Designing a Flexible Network Infrastructure to Support New Optical Technologies

Enterprise vs. Cloud Data Center Requirements

Dave Mullen, Sr. Product Manager, Leviton Network Solutions
Outline

• Definition of Enterprise and Cloud Data Centers
• The Growth of Cloud Computing
• Market forecast for 25G/50G/100G/200G/400G Ethernet
• Trends with Multi-mode vs. Single-mode Optics
• Use case: 40G for Enterprise data centers
• Use case: 100G+ for Cloud data centers
## Enterprise vs. Cloud Data Centers

### Major Characteristics of Data Centers

<table>
<thead>
<tr>
<th>Feature</th>
<th>SMB</th>
<th>Large Enterprise</th>
<th>Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Servers</td>
<td>&lt;500</td>
<td>10,000</td>
<td>&gt;100,000</td>
</tr>
<tr>
<td>Number Of Customers</td>
<td>&gt;1,000,000</td>
<td>&lt;5,000</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Number of Top-of-Rack / Leaf Switches</td>
<td>&lt;25</td>
<td>&lt;500</td>
<td>&gt;2,000</td>
</tr>
<tr>
<td>Number of Spine / Aggregation Switches</td>
<td>1-2</td>
<td>&lt;25</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Number of Core Switches</td>
<td>N/A</td>
<td>&lt;12</td>
<td>&gt;12</td>
</tr>
<tr>
<td>Deal Size</td>
<td>&lt;$100,000</td>
<td>&lt;$5,000,000</td>
<td>&gt;$20,000,000</td>
</tr>
<tr>
<td>Ethernet Switch Vendor Margin</td>
<td>&gt;60%</td>
<td>&gt;50%</td>
<td>&lt;25%</td>
</tr>
</tbody>
</table>

Source: Dell'Oro, 2015

### Total Ethernet Switch Data Center Revenue

[Graph showing data center revenue from 2010 to 2019, split into Top 7 Cloud Providers, Rest of Cloud and SPs, Enterprise and SMB Market]

Source: Dell'Oro, 2015

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2017 BICSI CANADIAN CONFERENCE & EXHIBITION
MAY 8-11 • VANCOUVER, BRITISH COLUMBIA, CANADA
PRIVATE

Used for a single organization.
Can be externally or internally hosted.

COMMUNITY

Shared by several organizations.
Typically externally hosted.

HYBRID

Two or more clouds bound together.
Usually part internally and part externally hosted.

PUBLIC

Provisioned for open use by the hosting company which operates the data centers.
Global Cloud Traffic Growth

Cloud Traffic **Will Grow 3.7-Fold** from 2015 to 2020

Cloud Accounts for **92% of Traffic** by 2020 **up from 82%** in 2015

Source: Cisco Global Cloud Index, 2015-2020
Trends in the Data Center

- Many traditional enterprise data centers are moving to the cloud
- Flatter network designs...3-tier to Leaf-Spine
- Data Centers are getting larger
- More companies are outsourcing to co-location providers
- Creation of a new 25Gb/s ecosystem
- New cost-effective 100G switches
The Need for Speed
Ethernet Speed Market Forecast

Transceiver modules by speed, percent of total

Dramatic Growth of 100G Expected...

The IEEE802.3ba standard, published in June 2010 defined 10Gb/s lanes for 40G & 100G transmission.

On April 29 2015, IEEE published the new IEEE802.3bm standard.

Primary objectives of the standard:
- Reduce cost of 100Gb/s
- Reducing power requirements
- Reduce # of lanes required

The standard defines 100G-SR4:
- Uses 4 x 25Gb/s lanes in each direction
- MTP connector with 8-fibers is required
- Same requirements as 40G-SR4
25G Lane Ecosystem is starting... with 100G/200G & 400G

- 1st phase will likely use 25G down to server + 100G Uplinks
- 75% of 100G options will utilize MPO connectors with 4 or 8 fibers
- Very little adoption of SR16 expected...no need for OM5
- Majority of options use single-mode

<table>
<thead>
<tr>
<th>Rate</th>
<th>Fiber Type</th>
<th># fibers</th>
<th>Connector</th>
<th>Reach</th>
<th>IEEE Std</th>
<th>Est. Release</th>
</tr>
</thead>
<tbody>
<tr>
<td>100GBASE-SR4</td>
<td>OM4</td>
<td>8</td>
<td>MPO</td>
<td>70m</td>
<td>802.3bm</td>
<td>Apr-15</td>
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<tr>
<td>100GBASE-SR2</td>
<td>OM4</td>
<td>4</td>
<td>MPO</td>
<td>100m</td>
<td>802.3cd</td>
<td>Sep-18</td>
</tr>
<tr>
<td>100GBASE-DR2</td>
<td>OS2</td>
<td>4</td>
<td>MPO</td>
<td>500m</td>
<td>802.3cd</td>
<td>Sep-18</td>
</tr>
<tr>
<td>100GBASE-FR2</td>
<td>OS2</td>
<td>2</td>
<td>LC</td>
<td>2km</td>
<td>802.3cd</td>
<td>Sep-18</td>
</tr>
<tr>
<td>200GBASE-DR4</td>
<td>OS2</td>
<td>8</td>
<td>MPO</td>
<td>500m</td>
<td>802.3bs</td>
<td>Dec-17</td>
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<tr>
<td>200GBASE-FR4</td>
<td>OS2</td>
<td>2</td>
<td>LC</td>
<td>2km</td>
<td>802.3bs</td>
<td>Dec-17</td>
</tr>
<tr>
<td>400GBASE-SR16</td>
<td>OM4 / OM5</td>
<td>32</td>
<td>MPO</td>
<td>100m</td>
<td>802.3bs</td>
<td>Dec-17</td>
</tr>
<tr>
<td>400GBASE-FR8</td>
<td>OS2</td>
<td>2</td>
<td>LC</td>
<td>2km</td>
<td>802.3bs</td>
<td>Dec-17</td>
</tr>
</tbody>
</table>
50G Lane Ecosystem is not far off
100G/200G & 400G

- Most options use single-mode cabling

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<th>IEEE Std</th>
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<tr>
<td>100GBASE-DR</td>
<td>OS2</td>
<td>2</td>
<td>LC</td>
<td>500m</td>
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<td>Sep-18</td>
</tr>
<tr>
<td>100GBASE-FR</td>
<td>OS2</td>
<td>2</td>
<td>LC</td>
<td>2km</td>
<td>802.3cd</td>
<td>Sep-18</td>
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<td>LC</td>
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<td>802.3bs</td>
<td>Dec-17</td>
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Multi-Sourcing Agreements (MSAs)

- In addition to IEEE standards, there are many technologies being developed thru MSAs with industry consortiums
  - 100G CLR4 Alliance – Duplex SMF
  - SWDM Alliance – Duplex MMF for 40 & 100G
  - 100G PSM4 MSA…Parallel SMF for 100G+
  - 10x10 MSA…Parallel SMF
  - CWDM4 MSA…Duplex SMF for 100G+
  - OpenOptics MSA – Duplex SMF for 100G & 400G
Sale of Ethernet Transceivers by Market
SM vs. MM Transceiver Estimated Volumes
100G – 400G Ethernet

SM will account for 65% of volume

Market Leaders Setting an Example

99% Single-mode

Source: The Next Platform
Cost of SMF Optics expected to decline
Closer to MMF Optics

Source: Facebook presentation at IEEE Optical Interconnects Conference, 2016
End-to-end 40G Channel Cost Comparison
MMF vs. SMF  (August 2016)

SR4
MM: Parallel Dist.: 150m
$2,000

Bidi
MM: Duplex Dist.: 150m
$500

UNIV
MM: Duplex Dist.: 150m
$1,500

SWDM4
WBMMF: Duplex Dist.: 150m
$1,000

LRL4
SM: Duplex Dist.: 1km/2km
$2,500

PLRL4
SM: Parallel Dist.: 1 km
$3,000

Parallel SM now 50% more than SR4
SWDM4 40% more than Bidi

Optics
Cabling
Estimated List Prices: 100G Transceivers

High Density 40/100G Switches

QSFP+ ports

Arista 7300 Series
Juniper 9214
Cisco Nexus 6004
Cisco Nexus 7700

<table>
<thead>
<tr>
<th>Transceiver</th>
<th>Switch Mfrs</th>
<th>Form Factor</th>
<th>IEEE Compliant</th>
<th>Fiber Type</th>
<th>Distance</th>
<th># of fibers</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>40G-SR4</td>
<td>All</td>
<td>QSFP+</td>
<td>Yes</td>
<td>OM3/OM4</td>
<td>100m/150m</td>
<td>8</td>
<td>12F MTP</td>
</tr>
<tr>
<td>40G-C/X/ESR4</td>
<td>Cisco, Arista, Juniper</td>
<td>QSFP+</td>
<td>No</td>
<td>OM3/OM4</td>
<td>300m/400m</td>
<td>8</td>
<td>12F MTP</td>
</tr>
<tr>
<td>40G-BIDI</td>
<td>Cisco, Arista</td>
<td>QSFP+</td>
<td>No</td>
<td>OM3/OM4</td>
<td>100m/300m</td>
<td>2</td>
<td>LC</td>
</tr>
<tr>
<td>40G-LX4</td>
<td>Juniper</td>
<td>QSFP+</td>
<td>No</td>
<td>OM3/OM4</td>
<td>100m/150m</td>
<td>2aiai</td>
<td>LC</td>
</tr>
<tr>
<td>40G-UNIV</td>
<td>Arista</td>
<td>QSFP+</td>
<td>Yes</td>
<td>OM3/OM4, OS2</td>
<td>150m, 500m</td>
<td>2</td>
<td>LC</td>
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<tr>
<td>40G-LR4</td>
<td>All</td>
<td>QSFP+</td>
<td>Yes</td>
<td>OS2</td>
<td>10 km</td>
<td>2</td>
<td>LC</td>
</tr>
<tr>
<td>40G-LRL4/IR4</td>
<td>Cisco, Arista, Juniper</td>
<td>QSFP+</td>
<td>Yes</td>
<td>OS2</td>
<td>1km/2km</td>
<td>2</td>
<td>LC</td>
</tr>
<tr>
<td>40G-PLR4</td>
<td>Arista</td>
<td>QSFP+</td>
<td>No</td>
<td>OS2</td>
<td>1 km</td>
<td>8</td>
<td>12F MTP</td>
</tr>
<tr>
<td>4x10G-IR</td>
<td>Juniper</td>
<td>QSFP+</td>
<td>No</td>
<td>OS2</td>
<td>1.4 km</td>
<td>8</td>
<td>12F MTP</td>
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<tr>
<td>4x10G-LR- NEW</td>
<td>Cisco</td>
<td>QSFP+</td>
<td>No</td>
<td>OS2</td>
<td>10km</td>
<td>8</td>
<td>12F MTP</td>
</tr>
<tr>
<td>40G-SWDM4 Coming Soon</td>
<td>TBD</td>
<td>QSFP+</td>
<td>No</td>
<td>OM3/OM4/OM5</td>
<td>TBD</td>
<td>2</td>
<td>LC</td>
</tr>
</tbody>
</table>

More Than 12 Choices Available!
Switches now have 100G ports available

High Density QSPF28 ports

- Cisco 3232C
- Cisco 92160
- Cisco 9508
- Arista 7512R
# 100G Optical Transceivers – Dec. 2016

<table>
<thead>
<tr>
<th>Transceiver</th>
<th>Switch Mfrs</th>
<th>Form Factor</th>
<th>IEEE Compliant</th>
<th>Fiber Type</th>
<th>Distance</th>
<th># of fibers</th>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>100G-SR10</td>
<td>All</td>
<td>CFP/CFP2/CPAK</td>
<td>Yes</td>
<td>OM3/OM4</td>
<td>100m/150m</td>
<td>20</td>
<td>24F MTP</td>
</tr>
<tr>
<td>20G-SR10 MXP</td>
<td>Arista</td>
<td>Embedded optics</td>
<td>No</td>
<td>OM3/OM4</td>
<td>100m/150m</td>
<td>24</td>
<td>24F MTP</td>
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<tr>
<td>100G-XSR10</td>
<td>Arista</td>
<td>CFP2</td>
<td>No</td>
<td>OM3/OM4</td>
<td>300/400m</td>
<td>20</td>
<td>24F MTP</td>
</tr>
<tr>
<td>100G-SR4</td>
<td>All</td>
<td>QSFP28</td>
<td>Yes</td>
<td>OS2</td>
<td>2km</td>
<td>8</td>
<td>12F MTP</td>
</tr>
<tr>
<td>100G-XSR4 - NEW</td>
<td>Arista, Juniper</td>
<td>QSFP28</td>
<td>No</td>
<td>OS2</td>
<td>2km</td>
<td>2</td>
<td>LC</td>
</tr>
<tr>
<td>100G-LR4 – NEW FF</td>
<td>All</td>
<td>CFP2/CFAK/ QSFP28</td>
<td>Yes</td>
<td>OS2</td>
<td>10km</td>
<td>20</td>
<td>24F MTP</td>
</tr>
<tr>
<td>100G-SM4 – NEW</td>
<td>Cisco</td>
<td>CPAK</td>
<td>No</td>
<td>OS2</td>
<td>500m</td>
<td>8</td>
<td>12F MTP</td>
</tr>
</tbody>
</table>
Enterprise Data Center
Migration Strategy
Enterprise Data Centers

- Most are using 1G down to servers with 10G uplinks
- Considering to migrate to 10G down/40G Up or 25G/100G if costing looks attractive
- Majority of DCs have multi-mode cabling installed
- 85% of optical links are 150m or less
Migration Path for 40/100G Enterprise Networks
Multi-mode Solution

10G
- MTP-LC Modules
- Duplex LC Patch Cords
- 10G-SR

40G
- MTP 24-F to 3x8-F Modules
- 8-Fiber MTP Array Cords
- 40G-SR4

100G
- MTP 24-F to 3x8-F Modules
- 8-Fiber MTP Array Cords
- 100G-SR4

Leviton introduced January 2011
First in the Market
Multi-mode Migration Path
10G or 40G Duplex Channel

- 24-F MTP backbone
- Provides Duplex (2-fiber) connections at equipment
- Will support 1G/10GbE in SFP+ form factors
- Will support 40G using Wave Division Multiplexing Technology (WDM) like the Cisco/Arista BiDi in QSFP+ form factors
Multi-mode Migration Path

40G-SR4 Channel

- Same 24F MTP Backbone stays in place
- Swap out MTP-LC cassettes for MTP-MTP conversion cassettes
- Provides Parallel (8-fiber) connections at equipment

- 100% fiber utilization
- Will support 40GBASE-SR4 in QSPF+
**Multi-mode Migration Path**

**100G-SR4 Channel**

- Same 24F MTP Backbone stays in place
- Swap out MTP-LC cassettes for MTP-MTP conversion cassettes
- Provides Parallel (8-fiber) connections at equipment
- 100% fiber utilization
- Will support 100GBASE-SR4 in QSFP+
Cloud Provider
Migration Solution
Cabling Strategy for Cloud Providers

• Most are either already using or planning to move to Single-mode
  – 97% of single-mode links are 350m or less

• Key reasons why single-mode is being selected:
  – Requirements for reach beyond 150m
  – Transceivers costs have lowered significantly in last 2 years
  – Increasing bandwidth requirements
  – Majority of next gen speeds will use SMF
  – Need to “futureproof” cabling infrastructure
  – More flexibility to add more “hops” in channel
Single-Mode Migration Path
2-Fiber Channels: 10G, 40G or 100G

- 24-F MTP backbone
- Provides Duplex (2-fiber) connections at equipment
- Will support the following optics:
  - 10GbE in SFP+ form factor
  - 40GBASE-LR4/LRL4 in QSFP+ form factor
  - Arista 40G Universal in QSFP+ form factor
  - 100GBASE-LR4/LRL4 in CFP2/CPAK or QSFP28 form factors
Single-Mode Migration Path

8-Fiber Channels: 40G or 100G

- Same 24F MTP Backbone stays in place
- Swap out MTP-LC cassettes for MTP-MTP conversion cassettes
- Provides Parallel (8-fiber) connections at equipment
- 100% fiber utilization
- Will support the following optics:
  - 40GBASE-PLRL4/PLR4 in QSFP+ form factor
  - 40G: 4x10G-LR/IR in QSFP+ form factor
  - 100G-PSM4 in QSFP28 form factor
Single-Mode Migration Path
20-Fiber Channel: 100G

- Same 24F MTP Backbone stays in place
- Swap out MTP-LC/MTP-MTP cassettes with MTP pass-thru cassettes
- Provides Parallel (20-fiber) connections at equipment
- Will support Cisco 10x10-LR in CPAK form factor
Single-Mode Cabling System

- MTP-MTP Low Loss Trunks – 12F MTP and 24F MTP/APC
- MTP-LC cassettes
- MTP-MTP conversion cassettes
- MTP pass-thru adapter plates
- MTP-MTP Array cords and harnesses
  - 8F, 12F, 24F
End-Face Geometry Testing is Required for Single-Mode to Assure Consistent Quality

- End-face geometry testing with Interferometer
- 100% testing of single fiber single-mode connectors
- Tested to IEC-61755
  - Apex offset
  - Radius of curvature
  - Fiber protrusion
Laser Cleaving Recommended for SMF

- High-precision equipment used for single and multi-fiber connectors
- Required for consistent, high-quality terminations
- Hand Cleaving 8.3 µm SMF very difficult
Single-Mode Test Equipment is Critical
Must Test Both IL and RL

- Single-mode must be tested in both 1310nm and 1550nm
- Multi-channel tester required to test 12 and 24F MTPs
Summary

• Enterprise and Cloud DCs are very different

• 25G and 50G ecosystems are coming soon

• MMF and SMF Transceiver costs are getting closer

• Cloud data centers are migrating to single-mode