Demystifying Enterprise Fiber Networks

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In this session

• Multimode fiber types – distance matters
• How many fibers do I need for my application?
  – 2, 4, 8, 12, 16, 24 or 32?
• Current/Future IEEE and non IEEE applications
  – Will my existing fiber plant support these?
• Connectivity choices and conversion cassettes
Distance matters

FIBER TYPES
Which multimode fiber do you have or choose?

<table>
<thead>
<tr>
<th>Designation</th>
<th>Effective Modal Bandwidth @ 850 nm (MHz.km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM1</td>
<td>200</td>
</tr>
<tr>
<td>OM2</td>
<td>500</td>
</tr>
<tr>
<td>OM3</td>
<td>2,000</td>
</tr>
<tr>
<td>OM4</td>
<td>4,700</td>
</tr>
<tr>
<td>OM5</td>
<td>4,700</td>
</tr>
</tbody>
</table>

- With multimode, there are many modes (paths) of light
- The modes travel down the cable at different speeds
- A pulse of light will spread as it travels down the cable
- The longer the fiber, the more spreading (dispersion)
Which multimode fiber do you have or choose?

<table>
<thead>
<tr>
<th>Designation</th>
<th>Effective Modal Bandwidth @ 850 nm (MHz.km)</th>
<th>1000BASE-SX</th>
<th>10GBASE-SR</th>
<th>40GBASE-SR4</th>
<th>100GBASE-SR4</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Meters</td>
<td>Feet</td>
<td>Meters</td>
<td>Feet</td>
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<tr>
<td>OM3</td>
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<td>860</td>
<td>2,822</td>
<td>300</td>
<td>984</td>
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<tr>
<td>OM4</td>
<td>4,700</td>
<td>860</td>
<td>2,822</td>
<td>400</td>
<td>1,312</td>
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<tr>
<td>OM5</td>
<td></td>
<td>860</td>
<td>2,822</td>
<td>400</td>
<td>1,312</td>
</tr>
</tbody>
</table>
The Multi Push On (MPO) connector

- Also referred to as MTP®
  - MTP is a registered trademark of US Conec
  - MTPs are compliant with IEC Standard 61754-7 and TIA 604-5 – Type MPO
  - Typically provides better performance than standard MPOs

MTP trunk cables can support traditional LC duplex transceivers with the addition of breakout cassettes
Breakout - back to LC

- 40GBASE-SR4
- HDX Cassette
- 72 Fiber
- 10GBASE-SR
- Duplex LC
- HDX2 Cassette
Do I have to replace my links with MPO?

- There are 40 Gb/s solutions than run over duplex links today
- QSFP-40G-SR-BD
  - 30 m over OM2, 100 m over OM3 and 150 m over OM4
  - Transmits and receives on the same fiber using two wavelengths
Do I have to replace my links with MPO?

- There are 100 Gb/s solutions than run over duplex links today
- QSFP-100G-SR-BD
  - 70 m over OM3, 100 m over OM4 and 150 m over OM5
  - Transmits and receives on the same fiber using two wavelengths

50 Gb/s @ 908 nm
50 Gb/s @ 855 nm
Short Wave Division Multiplexing (SWDM4)

- Transmitting four wavelengths on a single multimode fiber
SR4 vs. SWDM4
Do I have to replace my links with MPO?

- There are 100 Gb/s solutions than run over duplex links today
- QSFP-100G-SWDM4
  - 70 m (OM3), 100 m (OM4) & 150 m (OM5), transmitting on four wavelengths

```
SFP Duplex   |   SFP Duplex
    ←—→      | ←—→
    ↑        | ↑
  25 Gb/s @ 850 nm | 25 Gb/s @ 880 nm | 25 Gb/s @ 910 nm | 25 Gb/s @ 940 nm
```
## Future multimode IEEE Ethernet applications

<table>
<thead>
<tr>
<th>Application</th>
<th>OM3</th>
<th>OM4</th>
<th>OM5</th>
<th>Fiber Count</th>
<th>Connector Type</th>
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<td></td>
<td>Meters</td>
<td>Feet</td>
<td>Meters</td>
<td>Feet</td>
<td>Meters</td>
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</table>

* Draft IEEE 802.3cm target distances
PAM4 - squeezing every bit out of the fiber

Non Return Zero

Pulse Amplitude Modulation 4 Levels

PAM4 DOUBLES the bit rate
Reduction in supported lengths (multimode)

- **1994** 100 Mb/s
  - Schindler’s List
  - 2,000 m (6561 ft.)

- **1998** 1000 Mb/s
  - Titanic
  - 550 m (1805 ft.)

- **2002** 10 Gb/s
  - A Beautiful Mind
  - 300 m (984 ft.)

- **2010** 40 Gb/s
  - The Hurt Locker
  - 150 m (492 ft.)

- **2015** 100 Gb/s
  - Birdman
  - 100 m (328 ft.)
Future single-mode IEEE Ethernet applications

<table>
<thead>
<tr>
<th>Application</th>
<th>OS1a/OS2</th>
<th>PAM4</th>
<th>WDM</th>
<th>Fiber Count</th>
<th>Connector Type</th>
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Termination options

CONNECTIVITY OPTIONS
Transceiver fiber interfaces

Most common SC, LC, and MPO

1000BASE-SX GBIC (SC)
1000BASE-SX SFP (LC)
10GBASE-SR SFP (LC)
40GBASE-SR4 QSFP+ (MPO)
SC/LC termination options

• Field Polish
  – Ideal for smaller installations
  – Craft sensitive
  – Labor costs a consideration
  – Consumables
    • Polishing paper
  – Concerns meeting updated TIA single-mode return loss (reflectance) requirements of 35 dB
Reflectance (return loss)

- This is the reflection of light back into the transceiver.
- Most common cause is the airgap between connectors:
  - Polishing the ceramic end face can result in an undercut.
  - When two connectors are mated, there is a small airgap between them.
  - Bigger the airgap, worse the return loss (reflectance).
- With higher speeds, now a concern in the enterprise.
Further minimizing return loss (reflectance)

- Put an 8-degree angle on the end face
- Any reflected light is forced into the cladding
  - Angled Physical Contact connector (APC)
  - APC connector housing is green
    - Avoids mixing PC and APC connectors
- Concatenated links (many connections) can result in optical return loss issues if return loss (reflectance) is not controlled
- IEEE 802.3cd (in progress) specifying discrete reflectance
Sensitive to reflectance (return loss)

<table>
<thead>
<tr>
<th>Number of connections where the reflectance is between -35 and -45 dB</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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</tr>
</tbody>
</table>

- Let’s take an example link containing four LC/MTP cassettes
  - Single-mode MTPs are APC, so there will be four of those (typically better than -55 dB)
  - The four LCs are factory polished (typically better than -50 dB)
  - We have no connections between -35 dB and -45 dB
  - So our allowable loss will be **3.0 dB**
Sensitive to reflectance (return loss)

- Let's take another example link containing four LC/MTP cassettes
  - Single-mode MTPs are APC, so there will be four of those (typically better than -55 dB)
  - The four LCs are factory polished (typically better than -50 dB)
  - Future performance could be between -35 dB and -45 dB
  - So our allowable loss will be 2.7 dB, not 3.0 dB
SC/LC termination options

• Mechanical splice
  – Faster termination than field polish
  – Less craft sensitive
  – Factory polished end faces
  – Better insertion loss
  – Better return loss (reflectance)
  – Less consumables
    • No polishing papers
  – Precision cleaver required
SC/LC termination options

• Pigtail – Fusion Splice
  – Factory polished connectors
    • Excellent insertion/return loss
  – Precision cleaver and splicer required

  – Skill in dressing splice trays
12 Fiber Multi-Push On (MPO) connector

With an MPO trunk cable, you get to choose interface connector

- 1000BASE-SX or 10GBASE-SR
- 40GBASE-SR4, 100GBASE-SR4, 200GBASE-SR4, 400GBASE-SR4.2
24 Fiber Multi-Push On (MPO) connector

With an MPO trunk cable, you get to choose interface connector

- 1000BASE-SX or 10GBASE-SR
- 40GBASE-SR4, 100GBASE-SR4, 200GBASE-SR4, 400GBASE-SR4.2
Takeaways

• Keep links under 100 m (328 ft.) for new OM4 multimode installs
• Proprietary technologies to reuse existing duplex links now available
• OM5 offers an advantage over OM3/4 for SWDM/BiDi only
• Field polished single-mode connectors may not support ≥100 Gb/s
• Concatenated single-mode links may benefit from APC connectors
• MPO trunk cables offer flexibility and performance
• 24-fiber multimode MPO cables cover you from 100 Mb/s to 400 Gb/s
• Interest in single-mode increasing due to historical length reductions
Thank You