collection of very narrow QAM subcarriers.
- D3.1 channel is 204.8 MHz, 4096 sub-carriers, 50 MHz spacing
  – 204.8 MHz ~= 34 x 6 MHz slots or 26 x 8 MHz
- Symbols are 20 usec long plus 1-2 usec of cyclic prefix.

What is OFDM? – A flexible, granular muli-tone QAM modulation system

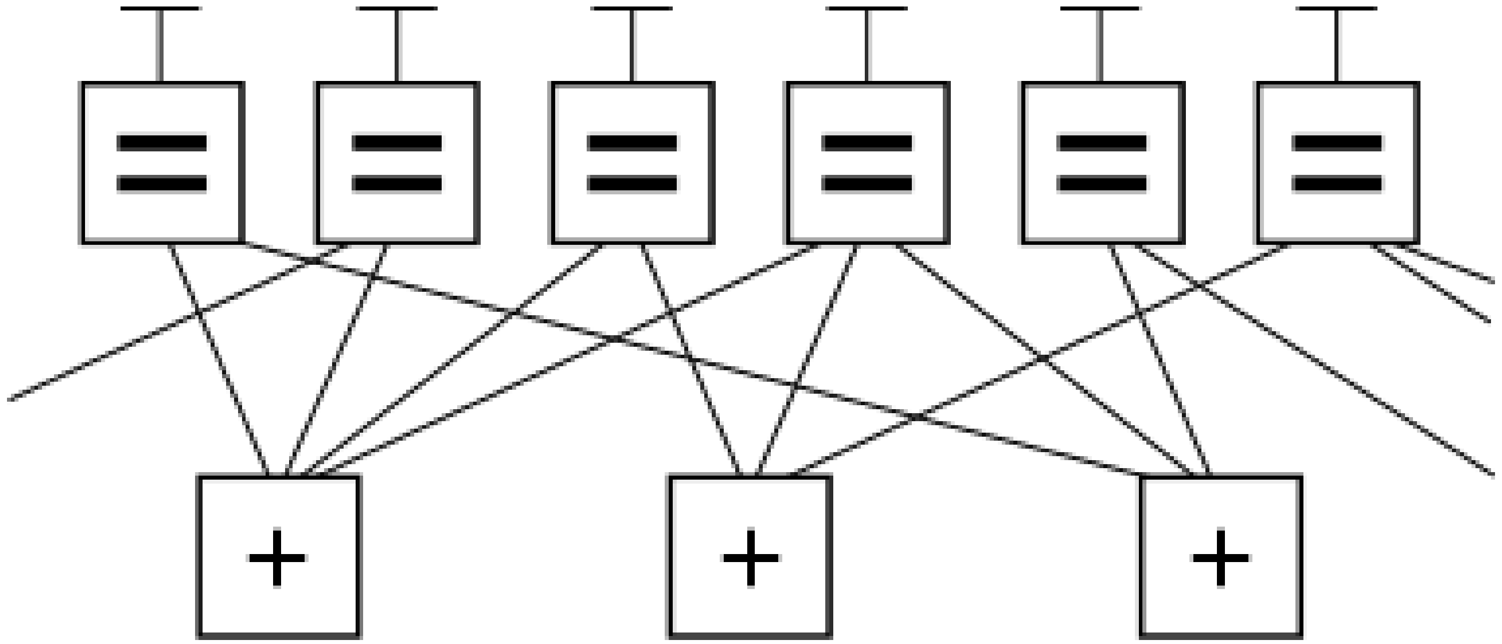
(Orthogonal Frequency Division Multiplexing)



FFT = Fast Fourier Transform

JAR 1.0

LDPC FEC

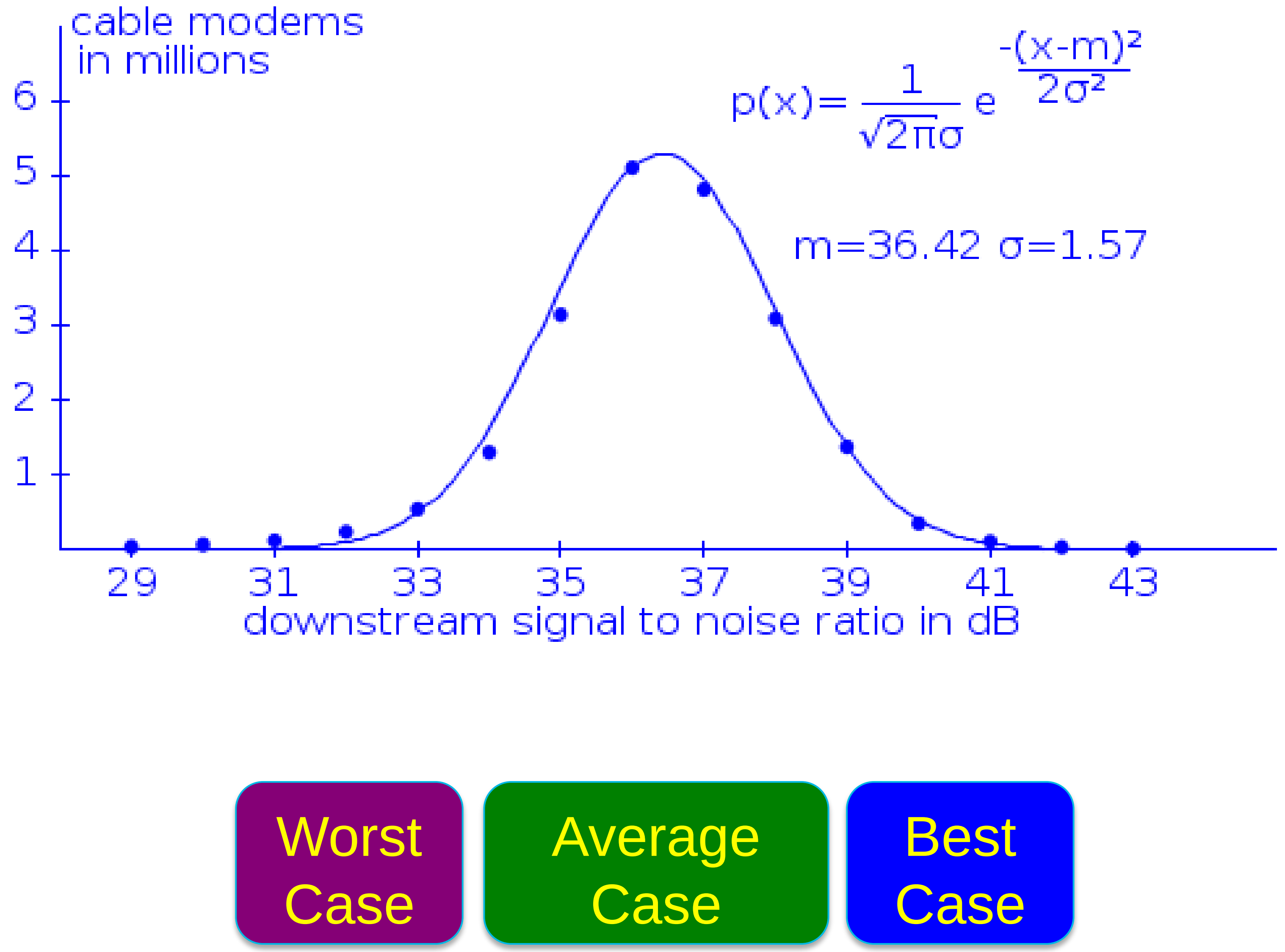


- FEC = Forward Error Correction
  - FEC adds redundant bits so that errored bits can be re-created.
  - FEC requires an interleaver in order to be truly effective.
- LDPC = Low Density Parity Check
  - Invented by Robert Gallager in 1962.
  - Could not be implemented in HW until recently.
- LDPC is much more robust than Reed-Solomon.

DOCSIS 3.1 Downstream

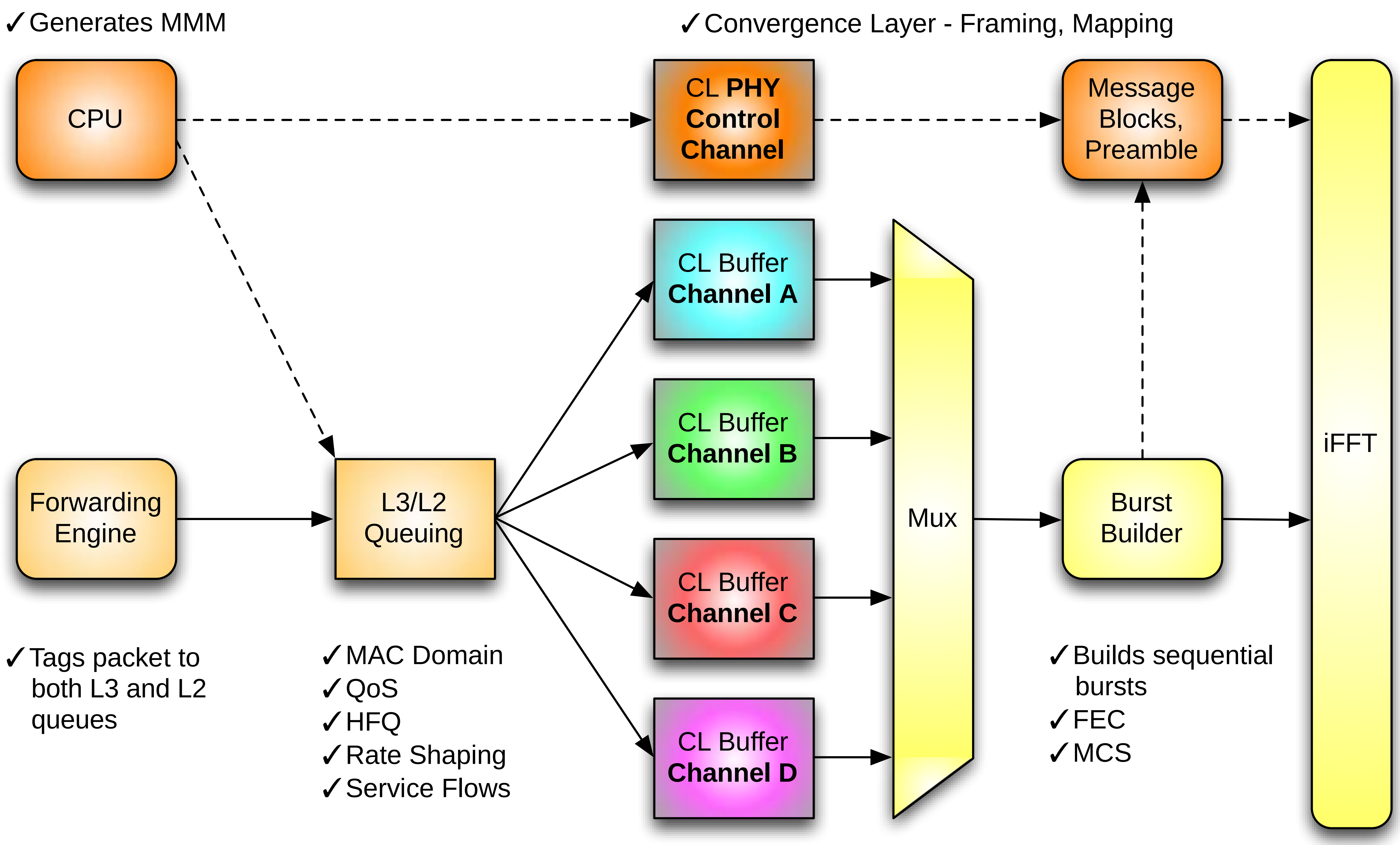
- D3.1 will introduce OFDM with LDPC.
  - Allows higher modulation and higher frequency operation.
  - The target modulation is 1024-QAM. (4K QAM will be specified)
- The initial goal is to 1150-1200 MHz. This should be possible with new amps but with existing taps.
  - Long term goal is 1.7 GHz but requires tap upgrades.
- The D3.1 downstream deployment may occur before D3.1 upstream deployment.

Slicing Up the Downstream



- The CNR can vary by at least 8 dB on a good plant.
  - Equivalent to ~3 orders of modulation
- D3.1 will sort CMs into different profiles
  - MCS = Modulation and Coding Scheme
  - Not one MCS per CM. No unicast.
- 4 profiles should suffice
  - A: Best Case (e.g. 4096-QAM)
  - B: Better Case (e.g. 2048-QAM)
  - C: Good Case (e.g. 1024-QAM)
  - D: Common channel (e.g. 256-QAM)

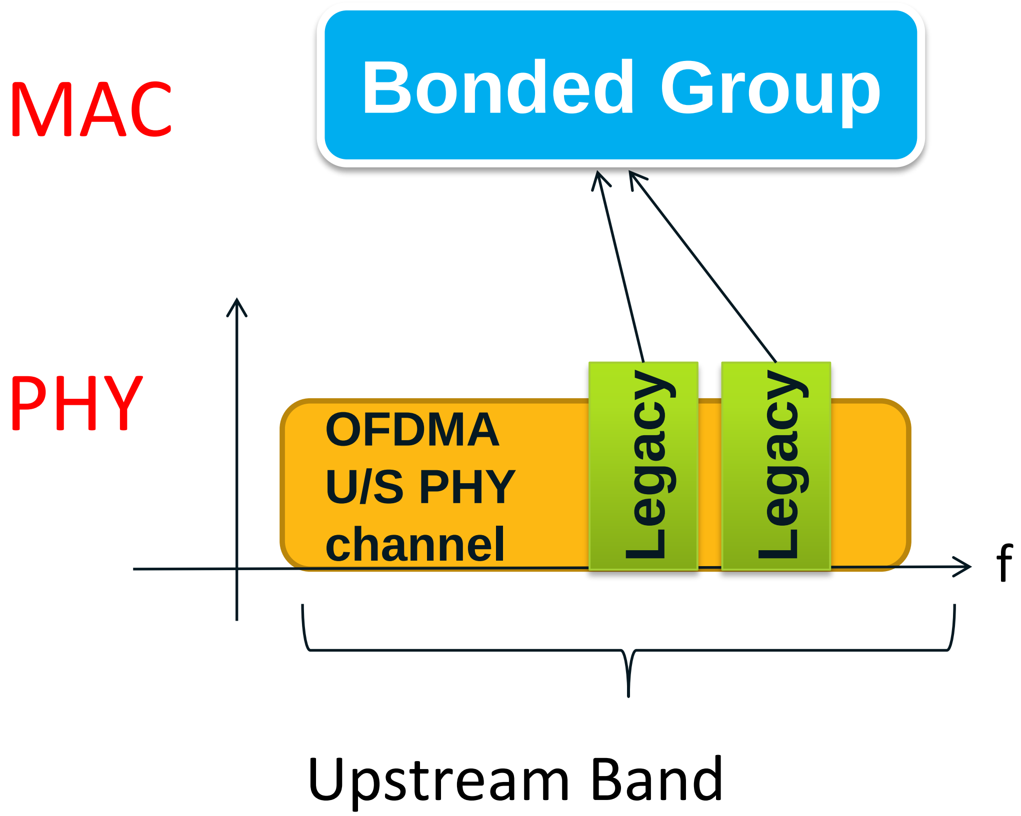
Downstream Transmit Path



Frequency Split Options

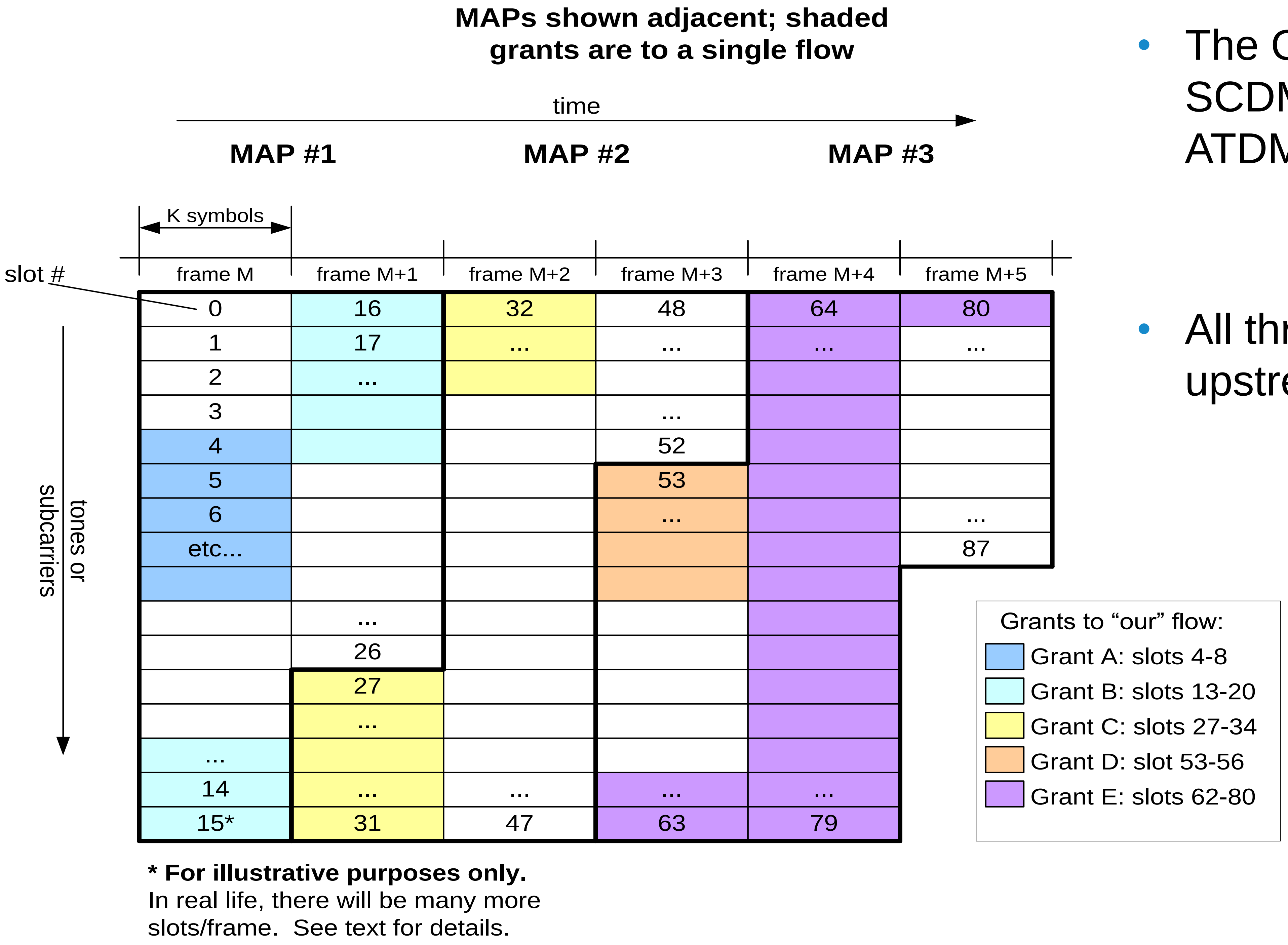
- Frequency split options:
  - *The immediate goal is to maximize sub-split. (42/65 MHz, 100 Mbps)*
  - *The short-term recommendation is mid-split. (85 MHz, 300 Mbps)*
  - *The long-term recommendation is high-split. (~230 MHz, 1 Gbps)*
- Mid-split triples upstream throughput and is available today with D3.0.

DOCSIS 3.1 Upstream



- D3.1 upstream will use OFDMA with an LDPC FEC
  - Target modulation is 256-QAM. Up to 4K will be spec'ed.
- Existing spectrum will be shared between ATDMA/SCDMA and OFDM. New spectrum will be OFDM only.

DOCSIS 3.1 Upstream MAC



- The OFDM MAC will be based upon the SCDMA MAC which is similar to the ATDMA MAC.

  Minislot = X sub-carriers for Y symbol times.

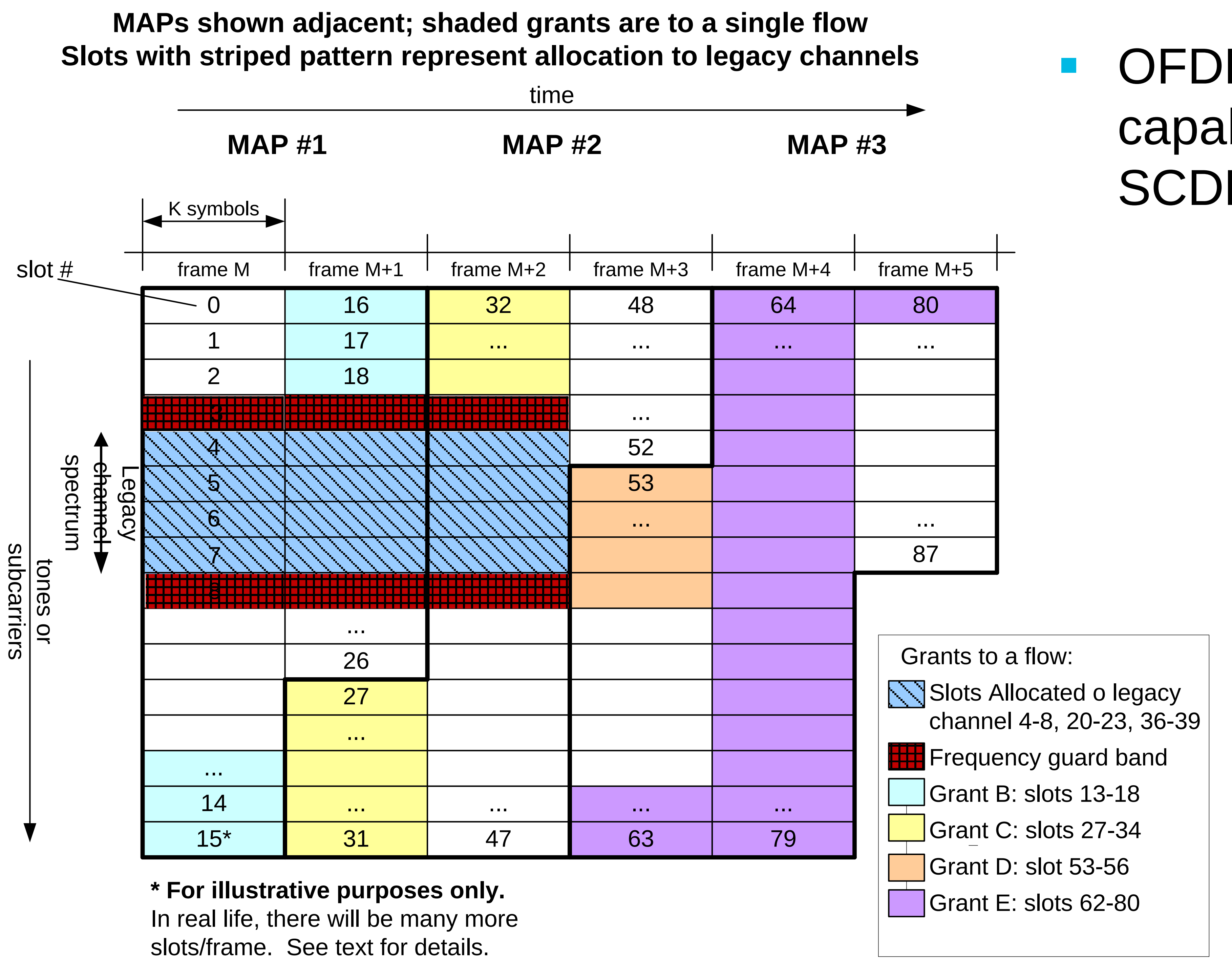
- All three MACs use mini-slots with upstream scheduling.

  ATDMA: minislots map to time

  SCDMA: minislots map to time and a group of codes

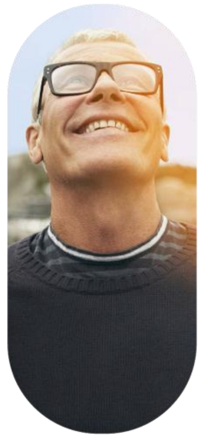
  OFDMA: minislots map to time and a group of tones

DOCSIS 3.1 with Legacy DOCSIS



- OFDMA Convergence layer is capable of multiplexing ATDMA, SCDMA, and OFDMA PHYs.

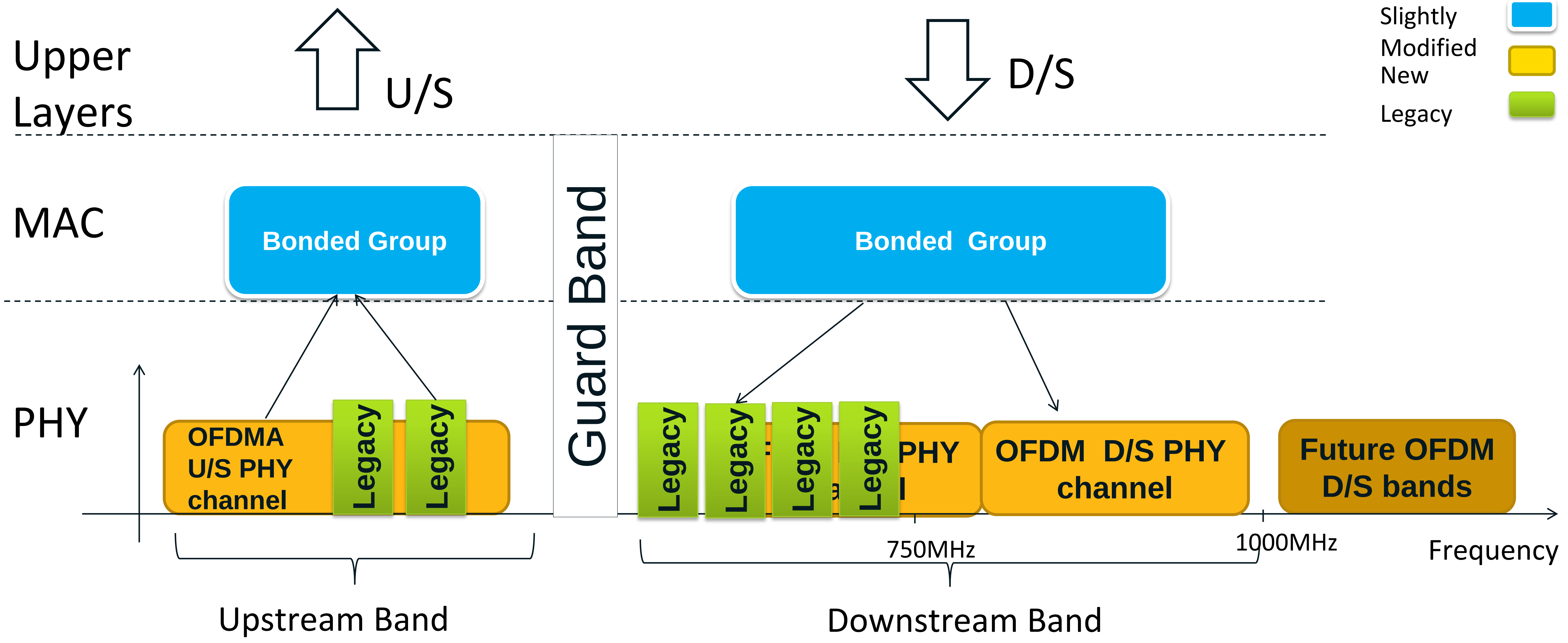
Backwards Compatibility and possible Migration to DOCSIS 3.1



Backwards Compatibility

- Upstream
  - ODFM and ATDMA/SCDMA can share the same spectrum
  - Bonding between OFDMA and ATDMA/SCDMA is possible
- Downstream
  - Bonding between OFDM and SC-QAM is supported.
- This allows a gradual and evolutionary introduction of DOCSIS 3.1.
  - This is a distinct competitive advantage that DOCSIS has over other non-DOCSIS solutions such as EPOC.
- DOCSIS 3.0 will get capped. The target cap is 16x4 or 24x8.

How OFDM Can Be Bonded With The Legacy DOCSIS PHY Channels

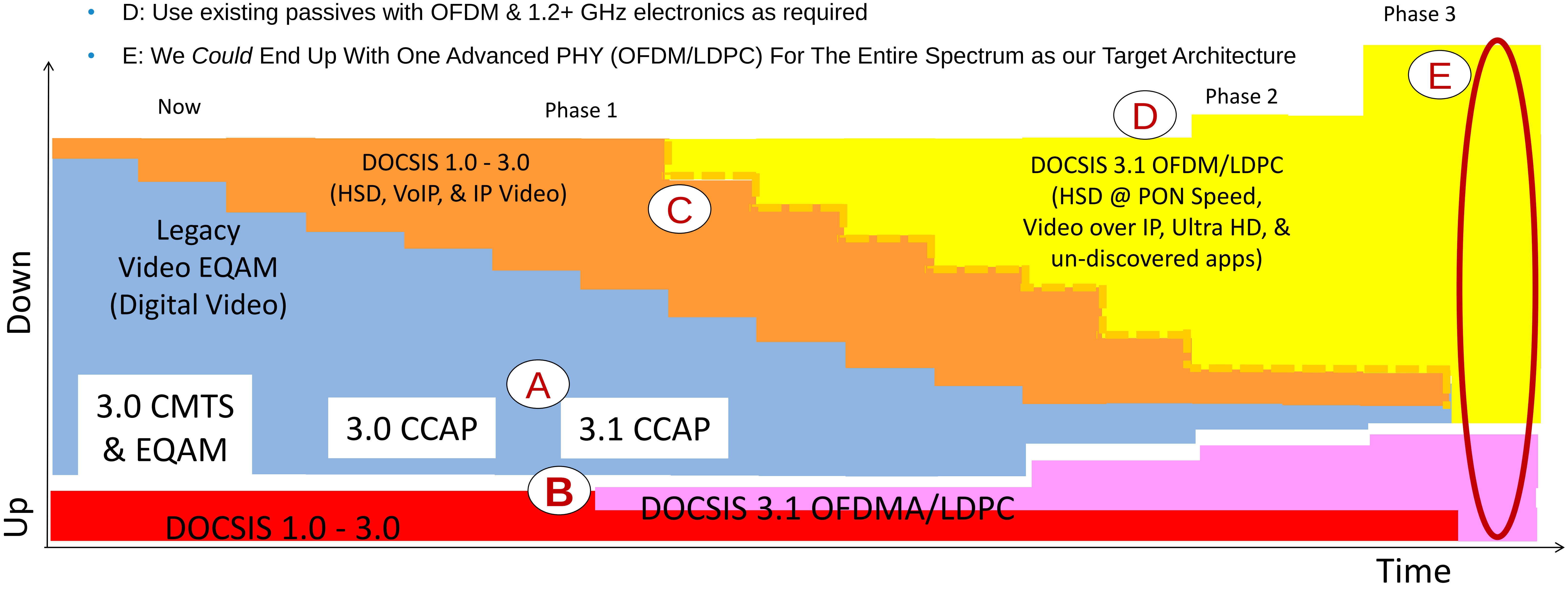


SCDMA Support in a DOCSIS 3.1

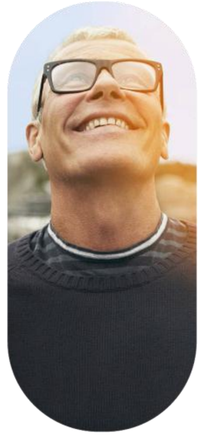
- DOCSIS 3.1 plans to state:
  - D3.1 CM MUST support SCDMA.
  - D3.1 CMTS MAY support SCDMA.
- It is generally agreed that OFDMA with LDPC will be able to replace the role that SCDMA and ATDMA perform today.
- Thus, support for SCDMA is for legacy D3.0 and below CMs.
- Long term use of SCDMA really depends upon if and how much of SCDMA gets deployed prior to D3.1 being available.

Possible HFC Migration Strategies Towards DOCSIS 3.1

- A: Initially run D3.1 CMs in D3.0 mode (avoiding RF Data Simulcasting Tax)
- B: For US, enable OFDMA and perform channel bonding with legacy D3.0
- C: Increase D3.1 CM count in SG. Enable some DS OFDM channels & bond with legacy D3.0
- D: Use existing passives with OFDM & 1.2+ GHz electronics as required
- E: We *Could* End Up With One Advanced PHY (OFDM/LDPC) For The Entire Spectrum as our Target Architecture



HFC Plant issues with DOCSIS 3.1

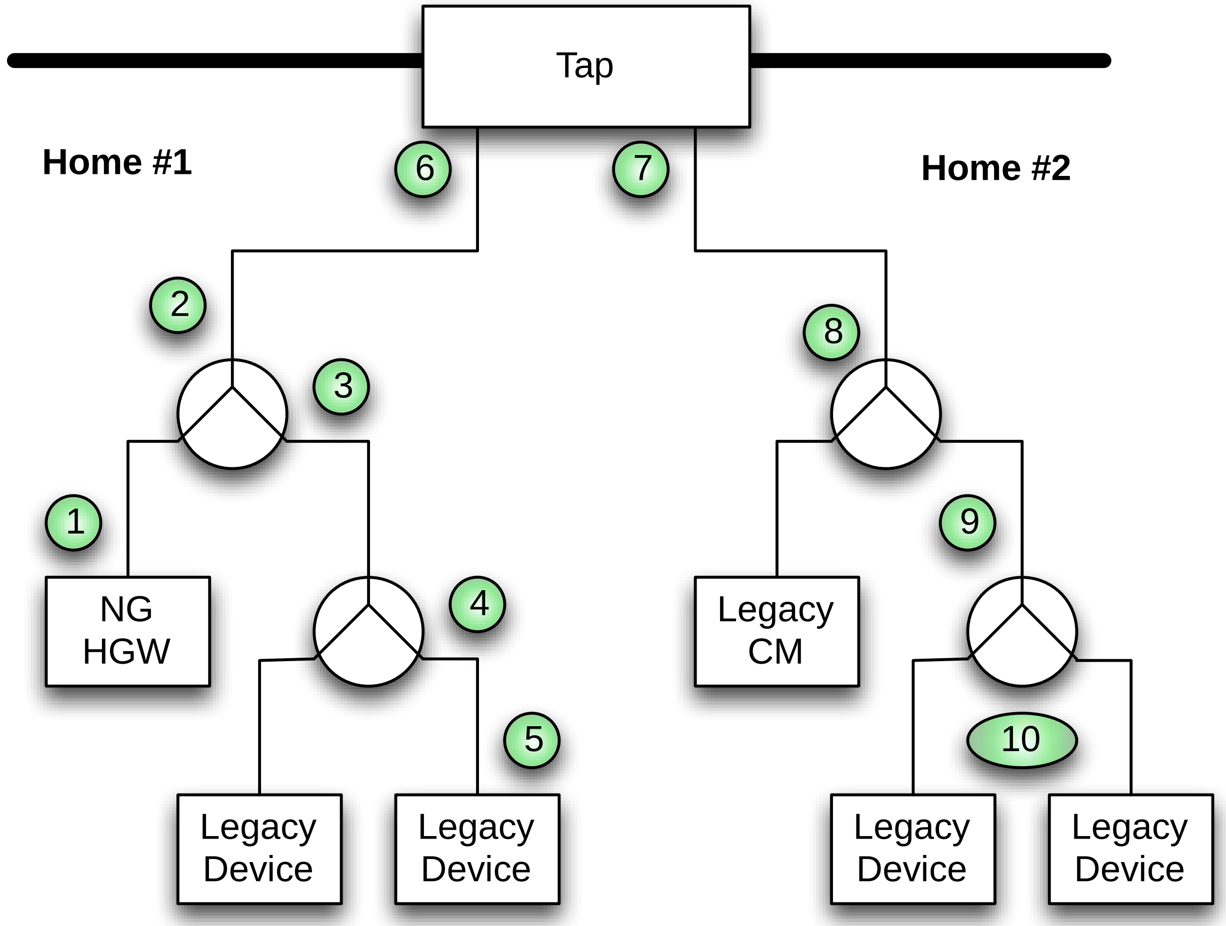


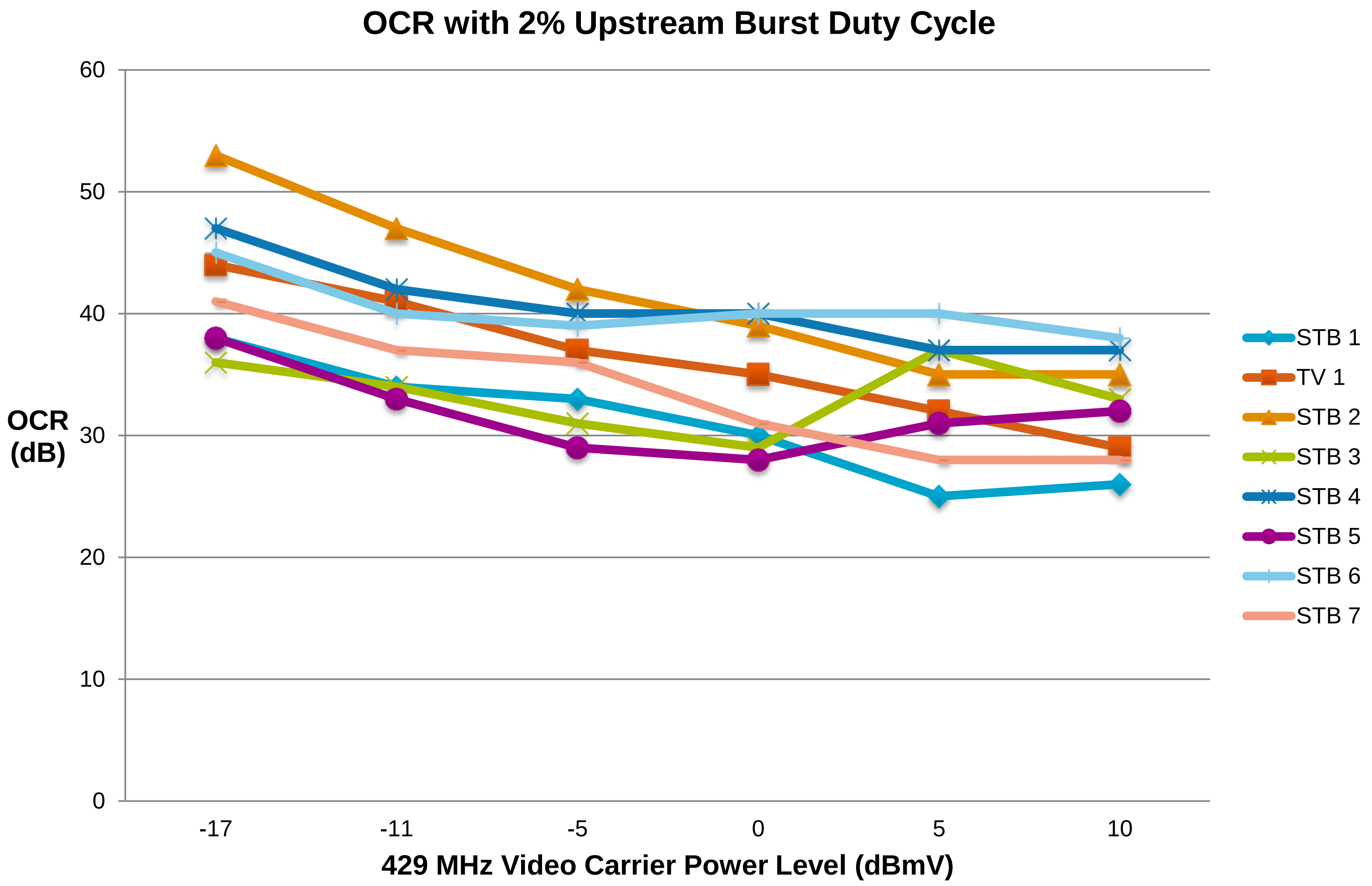
HFC Plant Legacy Issues

- *The legacy migration concerns with mid-split and high-split such as analog TV, RF interference, ADI and OOB, have workable solutions.*
- Analog TV can be reduced, removed, or remapped.
- Interference with specific OTA signals can be managed by attenuating specific OFDM tones.
- ADI = Adjacent Device Interference
  - HPF needed on coax in same house as mid/high-split HGW
  - Adjacent home should be okay if coax design is good.
- OOB can be replaced by DSG on most devices
- A Legacy Mitigation Device (LMA) can be used to fix OOB and ADI concerns if and when they occur.

DOCSIS 3.1 and Legacy Devices – ADI

Addressed in Cisco White Paper at the SCTE.





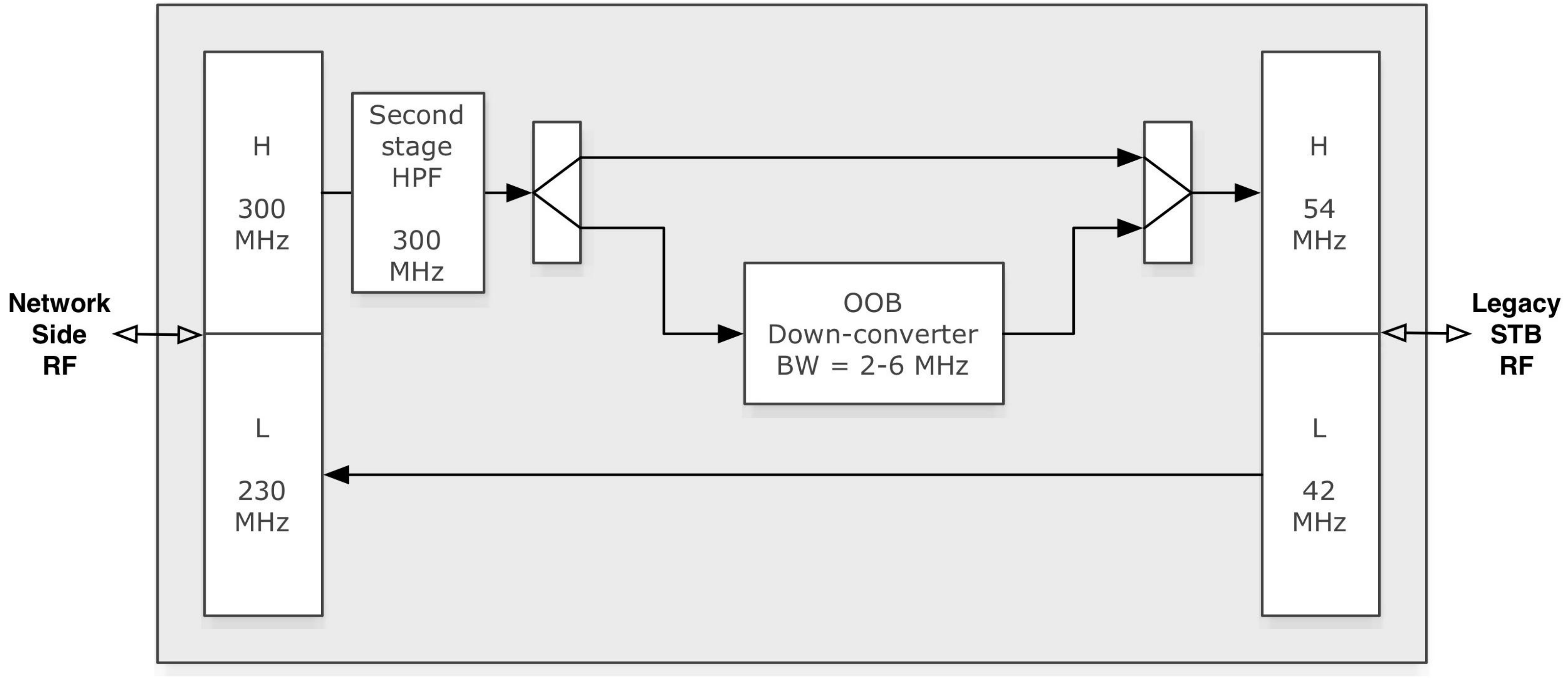
- ADI – Adjacent Device Interference
  - Same Home: Issue. Upgrade or filter home.
  - Adjacent Home: Should be fine.

- OCR – out-of-channel rejection

  Legacy device need > 23.5 dB OCR

  Tested Devices had 25 to 40 dB OCR

DOCSIS 3.1 and Legacy Devices – OOB

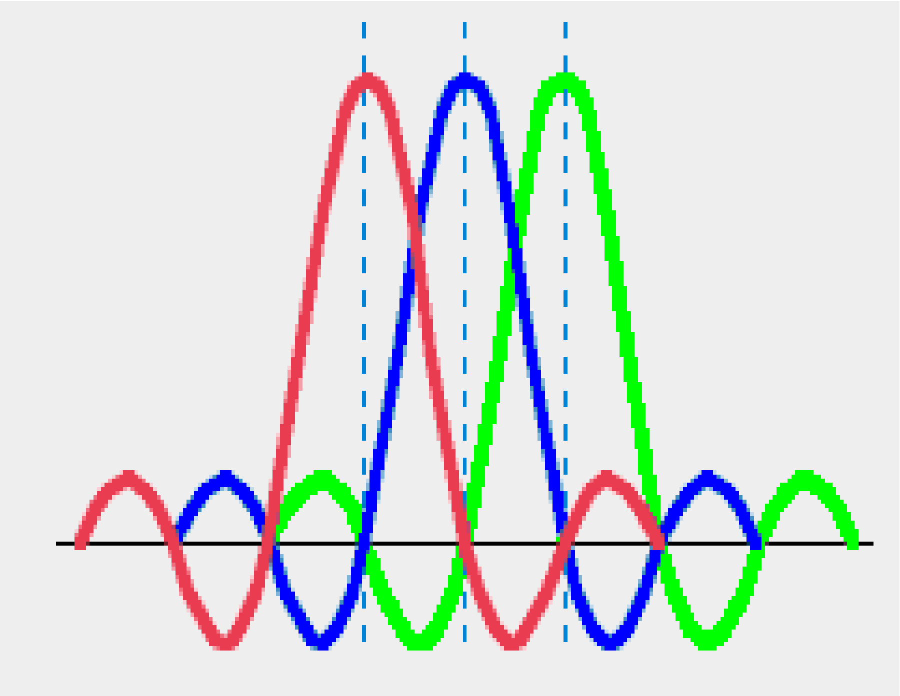


Solutions:

- Some STB already have a full spectrum OOB tuner.
- Very old STB won't have memory/cpu, and need be replaced anyway
- For the rest, use an LMA.

- Issue: 270 MHz upstream displaces OOB
- LMA – Legacy Mitigation Adaptor
  - Up-convert OOB to know frequency, then down-convert
  - LMA manages OOB and ADI

DOCSIS 3.1

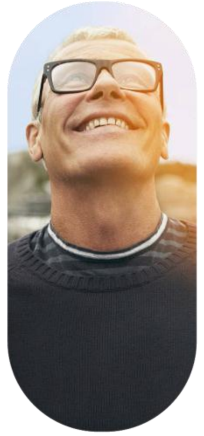


- Cisco is actively participating and helping to drive DOCSIS 3.1
- Cisco recently drove an OFDM multi-channel downstream proposal in response to our customer's needs.
- EPOC and DOCSIS 3.1 to use the same PHY.
- Questions:
  - When is DOCSIS 3.1 needed?
  - When is 85 MHz and/or 230 MHz return path needed?
  - What part of DOCSIS 3.1 gets deployed first?

DOCSIS 3.1 Technical Summary

- Backwards compatibility
  - CM and CMTS support D3.0 and D3.1.
  - D3.0 gets capped. Target is between 8x4 to 32x8 with 1-2 ch SCDMA
  - For D3.1, SCDMA is required on the CM and optional on the CMTS.
- Downstream
  - DS spectrum extends to 1150 MHz and to 1.7 GHz over time.
  - OFDM & LDPC
  - Target operation is 1024-QAM. Spec up to 4K QAM.
- Upstream
  - Target US Spectrum is 5 to 230 MHz (known as high-split).
  - OFDMA
  - LDPC & BCH FEC (SC-QAM will not be expanded to include a new FEC)
  - Target operation is 256-QAM. Spec up to 4K QAM.
  - OFDMA MAC is based upon SCDMA MAC.

DOCSIS 3.1 vs IEEE EPOC



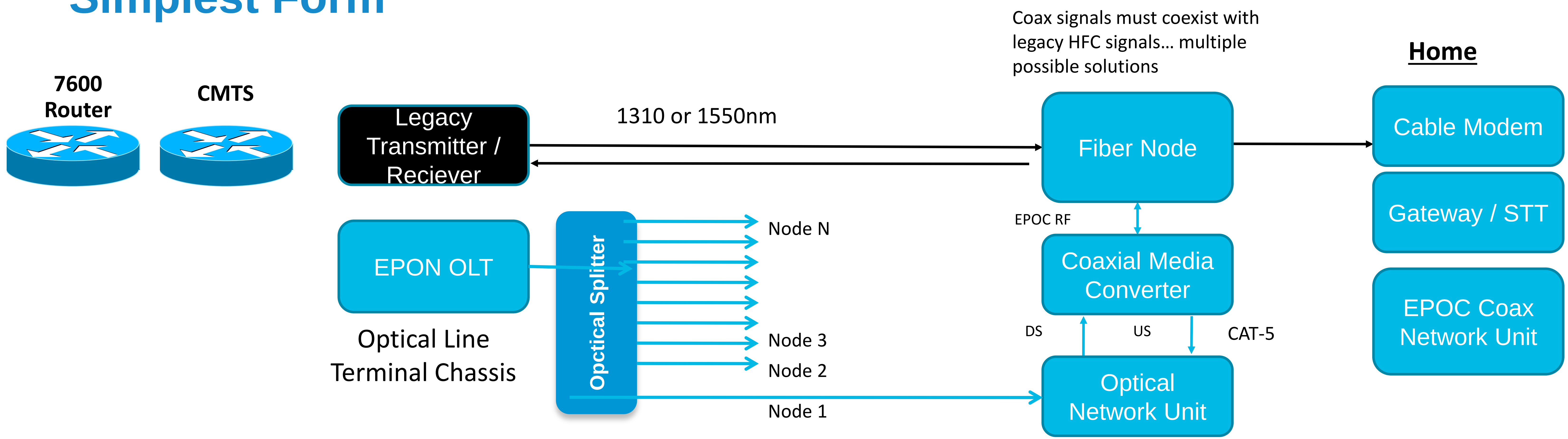
How Does DOCSIS size up to EPOC?

EPOC is EPON over Coax.

EPOC and D3.1 will use the same PHY.

DOCSIS (as it evolves) and EPOC are similar technologies but in different markets.

Ethernet POC & HFC Overlay Simplest Form



Fiber Network

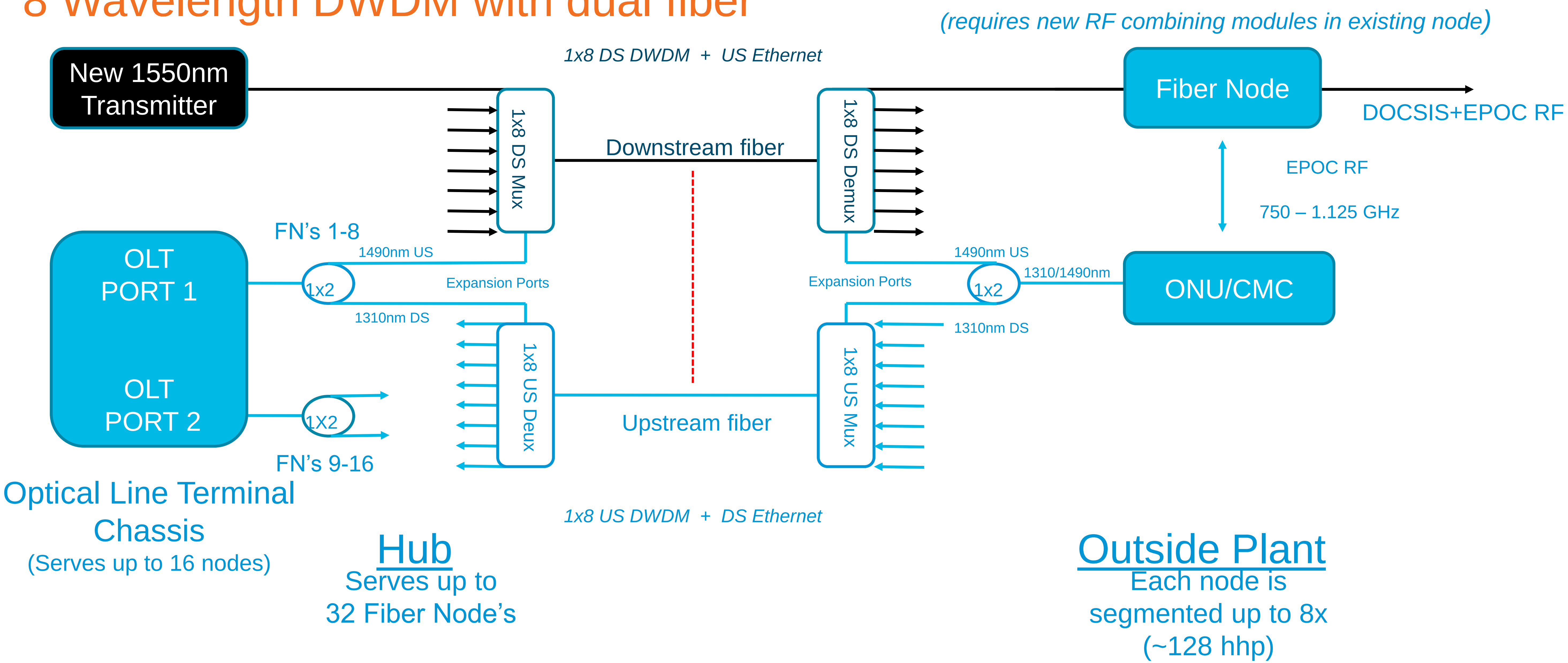
- Fiber plant is a parallel network using standard EPON equipment… does not necessarily require an additional fiber (does require some wavelength planning)
- If DPoE is utilized then EPOC can share CMTS chassis and use common provisioning tools.

Coax Network

- Coax Network requires outside plant changes to insert RF signal at the Node and make room for RF signals.
- Coax network must share RF spectrum with HFC and current services
- Multiple possible RF spectrum solutions, (i.e. Top Split, High Split)

Ethernet POC and HFC Overlay

8 Wavelength DWDM with dual fiber



- Initially eight fiber nodes are provisioned per 10G OLT
- Provisioning EPoC still allows the use of all 155x nm wavelengths
- Each "set" of 16 nodes requires an additional 10G OLT

DOCSIS 3.1 vs IEEE EPOC

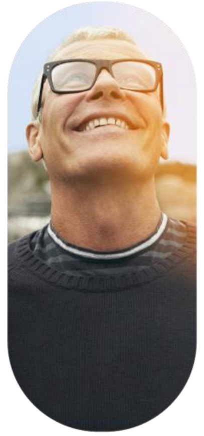
Topic	Comment
Spectrum Planning	Same spectrum available to both
HFC Plant	EPOC requires digital HFC (Ethernet/EPON/GPON)
L1: PHY	Same technology available to both
L2: MAC	Both are Ethernet over Coax. Both are point-to-multi point. DOCSIS allows multiple upstream transmitters.
L3+: Subscriber management	DOCSIS has a full suite of features DPoE maps a subset of features to EPOC
System	DOCSIS systems are BRAS + access EPOC systems tend to have separate BRAS and access with more ASIC integration.

- DPoE does not provide DOCSIS features to EPON/EPOC. DPoE only provides a translation from DOCSIS provisioning to EPON features.

DOCSIS 3.1 vs IEEE EPOC

- Since EPOC and DOCSIS 3.1 will use the same PHY, there will be no difference in RF Spectrum efficiency between DOCSIS 3.1 and EPOC
- EPoC is not backwards compatible with DOCSIS and therefore cannot bond with SC QAM (Single Channel QAM)
- The coexistence of EPoC and DOCSIS requires segregated RF spectrum for both technologies
- When provisioning 1 GHz EPoC, none of the previous investment in DOCSIS QAM’s can be leveraged
- The initial investment in EPoC is much higher than scaling DOCSIS 3.0 or the evolution to DOCSIS 3.1
- Although the total CAPEX for DOCSIS 3.0 and EPoC is similar, the evolution to DOCSIS 3.1 and the value of Capital over time indicates DOCSIS 3.1 is a wise investment

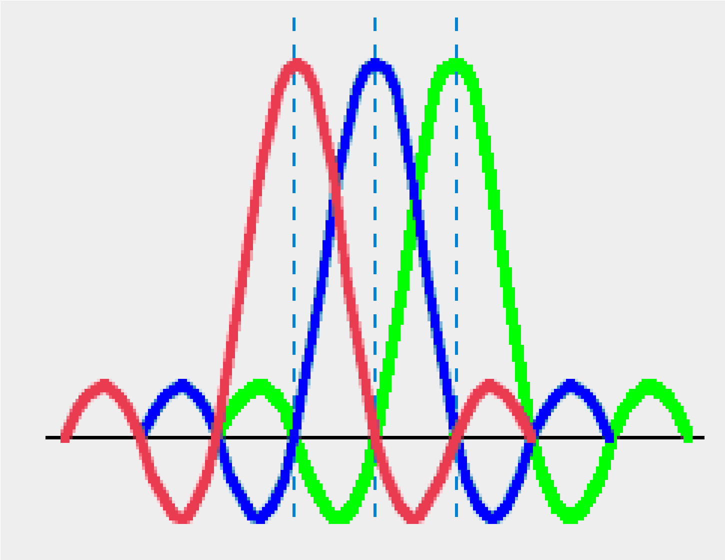
Conclusions



CCAP Conclusions

- MSO’s will cherry pick the parts of CCAP that suits them
  - Density
  - Power
  - Rack space
  - (to reduce cost per DS)
- Mention plans for convergence (video/DOCSIS) and objections are put forward
  - “Video and data operations will remain separate entities”...........So why CCAP ?
- What does CCAP give to offer service protection and competitive edge.
  - DOCSIS 3.0 ....Is it today’s technology spun differently .

DOCSIS Conclusion



- DOCSIS is defined by:
  - market requirements,
  - the HFC environment,
  - available technology, and
  - the will and creativity of the DOCSIS community.
- DOCSIS is the most successful Ethernet over Coax technology to date.
- DOCSIS can be anything the DOCSIS community wants or needs it to be.
- DOCSIS 3.1 is intended to scale the delivery of all IP services over the HFC plant and do so in a manner that is competitive with FTTH or any other broadband technologies.

Key Takeaways

The Key Takeaways of this presentation were:

- CCAP will enable convergence
- CCAP will increase density and reduce costs
- DOCSIS 3.1 will scale to 10 Gbps x 1 Gbps
- DOCSIS 3.0 can do 1 Gbps in 2013
- Cisco is helping to lead this effort.

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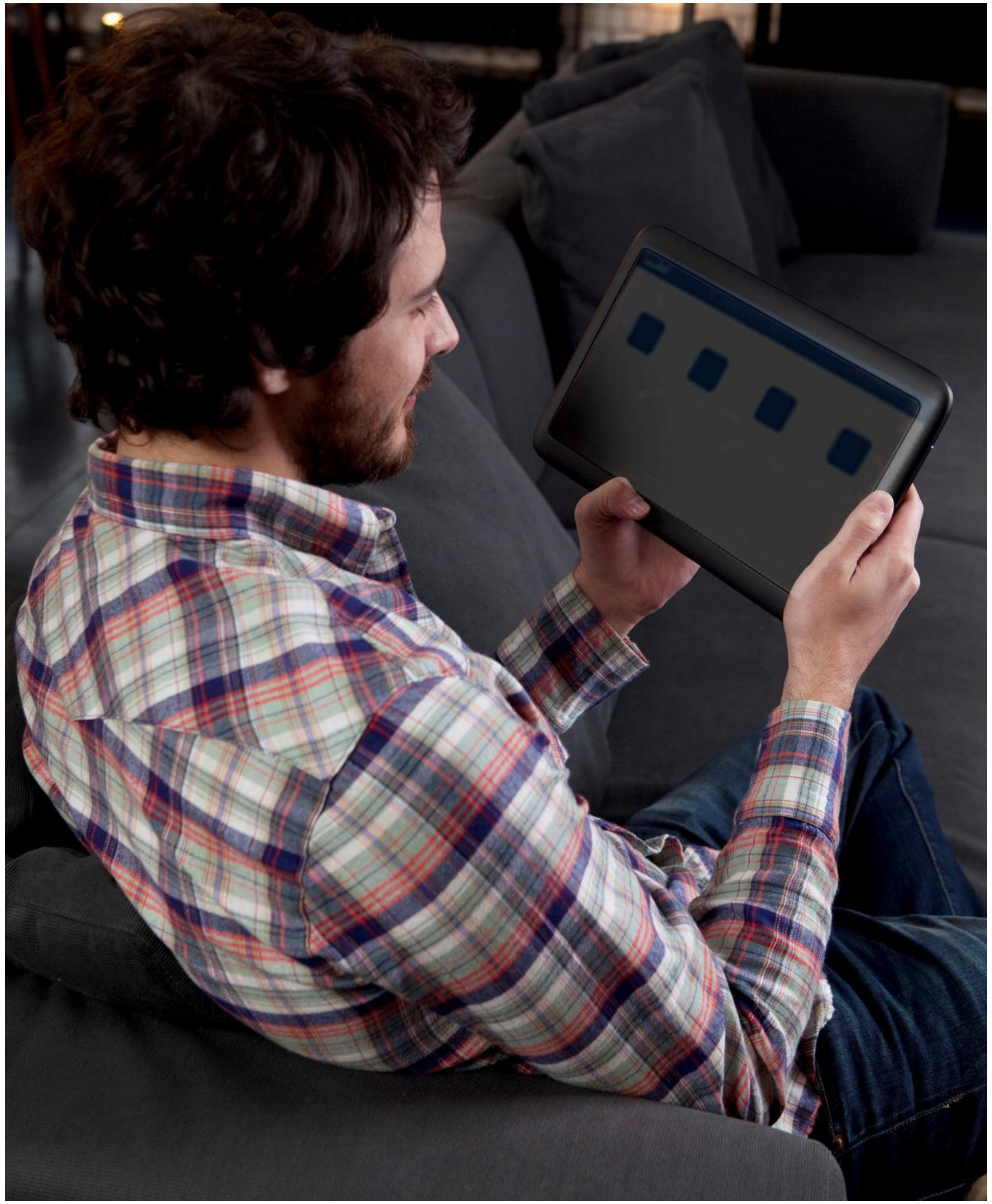

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