UNLEASH THE POWER OF LIMITLESS CONNECTIVITY
Wireline Access Network

Preparing for DOCSIS® 4.0
Upstream

Nader Foroughi
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Shaw Communications
Higher Upstream Splits → Higher Capacity & Complexity

Today:
- **Upstream**: 85 MHz
- **Downstream**: 1.0 GHz

**DOCSIS® 3.1 High-Split:**
- **Upstream**: 204 MHz
- **Downstream**: 1.2 GHz

**DOCSIS 4.0 @ 1.8 GHz**
- **D4.0 Upstream**: 396 MHz
- **Downstream**: 1.2 GHz

As we move to higher splits, complexity increases. Performance expectations rise.

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Baselines:

**CM Tx Power /6.4MHz**

- **Return Path BW**
  - 85 MHz
  - 204 MHz
  - 396 MHz
  - 492 MHz

- **Input Power to Return Path Amp. (dBmV/6.4MHz)**
  - 16
  - 12
  - 9
  - 8
Baselines:

FDD Upstream Allocated Spectrum Bandwidths

<table>
<thead>
<tr>
<th>Constellation</th>
<th>CNR (dB)</th>
<th>Power Level (dBmV/6.4 MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>256-QAM</td>
<td>29.0</td>
<td>3</td>
</tr>
<tr>
<td>512-QAM</td>
<td>32.5</td>
<td>3</td>
</tr>
<tr>
<td>1024-QAM</td>
<td>35.5</td>
<td>3</td>
</tr>
<tr>
<td>2048-QAM</td>
<td>39.0</td>
<td>10</td>
</tr>
<tr>
<td>4096-QAM</td>
<td>43.0</td>
<td>13</td>
</tr>
</tbody>
</table>

DOCSIS 3.1 High-Split Mode

DOCSIS 4.0 Mode
Plant Model Analyzed

**Span Loss:**
- 750MHz:
  - Distribution: 27dB
- 1GHz:
  - Typical Plant:
    - Distribution: 32dB
  - Stretched Plant:
    - Distribution: 35dB

35 dB of Span loss @ 1GHz
Base Plant Model

Plant Model with Two-Way Splitter

Rx Power/6.4MHz @ Amp/Node Port

492MHz Target Level

1kQAM @ Port

Rx Power/6.4MHz @ Amp/Node Port

492MHz Target Level

1kQAM @ Port
Boosting CM Tx

Upstream performance will not be power limited for most cases.
Higher CM Tx Powers Must be Balanced

- Higher transmit power from the CMs can increase the risk of neighbour interference.

Reference: Optimizing the 10G Transition to Full-Duplex DOCSIS® 4.0, Richard S Prodan, Comcast – with proposed changes to the methodology
## Noise Funneling

### All Ports Funneled

<table>
<thead>
<tr>
<th>Total Number of Amplifiers</th>
<th>CTN</th>
<th>CIN</th>
<th>Source MER (38 dB)</th>
<th>Source MER (40 dB)</th>
<th>Source MER (47 dB)</th>
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<tbody>
<tr>
<td>16</td>
<td>45.36</td>
<td>49.98</td>
<td>37.04</td>
<td>38.56</td>
<td>42.28</td>
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<tr>
<td>32</td>
<td>42.35</td>
<td>48.22</td>
<td>36.35</td>
<td>37.61</td>
<td>40.3</td>
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<td>44</td>
<td>40.97</td>
<td>47.55</td>
<td>35.92</td>
<td>37.04</td>
<td>39.3</td>
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<tr>
<td>56</td>
<td>39.92</td>
<td>46.97</td>
<td>35.52</td>
<td>36.54</td>
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<tr>
<td>68</td>
<td>39.07</td>
<td>46.00</td>
<td>35.12</td>
<td>36.04</td>
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<tr>
<td>4</td>
<td>51.38</td>
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<td>37.55</td>
<td>39.31</td>
<td>44.29</td>
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<td>6</td>
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<td>48.22</td>
<td>37.26</td>
<td>38.87</td>
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<td>7</td>
<td>46.99</td>
<td>47.55</td>
<td>37.08</td>
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<td>42.4</td>
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<td>8</td>
<td>45.94</td>
<td>46.97</td>
<td>36.9</td>
<td>38.37</td>
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<td>10</td>
<td>45.1</td>
<td>46.00</td>
<td>36.68</td>
<td>38.07</td>
<td>41.19</td>
</tr>
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### Single Node Leg

- Amplifier NF: 6 dB
- Amplifier CIN: 56 dB
- Input level to each amplifier in the return path: 6 dB flat across the spectrum
- Number of ports utilized in the node: 4
- CTN: All the amplifiers on either the entire node or each leg that would contribute to signal degradation
- CIN: Only the amplifiers in series on each leg of the node that would contribute to signal degradation
Noise Funneling

All Ports Funneled

Total Number of Amplifiers

<table>
<thead>
<tr>
<th>30</th>
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<th>34</th>
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MER Degradation (All Ports Funneled)

Single Node Leg

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<tbody>
<tr>
<td>4 (4 depth) 8 (6 depth) 11 (7 depth) 14 (8 depth) 17 (10 depth)</td>
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MER Degradation (Single Port)
Conclusions

• DOCSIS 4.0 upstream is very likely to work with high performance for a majority of cases
  • The biggest areas of concern are:
    • High flat loss areas that the CM will have to ‘overcompensate’ for in the upstream
    • Higher transmit powers may increase the likelihood of neighbour interference
  • Starting/Source MER from the modems in the return is the highest indicator of performance (assuming no plant impairments)
    • Thermal noise and distortion funneling from amplifiers can degrade the performance, but not by a large amount
      • Isolating node ports can be very important for limiting noise to a single port
      • High transmit powers should be balanced with neighbour interference
Thank You!

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