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OCTOBER 17-20

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Network Migration Strategies for the Era of DAA, DOCSIS 3.1, and New Kid on the Block…Full Duplex DOCSIS!

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SCTE·ISBE CABLE-TEC EXPO 2017
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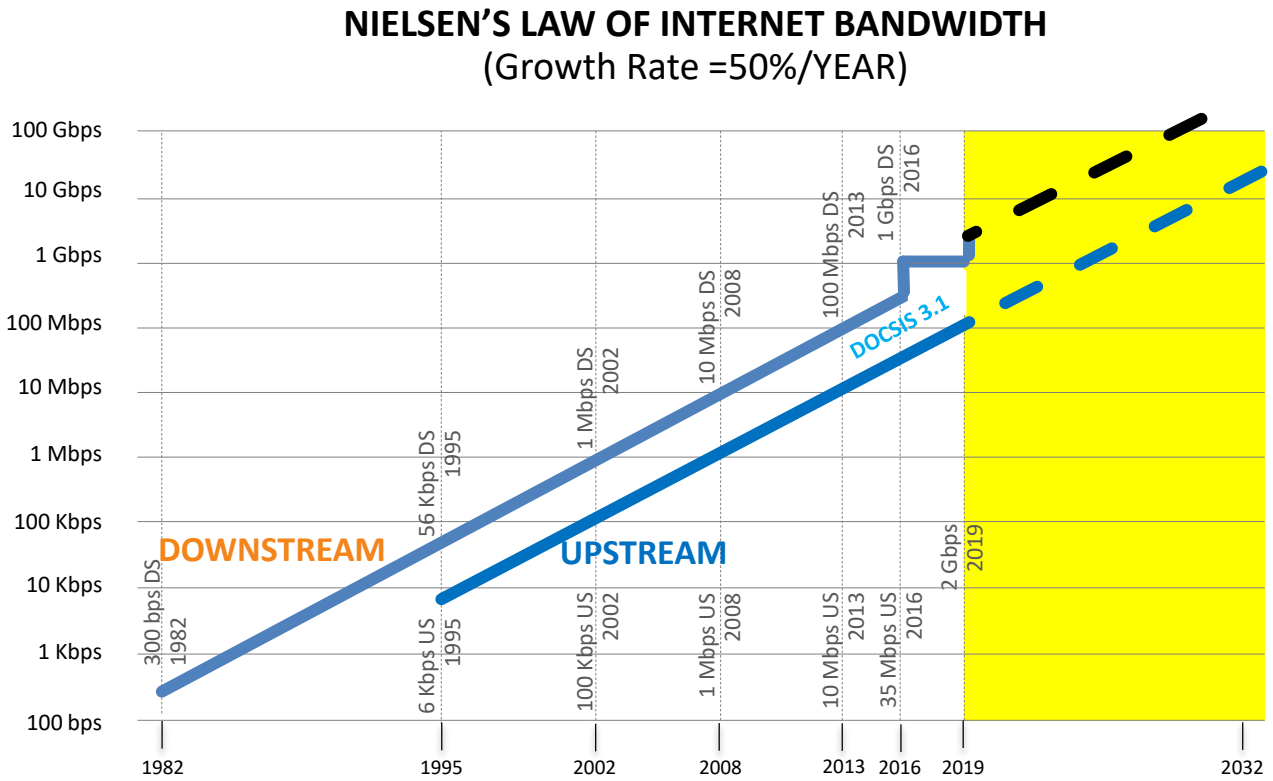
Agenda

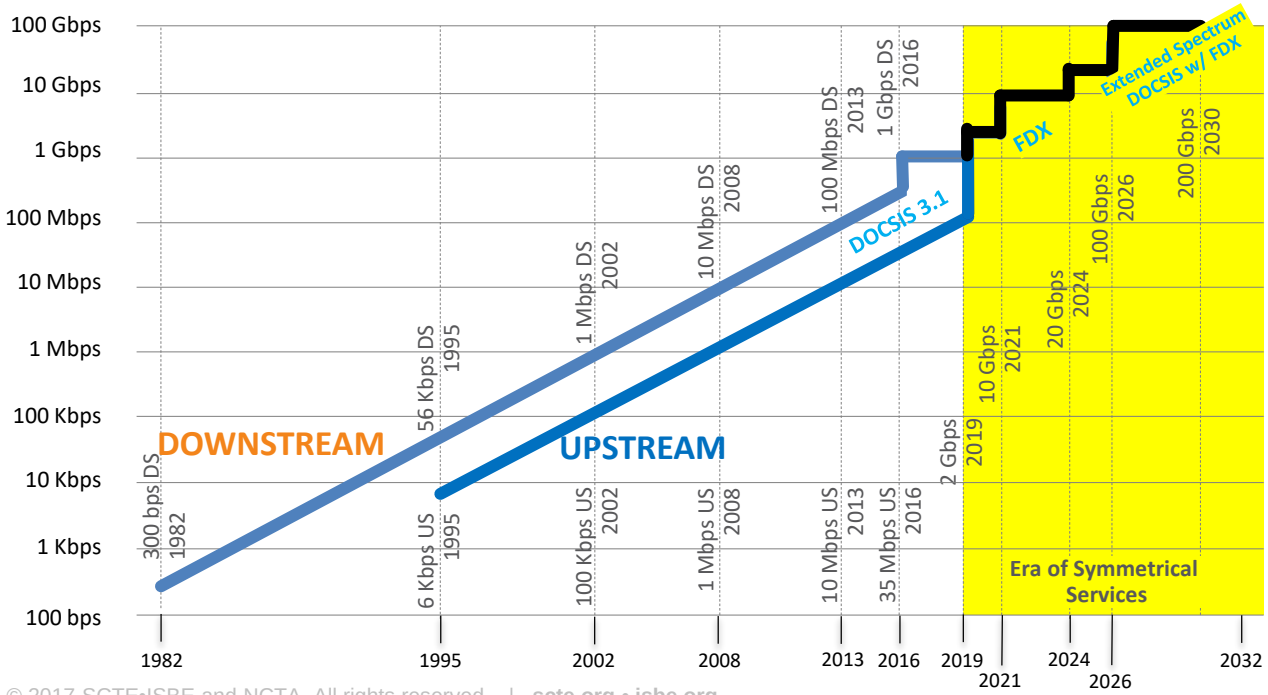
- **Drivers Behind Gigabit per Second Services**
- Technology Enablers Supporting BW Expansion
- Alternative Network Migration Paths



Large Quantities of Bandwidth (Upstream & Downstream) must be supported in the coming 15+ years

Re-Use of Existing HFC Investment Is Desirable, so MSOs will lean on many DOCSIS & HFC Plant Upgrades

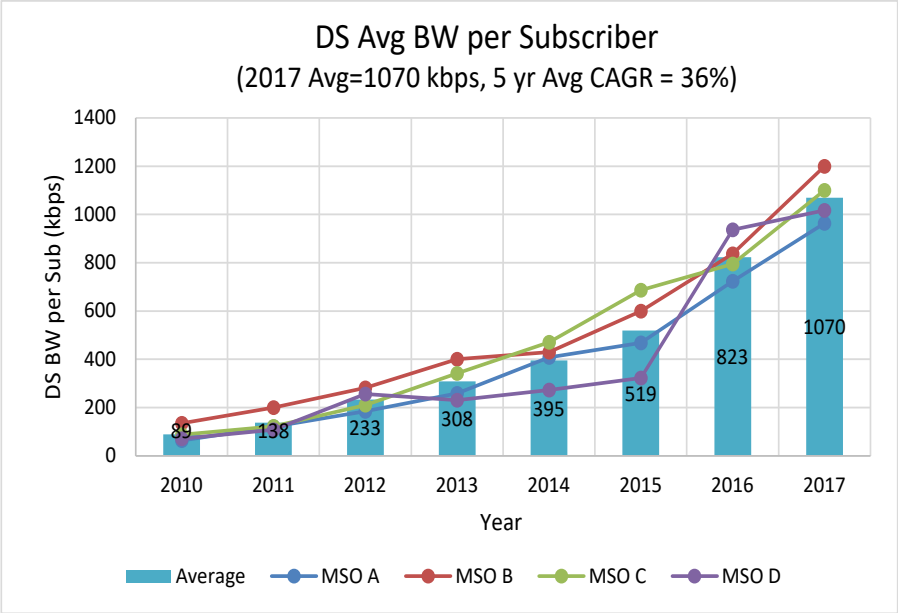
NIELSEN'S LAW OF INTERNET BANDWIDTH
(Growth Rate =50%/YEAR)



Entering the Era of Symmetrical Services

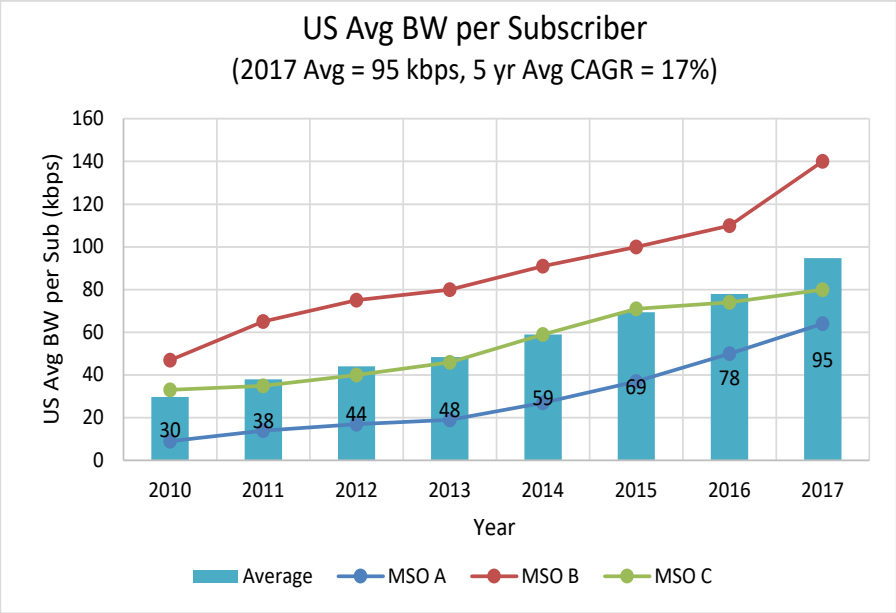
This results in a step function in the US BW

New Technologies (such as FDX) will be required & MSOs can select different paths



Recent MSO BW DS Trends

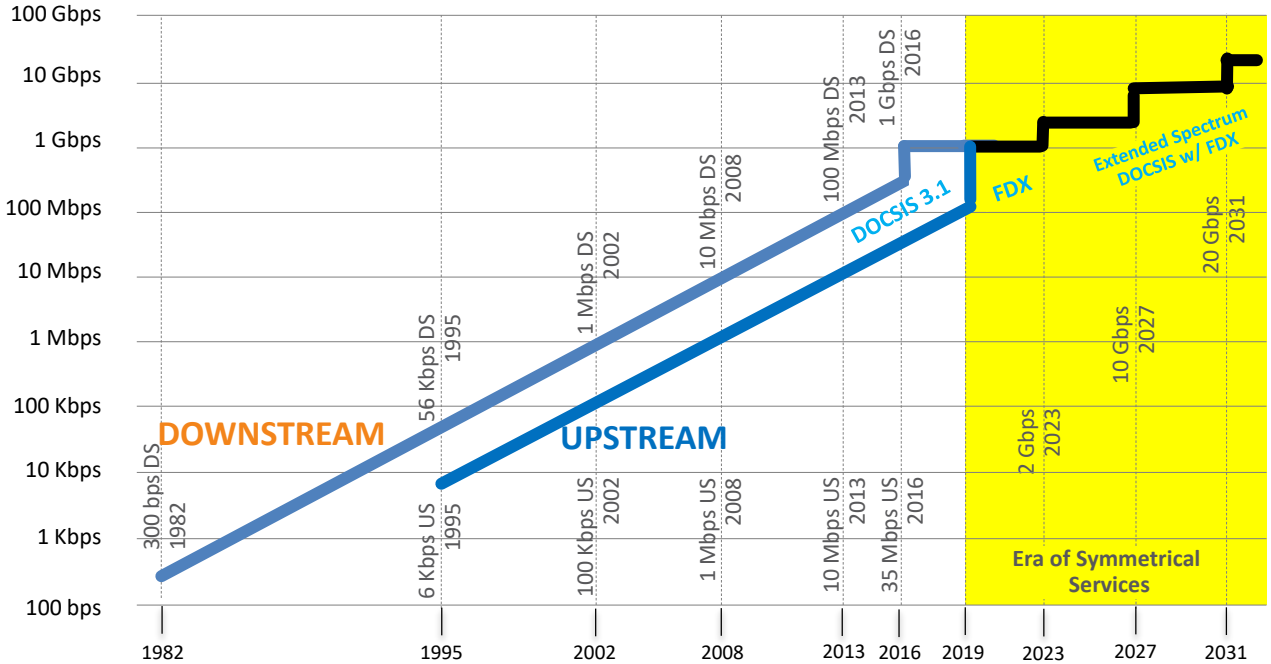
- DS Tavg passes 1Mbps in 2017
- DS Tavg CAGR below 40%
  - Not quite doubling every other year



Recent MSO BW US Trends

- US Tavg almost 100Kbps in 2017
- US Tavg CAGR below 20%
  - Doubling every ~4-5 years
  - For Network Capacity planning, typically use 20% to double every 4 years

NIELSEN'S "SLOWED" LAW OF INTERNET BANDWIDTH
(Growth Rate =40%/YEAR)



Slowing Growth Rate May Extend the Lifetime of the HFC Plant

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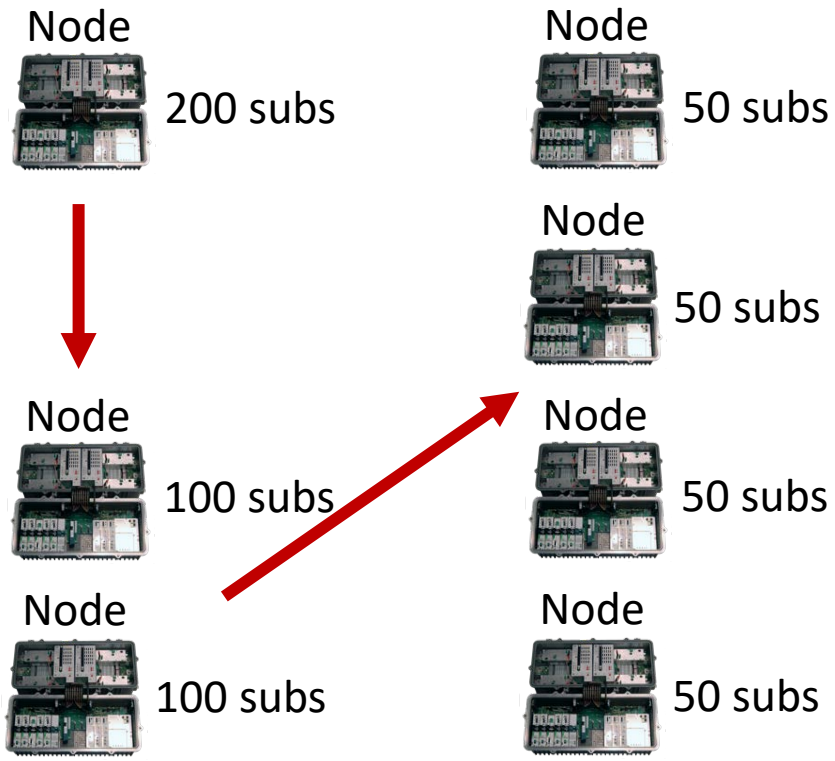
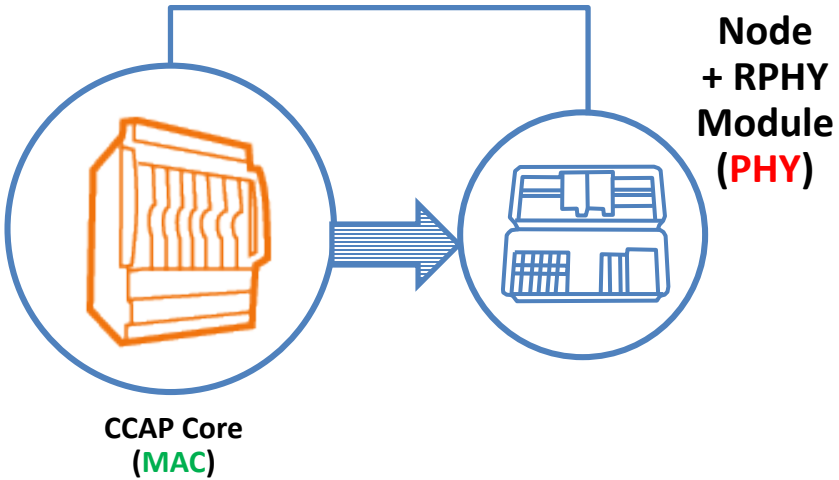


Nodes Splits and Fiber Deep

- Node Splits reduce number of subscribers per node
- Increases available BW per subscriber

- Fiber Deep eliminates noise contribution of amplifiers
- Fiber Deep enables Full Duplex DOCSIS



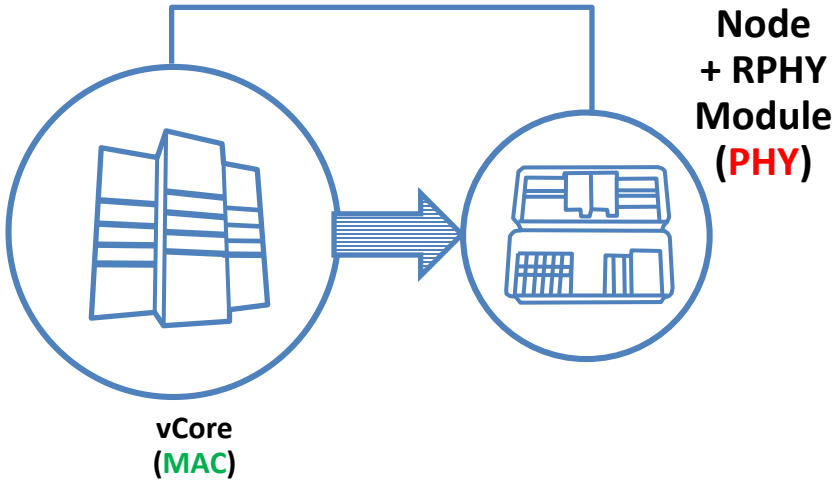
MAC = Packet-level processing
PHY = Bit-to-RF level processing

Distributed Access Architectures

CCAP Core / RPHY

Benefits:

- Uses digital optics to nonlinear optical noise problem
- Low Rackspace in HE
- Low Power in HE
- Existing HE equipment can be repurposed to provide CCAP Core functionality



MAC = Packet-level processing
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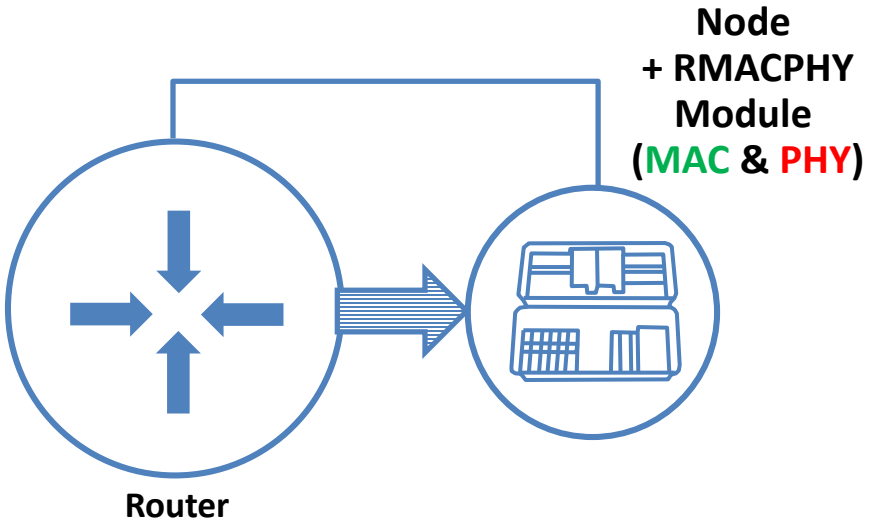
Distributed Access Architectures

vCore / RPHY

Benefits:

- Uses digital optics to nonlinear optical noise problem
- Med. Rackspace in HE
- Low Power in HE
- Elasticity & Feature Velocity w/ SDN & NFV



MAC = Packet-level processing
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Distributed Access Architectures

RMACPHY

Benefits:

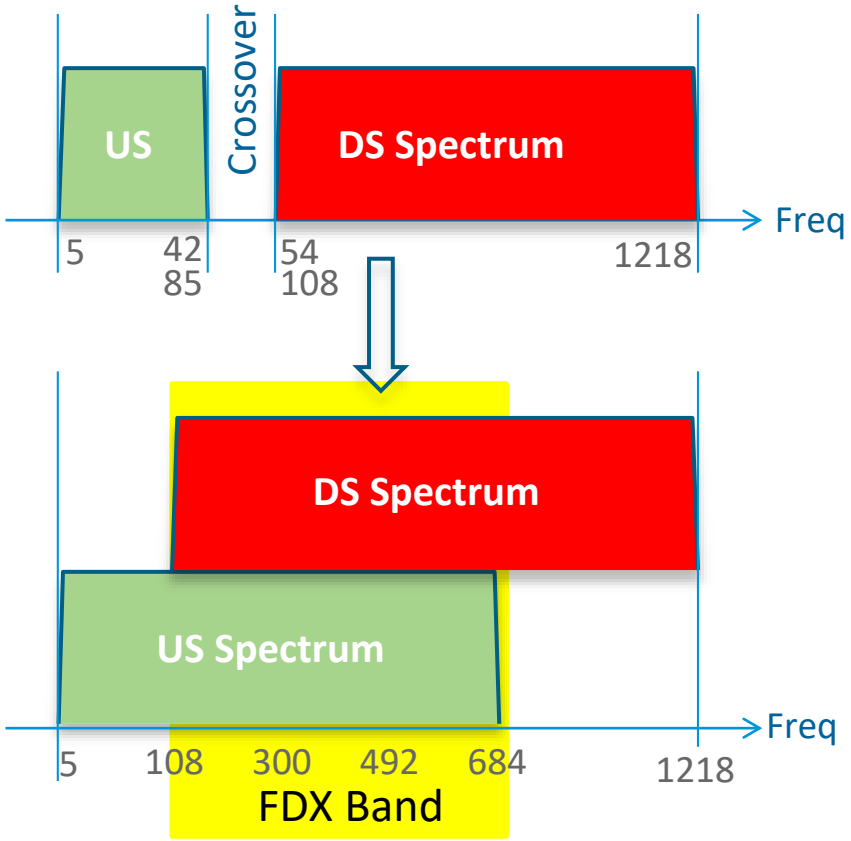
- Uses digital optics to nonlinear optical noise problem
- Low Rackspace in HE
- Low Power in HE
- Reduces protocol complexity in other DAA solutions

DOCSIS 3.1

- Spectral Efficiency Gain of OFDM/OFDMA and LDPC
- Higher QAM Orders
- Multiple Modulation Profiles
- Higher US Split

FTTx

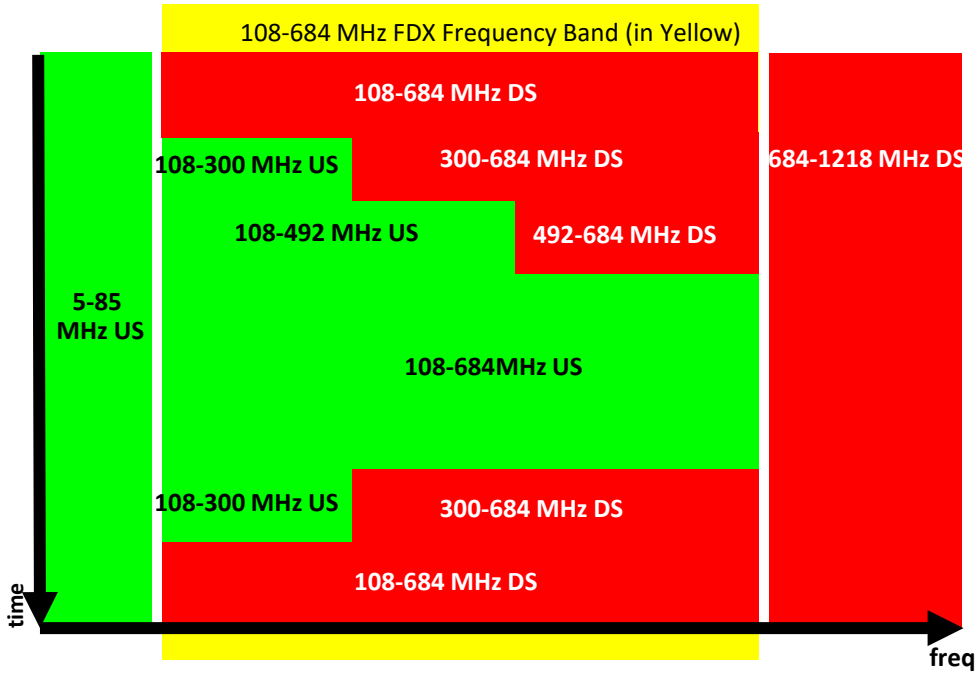
- PON technology provides high BW symmetric services
- PON can be combined with a Selective Subscriber Migration strategy
    - Move high BW subscribers from HFC to PON
    - Leaves more BW for remaining HFC subscribers
- OBI-free RFoG provides a graceful FTTP evolution strategy
- FTTT with short cable runs enables technology like Extended Spectrum DOCSIS



Full Duplex DOCSIS(FDX)

Augmenting US for Symmetrical Service

- 10G DS x 5G US is the target BW
- 684 MHz US versus 42 or 85 MHz today
- The biggest change in FDX is the expanded upstream spectrum
- Minimal impact on downstream capacity
- Optimized for Fiber Deep (Node+0) with DOCSIS Remote PHY Nodes



Full Duplex DOCSIS (FDX)

- From CM perspective, FDX can appear like Dynamic FDD
- Stair-step US BW up and down as a function of US traffic demand
- Some CMs use part of FDX spectrum as US while other CMs use same spectrum as DS
- Depending on HFC plant characteristic, MSOs goal is to provide from node
  - 10 Gbps Downstream
  - ~5 Gbps Upstream

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Factors to Consider

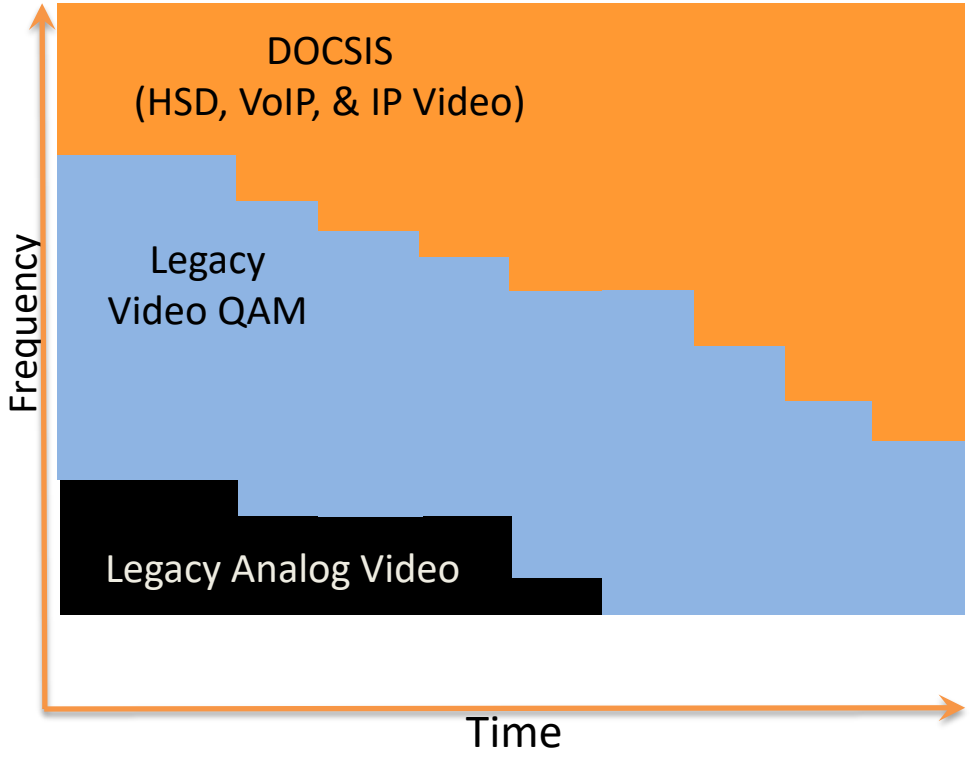
- There is no one “best” migration path; each MSO driven by unique factors
- Factors to consider:
    - Current service group size and target final service group size
    - When will transition from QAM video to IP video occur
    - When will symmetric services be required

Node Splits

- Latest indications are BW growth slowing to 40% CAGR
- Node split needed every 2.1 years
  - Assumes no other changes are made
  - Assumes additional US BW for symmetrical services not needed yet
- Reach diminishing returns at about 50 subscribers per service group

Plant Life with Node Splits

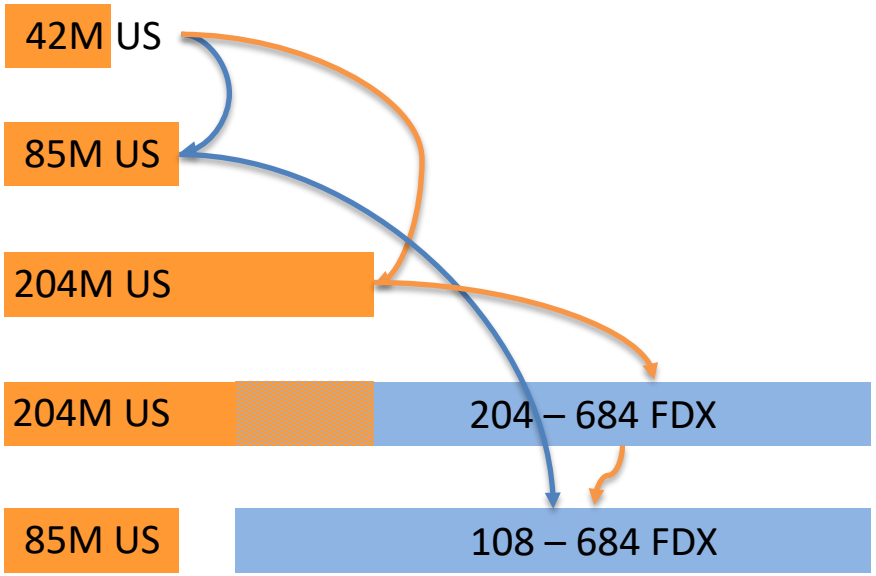
Current Average Service Group Size	Years
100	2.1
200	4.1
300	5.3
400	6.2
600	7.4
800	8.2
1000	8.9



Spectrum Migration

DS Spectrum Usage

- Additional spectrum for DOCSIS Usage gained by reducing video spectrum
- First Step is Analog reclamation
  - Moves analog video to digital QAM video
- Spectrum also gained by other techniques
  - E.g. H.264/MPEG-4, SDV, VOD
- Transitioning QAM video to IP video enables DOCSIS as a common transport



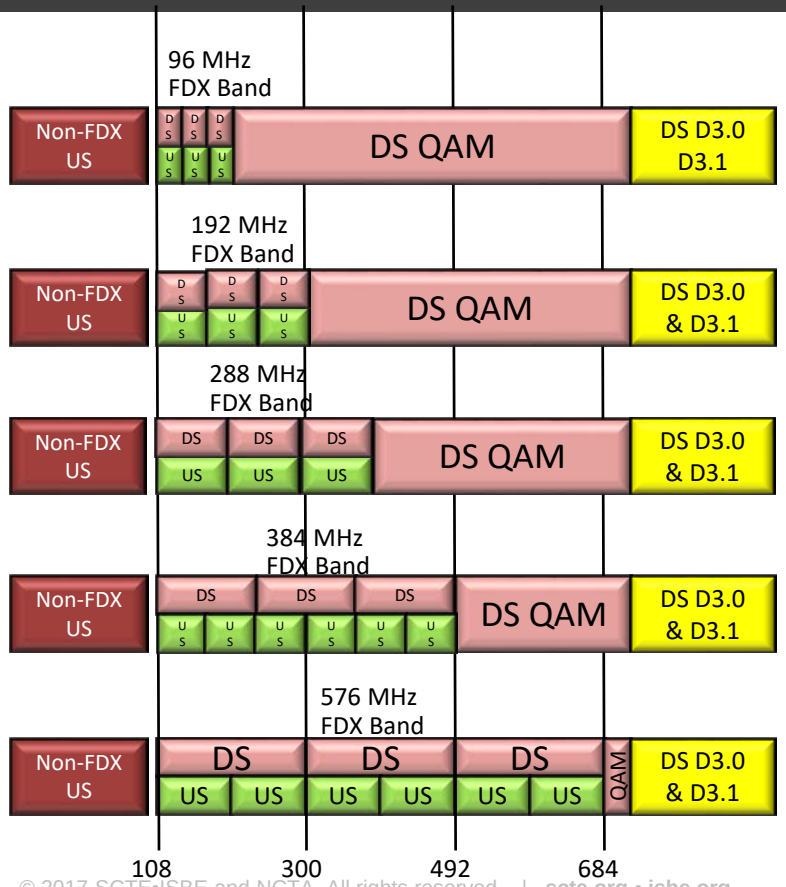
Spectrum Migration

US Spectrum Usage

- MSOs may take different paths to increase the US split
- Some may go to 85 MHz while others may go to 204 MHz
- Tradeoff between legacy equipment and demand for US BW
- FDX will open up even more US BW, while not sacrificing much DS BW

FDX CPE Introduction

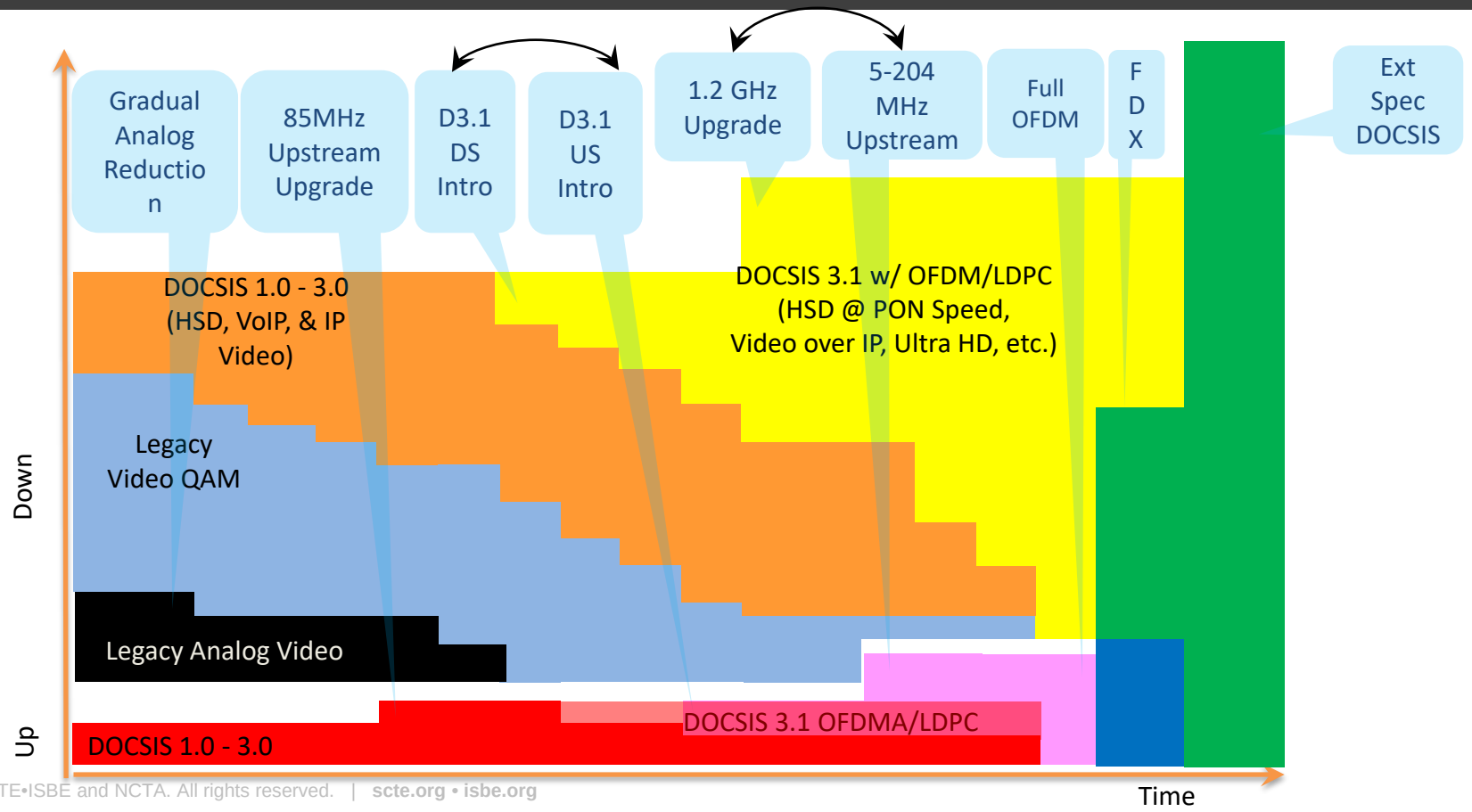
- Full FDX CMs likely not available until 2019
- Deploying DOCSIS 3.1 CMs until then will still allow subscriber to make limited use of the FDX spectrum when it becomes available
- Existing D3.1 CMs will be able to co-exist with new D3.1 FDX CMs
- Existing D3.1 CMs will require SW upgrade in order to participate on FDX channels
- Existing D3.1 CMs will only operate in one direction on FDX channels, depending on diplexer setting
    - CMs with 85MHz diplexer downstream only in FDX band
    - CMs with 204MHz diplexer upstream only in lower part of FDX band, downstream only in upper part of FDX band



FDX Spectrum Introduction

- Although FDX band is defined as 108 – 684 MHz, specification allows gradual usage of this spectrum for FDX channels
- Allows FDX spectrum to grow from 96 MHz wide to 576 MHz
- Remaining portion of FDX spectrum can be used for video QAMs

Conclusion: MSOs have Travelled Down Long DOCSIS Path… & Will Continue to Do So…



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THANK YOU!

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