Designing a Flexible Network Infrastructure to support new optical technologies

Enterprise vs. Cloud Data Center Requirements

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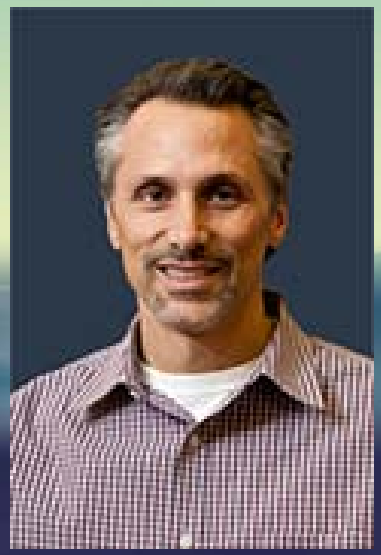
Leviton Network Solutions



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Outline

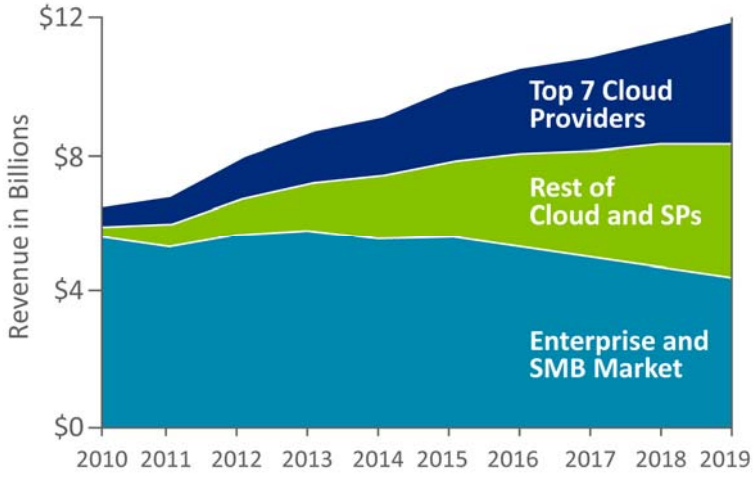
- Definition of Enterprise and Cloud Data Centers
- The Growth of Cloud Computing
- Market forecast for 25G/50G/100G/200G/400G Ethernet
- Trends with Multimode vs. Single-mode Optics
- Use case: 40G for Enterprise data centers
- Use case: 100G+ for Cloud data centers

Enterprise vs. Cloud Data Centers

Major Characteristics of Data Centers

	SMB	Large Enterprise	Cloud
Number or Servers	<500	10,000	>100,000
Number Of Customers	>1,000,000	<5,000	<100
Number of Top-of-Rack / Leaf Switches	<25	<500	>2,000
Number of Spine / Aggregation Switches	1-2	<25	>100
Number of Core Switches	N/A	<12	>12
Deal Size	<$100,000	<$5,000,000	>$20,000,000
Ethernet Switch Vendor Margin	>60%	>50%	<25%

Total Ethernet Switch
Data Center Revenue



Source: Dell'Oro, 2015

Used for a single organization.

Can be externally or internally hosted.

Shared by several organizations.

Typically externally hosted.

Two or more clouds bound together.

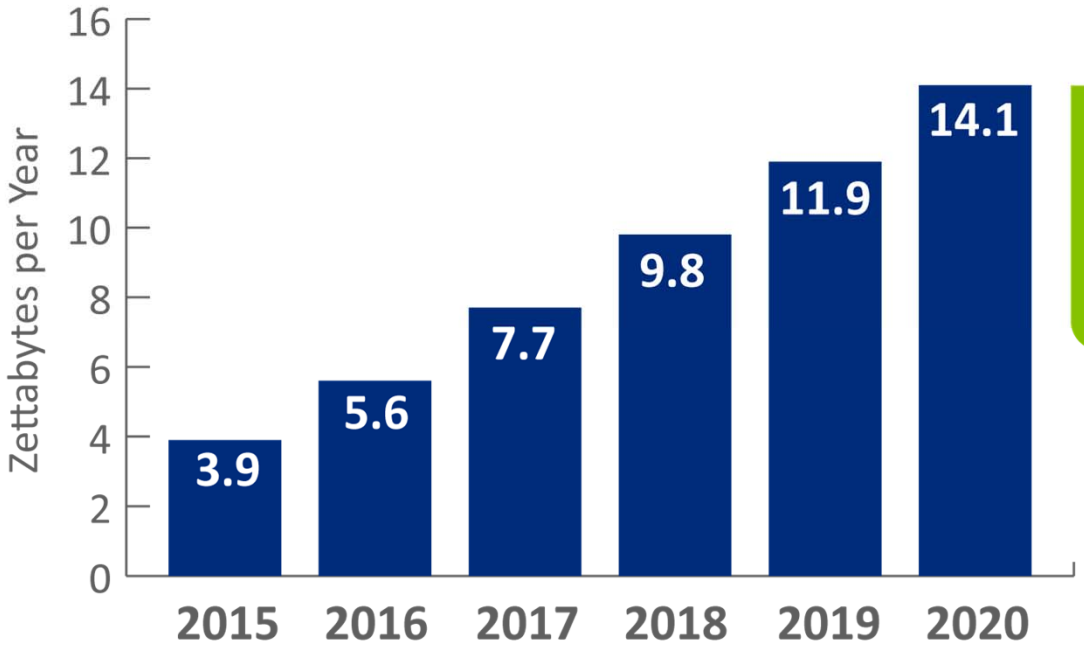
Usually part internally and part externally hosted.

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

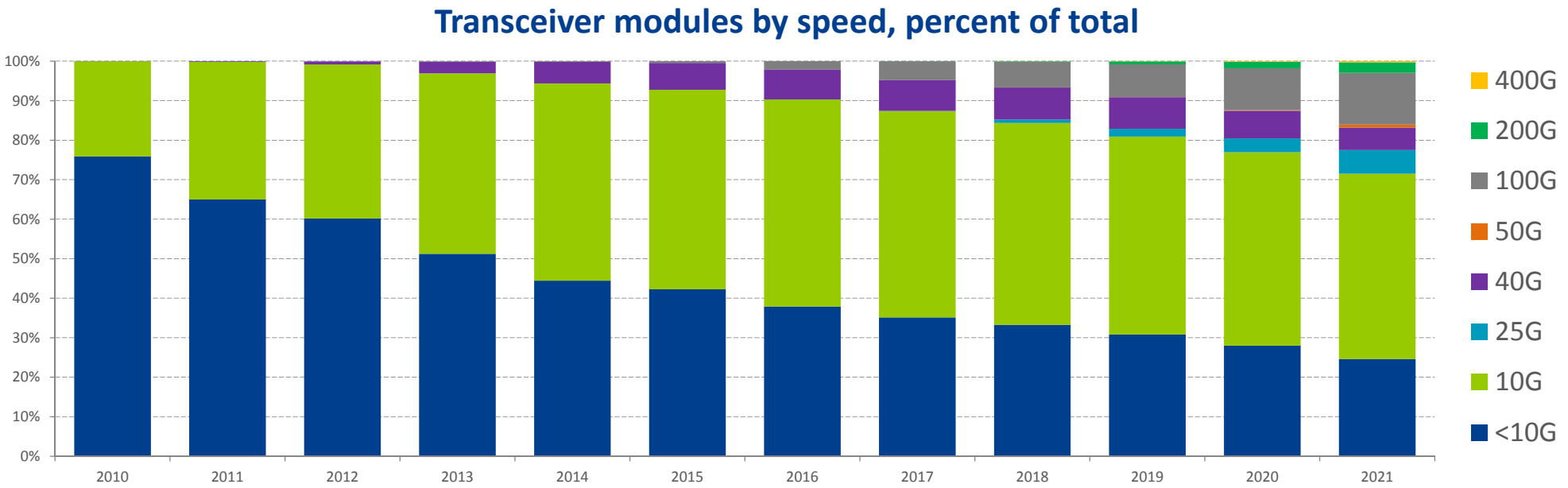


Source: Cisco Global Cloud Index, 2015-2020

Trends in the Data Center

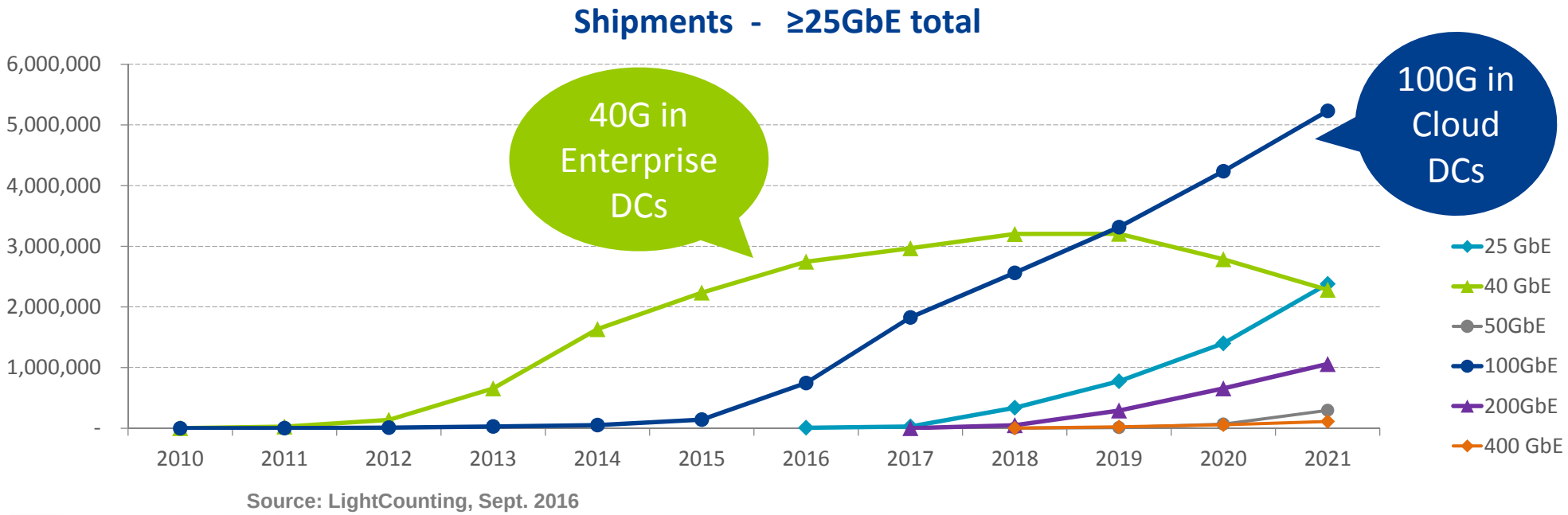
- Many traditional enterprise data centers are moving to the cloud
- Flatter network designs…3-tier to Leaf-Spine
- Data Centers are getting larger
- More companies are outsourcing to co-location providers
- Creation of a new 25Gb/s ecosystem
- New cost-effective 100G switches

The Need for Speed – Ethernet Speed Market Forecast



Source: LightCounting, Sept. 2016

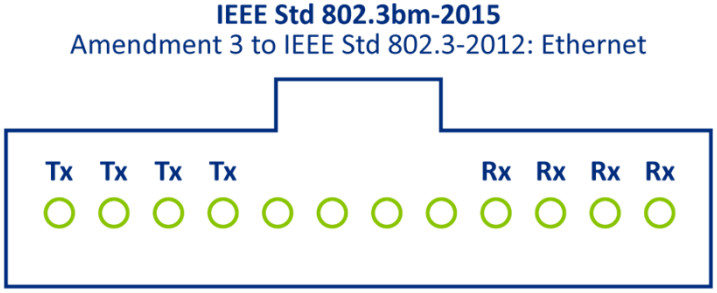
Dramatic Growth of 100G Expected…



Source: LightCounting, Sept. 2016

25 Gb/s Lanes vs. 10Gb/s Lanes

- 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 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

Rate	Fiber Type	# fibers	Connector	Reach	IEEE Std	Est. Release
100GBASE-SR4	OM4	8	MPO	70m	802.3bm	Apr-15
100GBASE-SR2	OM4	4	MPO	100m	802.3cd	Sep-18
100GBASE-DR2	OS2	4	MPO	500m	802.3cd	Sep-18
100GBASE-FR2	OS2	2	LC	2km	802.3cd	Sep-18
200GBASE-DR4	OS2	8	MPO	500m	802.3bs	Dec-17
200GBASE-FR4	OS2	2	LC	2km	802.3bs	Dec-17
400GBASE-SR16	OM4 / OM5	32	MPO	100m	802.3bs	Dec-17
400GBASE-FR8	OS2	2	LC	2km	802.3bs	Dec-17

50G Lane Ecosystem is not far off – 100G/200G & 400G

- Most options use single-mode cabling

Rate	Fiber Type	# fibers	Connector	Reach	IEEE Std	Est. Release
100GBASE-DR	OS2	2	LC	500m	802.3cd	Sep-18
100GBASE-FR	OS2	2	LC	2km	802.3cd	Sep-18
200GBASE-SR4	OM4	8	MPO	100m	802.3cd	Sep-18
400GBASE-DR4	OS2	8	MPO	500m	802.3bs	Dec-17
400GBASE-FR8	OS2	2	LC	2km	802.3bs	Dec-17

Enterprise vs. Cloud Network Speeds

Enterprise

NOW: 1G Down/10G Up

10G Down/40G Up **OR**
10G Down/25G Up

Cloud

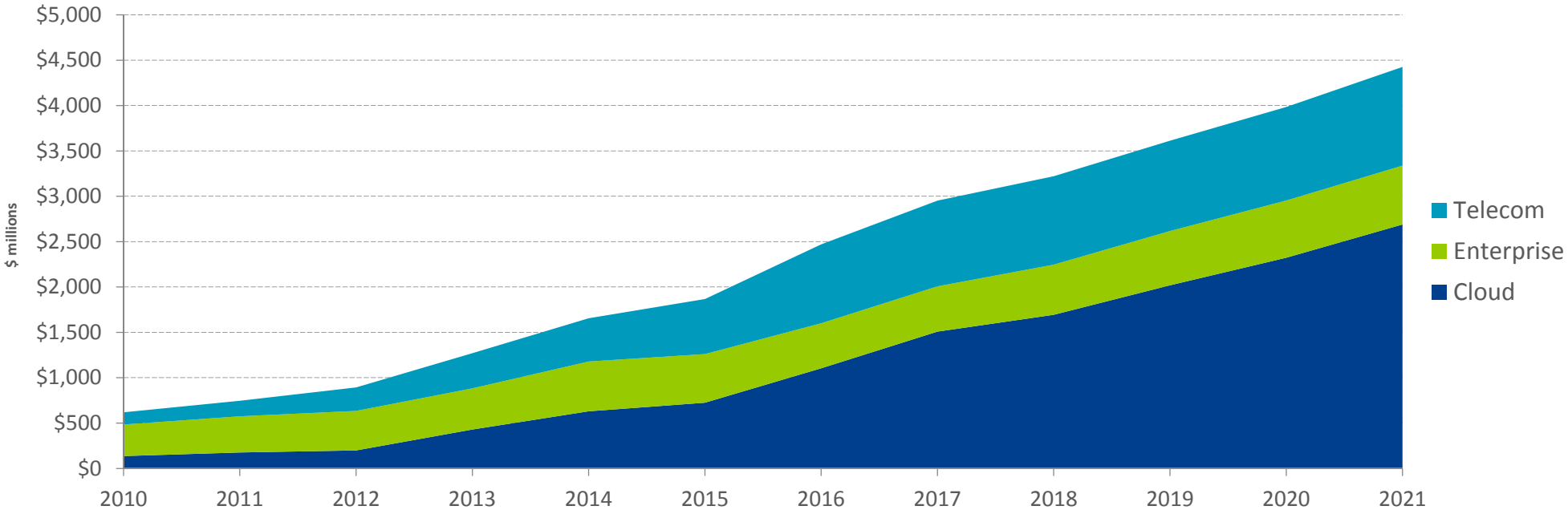
NOW: 10G Down/40G Up

25G Down/100G Up **OR**
50G Down/200G Up **OR**
100G Down/400G Up

Multi-Sourcing Agreements (MSAs)

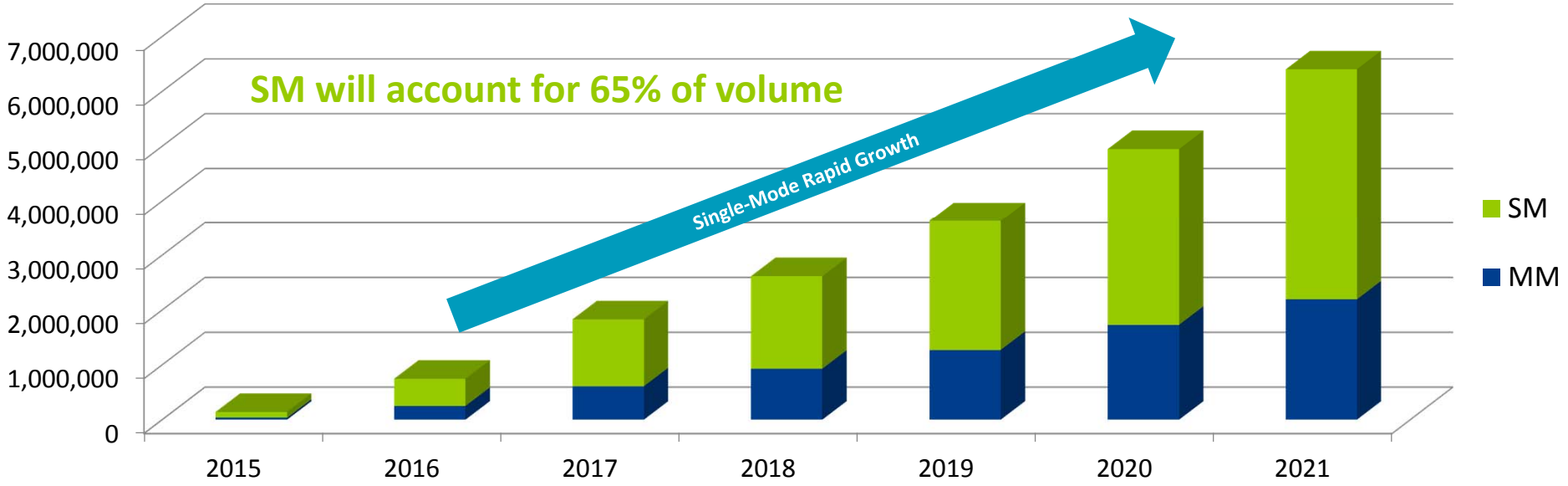
- In addition to IEEE standards, there are many technologies being developed thru MSAs with industry consortiums
  - 100G CLR4 Alliance – Duplex SMF
  - SWDM Alliance – Duplex MMF for 40 & 100G
  - 100G PSM4 MSA…Parallel SMF for 100G+
  - 10x10 MSA…Parallel SMF
  - CWDM4 MSA…Duplex SMF for 100G+
  - OpenOptics MSA – Duplex SMF for 100G & 400G

Sale of Ethernet Transceivers by Market



SM vs. MM Transceiver Estimated Volumes

100G – 400G Ethernet

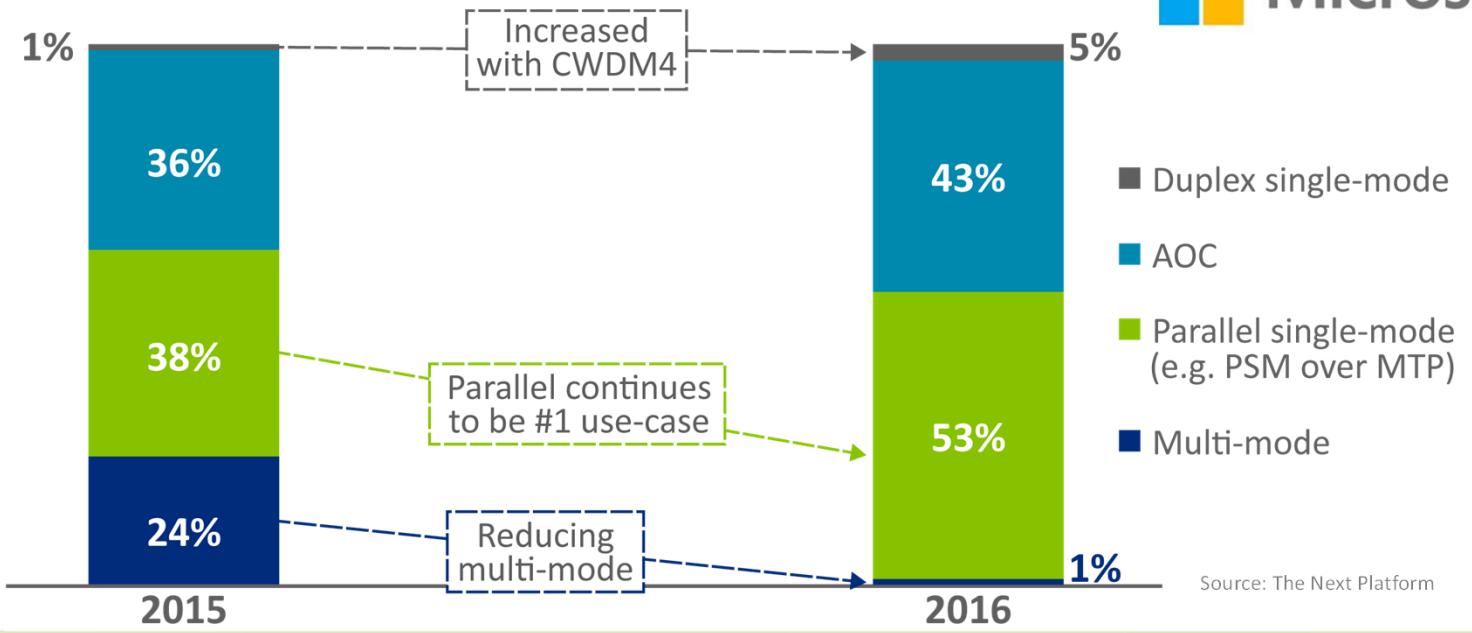


Source: LightCounting, Sept. 2016

Market Leaders Setting an Example

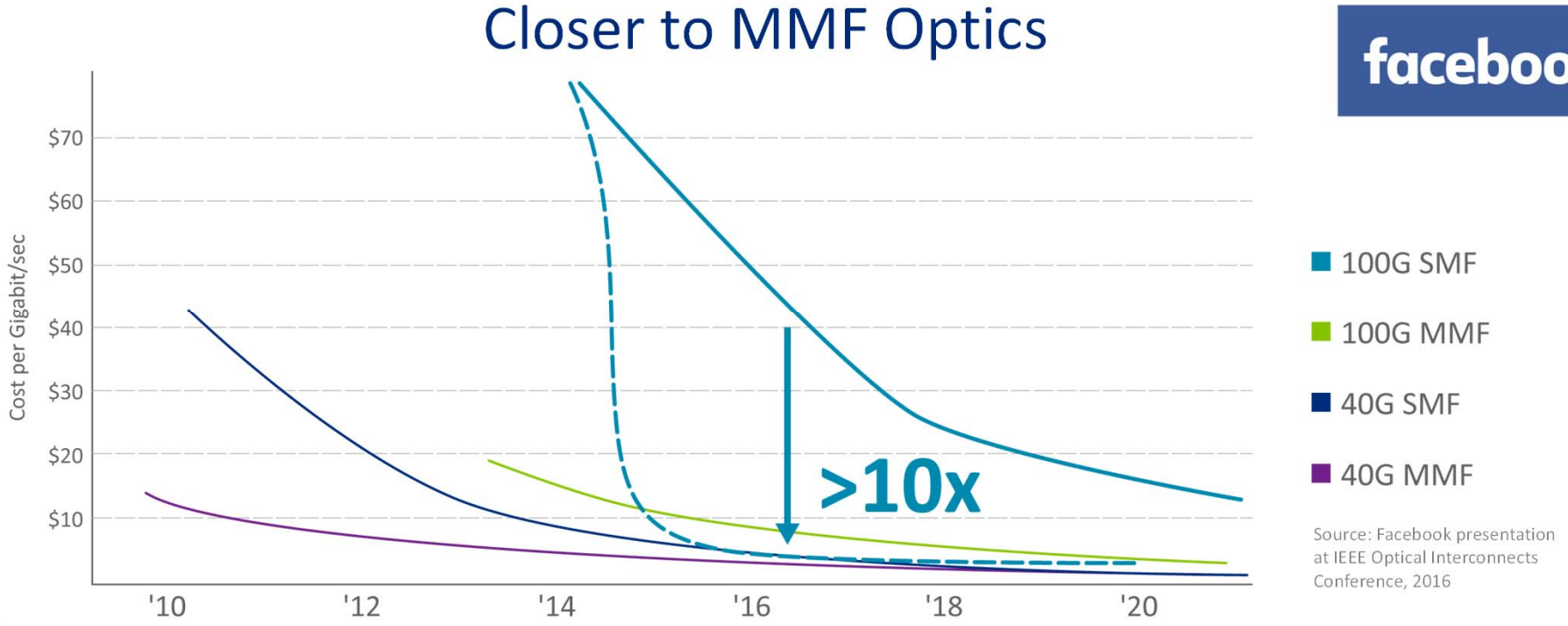
99% Single-mode

Microsoft



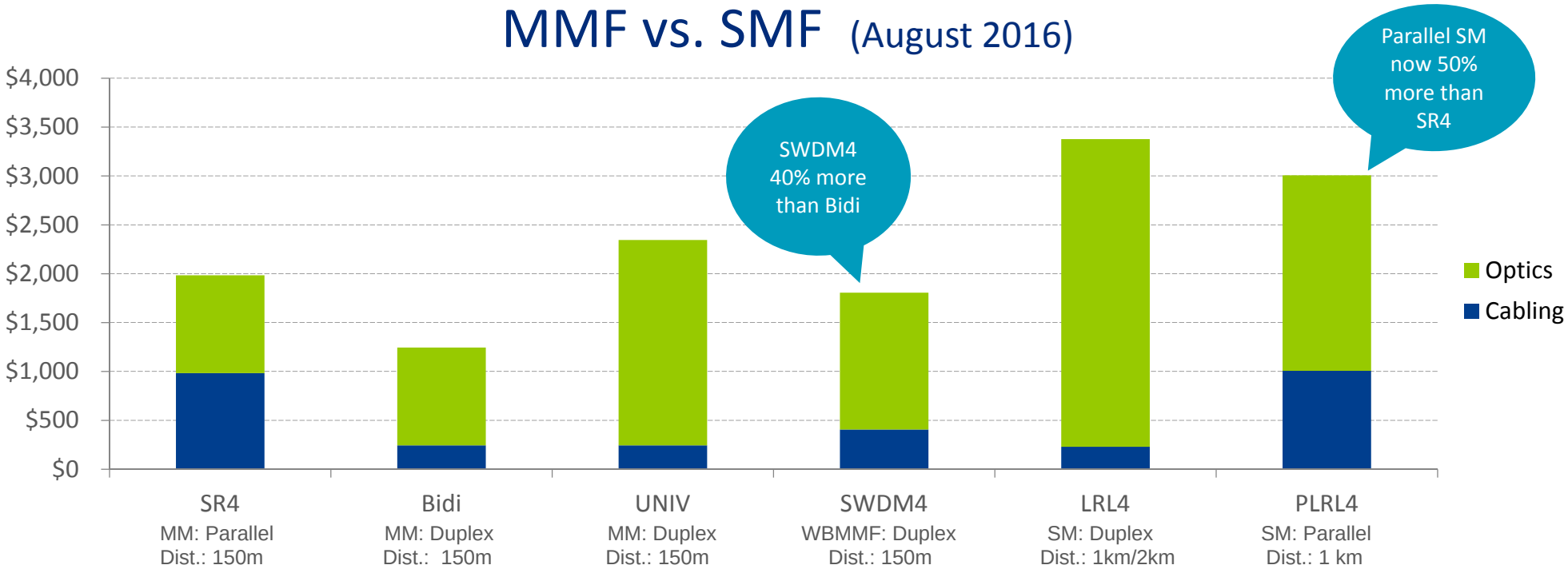
Source: The Next Platform

Cost of SMF Optics expected to decline

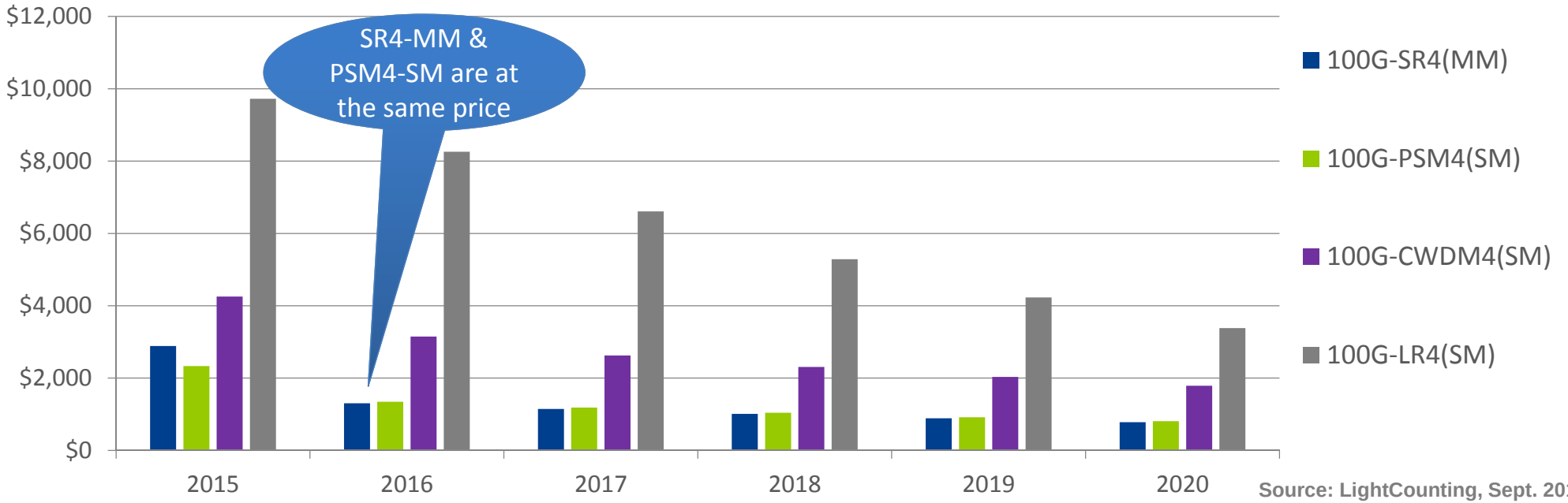


End-to-end 40G Channel Cost Comparison

MMF vs. SMF (August 2016)



Estimated List Prices: 100G Transceivers



Source: LightCounting, Sept. 2016

High Density 40/100G Switches

QSFP+ ports

Arista 7300 Series

Juniper 9214

Cisco Nexus 6004

Cisco Nexus 7700

40G Optical Transceivers – Dec. 2016

	Transceiver	Switch Mfrs	Form Factor	IEEE Compliant	Fiber Type	Distance	# of fibers	Connector
1	40G-SR4	All	QSFP+	Yes	OM3/OM4	100m/150m	8	12F MTP
2	40G-C/X/ESR4	Cisco, Arista, Juniper	QSFP+	No	OM3/OM4	300m/400m	8	12F MTP
3	40G-BIDI	Cisco, Arista	QSFP+	No	OM3/OM4	100m/150m	2	LC
4	40G-LX4	Juniper	QSFP+	No	OM3/OM4	100/150m	2	LC
5	40G- UNIV	Arista	QSFP+	Yes	OM3/OM4 OS2	150m, 500m	2	LC
6	40G-LR4	All	QSFP+	Yes	OS2	10 km	2	LC
7	40G-LRL4/IR4	Cisco, Arista, Juniper	QSFP+	Yes	OS2	1km/2km	2	LC
8	40G-PLRL4	Arista	QSFP+	No	OS2	1 km	8	12F MTP
9	4x10G-IR	Juniper	QSFP+	No	OS2	1.4 km	8	12F MTP
10	4x10G-LR- NEW	Cisco	QSFP+	No	OS2	10km	8	12F MTP
11	40G-PLR4	Arista	QSFP+	No	OS2	10 km	8	12F MTP
12	40G-SWDM4 Coming Soon	TBD	QSFP+	No	OM3/OM4/OM5	TBD	2	LC

More Than 12 Choices Available!

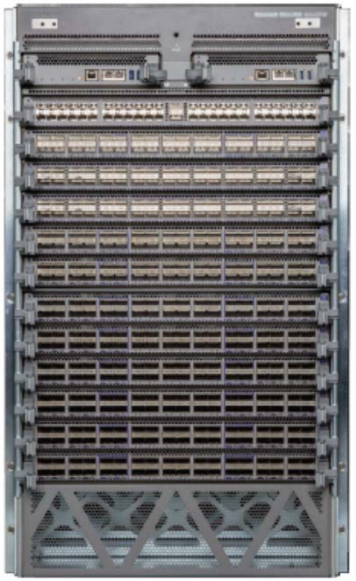
Switches now have 100G ports available

High Density QSPF28 ports

Cisco 3232C

Cisco 92160

Cisco 9508



Arista 7512R

100G Optical Transceivers – Dec. 2016

	Transceiver	Switch Mfrs	Form Factor	IEEE Compliant	Fiber Type	Distance	# of fibers	Connector
1	100G-SR10	All	CFP/CFP2/CPAK	Yes	OM3/OM4	100m/150m	20	24F MTP
2	100G-SR10 MXP	Arista	Embedded optics	No	OM3/OM4	100m/150m	24	24F MTP
3	100G-XSR10	Arista	CFP2	No	OM3/OM4	300/400m	20	24 F MTP
4	100G-SR4	All	QSFP28	Yes	OM3/OM4	70m/100m	8	12F MTP
5	100G-XSR4 - NEW	Arista, Juniper	QSFP28	No	OM3/OM4	300m	8	12F MTP
6	100G-LRL4 - NEW	Arista	QSFP28	Yes	OS2	2km	2	LC
7	100G-CWDM4- NEW	Arista, Cisco	QSFP28	No	OS2	2km	2	LC
8	100G-LR4 – NEW FF	All	CFP2/CPAK/ QSFP28	Yes	OS2	10km	2	LC/SC
9	10x10-LR	Cisco	CPAK	No	OS2	1 km	20	24F MTP
10	100G-PSM4- NEW	Arista, Juniper	QSFP28	No	OS2	500m	8	12F MTP

Many New 100G Options Available

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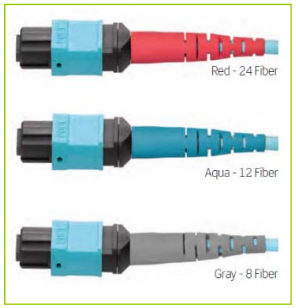
Enterprise Data Center Migration Strategy

Enterprise Data Centers

- Most are using 1G down to servers with 10G uplinks
- Considering to migrate to 10Gdown/40GUp 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

Multimode Solution



Colored-coded MTP Boots

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

Multimode 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

Multimode 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+

Multimode 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, 100G, 200G or 400G

- 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

- **Will support future applications of 100G-FR2, 200G-FR4,400G-FR8**

Single-Mode Migration Path

8-Fiber Channels: 40G, 100G, 200G or 400G

- 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 QSPF+ form factor
  - 40G: 4x10G-LR/IR in QSFP+ form factor
  - 100G-PSM4 in QSFP28 form factor

- **Will support future applications of 200G-DR4, 400G-DR4**

Single-Mode Migration Path

20-Fiber Channel: 100G

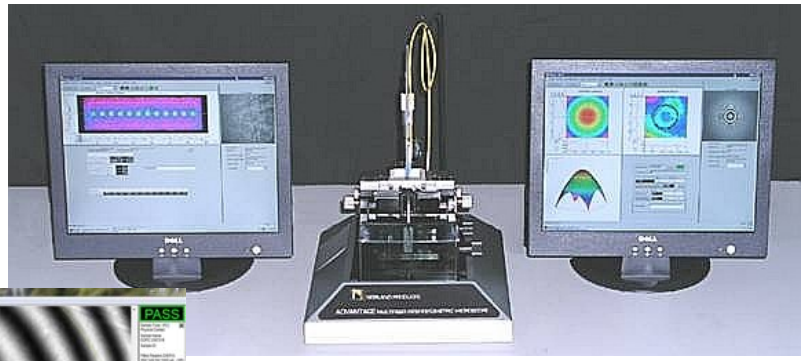
- Same 24F MTP Backbone stays in place
- Swap out MTP-LC/MTP-MTP cassettes with MTP pass-thru cassettes
- Provides Parallel (20-fiber) connections at equipment
- Will support Cisco 10x10-LR in CPAK form factor

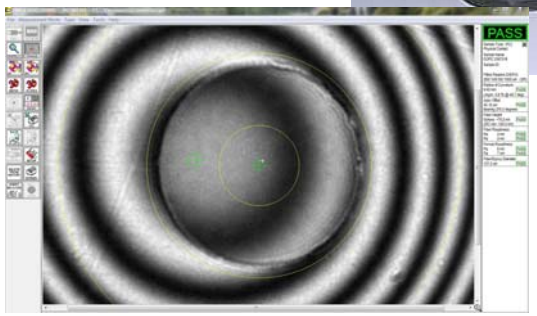
Single-Mode Cabling System

- 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





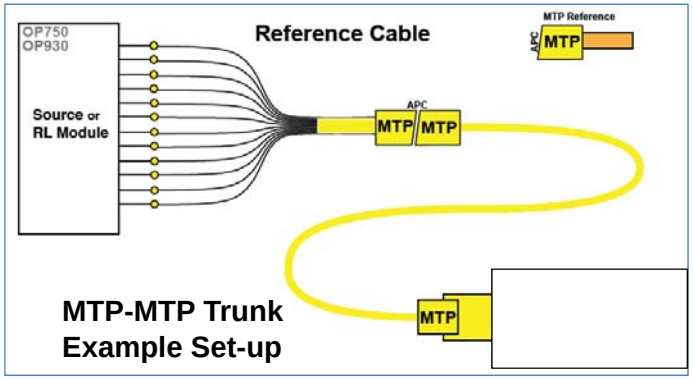
Laser Cleaving Recommended for SMF

- 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