UNLEASH THE POWER OF LIMITLESS CONNECTIVITY

2021 Fall Technical Forum
SCTE • NCTA • CABLELABS®
Wireline Access Network

Maximizing Returns on the Path to DOCSIS 4.0

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The Path to DOCSIS 4.0 | Starting Point

Fastest Broadband in Canada
Ookla ranked Shaw the fastest fixed broadband provider in Canada in Q2 2021

90%
Mid-Split Complete
Shaw began upgrading the HFC network to 1GHz/85MHz in 2017 and expects to be complete within a year

.1%
Network Congestion
Network congestion has been at historic lows and did not materially change during the COVID-19 pandemic

1Gbps
Tier Available to 99% of the Network
In mid-split areas a 1Gbps/100Mbps tier is offered. A 1.5Gbps/100Mbps tier is available to 80% of the network
The Path to DOCSIS 4.0 | COVID-19 Performance

**Upstream Protocol Difference During COVID-19**
- Traffic Growth:
  - May-19: 34%
  - Aug-19: 21%
  - Nov-19: 26%
  - Feb-20: 68%
  - May-20: 90%
  - Aug-20: 23%
  - Nov-20: 42%
  - Feb-21: 8%

**Downstream Protocol Difference During COVID-19**
- Percent Growth:
  - May-19: 30%
  - Aug-19: 78%
  - Nov-19: 28%
  - Feb-20: 56%
  - May-20: 60%
  - Aug-20: 34%
  - Nov-20: 43%
  - Feb-21: 12%
The Path to DOCSIS 4.0 | Need for Upgrade

- In the mid-split and high-split scenarios congestion rises until QAM reclaim in 2027
- Mid-split begins see significant congestion beginning in 2025
- D4.0 keeps congestion under control

Forecasts assumes
- 15% Downstream Broadband CAGR + IPTV transition
- 25% Upstream Broadband CAGR + IPTV transition
The Path to DOCSIS 4.0 | Demand vs Capability

Traffic Symmetry
Even during COVID-19 the downstream-to-upstream ratio observed on our network was above 15:1 for consumer and stayed close to 5:1 for business.

Upstream Usage
The majority of consumption on our higher upstream tiers was backup and file sharing, both background applications that may not impact the customer experience.

Downstream Capability
There is a bottleneck, likely due to in-home Wi-Fi that is currently limiting the majority of customers on a 1Gbps tier from hitting their peak speed.
Aggressive Fibre to the Home
Canadian telcos have been aggressive in FTTP builds, which now represent 81% of Telus’ broadband homes passed.

Symmetric Tier Offerings
Using GPON they are offering symmetric or near symmetric tiers, with a high tier of 1.5Gbps/940Mbps in most markets.

Simplified Upgrade Path
The FTTP network is future-proof and enables an upgrade to new PON technologies such as XGS-PON, which is 10Gbps capable, without plant re-work.
<table>
<thead>
<tr>
<th>Technology</th>
<th>Mid-Split +1 GHz Module Upgrades &amp; DOCSIS 3.1</th>
<th>DAA Nodes &amp; Module Upgrades for Amp &amp; Taps + OOB Removal</th>
<th>D4.0 FDD Upgrade of All Nodes &amp; Amps to 1.8 GHz</th>
<th>D4.0 FDX N+0 Build (removal of all amplifiers)</th>
<th>Extensive Fibre Over-Build to All Homes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Per HP</td>
<td>$</td>
<td>$</td>
<td>$</td>
<td>$$$</td>
<td>$$$$</td>
</tr>
<tr>
<td>Upgrade Rate</td>
<td><img src="speed_icon_medium" alt="Medium-Speed" /></td>
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</tr>
<tr>
<td>Capacity Created</td>
<td>4G / 400</td>
<td>4G / 1G</td>
<td>8G / 3G</td>
<td>7G / 5G</td>
<td>10G+ / 10G+</td>
</tr>
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The Path to DOCSIS 4.0 | Upgrade Options

- **Mid-Split**
  - Current State
  - Mid-Split +1 GHz Module Upgrades & DOCSIS 3.1
- **High-Split**
  - Available Now
  - DAA Nodes & Module Upgrades for Amp & Taps + OOB Removal
- **D4.0 FDD**
  - Beyond 2022
  - D4.0 FDD Upgrade of All Nodes & Amps to 1.8 GHz
- **D4.0 FDX**
  - Beyond 2022
  - D4.0 FDX N+0 Build (removal of all amplifiers)
- **FTTP**
  - Strategic Option
  - Extensive Fibre Over-Build to All Homes
The Path to DOCSIS 4.0 | High-Split

High-split upgrade increases US spectrum by 149% and DS spectrum by 7%.

Out of Band Removal
Video set top boxes requiring the use of the OOB must be removed prior to upgrade.

Signal Leakage
Signal leakage in the aeronautical band becomes an upstream issue for which a solution is required.

MoCA
MoCA signals are used by whole-home video solutions and must be considered.
The Path to DOCSIS 4.0 | DOCSIS 4.0 FDD

DOCSIS 4.0 FDD increases downstream spectrum to 1.8GHz and allows for multiple diplex frequencies

<table>
<thead>
<tr>
<th>Spectrum available to current CPE</th>
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</thead>
<tbody>
<tr>
<td>High-Split</td>
</tr>
<tr>
<td>UHS-300</td>
</tr>
<tr>
<td>UHS-396</td>
</tr>
<tr>
<td>UHS-492</td>
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<tr>
<td>UHS-684</td>
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</tbody>
</table>

**Plant Characteristics**

- A drop-in upgrade is expected to work in current plant cascades and spacings
- Performance gains can be realized as fibre is deployed deeper into the network

**Band Plan**

- For capacity purposes it is best to have a spectrum split similar to traffic ratios
- For competitive purposes it may be beneficial to offer symmetrical or near-symmetrical tiers
The Path to DOCSIS 4.0 | Full Duplex DOCSIS

Spectrum Overlap

FDX allows US and DS spectrum to be overlapped, effectively doubling the spectral efficiency.

N+0 Architecture

FDX requires an N+0 upgrade, the cost and speed of which is dependent on the mix of infrastructure types and agreements.

Operational Implications

Required fibre builds are simpler in owned aerial infrastructure when compared to underground.

FDX uses spectrum efficiently, but requires extensive fibre builds.
The Path to DOCSIS 4.0 | Potential Path

- **D4.0 FDD and FDX** provide similar capacity, but FDX requires deep fibre.
- **High-split** provides Gbps upstream.
- **Mid-Split**
- **High-Split**
- **FTTP**
The Path to DOCSIS 4.0 | Potential Path

Moving diagonally up and to the right increases efficiency and is more cost effective if fibre deployment costs go up.
The Path to DOCSIS 4.0 | Potential Path

- **Mid-Split**
- **High-Split**
- **D4.0 FDD**
- **D4.0 FDX**

Moving vertically while deploying fibre broadly optimizes upgrade timing.

Cascade Reduction:

Possible future - D5.0?
Option to leverage future DOCSIS technology in cascaded plant.
The Path to DOCSIS 4.0 | Potential Path

- **Legacy Video EoL**
  - Upgrade path needs to allow for legacy video equipment to be removed from the network.

- **Cascade Length Reduction**
  - Continued investment to reduce cascade lengths for optimal D4.0 performance now while providing risk mitigation against competitive threats with FTTP.

- **Mid-Split**
  - Allows for 4G/400Mbps capacity until mid 2020’s.

- **Greenfield FTTP**
  - Greenfield FTTP provides a tangible coverage over the long term. ~2% increase annually.
Thank You!

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