## DOCSIS 3.1

## High Level Overview at NANOG 59

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## Agenda DOCSIS 3.1 Overview

- Key Objectives
- PHY & MAC layer choices
- Evolution of the DOCSIS
   network architecture
- Summary





# DOCSIS Evolution ~1996... to... 2013... to...

- DOCSIS 1.0
  - High Speed Internet Access
- DOCSIS 1.1
  - Voice, Gaming, Streaming
- DOCSIS 2.0
  - Capacity for Symmetric Services
- DOCSIS 3.0
  - Channel Bonding, IPv6
- DOCSIS 3.1
  - OFDM, Wideband Channel



# DOCSIS 3.1 Key Project Objectives

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## DOCSIS® 3.1 : Key Objectives

#### **Develop new version of DOCSIS Specifications/Technology**

- Higher Capacity:
  - Efficient 10+ Gbps downstream, 2+ Gbps upstream
- Cost Reduction:
  - Significant cost per bit reduction w.r.t. DOCSIS 3.0
- Plant Adaptation:
  - Adapt to different spectrum, plant conditions
- Effective Migration Strategy:
  - Allow "success based" migration, investment
- Existing HFC Network Operation:
  - Operates without modification of network, actives



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## DOCSIS 3.1 : Higher Capacity New FEC and More Spectrum

- New Forward Error Correction (FEC)
  - Low Density Parity Check (LDPC) enables higher order modulation (e.g. 1024,4096 QAM)
  - Greater spectral efficiency (bits/second/Hz)
    - 256 QAM to 4096 QAM = 50% ↑
- Operation across large bands of spectrum
  - Multi-Gigabit speeds require larger spectrum bands
  - E.g. ~500 MHz of downstream spectrum at 10 bits/ symbol (net) for ~5 Gbps
    - Note: DOCSIS 3.0 would require ~780 MHz for 5 Gbps



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### DOCSIS 3.1 : Cost Reduction & Plant Adaptation Orthogonal Frequency Division Multiplexing (OFDM)

- OFDM for upstream, downstream
  - Robust operation, efficient use of spectrum
  - Multiple narrow sub-carriers transmitted together in a block
  - No more 6/8 MHz channel restrictions
- Enables plant adaptation
  - Adjustment to channel conditions with 25-50 kHz resolution
  - Operation into band edge
  - Easy expansion into available spectrum



## DOCSIS 3.1 Effective Migration Strategy Backward compatibility requirements

- DOCSIS 3.1 CMs will operate on DOCSIS 3.0 CMTSs
  - Deploy on existing CMTS/CCAP, incrementally activate new PHY capabilities when upgraded
- DOCSIS 3.1 CMTSs will support DOCSIS 3.0 CMs
  - Can continue to use DOCSIS 2.0 & 3.0 CMs after DOCSIS 3.1 upgrades
- CMs and CMTSs will support bonding
  - 24 downstream SC-QAM channels
  - 8 upstream SC-QAM channels
- CMs and CMTSs will support bonding between D3.0
   and D3.1 channels



## DOCSIS 3.1 Existing HFC Network Operation Achieving Project Objectives

- Upstream spectrum remains below downstream
- CPE devices support existing splits (42/65 MHz) and higher splits (85 and 200 MHz)
  - Activate OFDM sub-carriers to increase capacity as needed
- CPE devices operate in existing downstream and higher spectrum enabled by network and passive elements, up to ~1.2 GHz
- No plant changes required to deploy DOCSIS 3.1 equipment
- Future proof If MSOs chose to expand HFC spectrum in the future, no CPE or infrastructure swap required to increase capacity



## DOCSIS 3.1 PHY & MAC Layer Choices



## PHY Layer Notes

#### D3.1 is a completely new Physical Layer

- OFDM Numerology
  - Max Channel BW, varied channel sizes, Num of subcarriers
  - Downstream and Upstream, Number of OFDM channels
  - Varied FFT Sizes and Subcarrier spacing
- New Frequency Ranges, Splits
- Higher Modulation orders
- US/DS TX/RX
- New Fidelity requirements
- Proactive Network Maintenance
- New Convergence Layer



## **Channel Bonding**

#### Adopted packet bonding process from D3.0 MAC Layer

- OFDM "channel" treated like a SC-QAM channel
  - Provides flexibility to the scheduler for optimizing service
- Support for bonding between:
  - OFDM channels
  - SC-QAM (DOCSIS 3.0) channels
  - Between each type of channel
- Works along with Simultaneous Time and Frequency Division Multiplexing



## New MAC Concepts & features New to DOCSIS 3.1

- Ranging and Probing
- Profile Testing and assignment
- Larger MTU Size : 2000 bytes
- Energy Management : Light sleep mode
- Timing & Synchronization : Higher precision and accuracy
- Active Queue Management
- Hierarchical QoS : Advanced Bandwidth Management





## D3.1 Migration and Network Evolution

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# Termination Technology Evolution Docsis 3.1







## **DOCSIS 3.1 Network Implications**

#### Spectrum

- Operates on and increases efficiency on existing HFC
- Top speeds and capacity require more IP spectrum
- Start with a small block and bond to DOCSIS 3.0 channels
- Video optimization and all IP migration to free spectrum
- Optimize to high BW customers
- HFC upgrades can also benefit efficiency and opex
- Core network investments made with BW growth



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# Summary of Technical Direction

- New LDPC FEC and higher order modulation
- OFDM upstream and downstream
- Backward compatibility with DOCSIS 3.0 system
   Channel Bonding (24x8 SC-QAM channel minimum)
- Upstream below downstream (no "top split")
- Operates on existing plant without changes

## Evolving Cable Technology

Investing in the best broadband experience for all consumers

- DOCSIS 3.1 technology enables faster services
   Capital investment can be made per customer demand
- DOCSIS 3.1 specifications are latest in the series that has evolved to meet anticipated future demand and facilitate new applications
  - Cost-effectively scale to multi-gigabit services
  - Works in and further optimizes existing HFC plant
  - Options for new spectrum usage; increasing capacity
  - State-of-the-Art technologies and innovation

Questions ? Thanks ! k.sundaresan@cablelabs.com CableLabs®