



Cable Access Architecture Evolution

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Strategy to Deliver Customer Value

- *Demand for more Bandwidth continues – 40-50% increase Y/Y*
- *This presents two challenges to the service providers:*
 - *Must constantly build out capacity and upgrade networks and still maintain a profitable business*
 - *Keep up with new BB products from competition*

- **Cisco seeks to help by developing new technology, which:**
 - **Converges services, technology and platforms and thus offers higher densities and reduced OPEX as a consequence of reduced power, space and cooling requirements**
 - **By means of NFV and SDN technologies, makes it easier and less costly to operate the networks and much easier to introduce new applications and operations-tools.**
 - **Investment Protection: Platforms that last**

Agenda

- Architecture Evolution
- DOCSIS 3.1 Status – Standard – Solution
- R-Phy
- SDN / NFV

Architecture Evolution Overview

Agenda

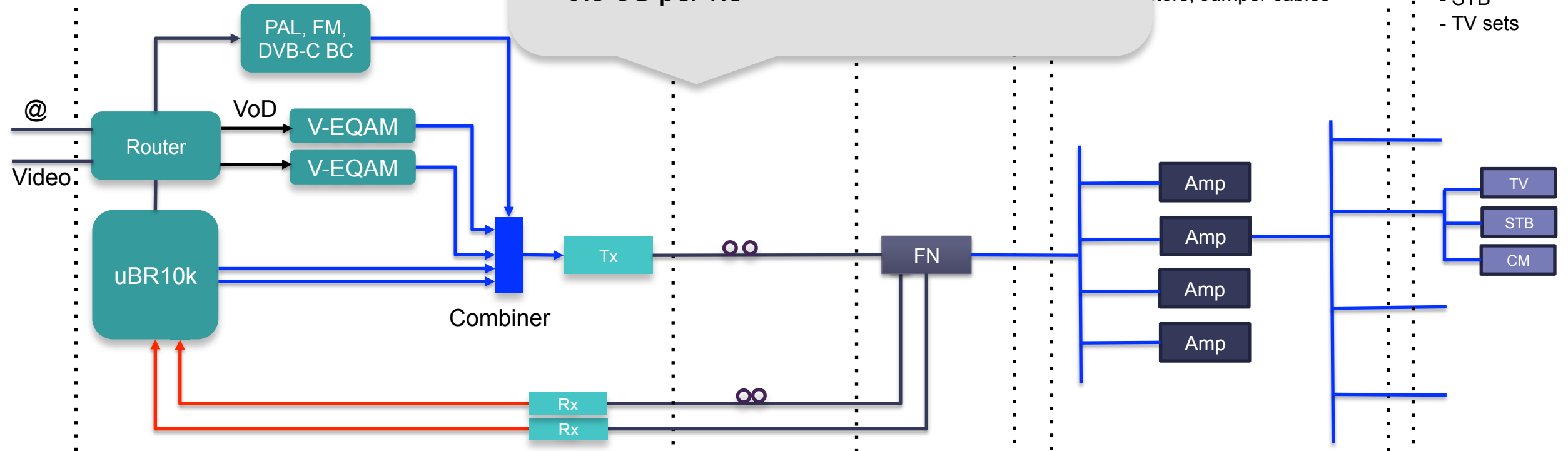
Architecture Evolution History and Roadmap

- I-CMTS (MC5x20, MC20x20)
- M-CMTS (MC5x20 + 1G-SPA -> 3G60 + 3G/6G-SPA)
- M-CCAP: One conn/SG. Integration of DVB-C BC & VoD with RFGW-10
- I-CCAP: cBR8
- I-CCAP + D3.1
- R-Phy
- NFV (Network Function Virtualization)

I-CMTS

PoP/Hub

Scenario: iCMTS, 5x20, 1 uBR, RFGW-1 for VoD, 2 DS/SG, 8 VoD QAM/SG
 ~ 7 DS QAM per RU
 ~ 0.9 SG per RU

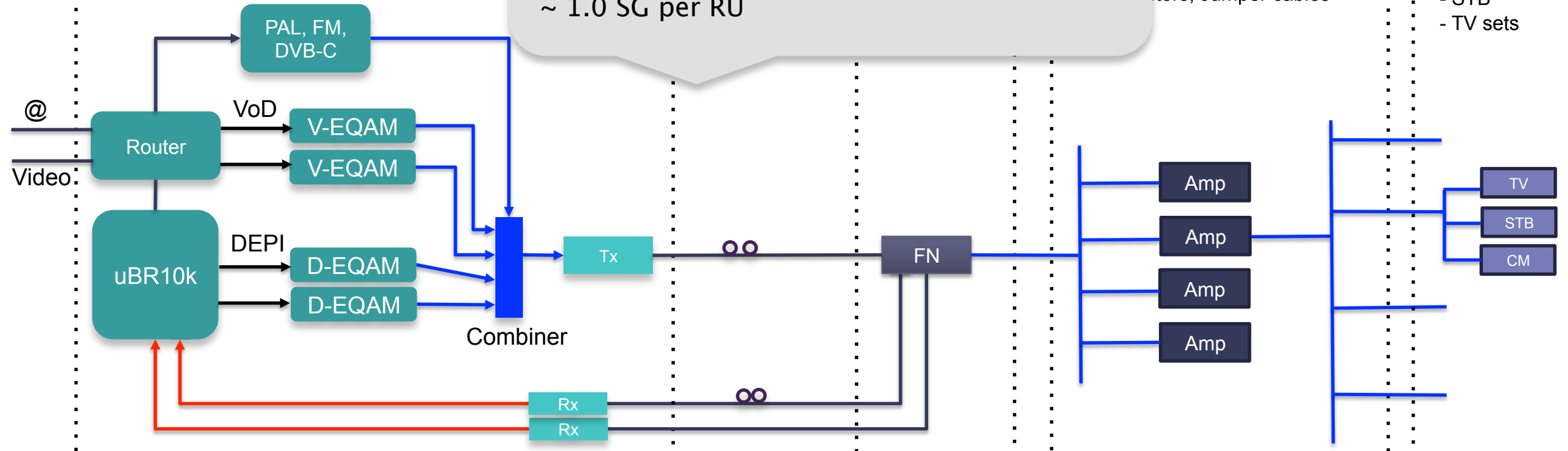


- work
- ers
- S
- ctors, Jumper cables
- Homes
 - Wall outlet
 - Amp
 - CM
 - STB
 - TV sets

M-CMTS

PoP/Hub

Scenario: M-CMTS, 5x20, 6x1G-SPA, 2 uBR, RFGW-1 for VoD and DOCSIS, 9 DS/SG, 8 VoD QAM/SG
 ~ 26 DS QAM per RU
 ~ 1.0 SG per RU

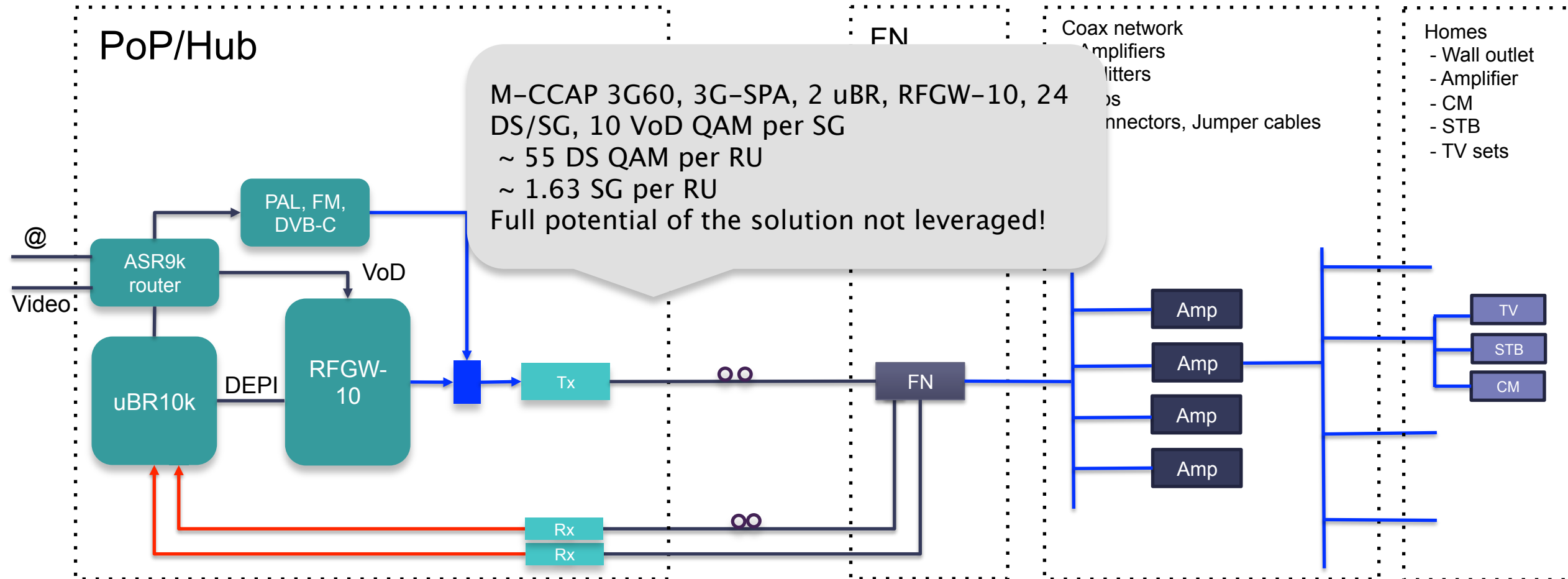


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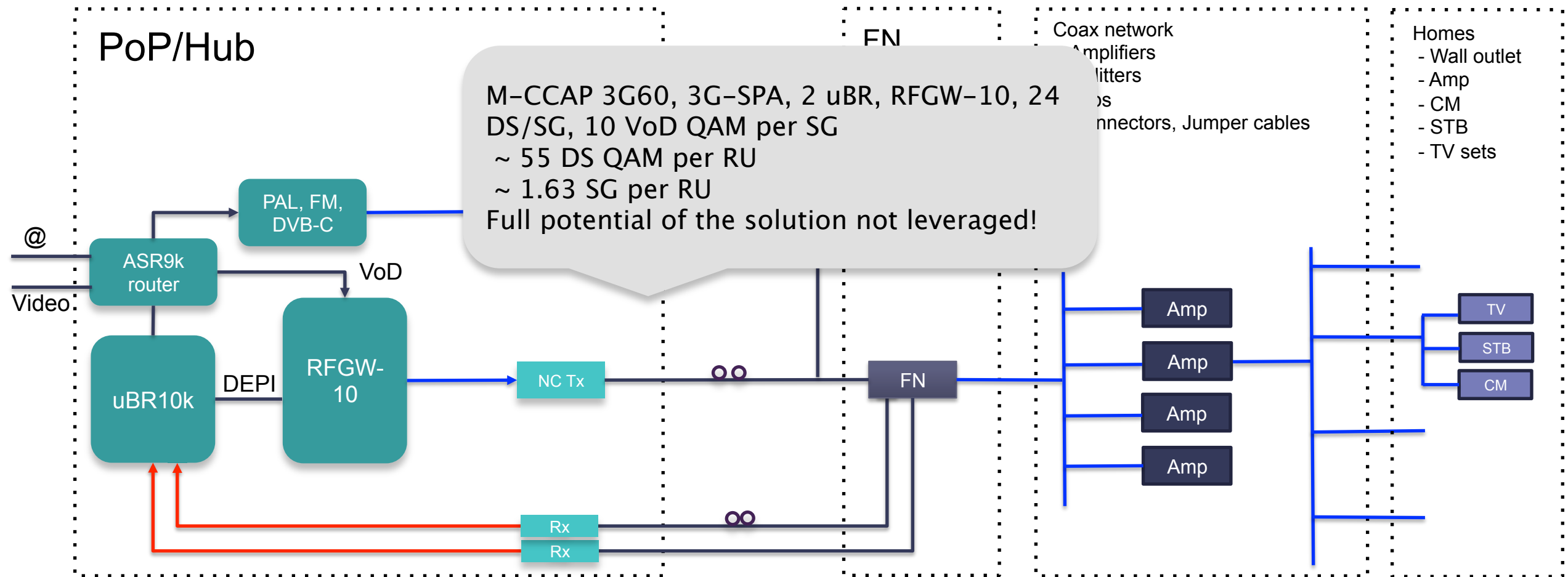
M-CCAP / Unified EQAM, DOCSIS & VoD

One Connector to one SG = Almost No Combining = OPEX Red.



M-CCAP / Unified EQAM, DOCSIS & VoD

One Connector to one SG = No Combining = OPEX Red.



M-CCAP / Unified EQAM, DOCSIS & VoD & DVB-C BC

True One Connector to one SG = No Combining = OPEX Red.

PoP/Hub

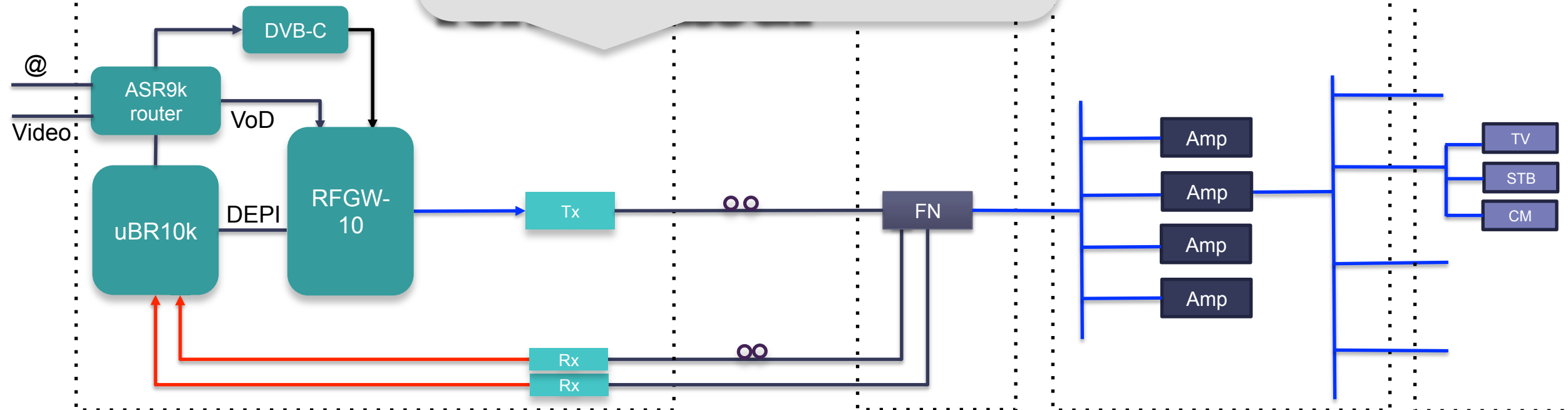
M-CCAP 3G60, 6G-SPA, 2 uBR, RFGW-10 for VoD/DOCSIS/BC, 32 DS/SG, 3 VoD QAM/SG, 30 BC QAM per SG
 ~ 106 DS QAM per RU
 ~ 1.63 SG per RU

Coax network

- Amplifiers
- Splitters
- Taps
- Connectors, Jumper cables
- etc

Homes

- Wall outlet
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Architecture Roadmap

cBR8: Integrated CCAP. Hub-in-a-Box

PoP/Hub

i-CCAP, 1 cBR, 32 DS/SG, 10 VoD QAM/SG,
30 BC QAM per SG
~ 354 DS QAM per RU
~ 5 SG per RU

@, DVB-C BC, VoD

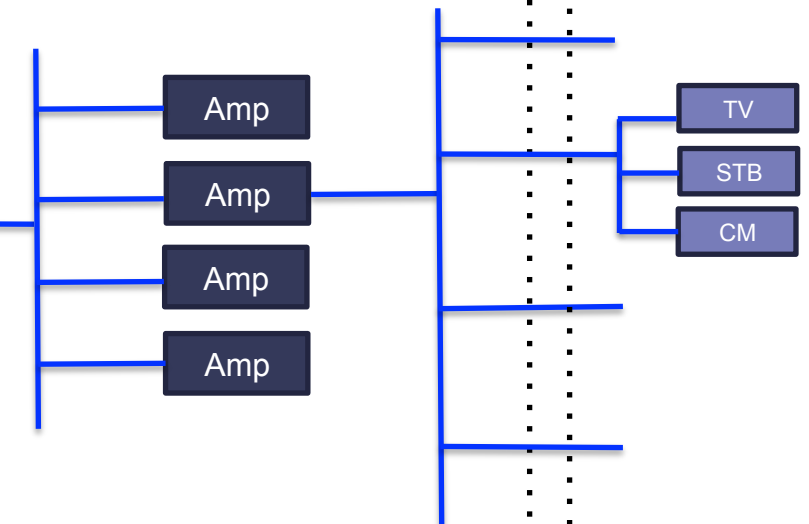


Coax network

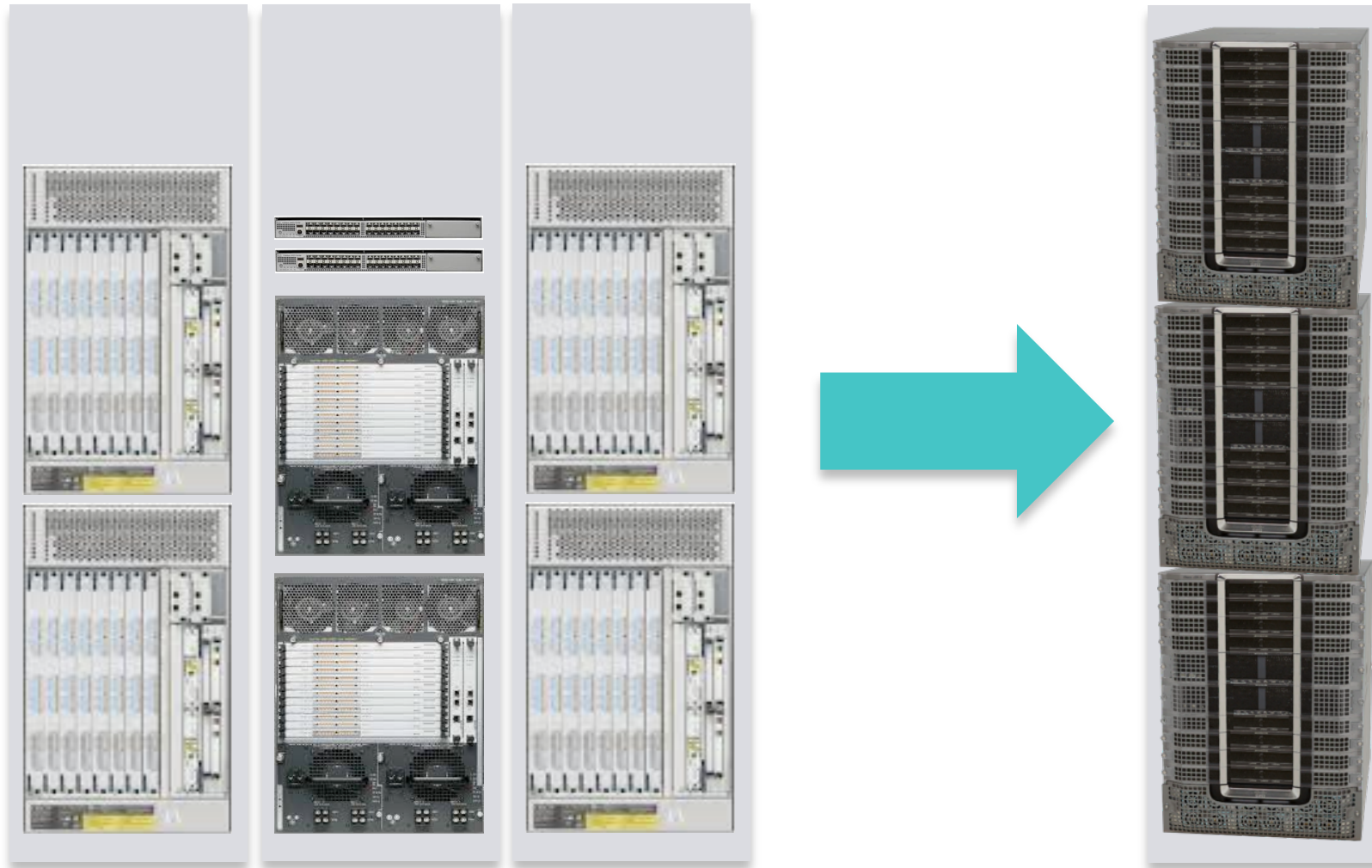
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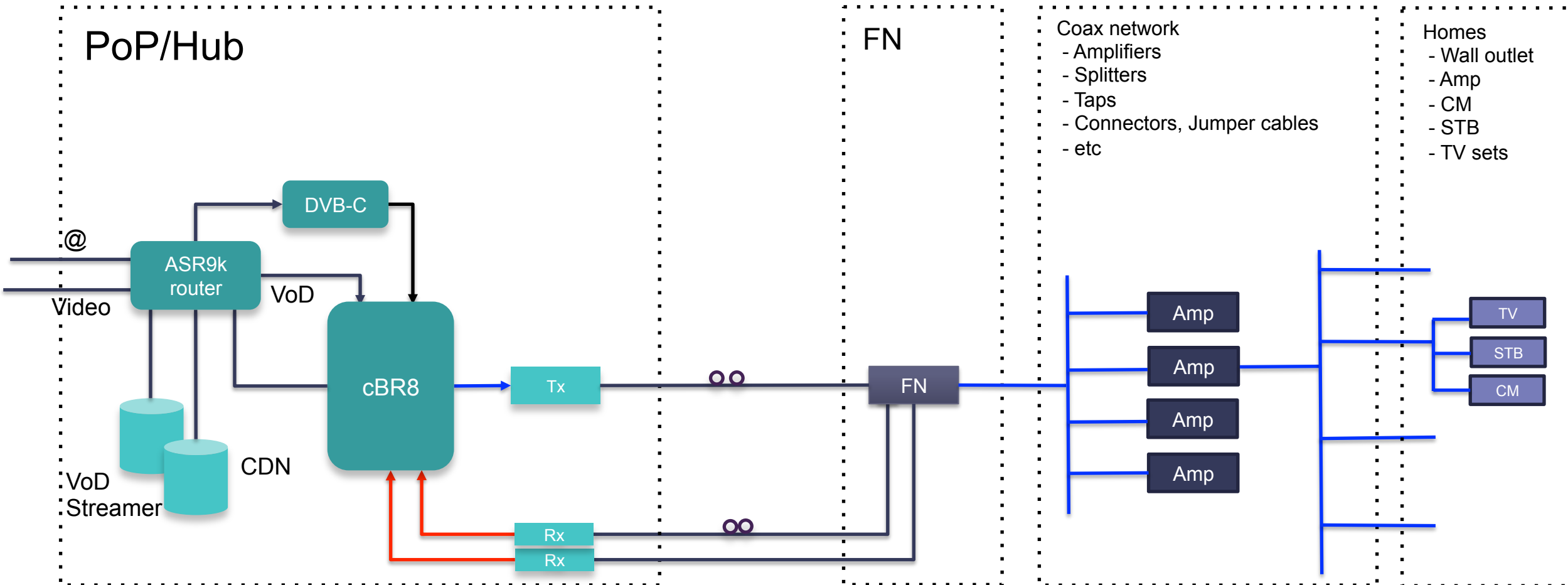


Sample Rack Layout, uBR10k + RFGW-10 -> cBR8 160 SG, 24 or 32 DS/SG

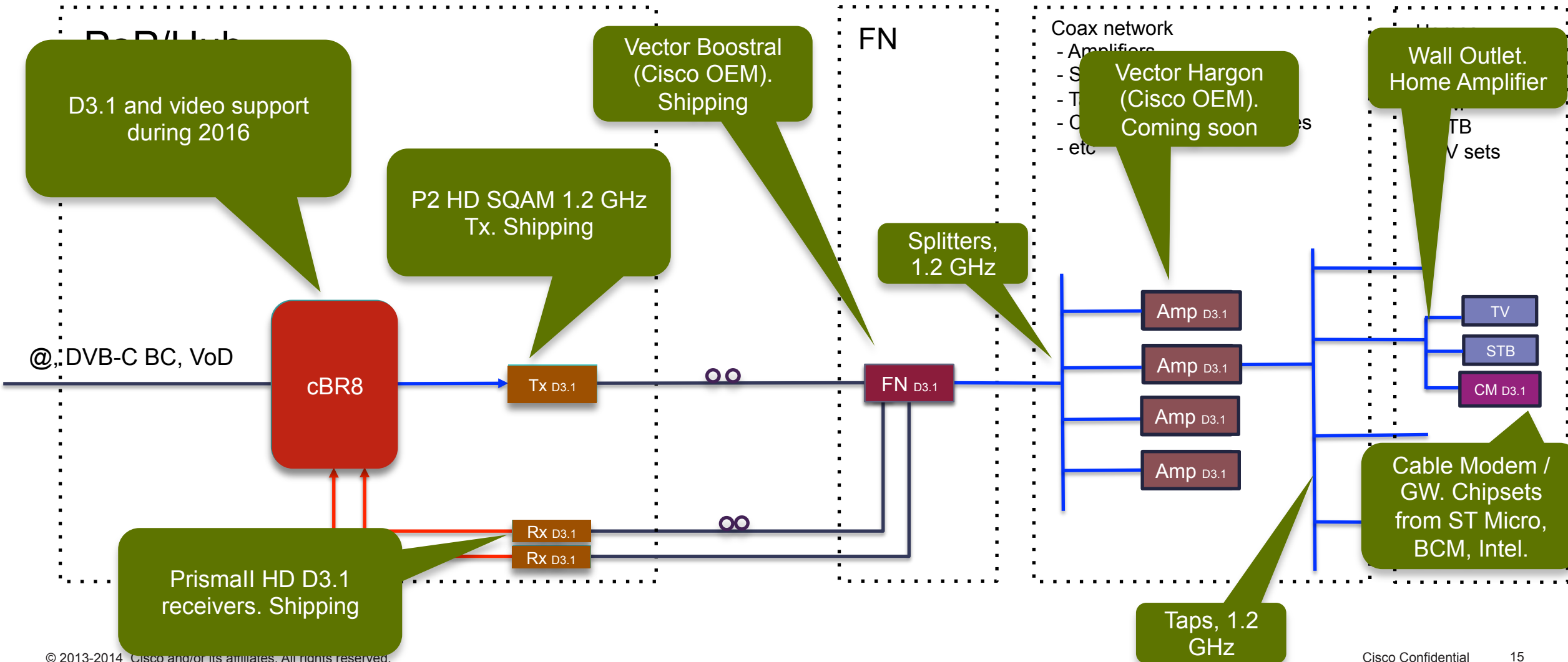


cBR8: Integrated CCAP

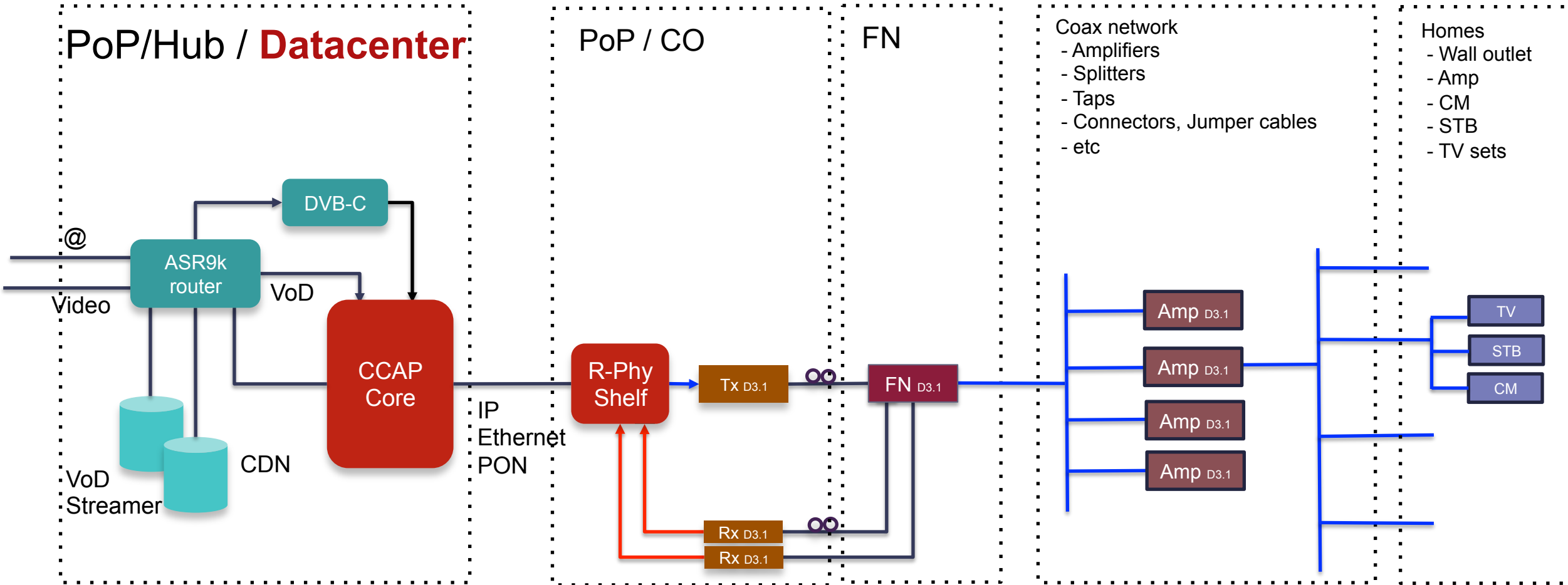
- Probably other components needed anyway



cBR8: Integrated CCAP. Introduction of DOCSIS 3.1



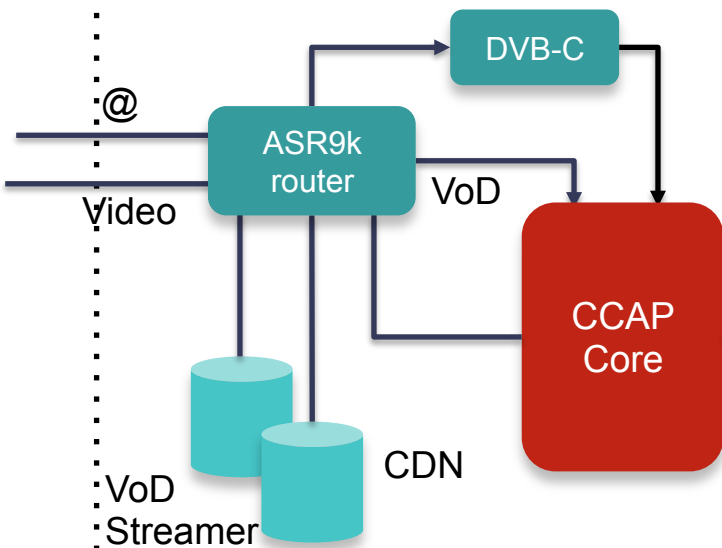
Future: Remote Phy Shelf



Future: Remote Phy Node

PoP/Hub / **Datacenter**

- ✓ Enables Centralization of Complex functions
- ✓ Enables Hub site Consolidation
- ✓ Enables virtualization (NFV)
- ✓ Better enables D3.1 high modulation schemes (QAM4096)
- ✓ Simplification – one network down
- ✓ Better Utilization of fibers and optics (more WL's per fiber)
- ✓ OPEX reduction

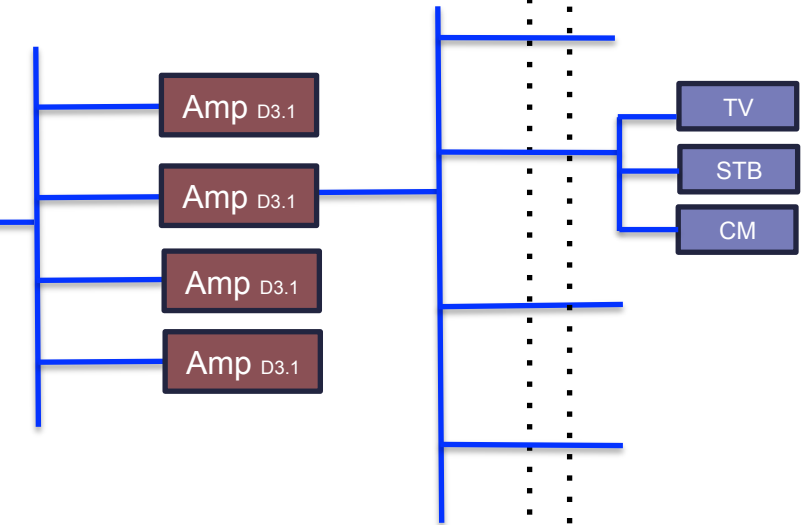


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DOCSIS 3.1

DOCSIS 3.1 in short

More info: CableLabs DOCSIS 3.1 Pocket Guide

- OFDM - Orthogonal frequency-division multiplexing
- LDPC - Low Density Parity Check
- US: QAM128, QAM256, QAM512, QAM1024
- DS: QAM512, QAM1024, QAM2048, QAM 4096
- US Lower Band Edge: 5 MHz. Upper Band Edge: 42, 65, 85, 117 or 204 MHz.
- US channel width: Up to 96 MHz => Max 2 96 MHz channels ~ 1.2 Gbps @ QAM256 / 204 MHz upper (Gross)
- DS Lower Band Edge: 108 MHz (should), 258 MHz (must). Upper Band Edge: 1GHz, 1.2 GHz
- DS channel width: 24 - 192 MHz, Up to 6 channels ~ 9 Gbps @ QAM1024 (Gross)

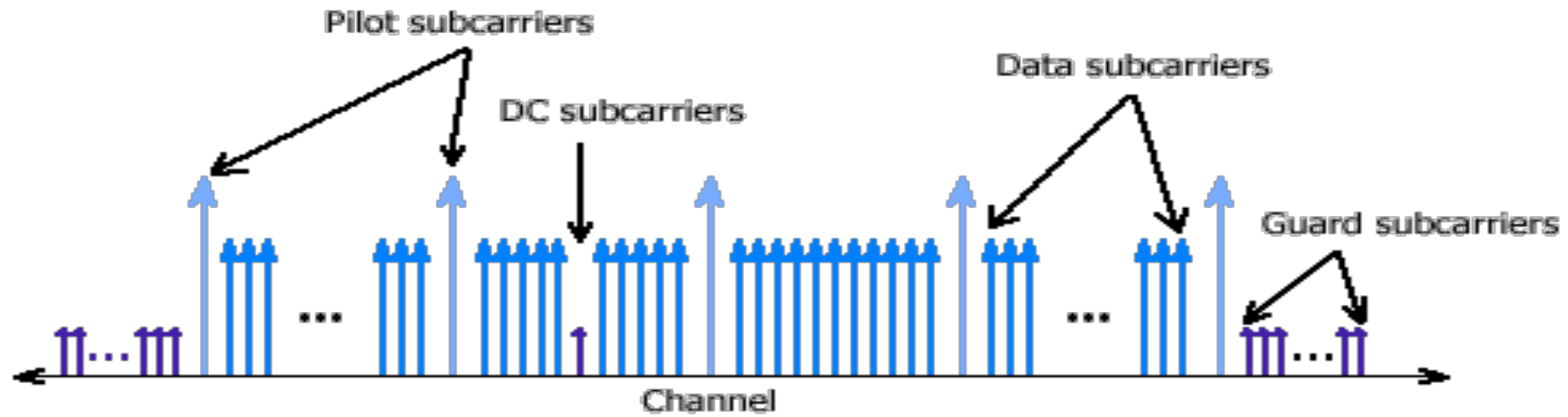
Technology Potential of DOCSIS 3.1

	DOCSIS 3.0		DOCSIS 3.1		
	Now	Phase 1	Phase 2	Phase 3	
DS Range (MHz)	54 - 1002	108 - 1002	254* - 1200	500* - 1700	
DS QAM Level	256	256	≥ 1024	≥ 1024	
# DS Channels	8	24	158**	200**	
DS Capacity (bps)	300M	1G	7G*	10G+*	
US Range (MHz)	5 - 42	5 - 85	5 - 85	5 – 200*	5 – 400*
US QAM Level	64	64	≥ 256	≥ 256	≥ 1024
# US Channels	4	12	12**	32**	60**
US Capacity (bps)	100M	300M	400M*	1G*	2.5G*

Note: * shows the value to be determined

is equivalent to numbers of single carrier QAMs

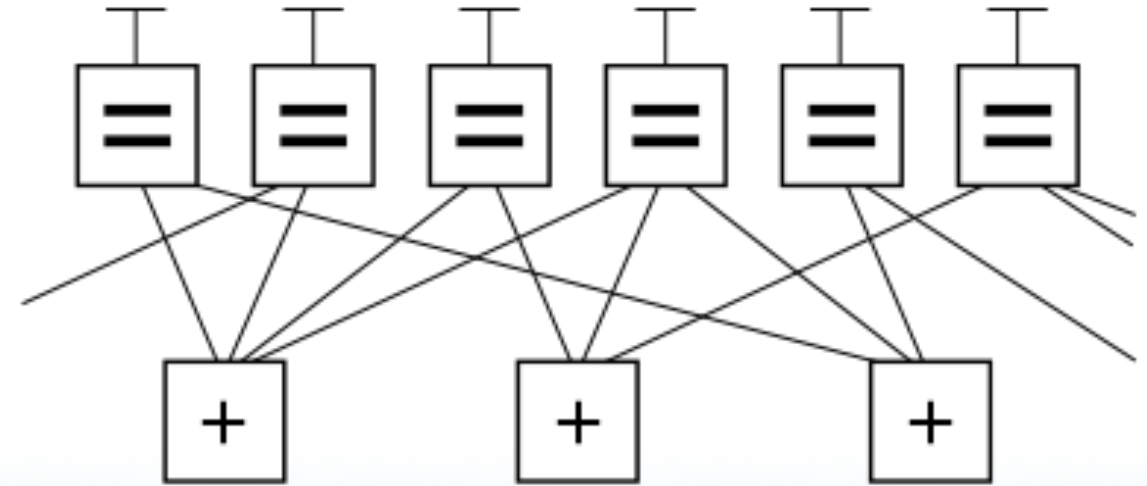
OFDM



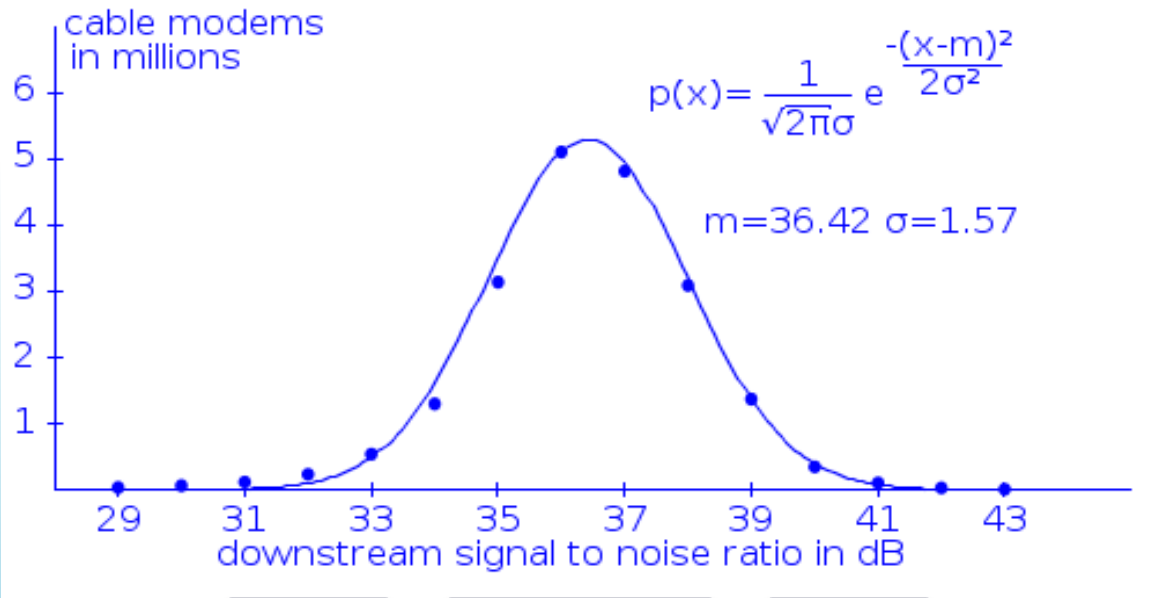
- Orthogonal Frequency Division Multiplexing is a large collection of very narrow QAM subcarriers.
- Sub-carriers are grouped into an “OFDM Channels” which are processed by an FFT.
 - Example block size is 192 MHz.
 - For example, a 2x1 CM could be 384 MHz DS, 192 MHz US.

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 1960.
 - Could not be implemented in HW until recently.
 - More robust than Reed-Solomon.



Downstream Profiles



Worst
Case

Average
Case

Best
Case

- The HFC plant has at least an 8 dB variation in CNR across the plant.
- Multiple downstream profiles could enable operators to leverage SNR variation to improve system capacity
- An example with four profiles:
 - A: Worst (say mostly 256-QAM)
 - B: Average (say mostly 1K-QAM)
 - C: Better (say mostly 2K-QAM)
 - D: Best (say mostly 4K-QAM)

Estimated Gross BW (Mbps) available with DOCSIS 3.1

Downstream	D3.0 BW / MHz	D3.1 BW / MHz	Increase %	D3.1 BW / 96 MHz	D3.1 BW / 192 MHz
QAM256	6,25	6,51	4,21%	625,27	1250,55
QAM512		7,03	12,49%	674,97	1349,94
QAM1024		8,14	30,28%	781,68	1563,37
QAM2048		8,96	43,30%	859,83	1719,66
QAM4096		9,77	56,33%	937,97	1875,95

Upstream	D3.0 BW / MHz	D3.1 BW / MHz	Increase %	D3.1 BW / 96 MHz	D3.1 BW / 192 MHz
QAM64	4,69	4,88	4,21%	468,92	937,85
QAM256		6,51	38,95%	625,27	1250,55
QAM512		7,03	49,99%	674,97	1349,94
QAM1024		8,14	73,71%	781,68	1563,37

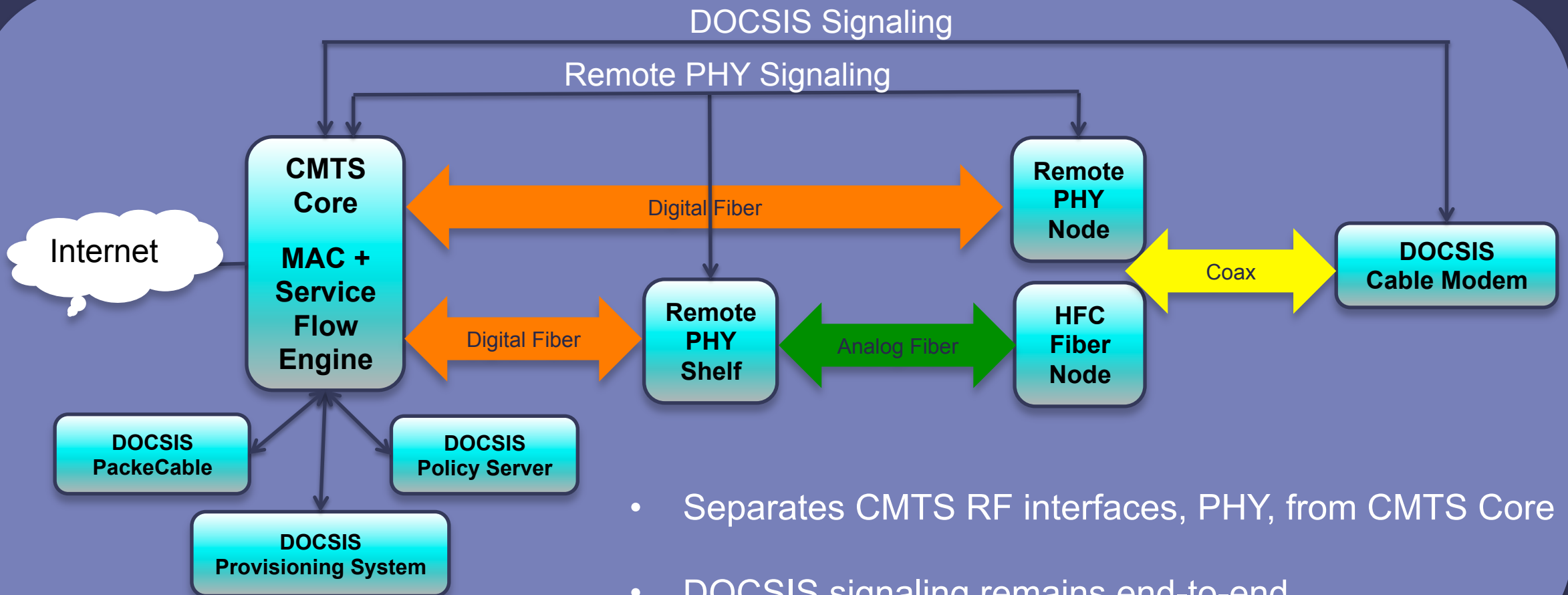
Estimates!

More Information

- CableLabs DOCSIS 3.1 Pocket Guide:
http://www.cablelabs.com/wp-content/uploads/2014/12/DOCSIS3-1_Pocket_Guide_2014.pdf
- CableLabs D3.1 Specification Library:
<http://www.cablelabs.com/specs/specification-search/?cat=docsis&scat=docsis-3-1>

R-Phy

Remote PHY Concept



- Separates CMTS RF interfaces, PHY, from CMTS Core
- DOCSIS signaling remains end-to-end

Remote PHY Shelf

Where does it fit?

- Consolidation of Small Hubs to a Central CCAP CMTS without the need to run analog optics to/from the central CCAP CMTS
 1. Better Density, Lower Power, Lower CAPEX
 2. Networkable Deep Digital Fiber between hubs and core CCAP system
 3. Expands the effective number of ports on the CMTS by 2x – 4x

How is this Different from M-CMTS?

- Internal Switching in CMTS Core
- Internal Timing in CMTS Core – no DTI timing required
- DS & US PHY are in external shelf

Remote PHY Standards update

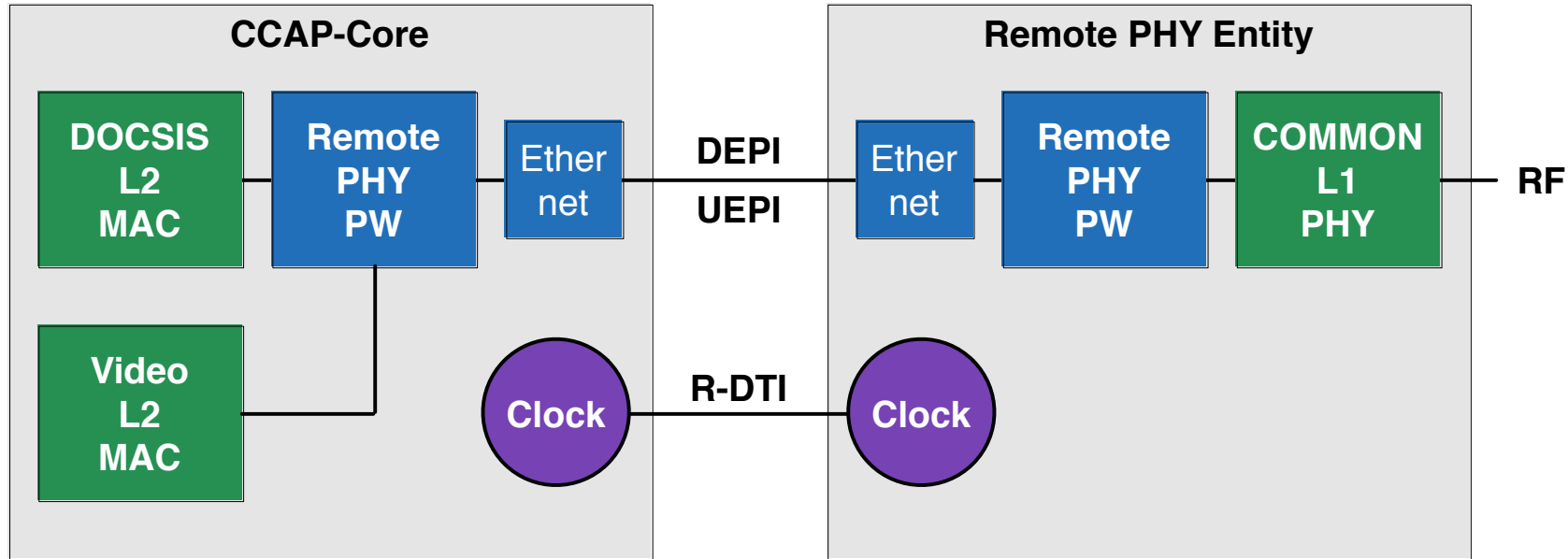
- Cisco is leading an international private standardization effort on the Remote PHY interface specifications
 - 2 CMTS Vendors
 - 7 Silicon Vendors
 - 14 customers
- The results will be given to CableLabs for public standardization
 - CCAP will write a product specification for Remote PHY Node
- Supports
 - DOCSIS 3.1, MPEG Video, OOB, and Spectrum Management
- Phase 1 Specifications
 - DEPI
Downstream DOCSIS PHY Interface
 - UEPI
Upstream DOCSIS PHY Interface
 - R-DTI
Remote DOCSIS Timing Interface
- Phase 2 Specifications
 - Authentication
 - Boot Procedure
 - Provisioning

Comparing Approaches

Criteria	BDR/BDF	Remote PHY	Remote MAC	Remote CMTS
IP Network	No	Yes	Yes	Yes
I-CCAP Impact	Low	Low	High	Medium
Remote SW	Losing Traction 0%	5%	50%	100%
Remote HW	10%	20%	40%	100%
Reliability	Highest	High	Medium	Low
Channels/10G	77	256	256	256

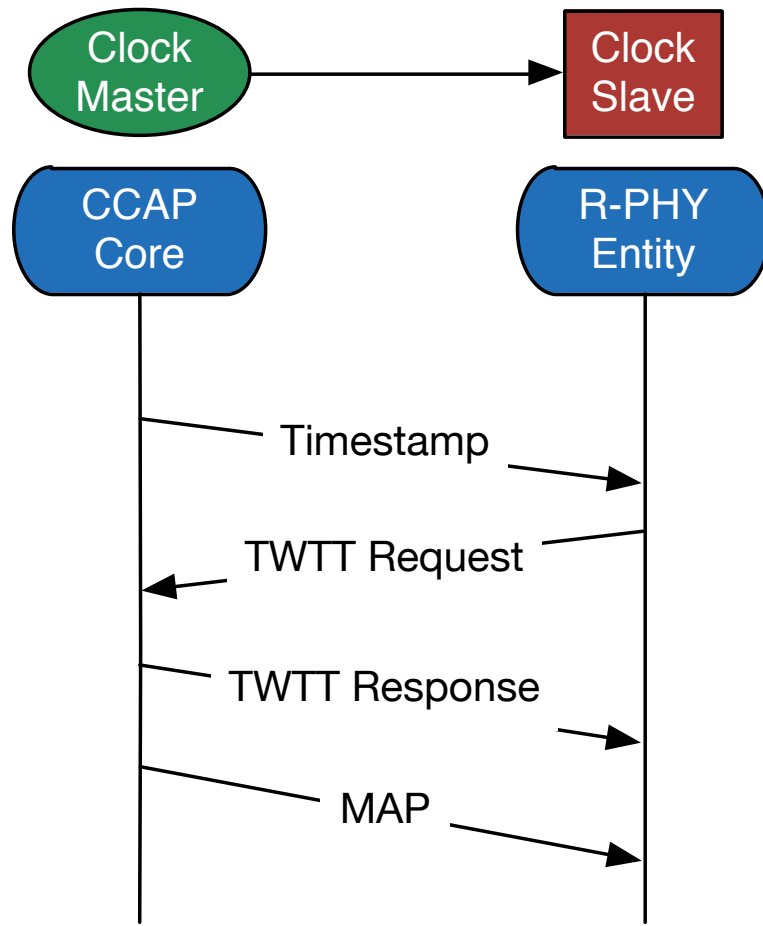
- Remote PHY uses the MAC/PHY chip boundary
- Remote PHY == centralized software
- Simplicity is remoted; complexity is centralized.

CCAP with Remote PHY



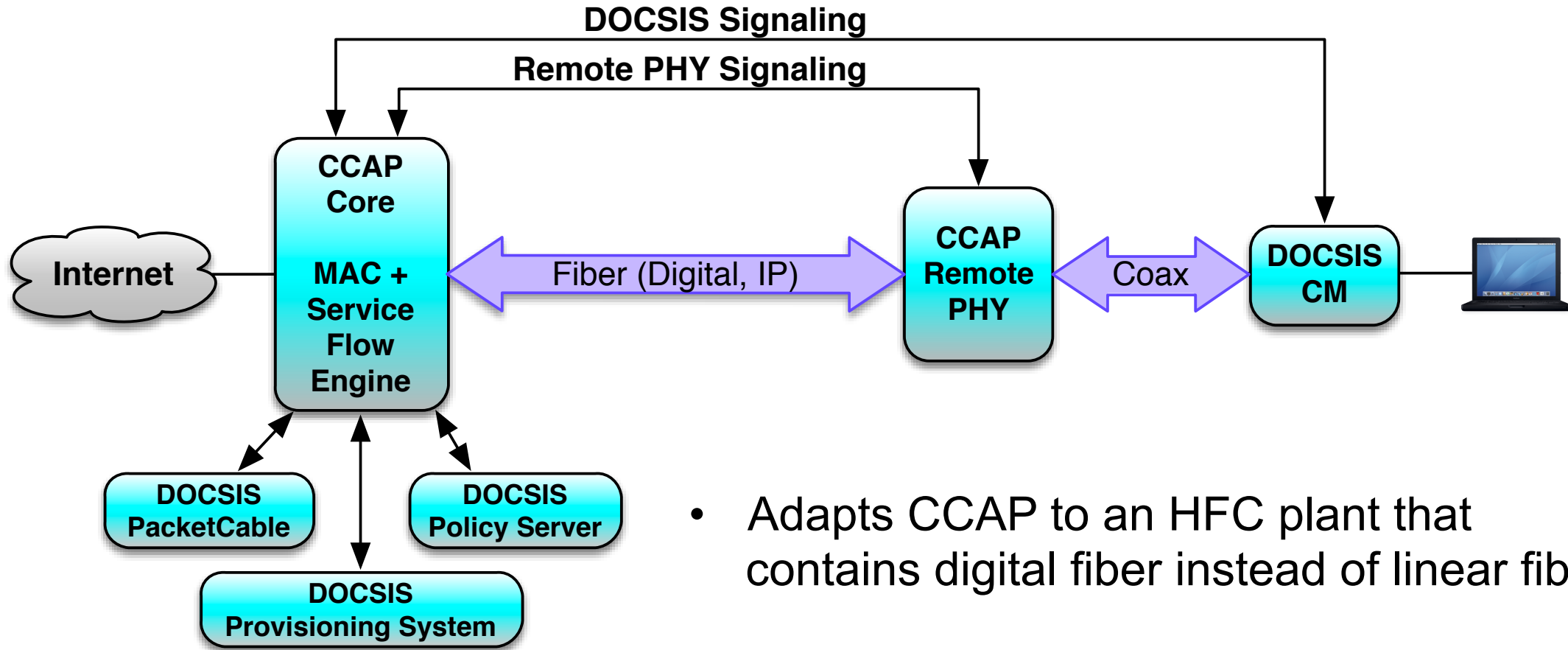
- The CCAP PHY chip is remotely located and connected by a pseudowire
- DEPI is the downstream pseudowire (PW)
- UEPI is the upstream pseudowire (based on DEPI)
- Remote DTI manages transfer of time and frequency

R-DTI



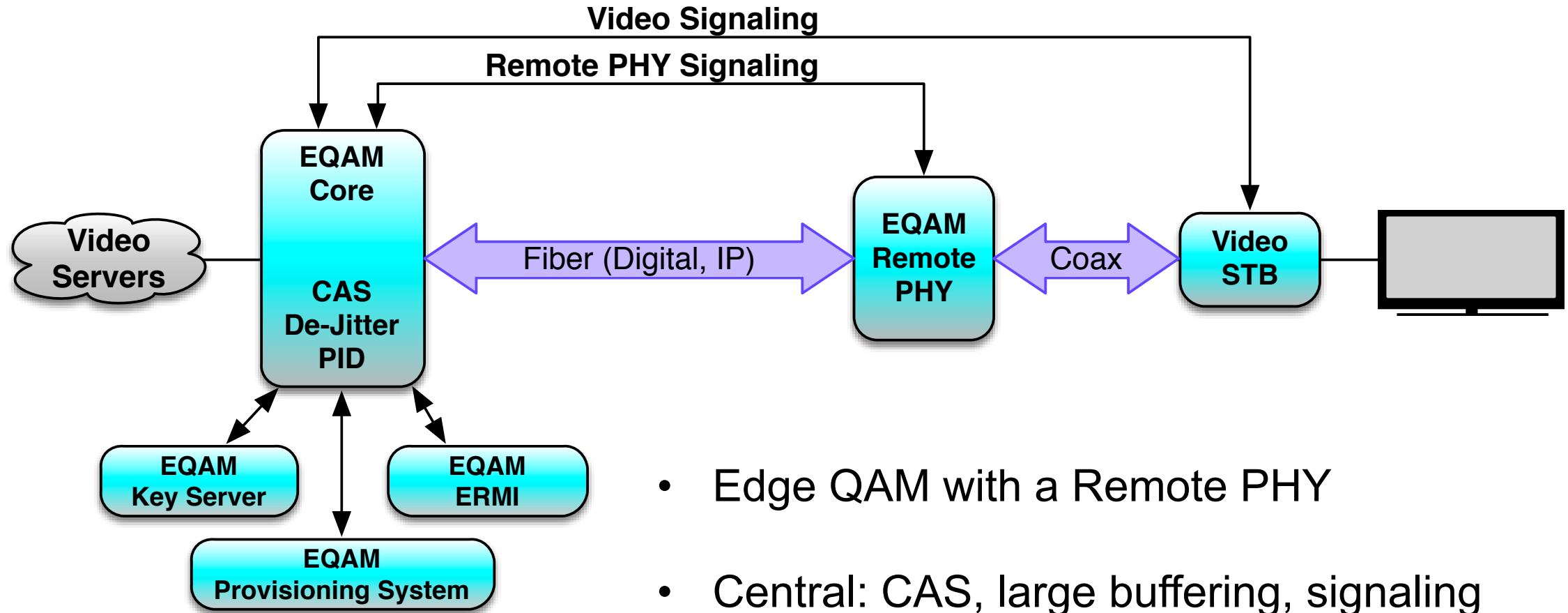
- Remote DOCSIS Timing Interface
 - Different protocol than DTI
- Primary approach is IEEE-1588.
 - DOCSIS 3.1 defines 1588 and DOCSIS relationship
- Other timing approaches include:
 - Synchronous Ethernet
 - CCAP-Core slave mode

Remote PHY for CCAP



- Adapts CCAP to an HFC plant that contains digital fiber instead of linear fiber
- DOCSIS signaling remains end-to-end

Remote PHY for Video



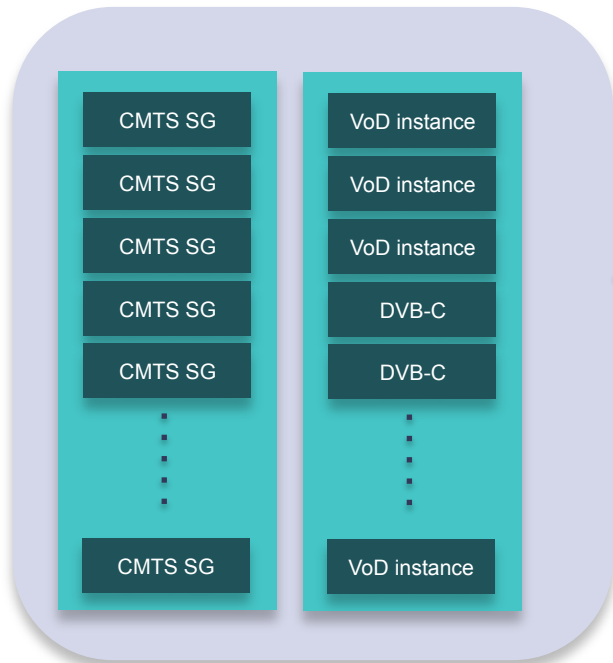
- Edge QAM with a Remote PHY
- Central: CAS, large buffering, signaling
- Remote: QAM PHY, small buffering

Benefits of R-Phy

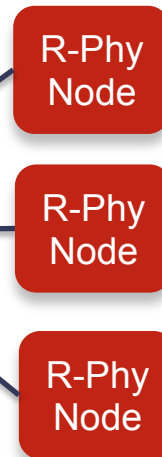
- Flexibility concerning number of SG supported by the central unit (cBR8)
 - Cancel out the limitation: Number of Phy ports on i-CMTS / i-CCAP
- Eliminate the analog optical network and converge into the IP/MPLS network already present = OPEX reduction
- Scalability: Enable centralization of the MAC and L3 capacity. Thus those will be a common pool of resources over many Service Groups. (Economy of scale)
- Better enable higher modulation schemes (QAM4096 DS).
 - More bits per Hertz = more BW capacity
- Higher reliability (Multiple paths through IP infra, Dual 10G interfaces)
- Enable the introduction of NFV and SDN

R-Phy with NFV

Datacenter

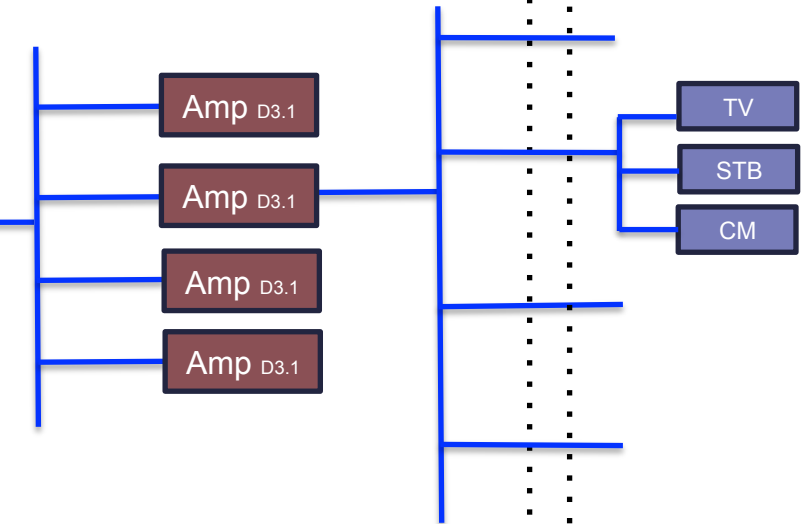


FN



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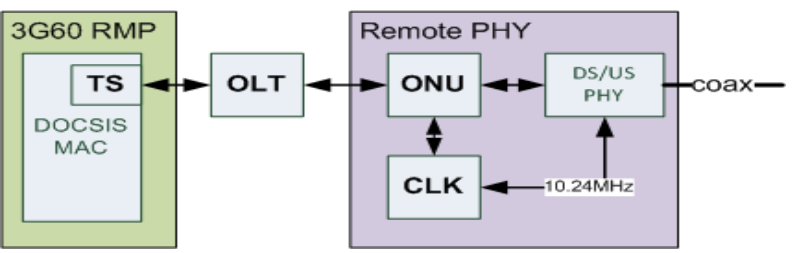
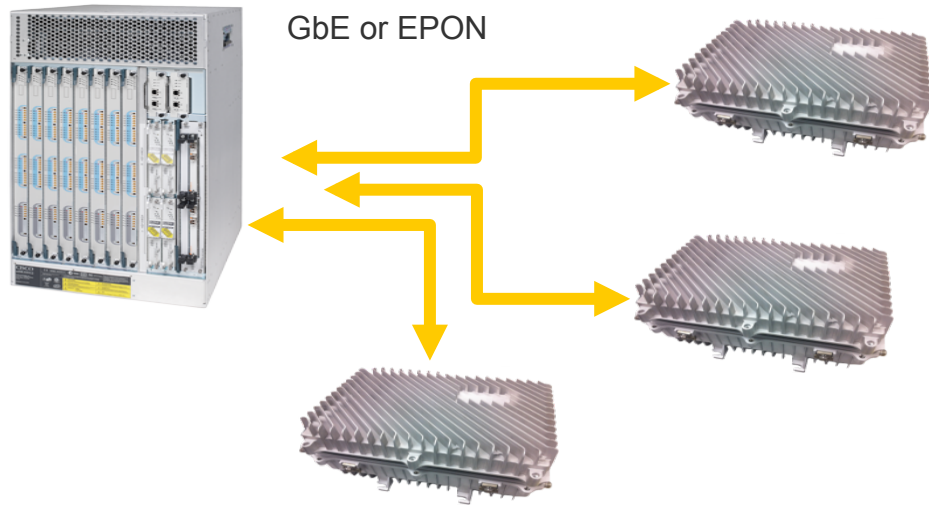
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Remote PHY – CMC Solution for uBR10k

- Central CMTS managing multiple distributed CMC's
- CMC slaved to and configured by the uBR10k
- CMC to look like modular cable interfaces to the uBR10k
 - DS configured as per current practice for modular cable interfaces
 - US config will be new but assigned to MAC domain as per modular DS
 - All DS/US stats collected by the uBR10012

Available with
uBR10k and
CMC 16x4



* Part of C-DOCSIS architecture

More information

- Remote PHY for Converged DOCSIS, Video, and OOB White Paper:
<http://www.cisco.com/c/en/us/solutions/collateral/service-provider/converged-cable-access-platform-ccap-solution/white-paper-c11-732260.html>
- CableLabs R-Phy Spec Library – 8 specs:
<http://www.cablelabs.com/specs/specification-search/?cat=docsis&scat=dca-mhav2>
- Data-Over-Cable Service Interface Specifications, DCA-MHAv2, Remote PHY Specification, CM-SP-R-PHY-I01-150615:
http://www.cablelabs.com/wp-content/uploads/specdocs/CM-SP-R-PHY-I01_150615.pdf
- **Remote MAC-PHY Technical Report, Version V01:**
<http://www.cablelabs.com/specification/remote-mac-phy-technical-report/>

NFV & SDN

Business Priorities For The MSOs' Data Businesses

Increase Revenue



Deliver more attractive services faster

- Business services – more complex & more demanding
- Consumers - Make customers lives simpler and richer
- Business agility & service velocity whilst reducing costs

Applications

Rapid Creation & Deployment

Drive Operational Speed & Efficiency



Orchestrate, Automate, Simplify

- Speed – reduce provisioning intervals to hours or days – “devops for the network”
- “Cross-domain” management fast and error free for business services and more
- From managing configurations to managing services

Orchestration

Automation, SDN, NFV and Policy

Stay Ahead of Competition



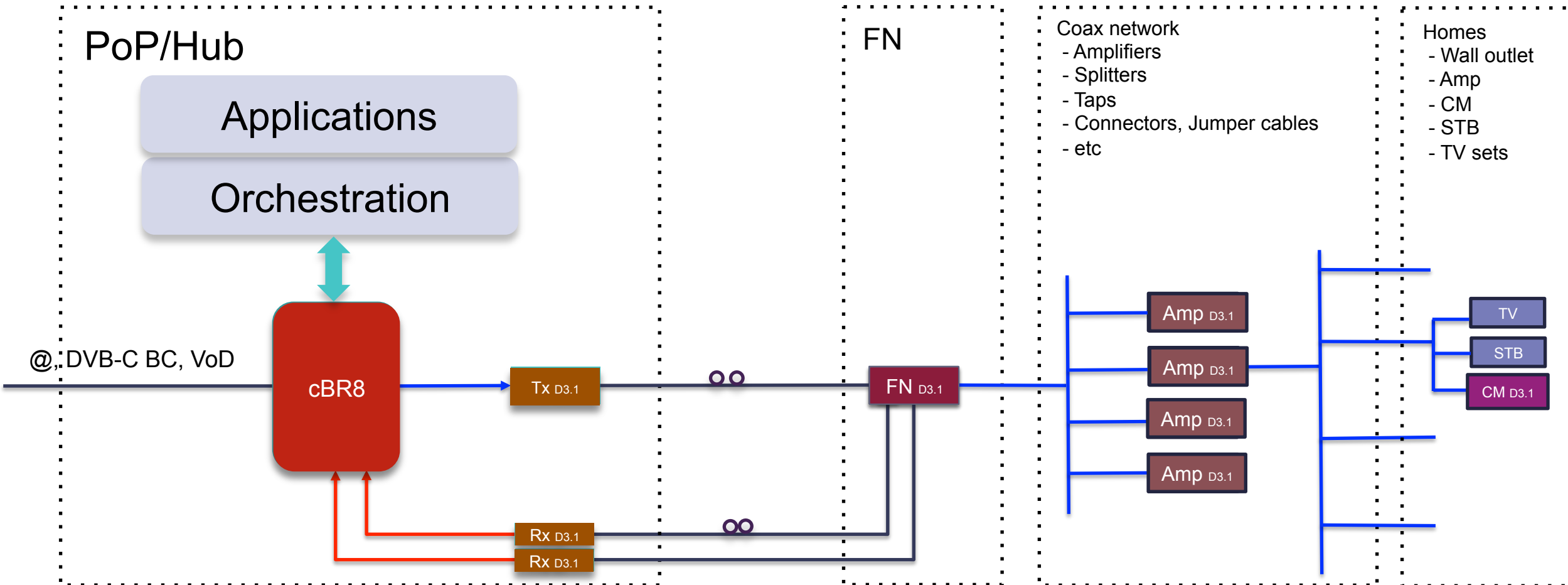
Deliver More - with Less

- Deliver faster internet tiers every year
- 10X bandwidth growth over 5 years challenges space, power & TCO

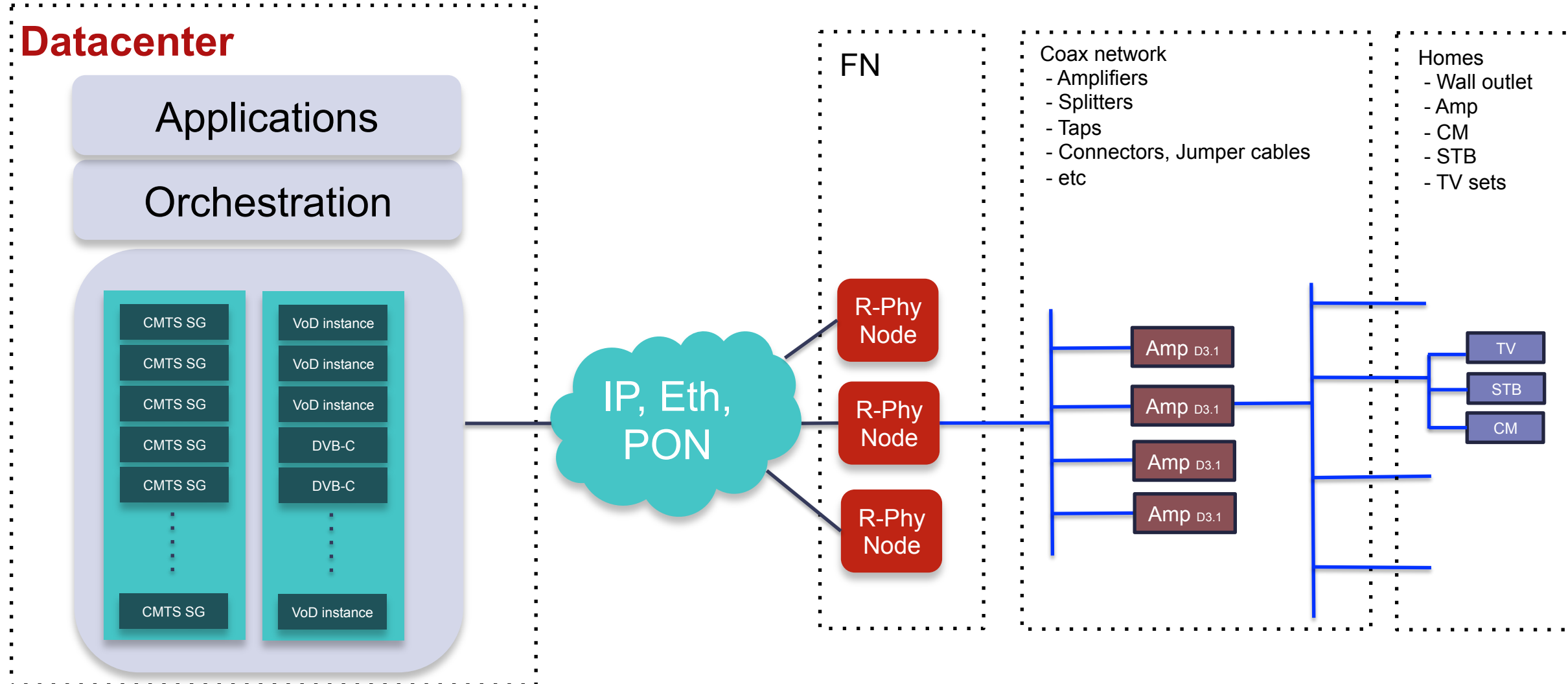
Infrastructure

Physical and Virtual Resources

cBR8: Integrated CCAP. Introduction of DOCSIS 3.1



NFV: Network Function Virtualization



Summary

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- Architecture History: From i-CMTS over M-CCAP and I-CCAP to R-Phy
- Cisco E2E D3.1 Solution
- cBR8 full support for D3.1 on all ports
- D3.1 capabilities and capacities
- R-Phy enabling NFV, Simplification, More bits/Hz, OPEX reductions
- SDN enables Automation and Programmability -> Shorter TTM for applications & ops-tools as well as reduced OPEX

Thank you.

