Specifying Optical Fiber for Data Center Applications

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Outline

- Data Center Market Drivers
- Data Center Trends
- Optical Fiber and Related Standards
- 40G & 100G Ethernet
- Opto-Electronics and Cabling Considerations
- Conclusions

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Data Center Market Drivers

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IP Traffic Growth

- Global IP traffic will quadruple from 2009 to 2014 – in other words, *the Internet will be 4 times larger!*
- Mobile data traffic will double every two years through 2014
- It will take 72 million years to watch the amount of video traffic that will cross Global IP networks in 2014

Cisco Visual Networking Index: Forecast and Methodology, 2009-2014 June 10, 2010

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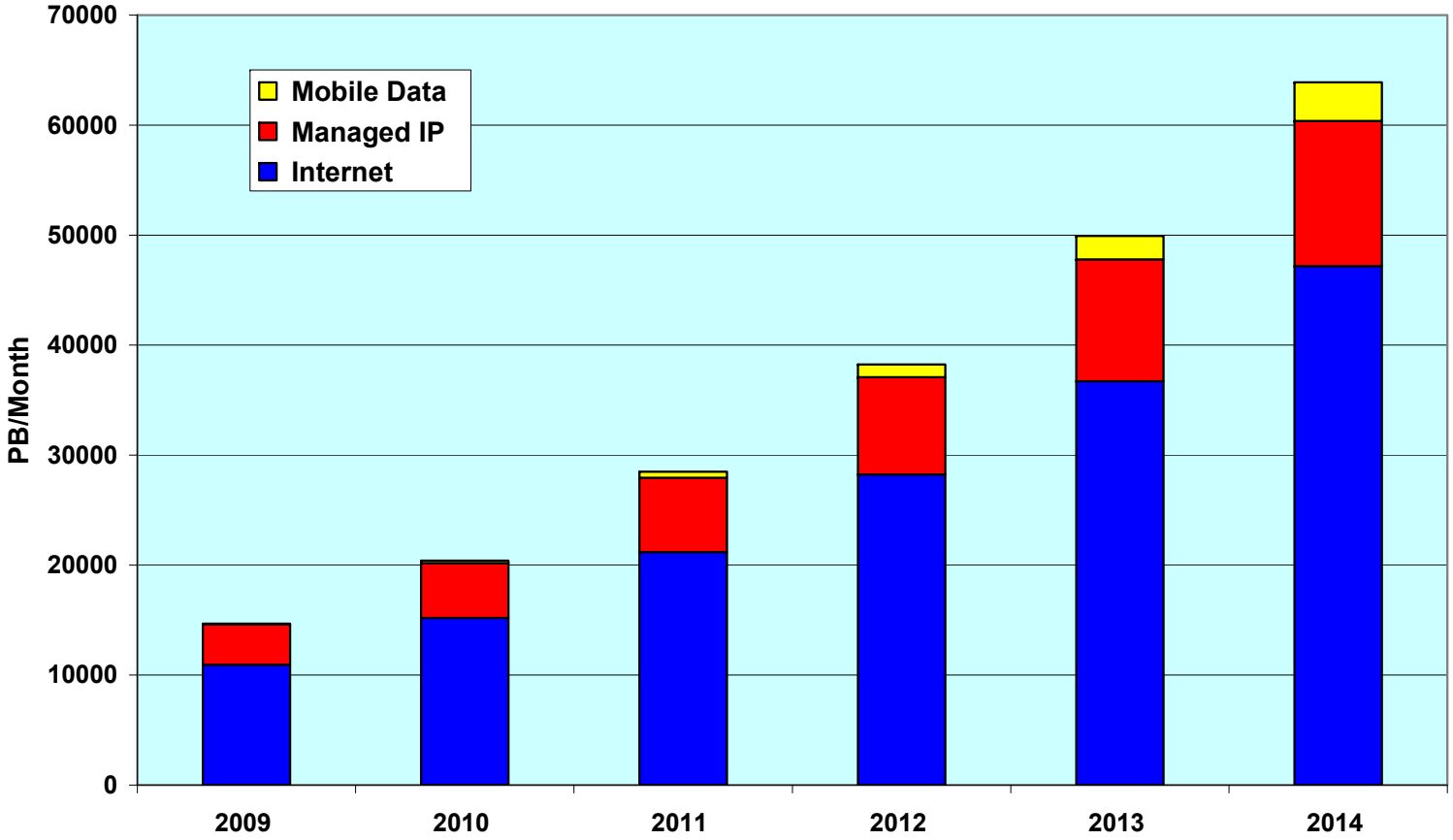
IP Traffic Growth

" Cisco Visual Networking Index (VNI): Forecast and Methodology, 2009-2014"
June 2, 2010



CAGR

108%

29%

34%

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Internet Applications

YouTube

- March 2010 – 24 hours of video uploaded every minute [1]
- May 2010 – reaches 2 billion views/day [1]

Facebook

- June 2010 – 400 million active users, spending 500 billion minutes per month on site [2]

Apple

- June 2010 – 600,000 iPhone 4's sold 1st day of presales [3]

Apple iTunes

- February 2010 – reaches 10 billion songs sold [4]

[1] http://mashable.com/2010/05/17/youtube-2-billion-views/
[2] http://www.facebook.com/press/info.php?statistics
[3] http://www.apple.com/pr/library/2010/06/16iphone.html
[4] http://www.apple.com/pr/library/2010/02/25itunes.html

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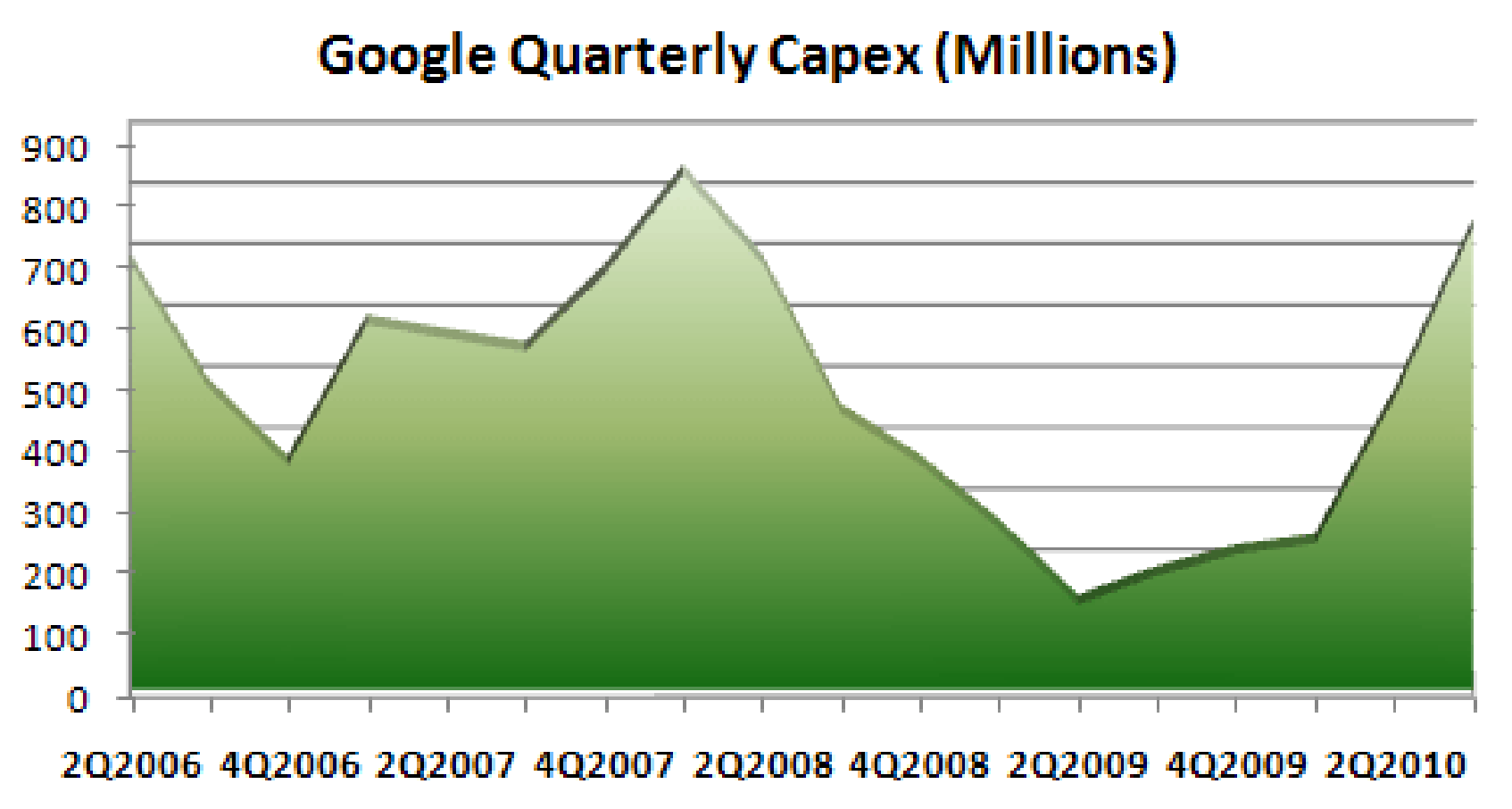
Internet Applications



http://www.datacenterknowledge.com *"Google's Data Center Spending Soars", Oct. 15, 2010*

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Data Center Trends

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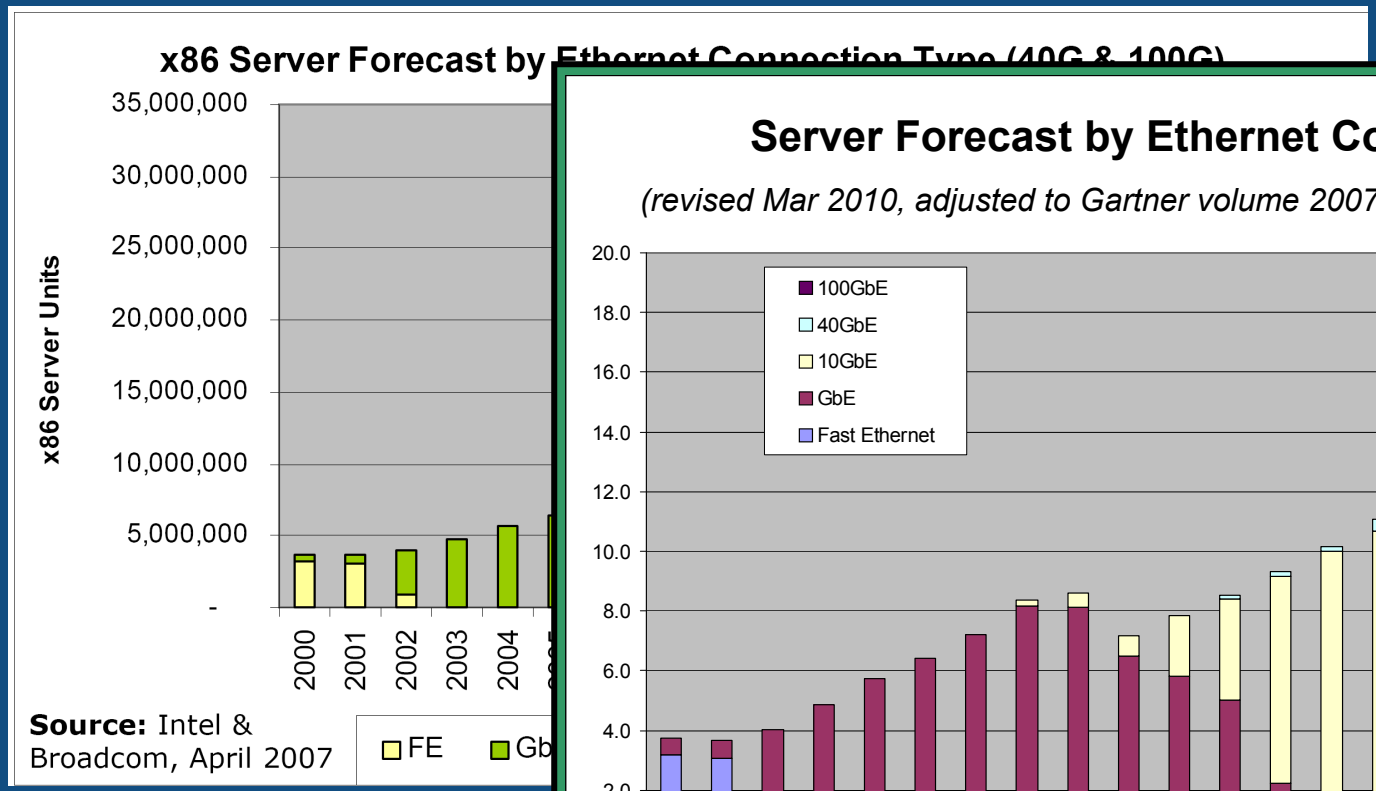
Server growth forecast

Revised with actual 2007-2009 server shipments



Migration t
links drive

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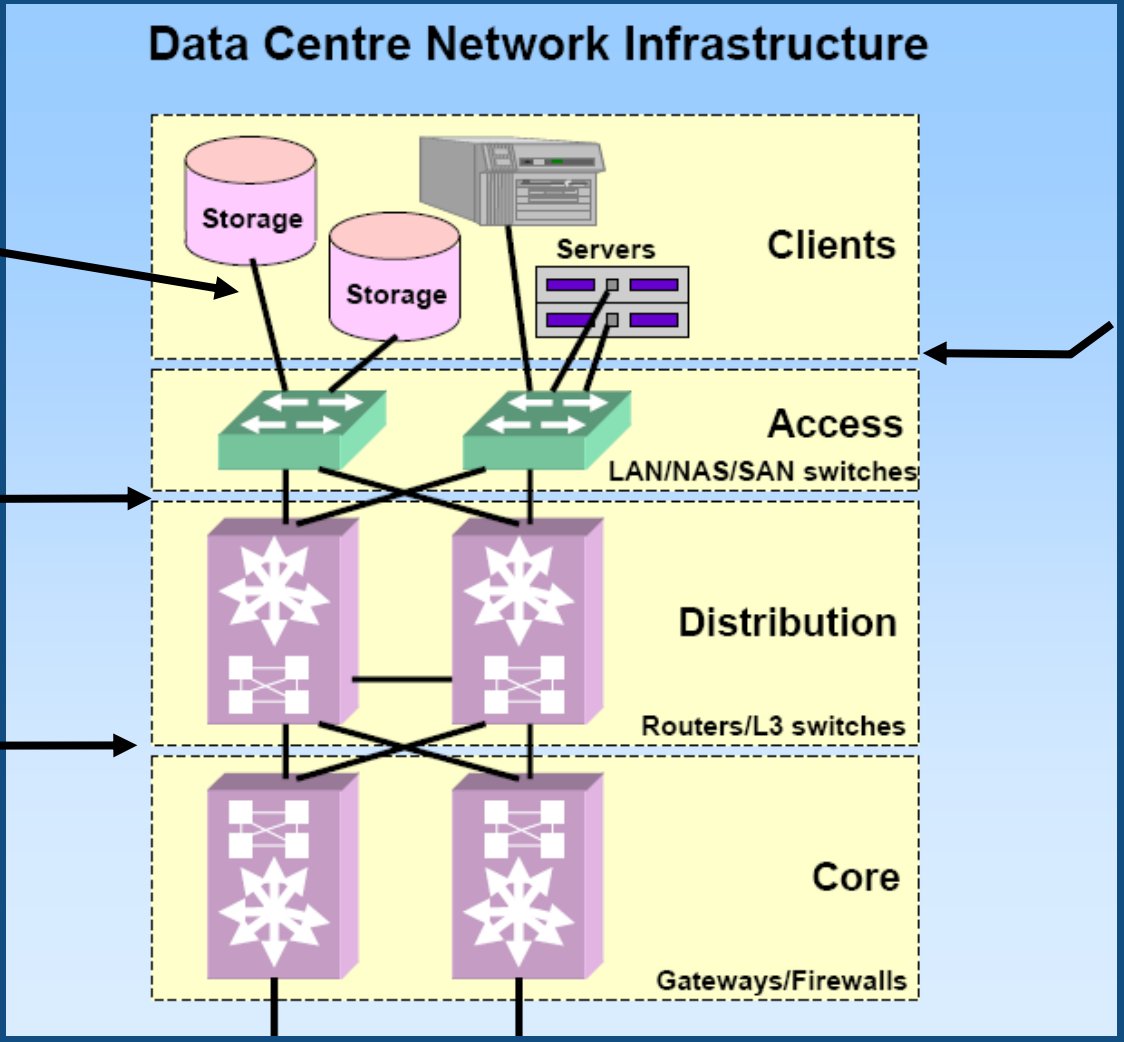
Data Center Link Speed Evolution

Migration to 16G FC

(OM3 & OM4)

Migration to 40G & 100G Ethernet

(OM3 & OM4 or SM)



Migration to 10GbE

(Fiber, Copper)

Data from Alan Flatmann
presented to IEE 802.3 High Speed Study Group
January 2008

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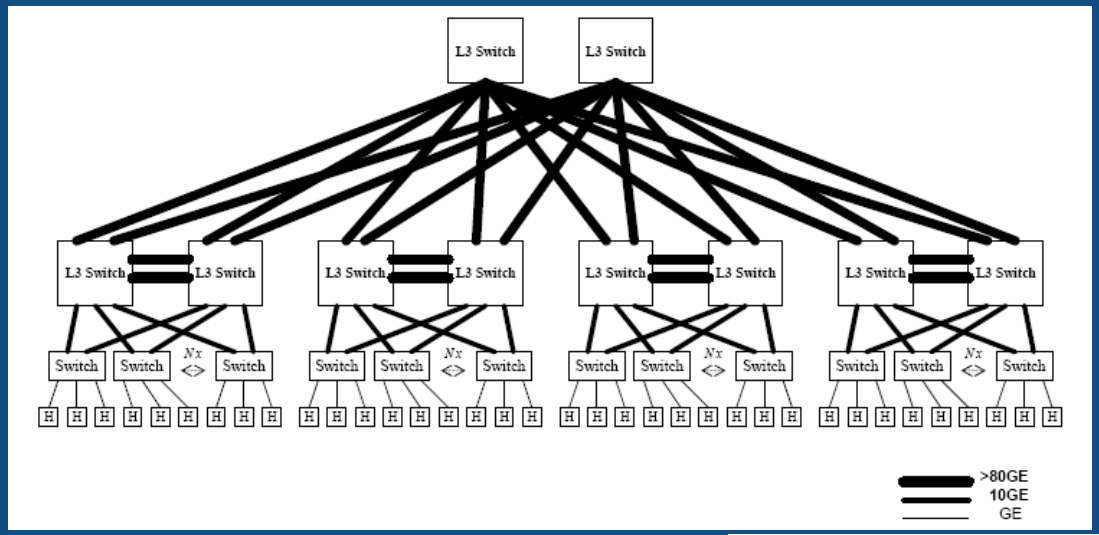
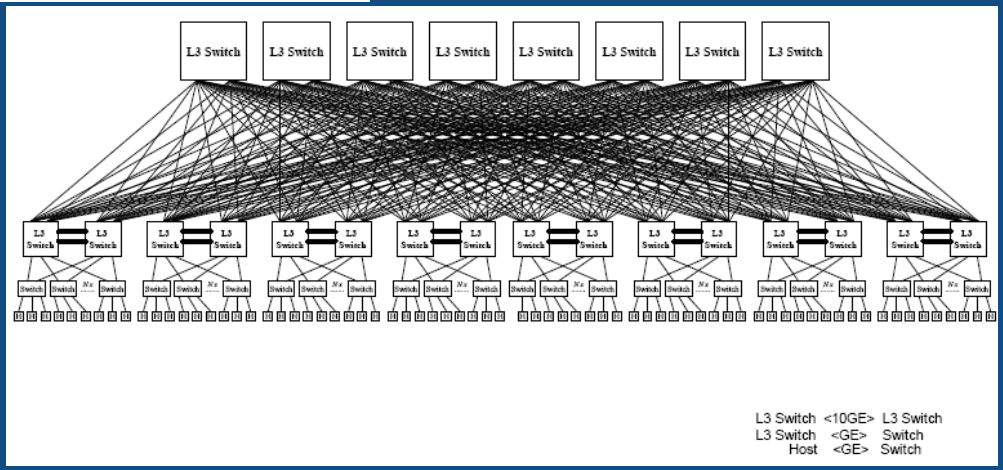
Why the higher speeds?



High speed connections simplify the network

More interconnects and switches required



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Pictures presented by Adam Bechtel – Yahoo! Chief Architect
IEEE 802.3 Plenary March 2007

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Key Network Points for 40G & 100G

- Deployment of 40G Ethernet will support primarily Servers
  - Interconnection links
  - Data center servers
  - Storage Area Networks
  - Corporate, video, medical, R&D Enterprises
- Deployment of 100G Ethernet will be driven by high-bandwidth switching, routing, and aggregation interconnect points
  - Metro, core, carrier/service provider networks
  - Internet exchanges and aggregation points
  - Will drive growth of Content Provider applications such as:
    - Video on demand / IPTV / HDTV / 3DTV, Gaming
  - Interconnects for high performance super computing environments
- Not intended for riser or horizontal building cabling

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Optical Fiber and Related Standards

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Multimode Fiber Types, Performance Grades

Fiber Type	Wavelength (nm)	Max CABLE Loss (dB/km)	Min Bandwidth (MHz·km)	
			OFL BW	EMB
OM1 62.5 µm	850 1300	3.5 1.5	200 500	n.s. n.s.
OM2 50 µm	850 1300	3.5 1.5	500 500	n.s. n.s.
OM3 50 µm	850 1300	3.5 1.5	1500 500	**2000** n.s.
OM4 50 µm	850 1300	3.5 1.5	**3500** 500	**4700** n.s.

OFL BW =

Overfilled Launch Bandwidth

EMB =

Effective Modal Bandwidth

(*also known as "Laser" BW*)

OMx designations are from ISO/IEC 11801 International Cabling Standard

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Multimode Fiber Standards

ISO / IEC 11801	TIA / EIA	IEC 60793-2-10
OM1 (62.5 µm)	**492AAAA**	**A1b**
OM2 (50 µm)	**492AAAB**	**A1a.1**
OM3 (50 µm)	**492AAAC**	**A1a.2**
OM4 (50 µm)	**492AAAD**	**A1a.3**

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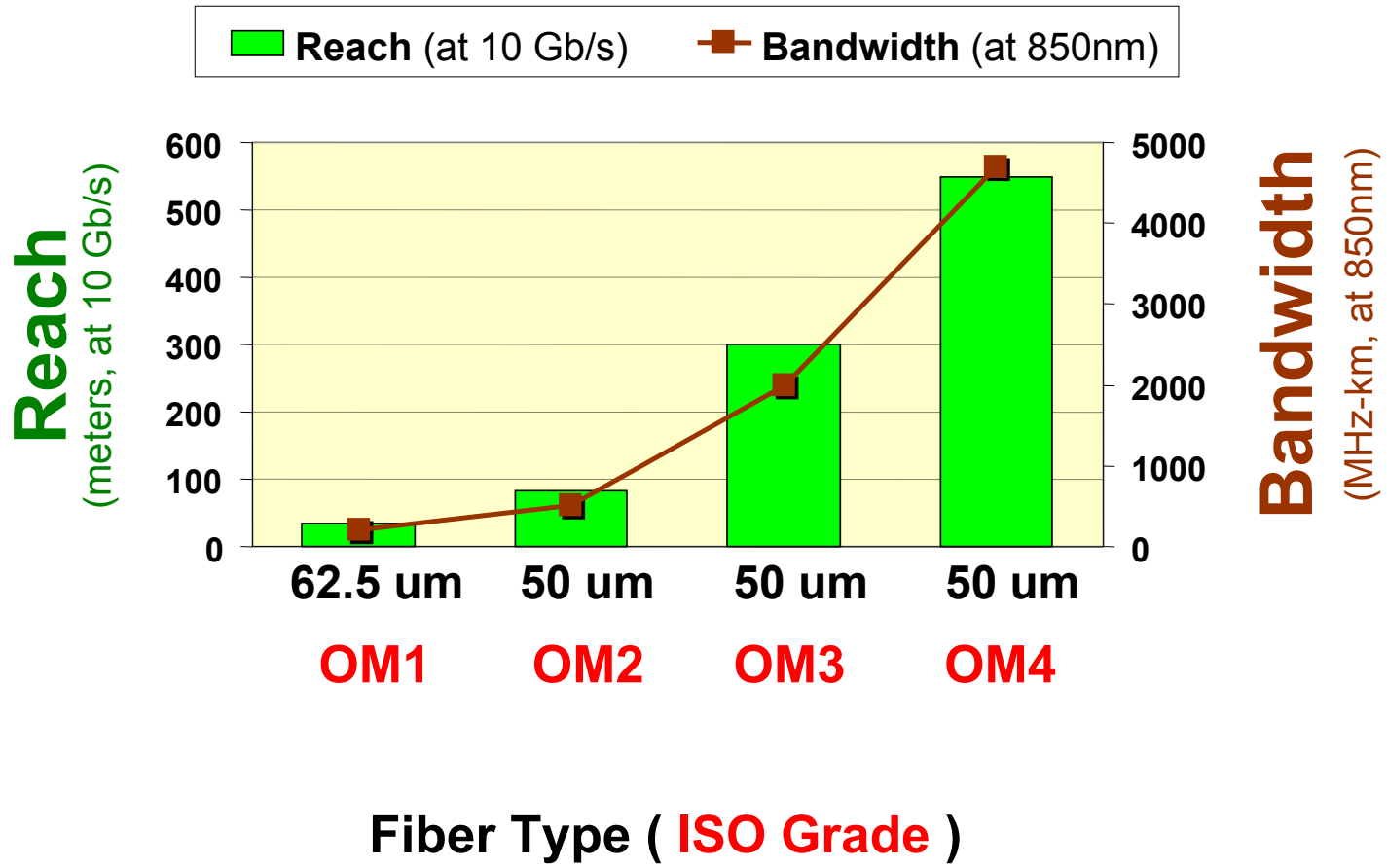
Multimode Fiber Performance (10G) by Type & Grade

Reach & Bandwidth by MM Fiber Type



OM4 Specifications

- Effective Modal Bandwidth (EMB) **>/= 4700** MHz-km
  - Allows 2 methods for verification– **DMD Masks** or **EMBc**
- OFL Bandwidth at 850nm **>/= 3500** MHz-km
  - Ensures performance with sources that launch more power into outer modes
- OFL Bandwidth at 1300nm **>/= 500** MHz-km
  - Ensures backward compatibility with OM1, OM2, OM3 fibers for applications such as FDDI, 100BASE-FX, 1000BASE-LX, etc.

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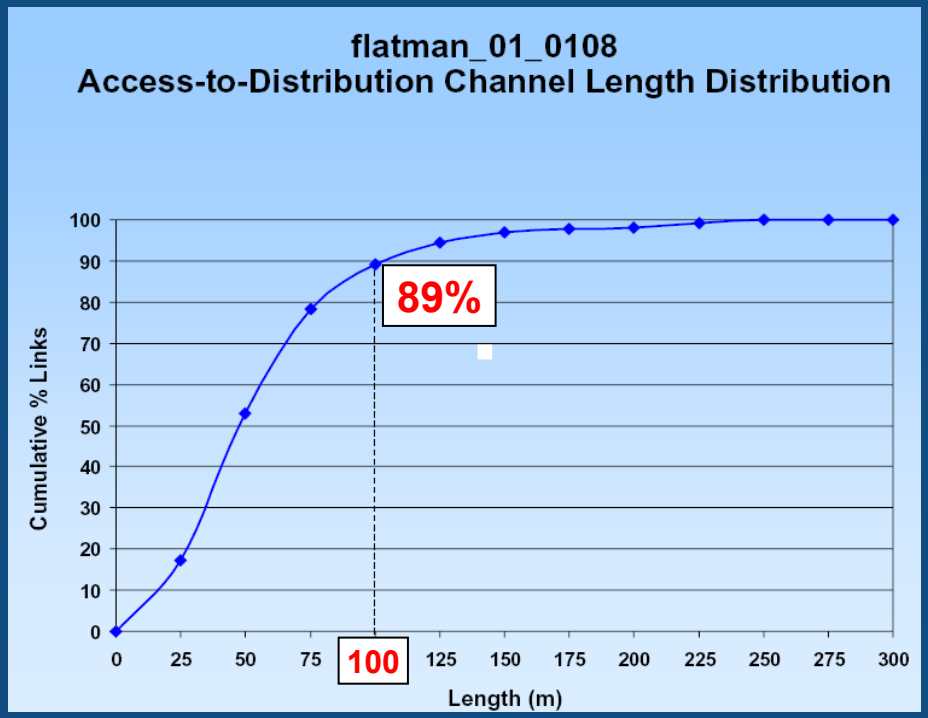
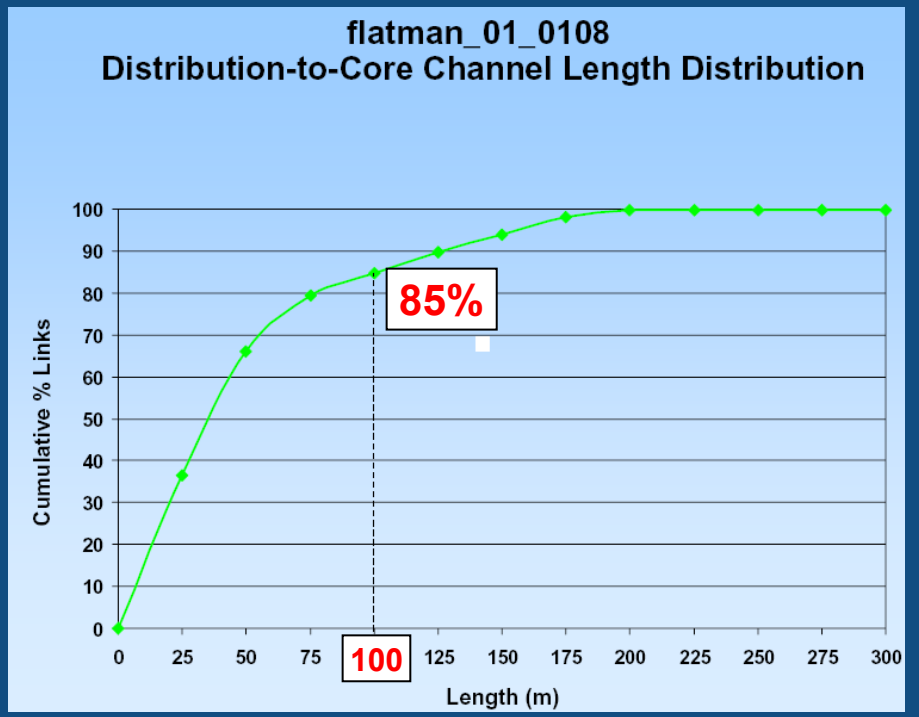
Why is OM4 important?

Fiber dominates in Access to Distribution and Distribution to Core links.

OM3 Fiber only supports < 90% of Links





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Alan Flatman – Principal Consultant, LAN Technologies, UK
"Long Data Center Links vs. Length"
IEEE802.3ba, Jan. 2008, Flatman_01_0108

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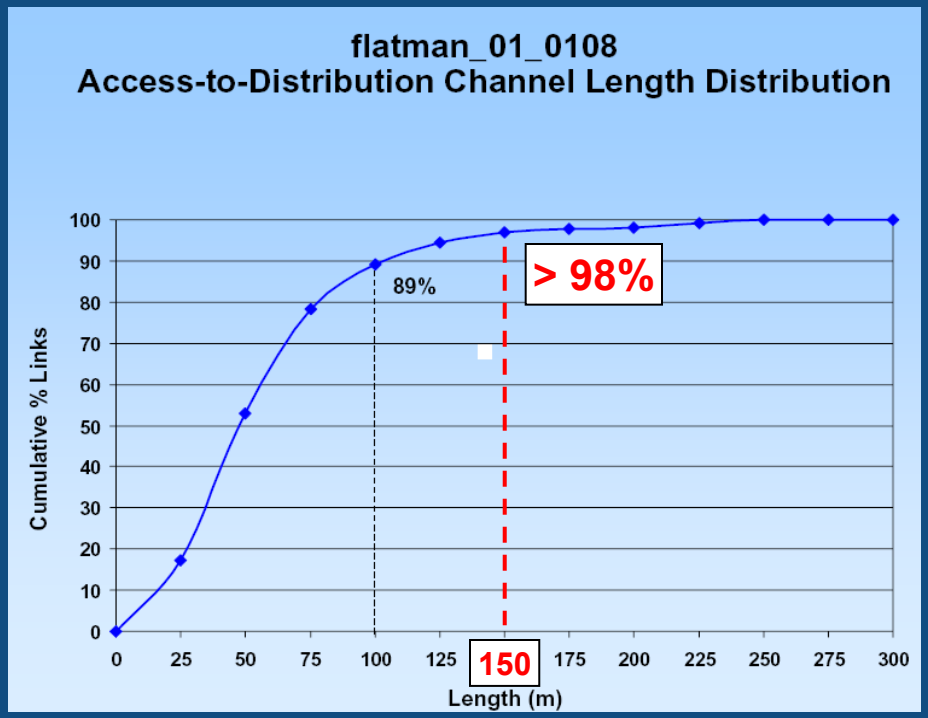
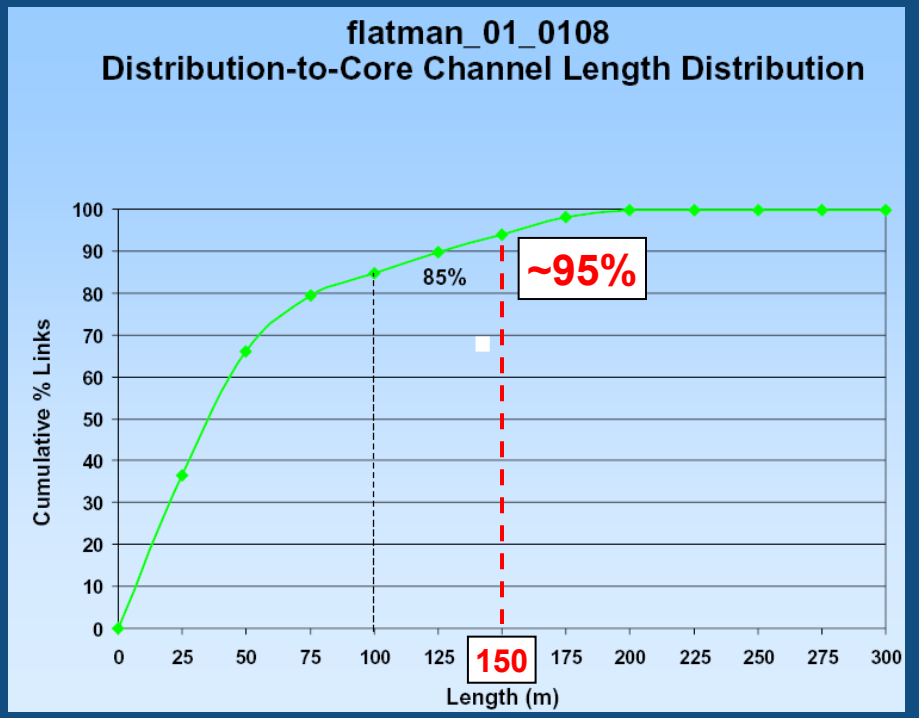
Why is OM4 important?

Fiber dominates in Access to Distribution and Distribution to Core links.

OM4 Fiber supports 95%+ of Links





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Alan Flatman – Principal Consultant, LAN Technologies, UK
"Long Data Center Links vs. Length"
IEEE802.3ba, Jan. 2008, Flatman_01_0108

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Singlemode Fiber Types

Fiber Type	Wavelength (nm)	Max CABLE Loss (dB/km)
OS1	1310 1383 1550	1.0 --- 1.0
OS2 Low Water Peak	1310 1383 1550	0.4 0.4 0.4

OSx designations are from ISO/IEC 11801 International Cabling Standard

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Singlemode Fiber Standards

ISO / IEC 11801	TIA / EIA	IEC 60793-2-50	ITU-T
OS1	492AAAA	B1.1	G.652.A or B
OS2 (Low Water Peak)	492AAAB	B1.3	G.652.C or D
---	---	---	G.657 (Bend Insensitive)

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40G & 100G Ethernet
IEEE 802.3ba

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IEEE 802.3ba 40G & 100G Ethernet

40G – for Servers, Access

– 10 km over single-mode fiber (1310 nm)	40GBASE-LR4
– 150 m over OM4 multimode fiber (850 nm)	40GBASE-SR4
– 100 m over OM3 multimode fiber (850 nm)	40GBASE-SR4
– 7 m over copper	40GBASE-CR4
– 1 m over backplane	40GBASE-KR4

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IEEE 802.3ba 40G & 100G Ethernet

100G – for Switching, Routing, Aggregation

– 40 km over single-mode fiber (1310 nm)	100GBASE-ER4
– 10 Km over single-mode fiber (1310 nm)	100GBASE-LR4
– 150 m over OM4 multimode fiber (850 nm)	100GBASE-SR10
– 100 m over OM3 multimode fiber (850 nm)	100GBASE-SR10
– 7 m over copper	100GBASE-CR10

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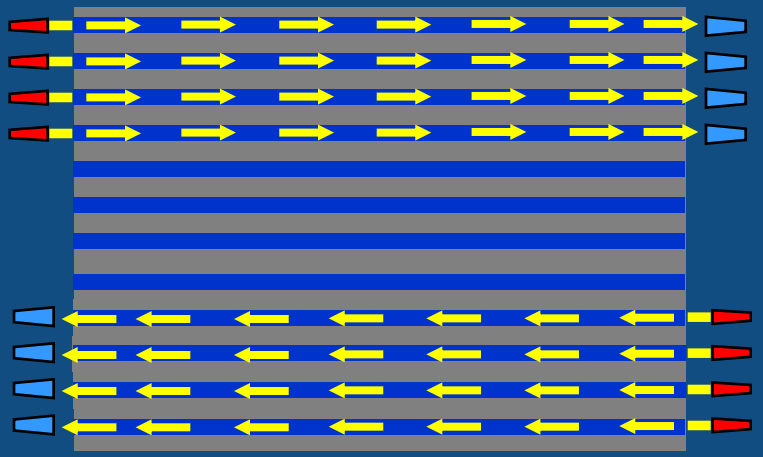
Short Reach Multimode: Multiple Fiber Parallel Systems

for 40G:

- One 12-fiber cable
  - 8 active fibers
  - Duplex link
- One wavelength per fiber
- 4 x 10 Gb/s
- 12 Fiber MPO connector



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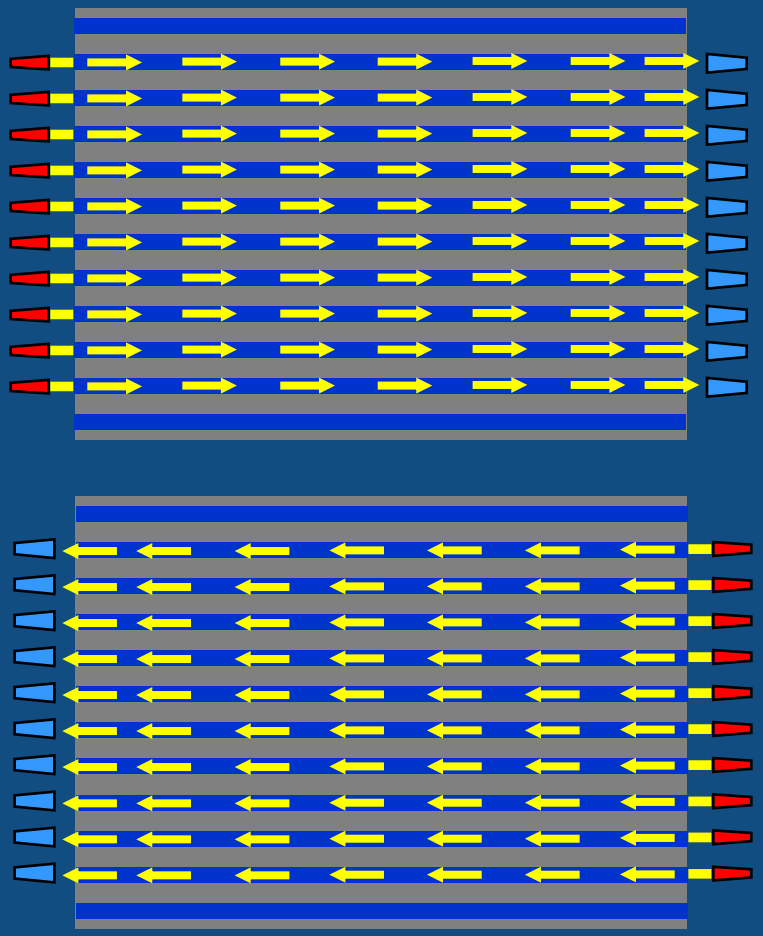
Short Reach Multimode: Multiple Fiber Parallel Systems

for 100G:

- Two 12 Fiber Cables, or 24 fiber Cable
  - 20 active fibers
  - Duplex link
- One wavelength per fiber
- 10 x 10 Gb/s
- MPO connector
  - 2 x 12 fiber
  - 1 x 24 fiber



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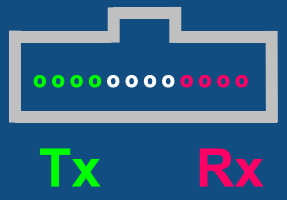
40G & 100G Ethernet – MDI Recommendations

References MPO interface req's/specs of IEC 61754-7

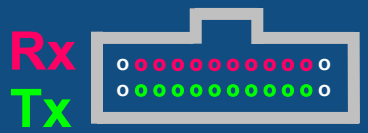
40GBASE-SR4 :



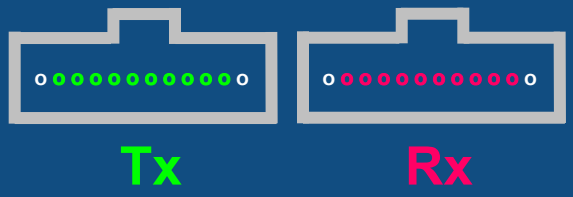
O = unused

100GBASE-SR10 :

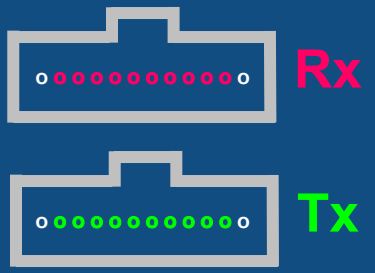
Option A
(recommended)



Option B



Option C



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IEEE802.3ba
40 & 100 Gb/s Ethernet

- Reduced Reach *(from 10Gb/s)* on OM3 due to relaxation in transmitter spectral width:
  - from 0.45 to 0.65 nm

- 150 meter reach on OM4 requires connection / splice loss **≤ 1.0 dB**

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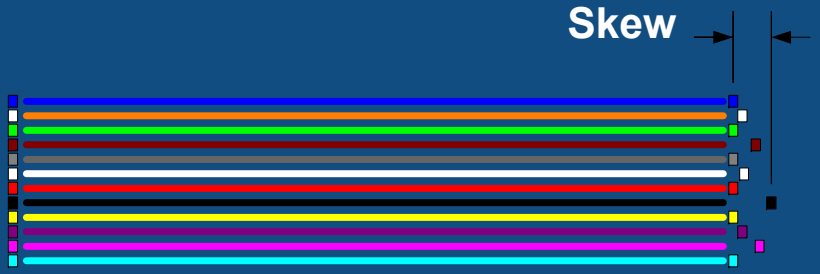
What is Skew ?

- Skew
  - Difference in arrival time



  - Two primary reasons
    - Differential fiber length in a cable
    - Numerical aperture

- What are “typical” numbers for skew in a 100 meter cable?
  - Ribbon: 0.3 ns
  - Loose tube: 0.8 ns

Source:
Alfred Flores, RCDD
Berk-Tek, a Nexans Company
“40/100 Gb/s Ethernet Over Multi-mode Optical Fiber”
January 2009
Winter BICSI Conference

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Is Skew Important?

- Not for fiber-based parallel transmission
  - 40G & 100G Ethernet requirement is **79 ns**
  - Fibre Channel is using serial transmission
  - Infiniband specification has a tight skew requirement (0.75 ns) that assumes the presence of repeaters in the link. Repeaters are not required for 100 meter multimode links.
  - Both ribbon and loose tube cables support Ethernet, Fibre Channel and short reach Infiniband needs

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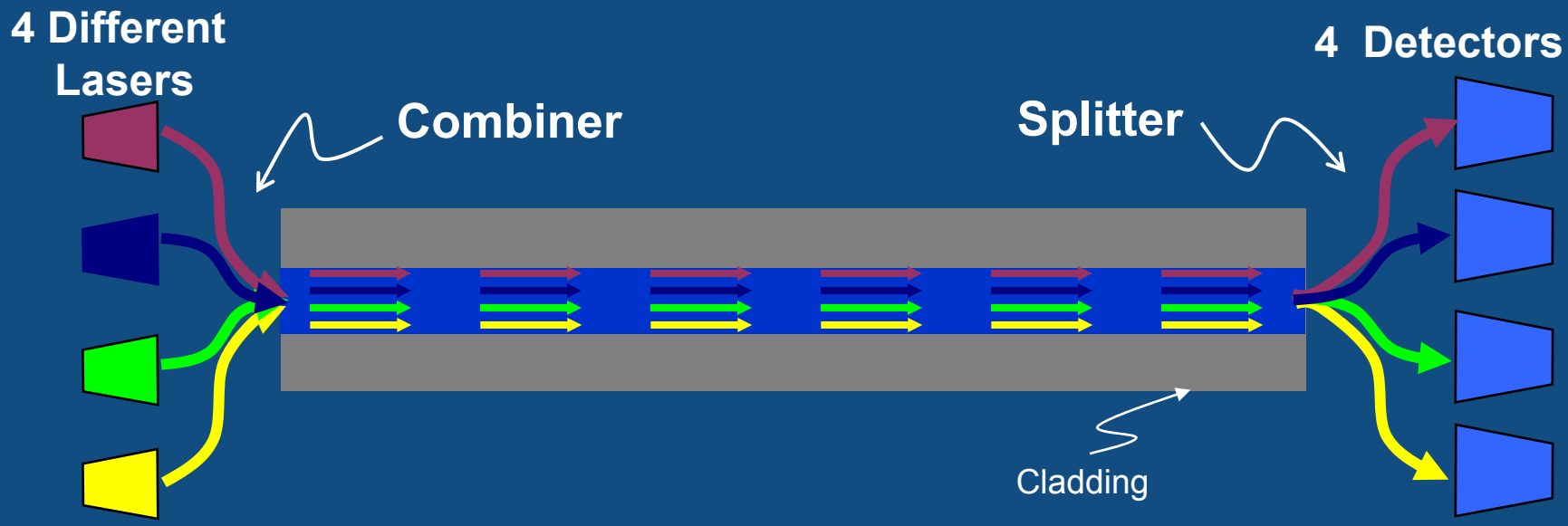
Long Reach Singlemode: Wavelength Division Multiplexing



For 100G

- 2 Fiber Cable
- Multiple Lasers and Detectors
- 4 x 25 Gb/s

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Fibre Channel, InfiniBand

- FibreChannel (FC)
  - Data Center Storage Area Networks
  - Migration path:
    - 8G (FC-PI-4) → 16G (FC-PI-5) → 32G (FC-PI-6)
    - All serial transmission
  - Will require OM3 & OM4

- InfiniBand
  - Primarily used in High Performance Computing (HPC)
  - Migration from 2.5Gb/s → 10 Gb/s → 40/100 Gb/s
  - Parallel transmission paths for 40/100 Gb/s

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Opto-Electronics & Cabling Considerations

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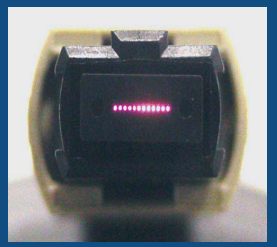
Transceiver Considerations

- Moving to array-based, parallel transmission over multimode
- Tx mfr's focused on creating lower-cost 850 nm based transceiver arrays for short-reach applications
- Increase mfg yield by relaxation of spectral width requirements



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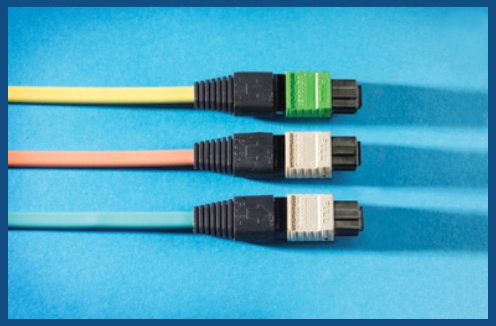
System Considerations

- Transceivers
  - **Will leverage existing fiber and transceiver technologies**
    - 850nm Parallel VCSEL Arrays
    - 1310 nm CWDM Transceivers
    - Good reference: TIA TSB-172
- Multi-fiber Connectivity
  - **MPO cable terminations**
  - **SNAP12 Tx connections**



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Cabling Media Trends

- Data centers largest growth area in enterprise cabling
- Rapidly moving from copper to fiber cabling
  - Historically, ~80% copper (familiarity, cost per port, copper cabling companies)
  - Typical cabling lengths →60-90 meters
  - This mix has more fiber for the high end data centers (70% or more fiber)
- Considerations favoring fiber
  - Prices of fiber cable and optical ports decreasing
  - Price, size, power consumption of copper cable increasing

Fiber supports GREEN-friendly solutions

  - 40 and 100 Gb/s over copper limited to 7m

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Cabling Media Trends

- Optical Cabling Systems
  - ~80% multimode fiber, 20% single-mode
  - Pre-terminated multi-fiber trunk cables to interconnect racks
  - MPO connectors and cassettes
- Optimum solutions OM3 and OM4
  - Supports evolution in transmission speeds
  - Maintains multimode cost benefit over single-mode
- Super-Computing market driving towards 24 fibers / link, 100 Gb/s OM3 & OM4 solutions

Fiber / Cabling Considerations

- ✓ Multimode Fiber Counts
  - **12 fibers required for duplex 40G link (8 active)**
  - **24 fibers required for duplex 100G link (20 active)**

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Plug & Play Data Center Systems

High Fiber counts and lower installation costs

Hub

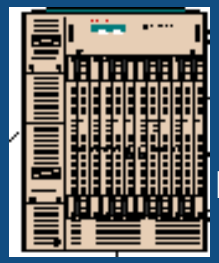
LC

MPO

Modular pre-terminated optical cassette systems

Backbone Cable

MPO

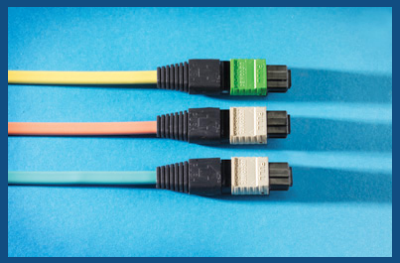


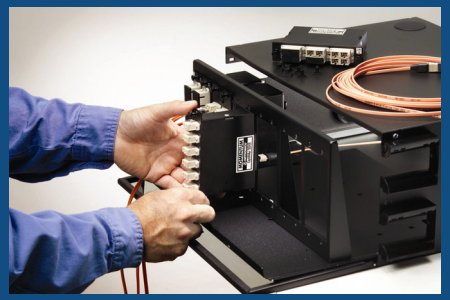
Switch

LC

Patch panel (interconnect)

LC





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Cost Comparison between Single-mode and Multimode Fiber Systems

Traditionally, optoelectronics have driven the cost difference between single-mode and multimode

- Single-mode CWDM system
  - Pro – Lower cable cost
  - Con – Significantly higher transceiver cost
- OM3 and OM4 multimode parallel systems
  - Pro – Much lower transceiver cost using existing 10Gb/s VCSELS
  - Con – Higher cabling cost

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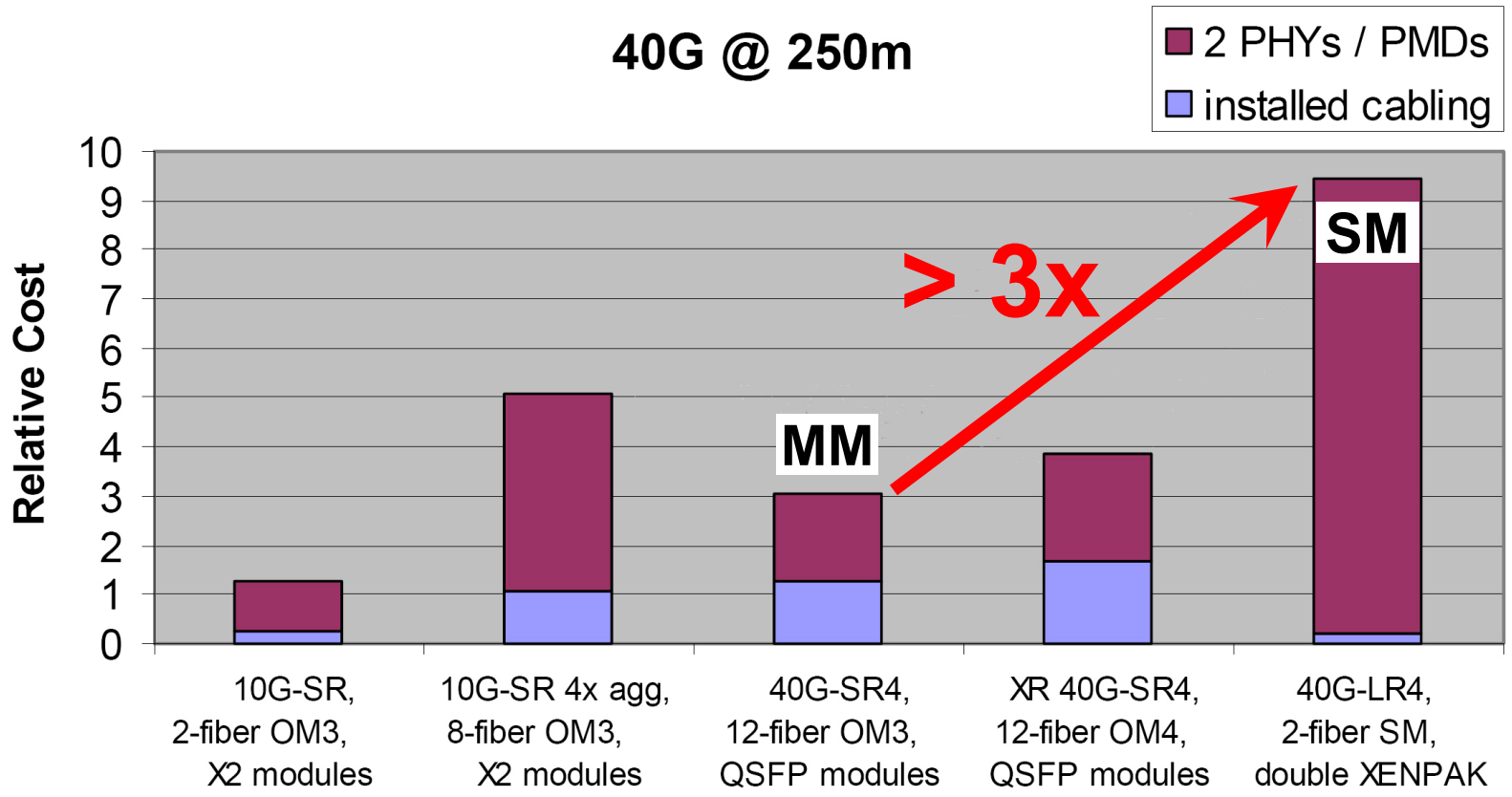
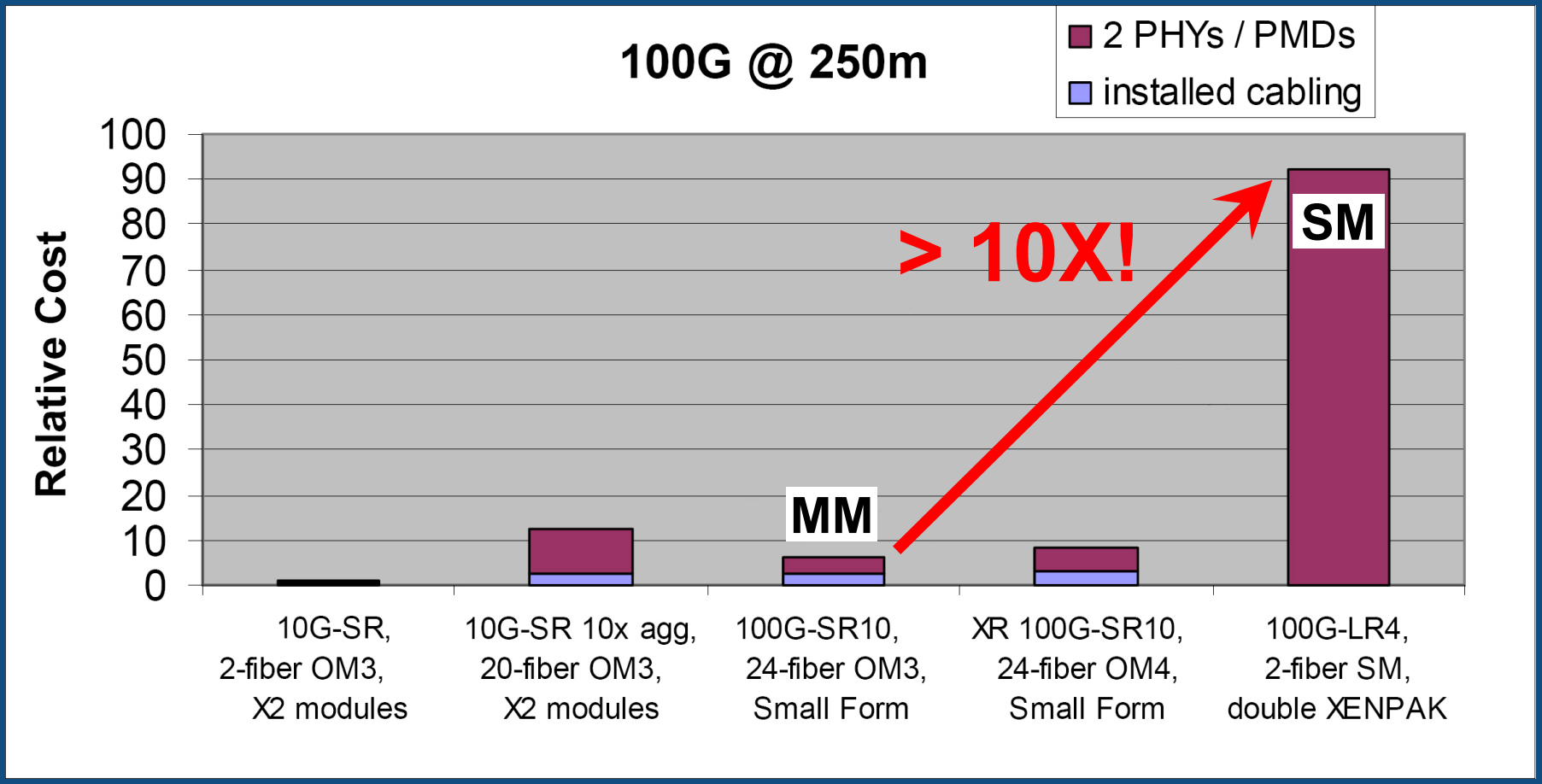
40G Systems Cost Comparison between Multimode and Single-mode



100G Systems Cost Comparison between Multimode and Single-mode



Cabling costs insignificant compared to optoelectronics

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Paul Kolesar, CommScope, "The Case for Extended Reach Multimode Objectives"
IEEE 802.3ba, September 2008, Kolesar_01_0908

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Cost implications (40G & 100G)

	Copper	OM3	OM4	SM	
Distance	7m	100m	150m	10 km	
Transceiver					CAPEX
Cable cost					CAPEX
Power use	10+ w ?	</= 3 w	</= 3 w	</= 20 w	OPEX

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Conclusions

- Data centers are shifting from copper to fiber
  - Copper is more costly and has limited transmission distance
  - Fiber has much lower power consumption
- OM3 and OM4 Multimode fiber will play an important roll in 40-100 Gb/s transmission rates in data centers
- OM4 is well accepted and has been incorporated in system standards
- There will be a shift to parallel transmission over multimode with MPO connections