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High Speed Data Networks – 40G, 100G & Beyond

BRKOPT-2116

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Cisco live!

Abstract

Session ID: BRKOPT-2116
Title: High Speed Data Networks- 40G, 100G & Beyond

The continuous growth in IP Services and access speeds has created an exponential growth in bandwidth in packet networks, driving the need for higher speed interfaces in routers and switches. This session will introduce the different standards for 40Gbps and 100Gbps interfaces and explain how to use them in different applications and network designs. Outline the impact of these new standards end-to-end, from transceivers and cables, to cabling, optical fibre and transport implications . Transceivers and cabling infrastructure define a significant portion of the CAPEX and customers need to plan ahead for 2 or 3 port speed generations. The choice of multimode vs single-mode cabling, dual strand vs parallel strand fibre, required port density, and power envelope all impact infrastructure costs. The session will also provide a framework on how to make these trade-off decisions.

Agenda

- Trends / Introduction
- 40GE & 100GE Standards
- 40GE Transceivers and Cables
- 100GE Transceivers and Cables
- Impact of 40GE & 100GE on DC Fabric
- Summary




Trends

The Internet of Everything
Exponential Growth

- **Video, Mobile & Cloud** is Driving Traffic Growth
- Content & traffic patterns are becoming more dynamic and distributed
- **The Internet of Things** will accelerate traffic beyond recognition:
  - Radically increase volume
  - Dramatically change traffic patterns
  - Challenge traffic engineering and management
  - Demand new service definitions (SLAs)
- To keep pace, **Enterprise** and **Service Providers** need **agile solutions** that reduce complexity and TCO
- As demand for **bandwidth** continues to increases, there is a need for
  - **Higher speeds: 40G and 100G**
  - **Smaller size optics: Enables higher density**
  - **Lower cost/bit: Enables higher adoption**

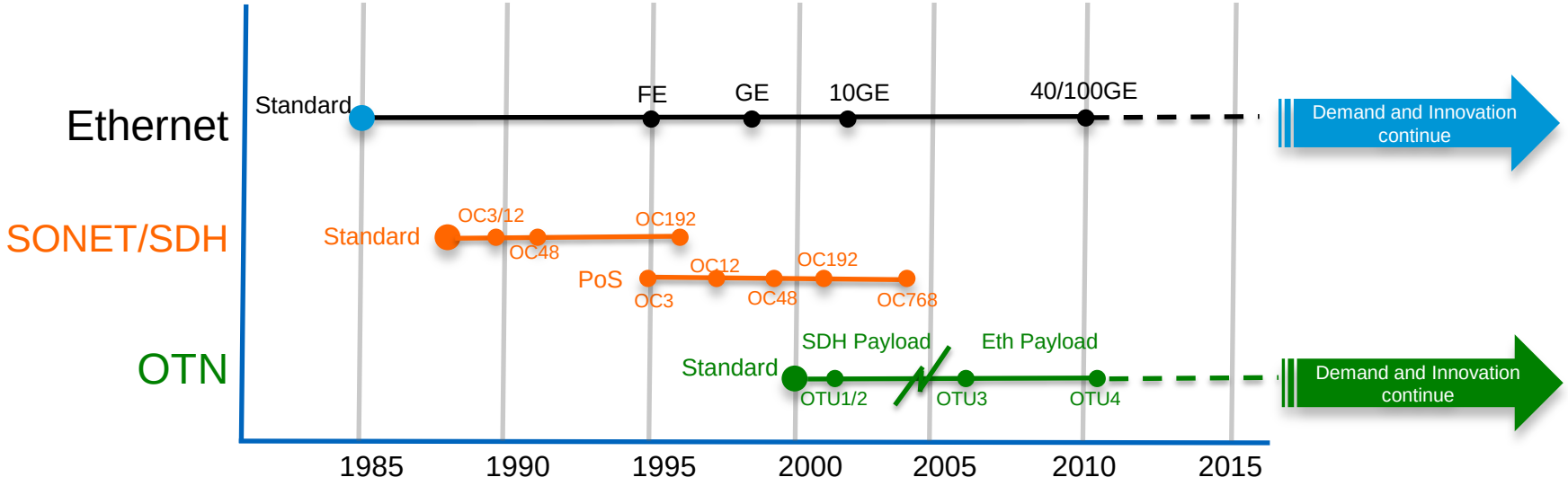
Industry Trends

- Ethernet is a standard that continues to evolve and show innovation - FE - GE - 10GE - 40GE - 100GigE – 400GE-1TB?
- Cost, reach, size, power optimisation continues
- Ethernet interfaces dominate over POS interfaces - 95% of services are driven by Ethernet
  - SONET / SDH innovation stopped at 10G XCONN and OC-768 interfaces - no future beyond - Replaced with OTN
- Transitioning to OTN - from SDH payload to Ethernet payload
- Ethernet wrapped in OTN provide SDH type service and better OAM
- Market need for flexible interfaces on client devices – plugables long/short/DWDM interfaces

This transition in the Industry will continue to drive down the cost of interface technology

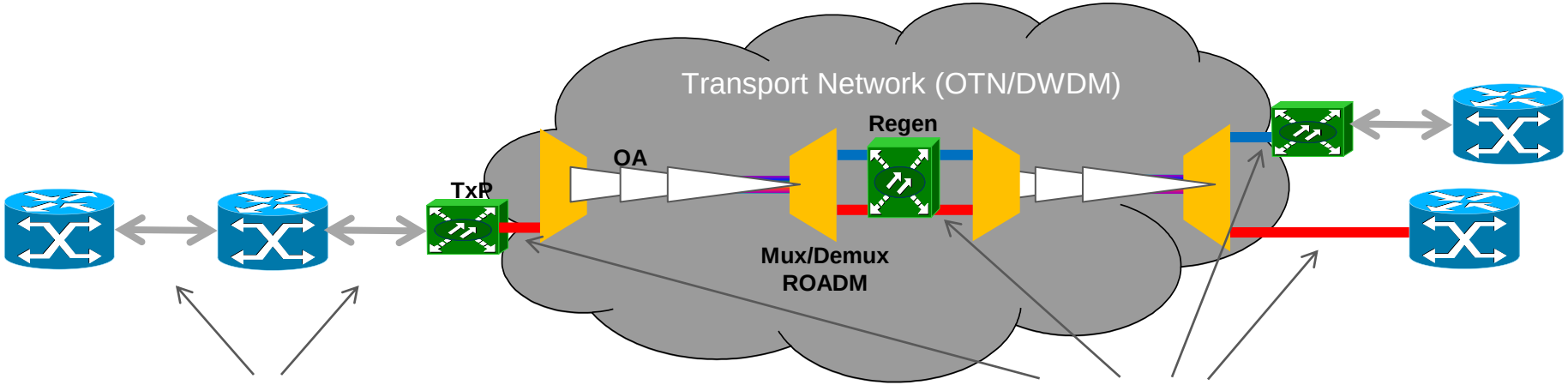
POS / Ethernet / OTN Migration

- POS and SDH R&D / Innovation caps 1995 / 2004
- Ethernet has undergone continual innovation since standardisation
- OTN transitions in 2004/5 from SDH hierarchy to Ethernet payloads



SPs are making transition from SONET/SDH / POS to Ethernet & OTN

40/100G Client and Transport Reference



Client Optics

- Within a building/campus (< 10km)
- Single I/F / Fibre (Grey optics)
- POS, OTN & Ethernet
- Cost is King

Line Optics

- Across country (1000s km)
- Multiple channels / Fibre (DWDM)
- OTN
- Performance is king

Enterprise and MSDC DC Trends

- Interest in use of MM fibre for forward and backward connectivity in migration from 10GE->40GE->100G where possible
- Continued evaluation of MM vs SM for future bandwidth needs

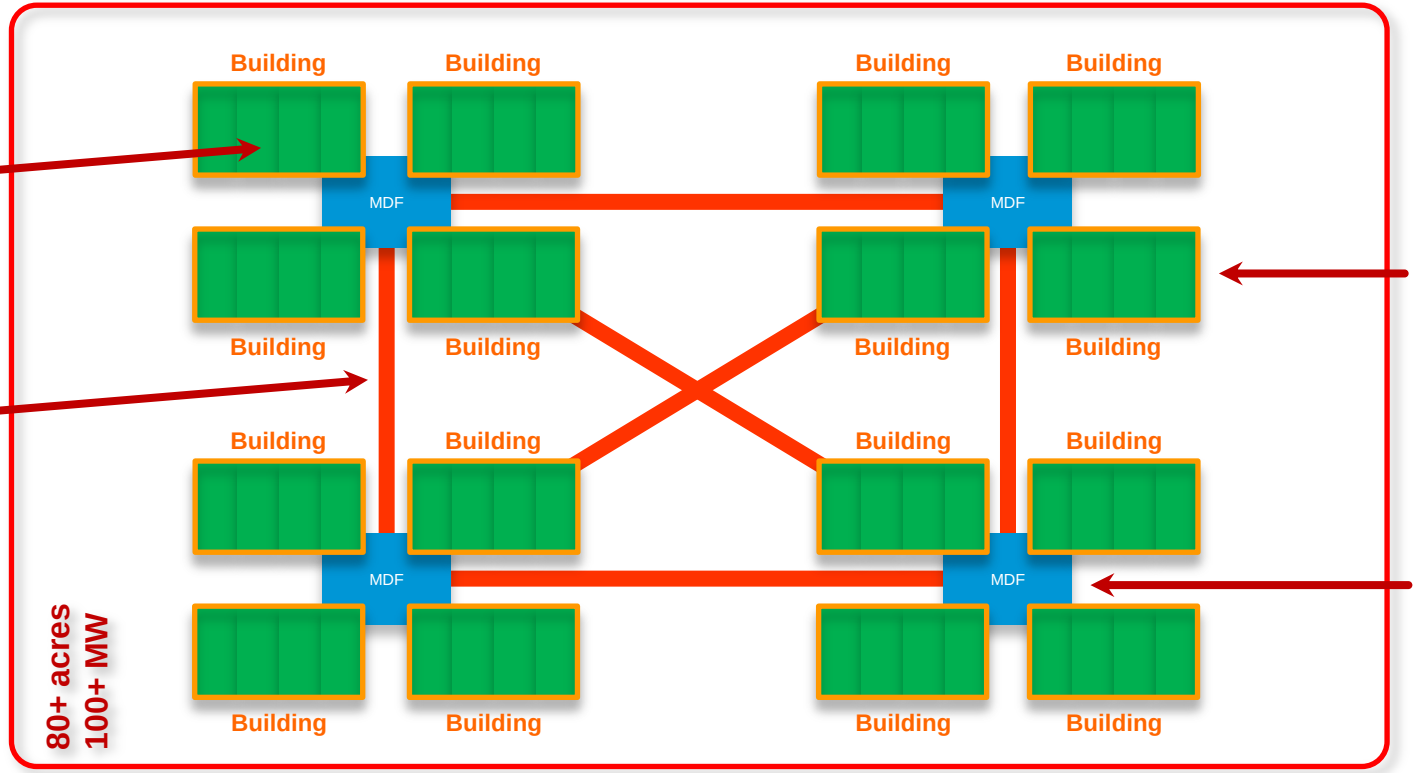
MDSDC Trends

- Emerging data centres are no longer constrained by the walls of a building
  - Each unit of deployment most likely defined by a power zone (2-4 MW each) that resembles the data centre of the past
  - Deployment units are interconnected to form a larger data centre (aka “DC Park”)
- A unit of deployment, or a small collection of these units, represents an availability zone
  - And a collection of availability zones represents the “DC park”
- A Campus might consist of a few or many buildings and support over 100MW of power delivery
- A Campus will consume many acres and require significant amounts of fibre interconnect
  - Up to, maybe exceeding, 1km from building to building

DC Park DC Logical/Physical Layout

One or more data centre rooms per building, each a power zone

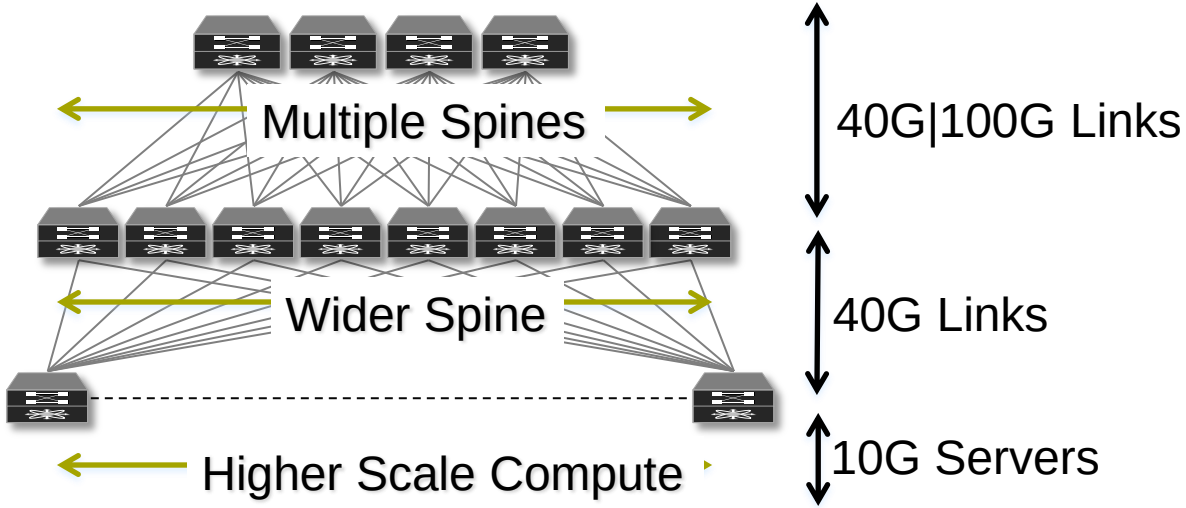
Rich fibre requirements for campus inter-connectivity (with fibre runs up to or exceeding 1km)



Each room or each building might compose a power availability zone

Multiple MDF's

DC Fabric Trends



Overall bandwidth capacity increases
Switching
Width of spines
Redundancy Model

Physical Infrastructure

Early Integration of 100G north-south focused – DC edge

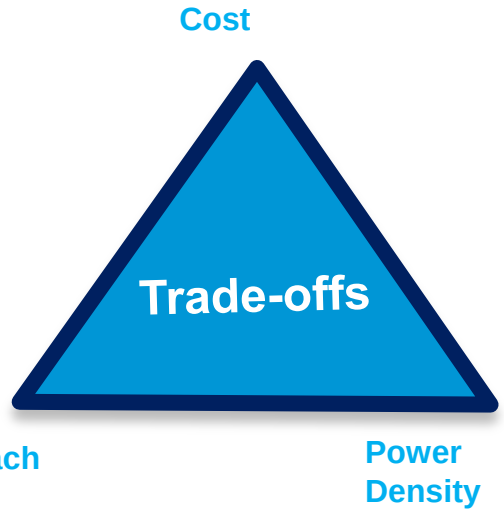
Optical Technology…

…Is the key enabler for systems to maintain pace with the requirements of the bandwidth pressures

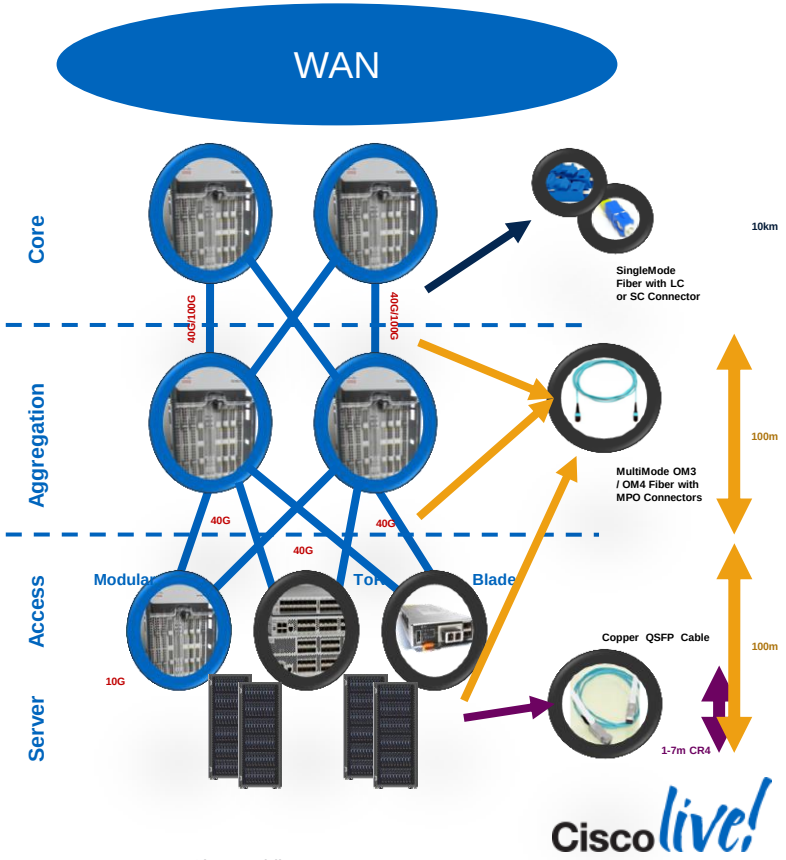
Challenge		Goal
Size reduction	→	Port Density increase
Power reduction	→	Port Density increase
Reach	→	System/network scaling
Packaging simplification	→	Increased Yield, lowers cost
The next speed (400G/1T)	→	System Scale, lower costs

Optical Interconnects Increasingly Important for DC Performance, Scale, and Cost!

Need to optimise all 3 vertices simultaneously…
Design Choices will vary by network use-case!



Fibre type MM vs SM



Challenges

- Price of optics significant portion of system and solution cost
- Legacy DC architectures built around 1GE/10GE reach for MM – Migration to higher speeds needs to address reach and fibre density
- Reach challenges with MM driving need lower cost, form factor and power for single mode optics > 300 – 1/2km
- Transition to new architectures – driving higher systems densities to address cost ,scale and architecture consistency
- How to manage **transition to 40G/100GE** monitoring - optical taps, ribbon TAPs for 40/100GE on MM?
- How to extend CLOS architecture to metro for inter DC – lower cost shorter reach coherent higher density optics need
- As optics shrink how do we retain optics choices with new form factor 4x25G to SR10 break out.
- 100G form factor and churn – decreased adoption
- How to achieve 10G system densities for higher speed interfaces
- SM fibre and optics promise greater bandwidth (IEEE 400GE) and reach – how address form factor, density, power and cost

40GE and 400GE Standards

40G/100G Industry Standards

- IEEE 802.3ba: 40Gb/s and 100Gb/s Ethernet Task Force
  - 40G and 100G Ethernet
  - Physical interfaces for Backplane, Copper, Fibre PMDs
- IEEE 802.3bg: 40Gb/s SMF Ethernet Task Force
  - 40G Serial PMD optimised for carrier applications
- ITU Study Group 15: Optical and Transport Networks
  - OTU4 frame format
  - Single mapping for 40GE/100GE into OTU3/OTU4
  - OTL protocol enabling OTU3/4 over multi-lane (low cost) optics
- OIF: 100G Long-distance DWDM Transmission
  - Industry consolidation around a single 100G DWDM solution

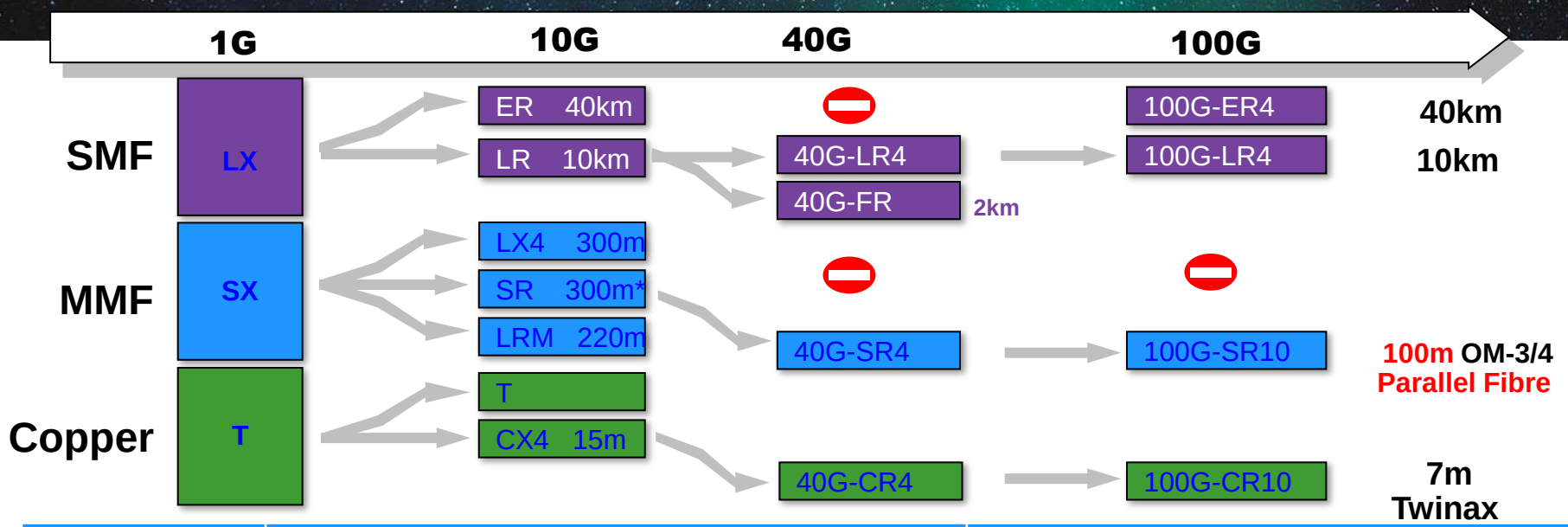
Industry Developments

- 802.3bm Task force goal of group is to lower 100G costs.
- For the SMF objective of 500m there were several proposals under consideration, but the group was unable to achieve consensus.
  - 100G CWDM - 4x25G wavelengths
  - 100G PSM4 - 4x25G parallel fibre
  - 100G DMT - single wavelength advanced modulation using Discrete Multi-Tone
  - 100G PAM8 - single wavelength advanced modulation using Pulse Amplitude modulation
- The discussion raised awareness of two key issues:
  1) Advanced modulation is important as it may fundamentally lower complexity/cost (PAM, DMT)
  2) New technologies like CMOS Photonics may alter costs (CWDM, PAM)
- 400GE study group: Initial focus will be on where 400G is needed. Likely the SMF ~500-2000m application for SP and DC interconnect. Advanced modulation considered a strong option here.
- Focus on 400GE vs 1TE as cost is very important. It was felt that for Ethernet interconnect applications, 1TE solutions would not be possible cost effective in timescales needed. This may be different from long-haul application where economic tradeoffs are different.

IEEE Standard vs MSA Form-factor

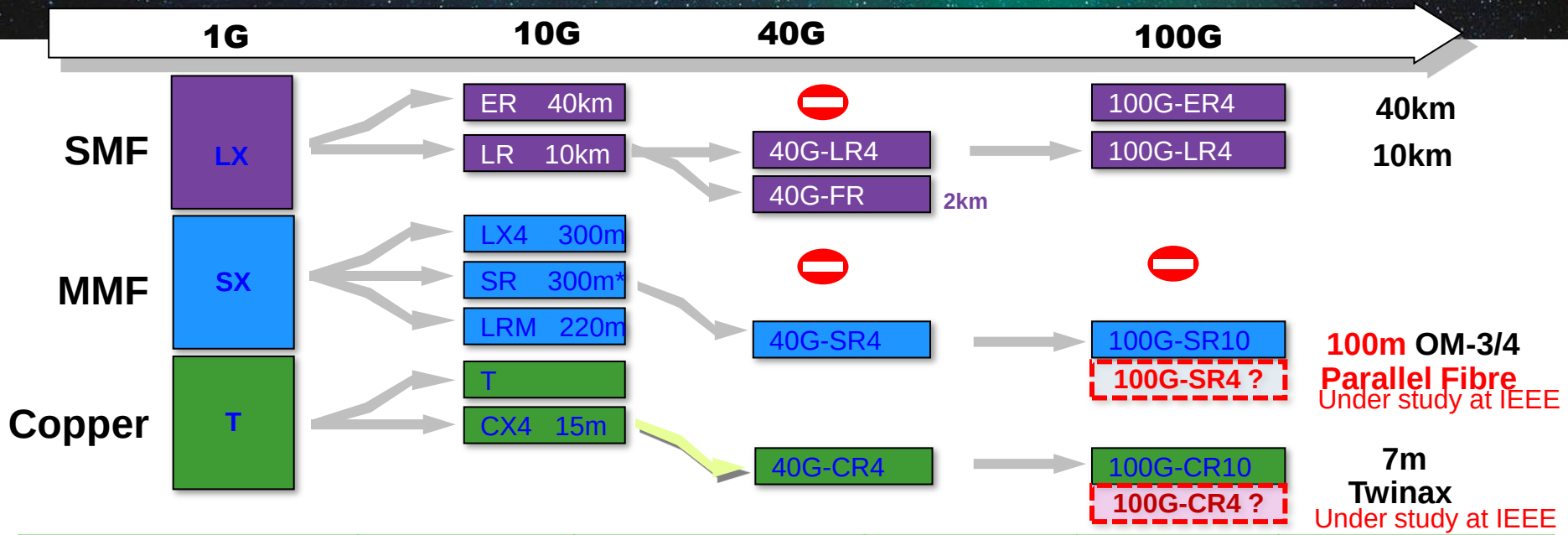
- IEEE defines physical network interfaces i.e PMDs
  - 10GBASE-SR, 40GBASE-SR4, 100GBASE-SR10 etc
- MSA (multi-source agreements) define transceiver form factors
  - CFP, QSFP, SFP+, X2 etc
  - Usually defined by a group of transceiver vendors based on technology availability and roadmap
- PMDs of the same speed/ reach/ protocol must interoperate, irrespective of the form factor
  - X2-10GB-SR interoperates with SFP-10G-SR, both being defined by the 10GBASE-SR physical interface
- Multiple 40G and 100G form factors are being released simultaneously at Cisco and other system vendors
  - Decisions being driven by the port density requirements vs reach availability

High Speed Ethernet Standard Interfaces



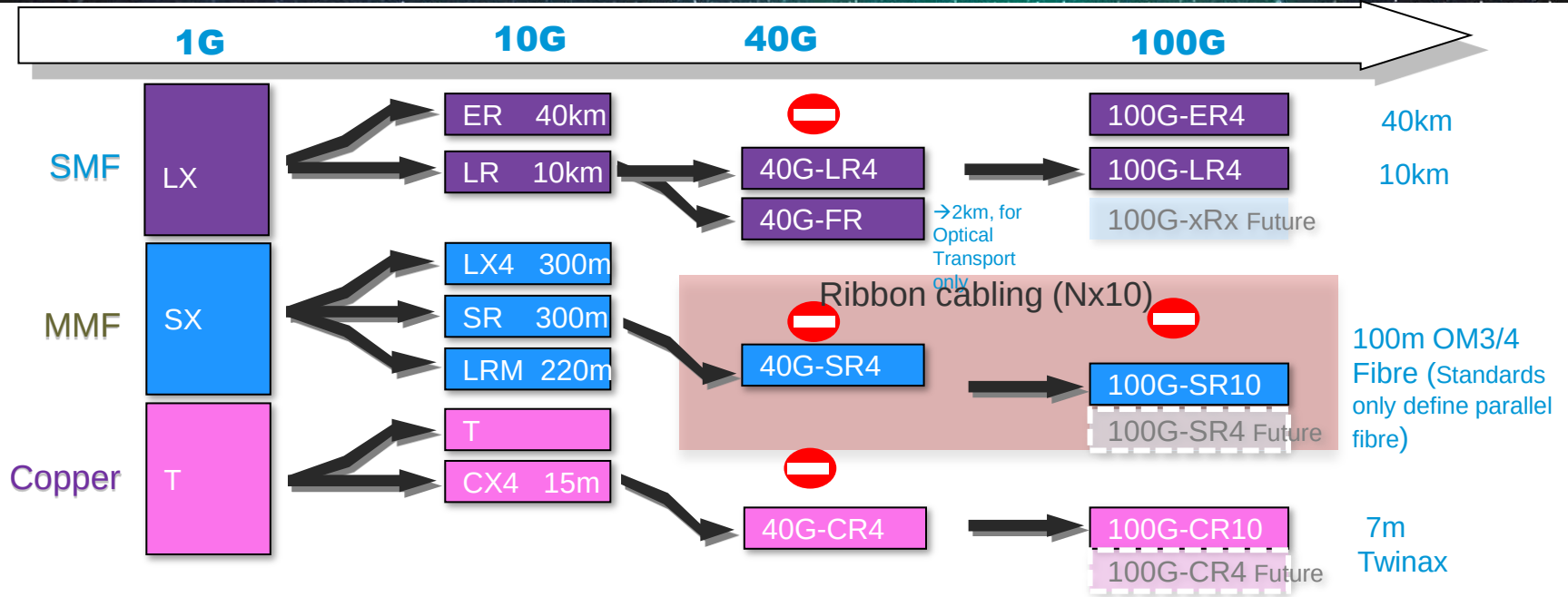
	Multimode 40G/100G optics	Singlemode 40G/100G optics
Fibre Infrastructure	40G-SR4/ 100G-SR10 Need parallel ribbon fibre (not duplex fibre); 12-strand for 40G-SR4/ 24-strand for 100G-SR10	40G-LR4/ 100G-LR4 Same duplex fibre infrastructure as 10G-LR
Reach	IEEE definition for a shorter reach than 10G; 100m OM3/ 150m OM4 multimode ribbon fibre	IEEE definition for 10km reach
Complexity	Less complex optics with 10Gb/s lane VCSEL array technology	Complex optical design → higher power dissipation → innovation opportunity !!

High Speed Ethernet Standard Interfaces



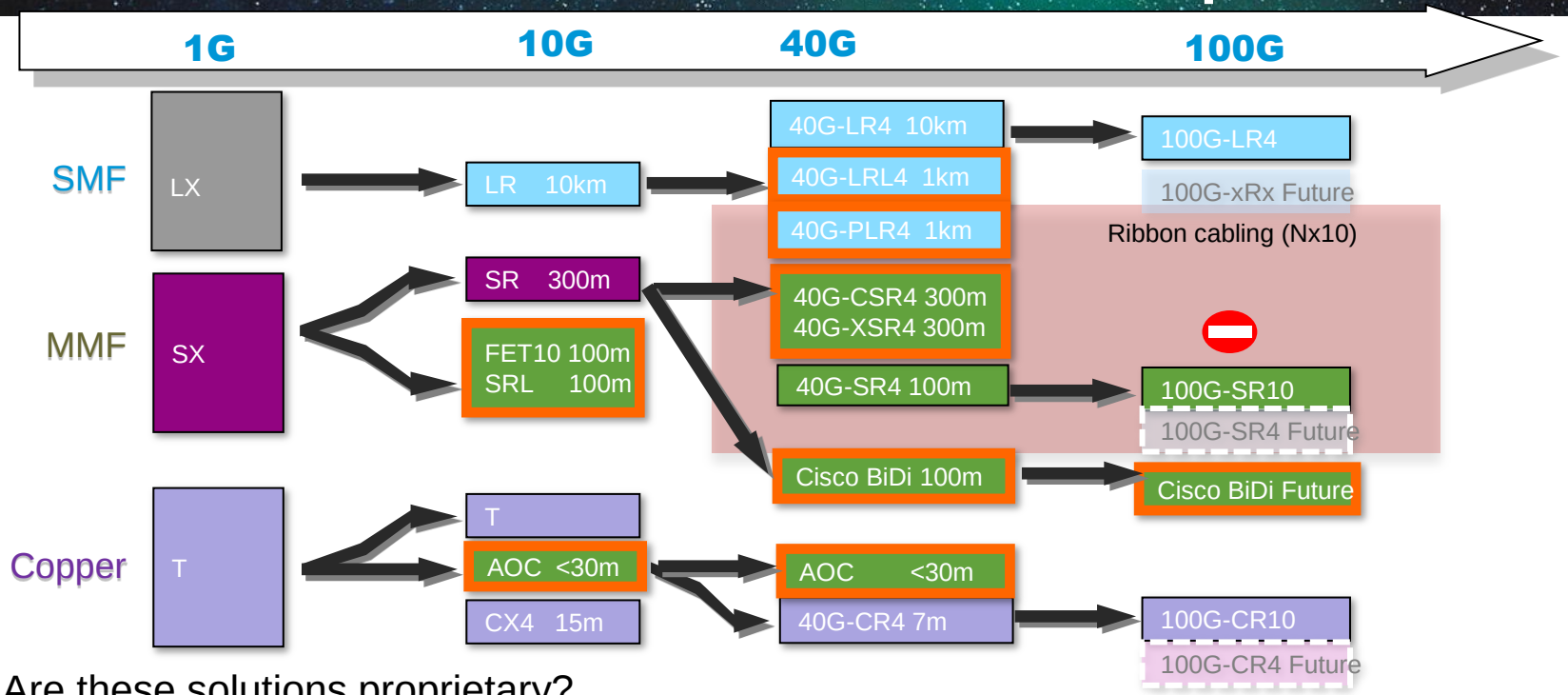
PMD's under study at IEEE	Standard Status	Publication Date (target)	Reach	Media	Cabling
100G-CR4	802.3bj Task Force	CY2014	<5 m ?	Copper	Twinax cable
100-SR4	802.3bm Task Force	CY2015	<20 m & < 100 m	OM-3/4 MMF	1x12 MMF Ribbon fibre
100G-xRx	802.3bm Task Force	CY2015 ??	<500m	SMF	TBD

Ethernet Standard Interfaces



Q: What is missing from list of Ethernet Standard interfaces?
A1: Data centre optimised optics replacing 100m sweet-spot.
A2: Data centre optimised optics for emerging 1km sweet-spot.
A3: 40G/100G optic that will reuse 10G fibre infrastructure

Industry Response in Data Centre – Non-Standard Solutions for 100m and 1km DC Sweet Spot

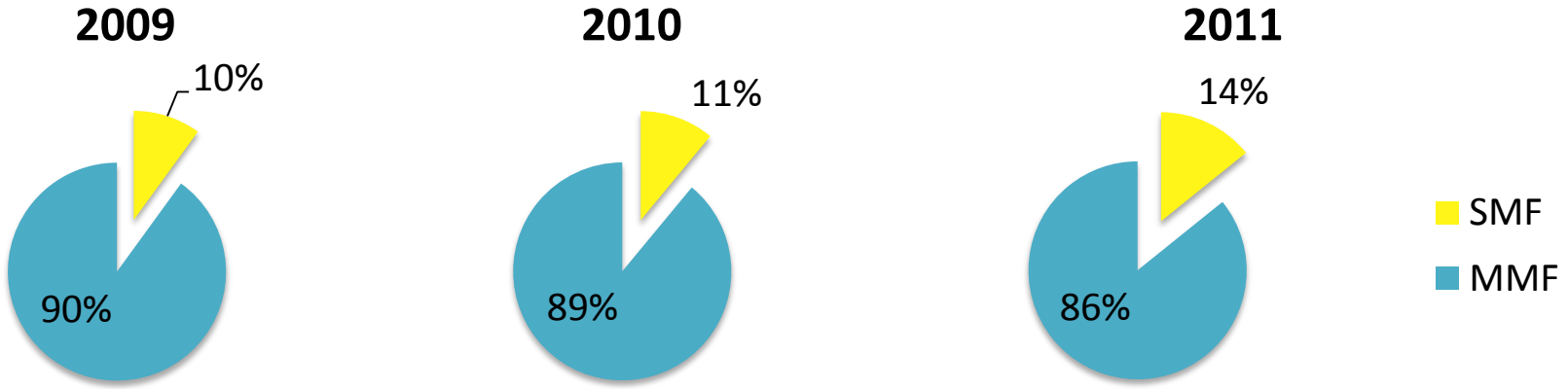


Q: Are these solutions proprietary?

A: They are not based on an IEEE standard but in most cases comply with relevant MSA for pluggable interfaces to allow use across different vendor's equipment.

40GE Transceivers and Cables

Multimode vs. Singlemode Deployed Fibre

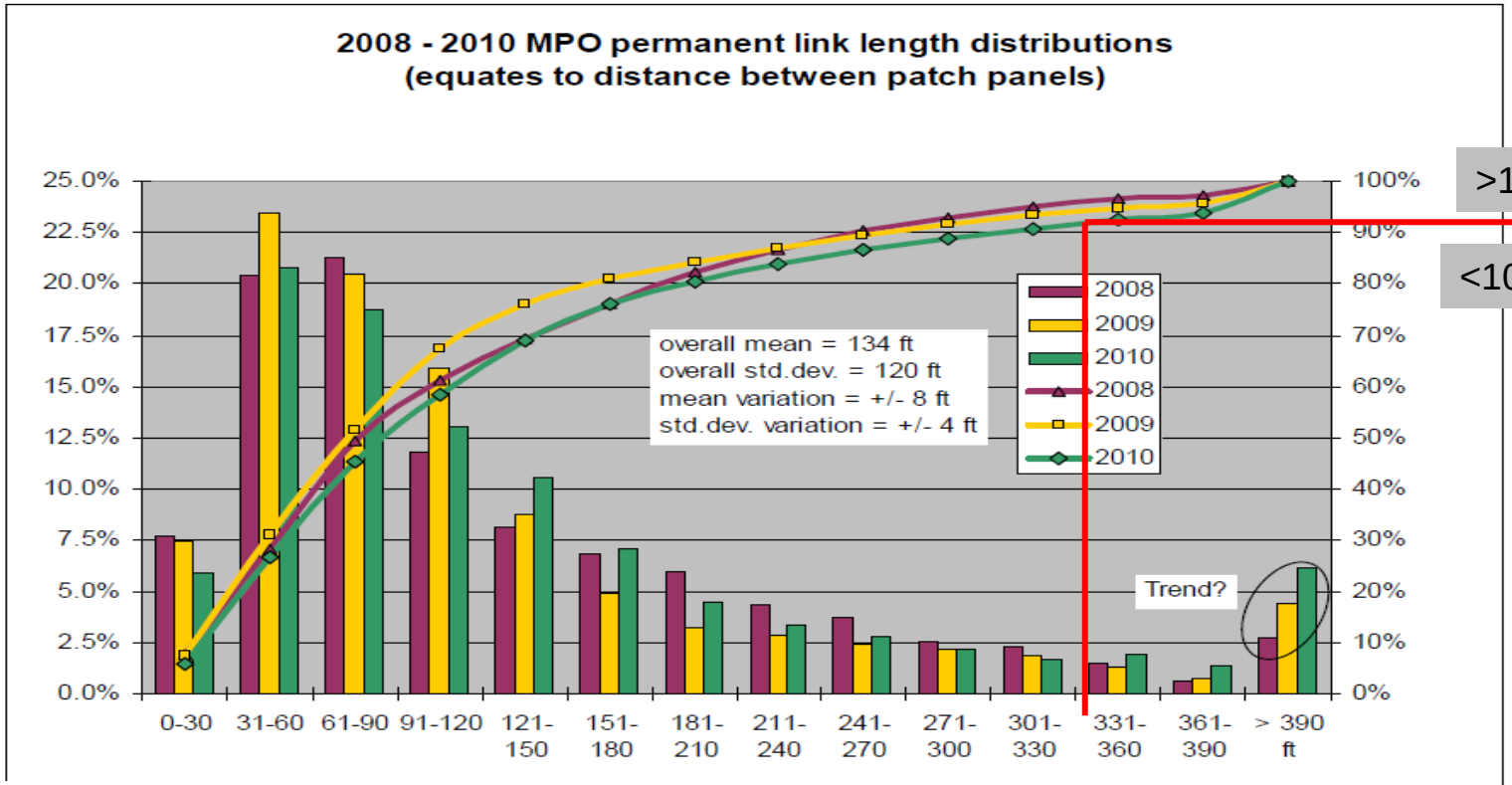


Multimode fibre deployments dominate singlemode fibre*

Global 10G Multimode optics shipment is 10x of singlemode optics, and follows the same trend as fibre**

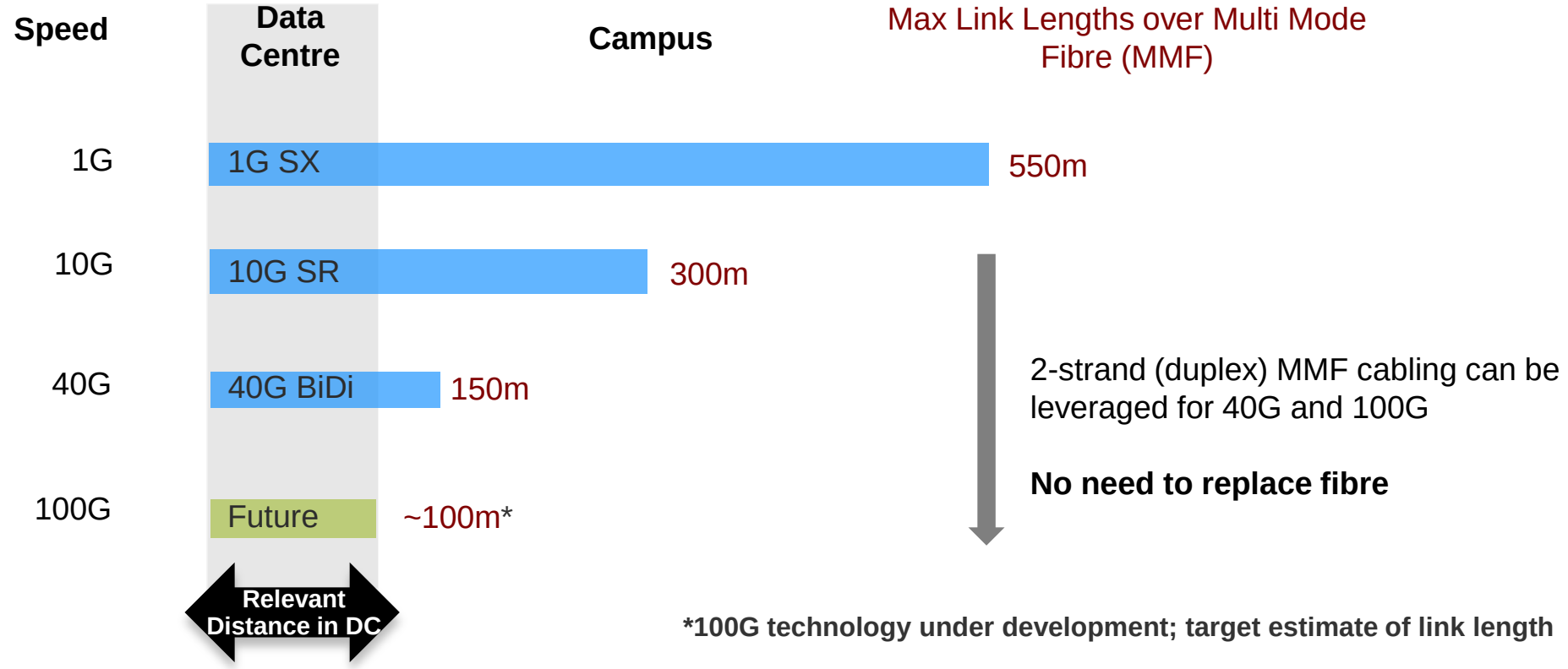
*Cable manufacturers shipment data
**Lighcounting Market report

Data Centre Permanent Link (Trunk) Distributions
(2008-2010)



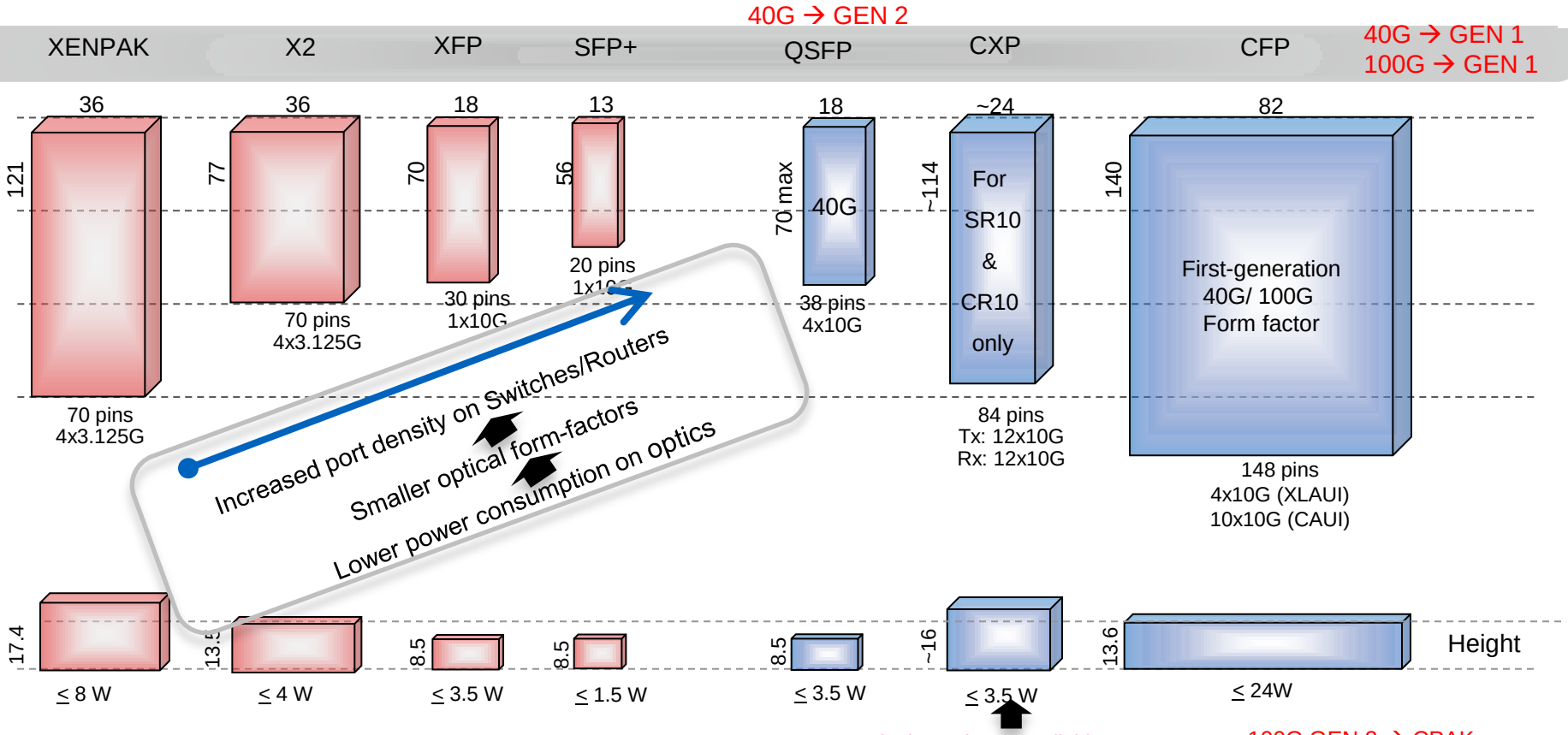
Presented by Paul Kolesar, CommScope, IEEE 802.3 Next Gen Optics Study Group, Sep 2011

Multimode Fibre is FORWARD and BACKWARD Compatible

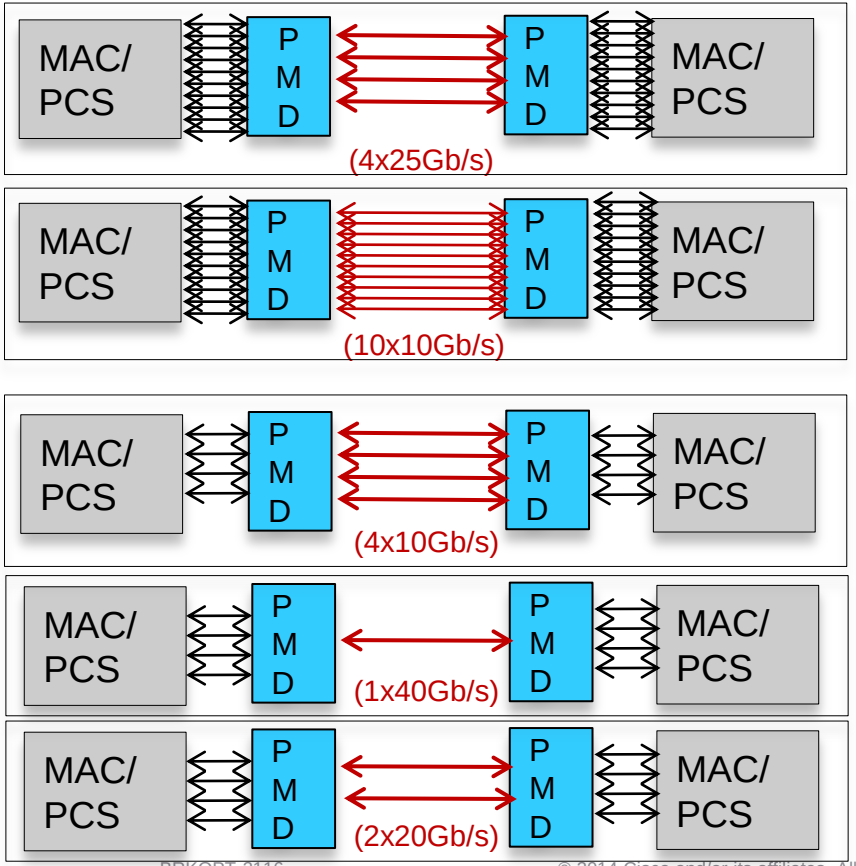


***100G technology under development; target estimate of link length**

10G/ 40G/ 100G Transceiver Form Factors



Parallel Data Streams



Singlemode 100Gb/s Ethernet

Multimode 100Gb/s Ethernet

40Gb/s Ethernet (802.3ba). Singlemode & multimode

40Gb/s singlemode fibre PMD (2km) (803,2bg)

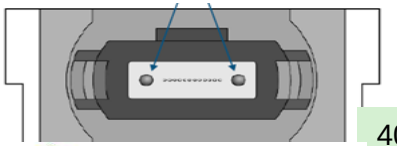
40Gb/s **Multimode** fibre PMD (100m) (Cisco Proprietary)

Electrical data lane 10Gb/s (black)

Optical data lane (red)

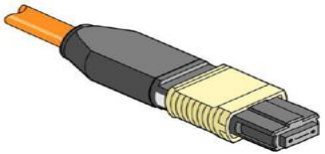
- Device interfaces in Switches & Routers (ASICs) currently cannot handle single 40Gb/s and 100Gb/s data streams (only 10Gb/s)
- IEEE has defined ‘parallel lanes’ to handle flow of data
- Multi-lane Distribution (in the PCS layer) provides a simple way to map 40G/100G to physical interfaces of different lane widths – with Virtual lanes
- Data from any particular virtual lane will reside on the same electrical and optical lane across the link – No skew introduced between bits within the virtual lane

Parallel Ribbon Fibre for 40G/100G Interfaces



40G MPO interface
(one row of 12 fibres)

40G 12-strand ribbon fibre
(4 fibres in the middle left unused)



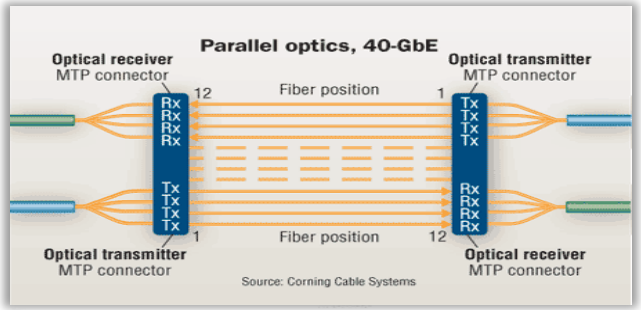
MPO Optical Connector

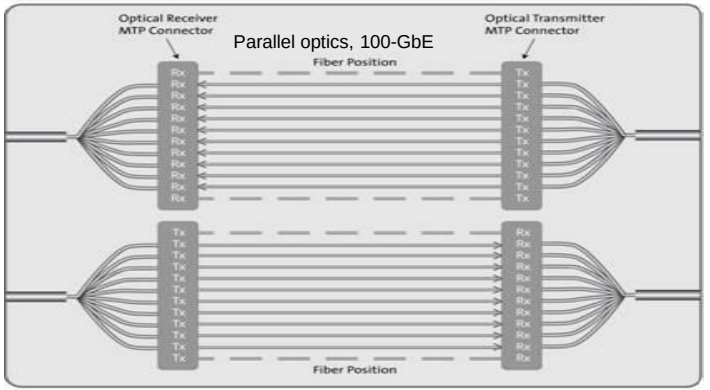
MPO to MPO patch cable

Inside a ribbon fibre

100G MPO interface
(2 rows of 12-fibres)

100G 24-strand ribbon fibre
(4 fibres in the left unused)



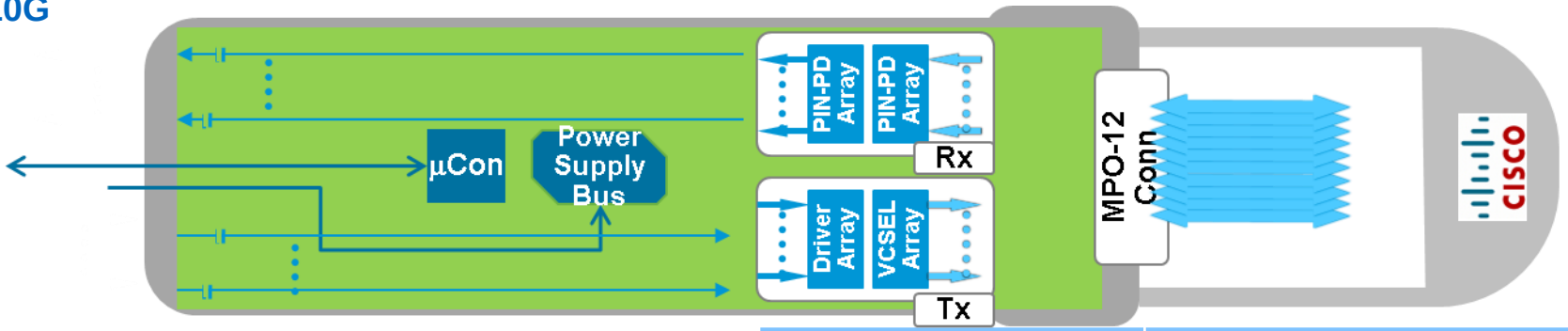


MPO is a generic name for a ribbon optical connector, while MTP is a brand name

40GE: QSFP-40G-SR4 for 100 m

KEY
- VCSEL= Vertical Surface Emitting Laser
- PD = Photo Diode
- TIA = Transimpedance Amplifier

nPPI
4x 10G



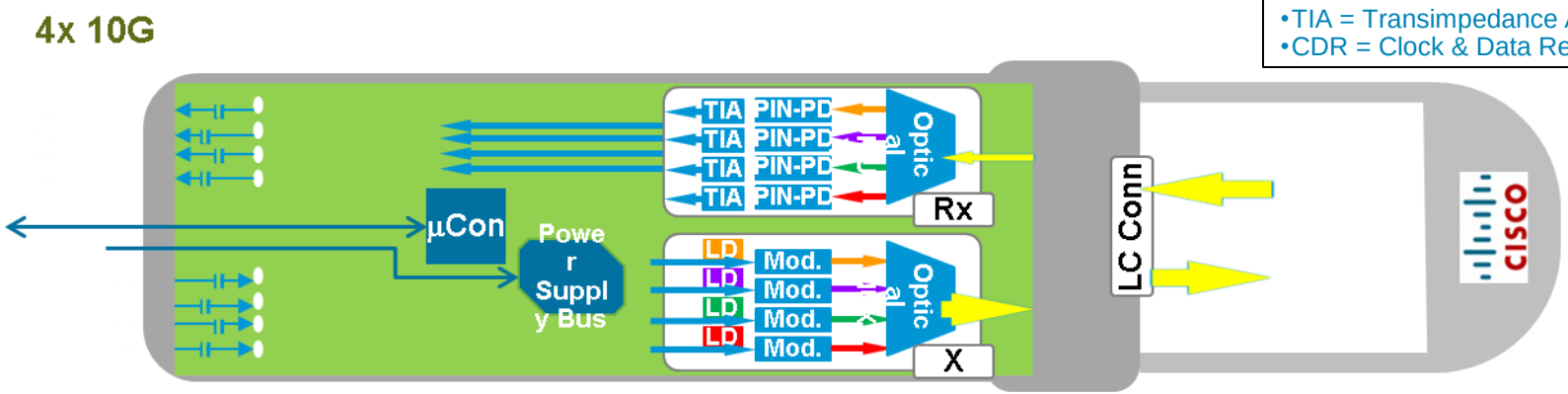
FEATURES

- IEEE 40GE Compliance
- Configurable to run in 4x10G SR mode
- Up to 100 m reach on MMF OM3
  - Up to 150 m reach on MMF OM4

Key Specs	QSFP-40G-SR4
Standard	40GBASE-SR4
Connector	MPO-12
Reach	OM3: ≤ 100 m OM4: ≤ 150 m
Fibre	Multi Mode ribbon
Power Consumption	1.5W
Form factor	QSFP

40GE: QSFP-40G-LR4 for 10 km

KEY
- LD = Laser Diode
- PD = Photo Diode
- Mod. = Modulator
- TIA = Transimpedance Amplifier
- CDR = Clock & Data Recovery



FEATURES

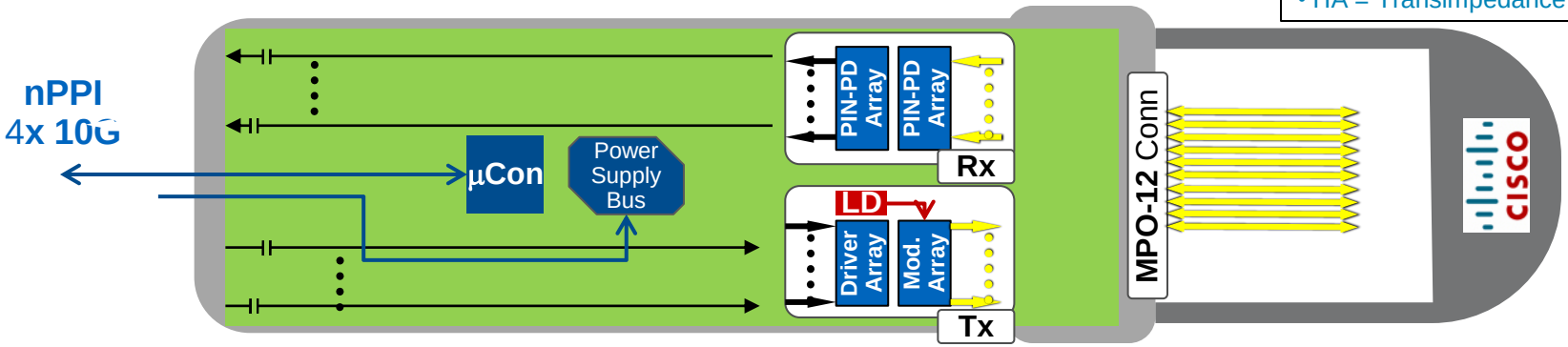
- IEEE 40GE Compliance
- Embedded optical Mux/Dmux
- Up to 10 km reach on SMF

Key Specs	QSFP-40G-LR4
Standard	40GBASE-LR4
Connector	LC
Reach	≤ 10 km
Fibre	Single Mode duplex
Power Consumption	≤ 2.5 W
Form Factor	QSFP

QSFP-40G-4X10GLR for 10 km

10G Density

KEY
- VCSEL= Vertical Surface Emitting Laser
- PD = Photo Diode
- TIA = Transimpedance Amplifier



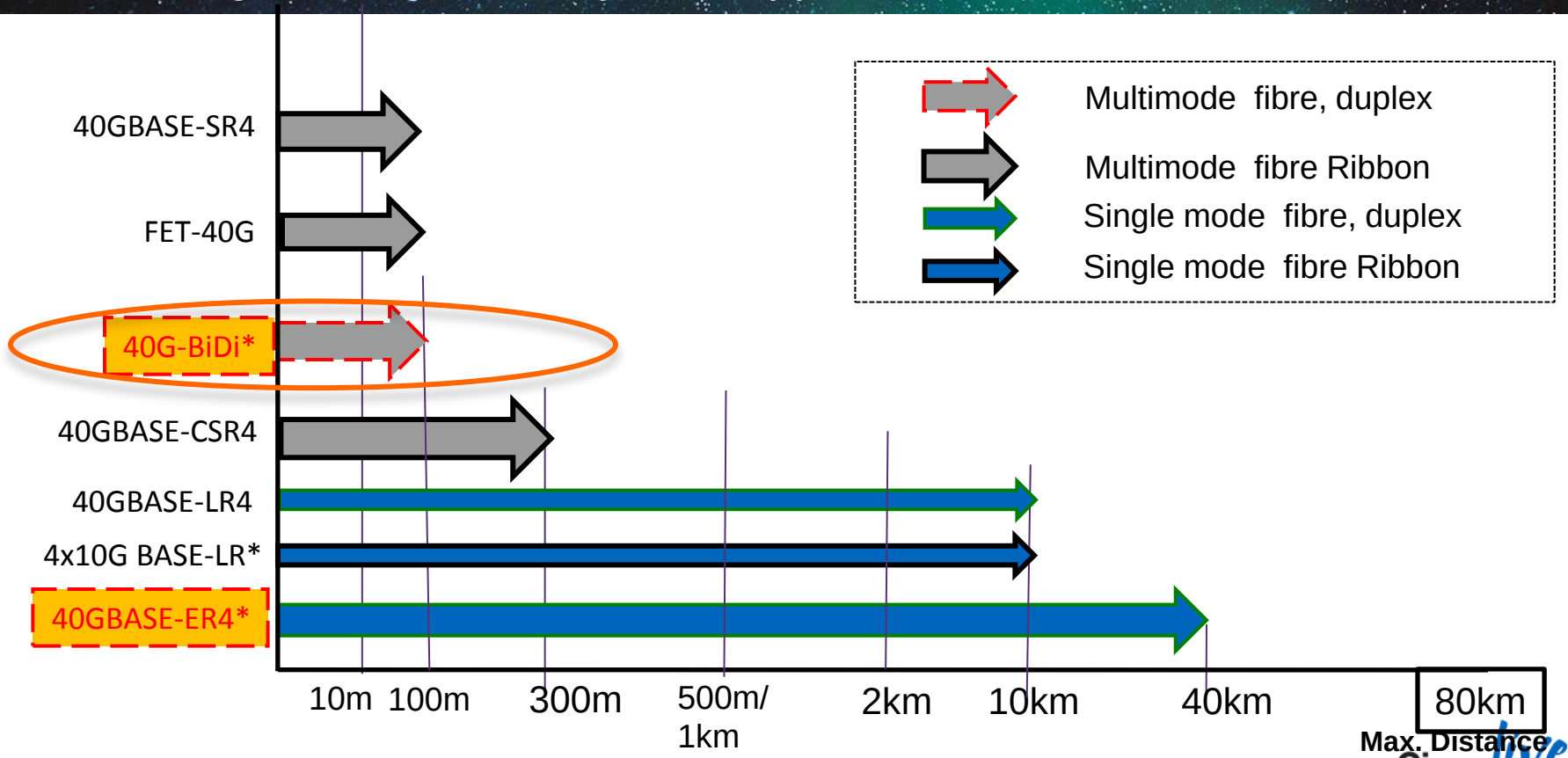
FEATURES

- IEEE 4x10GBase-LR Compliance
- CMOS Photonics for low power consumption
- Up to 10 km reach on SMF
- Interoperability with 10G-LR

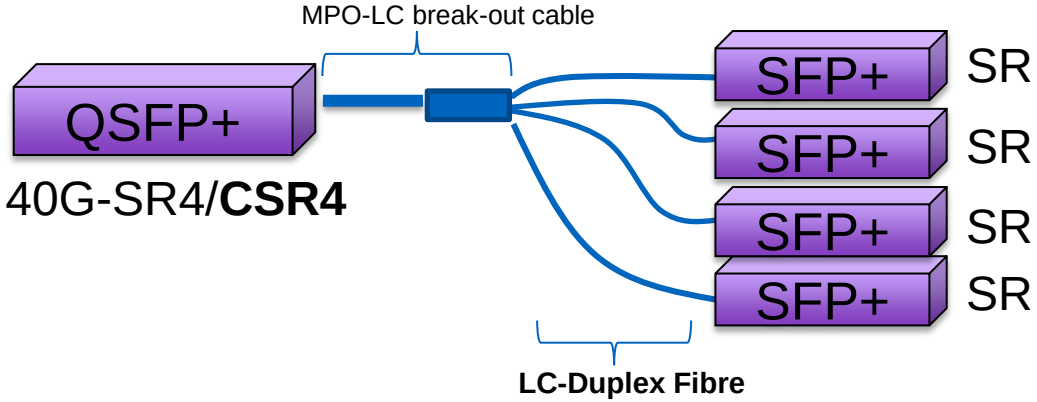
Key Specs	QSFP 40G-4X10GLR
Standard	10GBASE-LR
Connector	MPO-12
Reach	≤ 10 km
Fibre	Single Mode ribbon
Power Consumption	<3.5W
Form Factor	QSFP

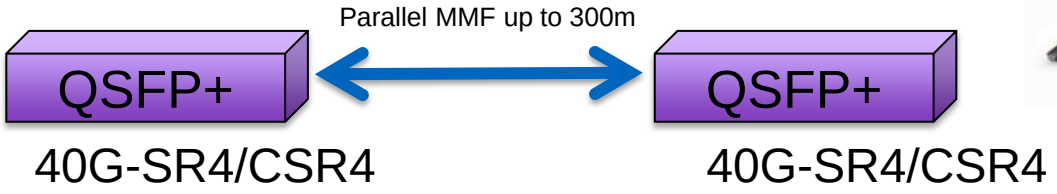
Cisco 40G Portfolio

Wide Range of High Density 40G Applications

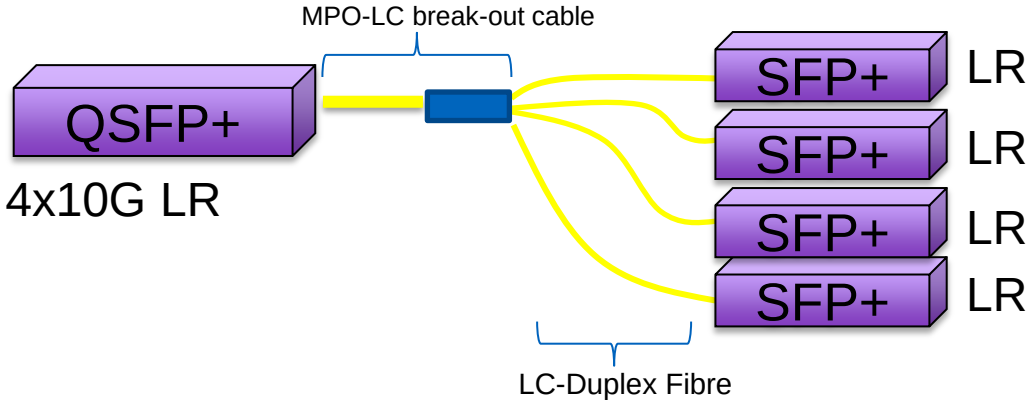


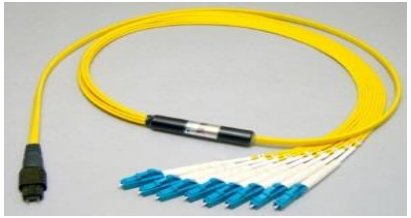
QSFP40G 40G-SR Interoperability

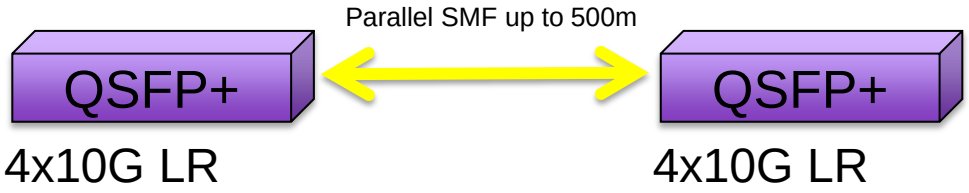




QSFP40G 4x10G LR Interoperability







SR4 and CSR4 QSFP40G INTEROPERABILITY

INTEROPERABILITY	**10GBASE-SR** (300m OM3/ 400m OM4 MMF)	**Cisco QSFP-40G-SR4**[2] (100m OM3/ 150m OM4 MMF)	**Cisco QSFP-40G-CSR4**[3] (300m OM3/ 400m OM4 MMF)	IEEE 40GBASE-SR4[1] (100m OM3/ 150m OM4 MMF)
10GBASE-SR (300m OM3/ 400m OM4 MMF)		✓	✓	✗
Cisco QSFP-40G-SR4[2] (100m OM3/ 150m OM4 MMF)	✓		✓	✓
Cisco QSFP-40G-CSR4[3] (300m OM3/ 400m OM4 MMF)	✓	✓		✗
IEEE 40GBASE-SR4[1] (100m OM3/ 150m OM4 MMF)	✗	✓	✗	✓

40GE: QSFP-40G Portfolio

Key Specs	QSFP 40G-4X10GLR
Standard	10GBASE-LR
Connector	MPO-12
Reach	≤ 10 km
Fibre	Single Mode ribbon
Power Consumption	<3.5W
Features	Interoperability with 4x10G LR mode leveraging Silicon Photonics

Key Specs	QSFP-40G-LR4 (IEEE)
Standard	40GBASE-LR4
Connector	LC
Reach	≤ 10 km
Fibre	Single Mode duplex
Power Consumption	≤ 2.5 W
Features	Uses SM Duplex Fibre

Key Specs	QSFP-40G-CSR4
Standard	4x10GBASE-SR
Connector	MPO-12
Reach	OM3: ≤ 300 m OM4: ≤ 400 m
Fibre	Multi Mode ribbon
Power Consumption	1.5W
Features	10G-SR (300m) to 40G-CSR4 (300m) migration

Key Specs	QSFP-40G-SR4 (IEEE)
Standard	40GBASE-SR4
Connector	MPO-12
Reach	OM3: ≤ 100 m OM4: ≤ 150 m
Fibre	Multi Mode ribbon
Power Consumption	1.5W
Features	Configurable to run in 4x10G SR mode

40G QSFP Cables and Adapters

QSFP TO SFP/SFP+ adapter

- QSFP adapter supports one SFP or SFP+ module
- Use case: 10G connectivity on a 40G port

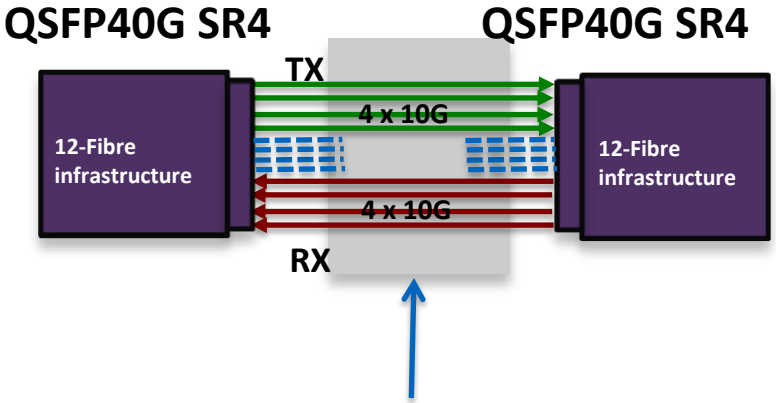
40G Copper Cables:
(Available now)

- QSFP to QSFP 40G for 1m thru' 10m
- QSFP to 4 X SFP10G Breakout cables for 1m thru 10m

40G Optical Cables (AOC):

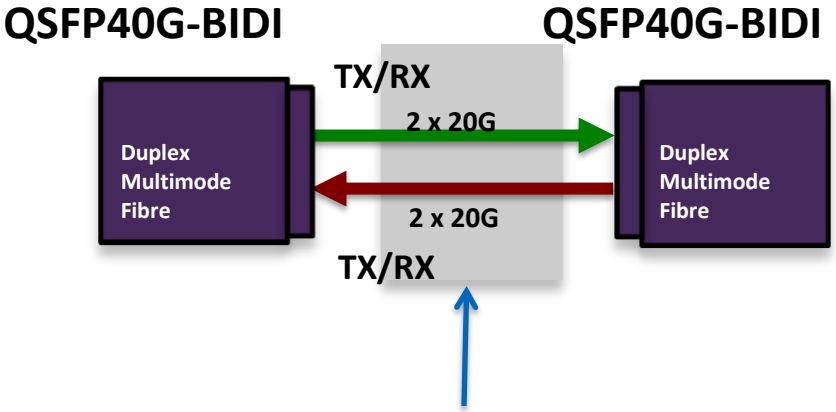
- QSFP to QSFP 40G
  - 1m thru' 10m (available early 2014)
  - 15m cable available in mid CY14
  - 30m cable availability target CY15
- QSFP to 4 X SFP10G Breakout cables for 1m thru 10m (available early 2014)

QSFP40G-BIDI Value Proposition



12-Fibre ribbon cable with MPO connectors at both ends

Higher cost to upgrade from 10G to 40G due to 12-Fiber infrastructure



Duplex multimode fibre with Duplex LC connectors at both ends

Use of duplex multimode fiber lowers cost of upgrading from 10G to 40G by leveraging existing 10G multimode infrastructure

Bi-Directional QSFP40G-SR

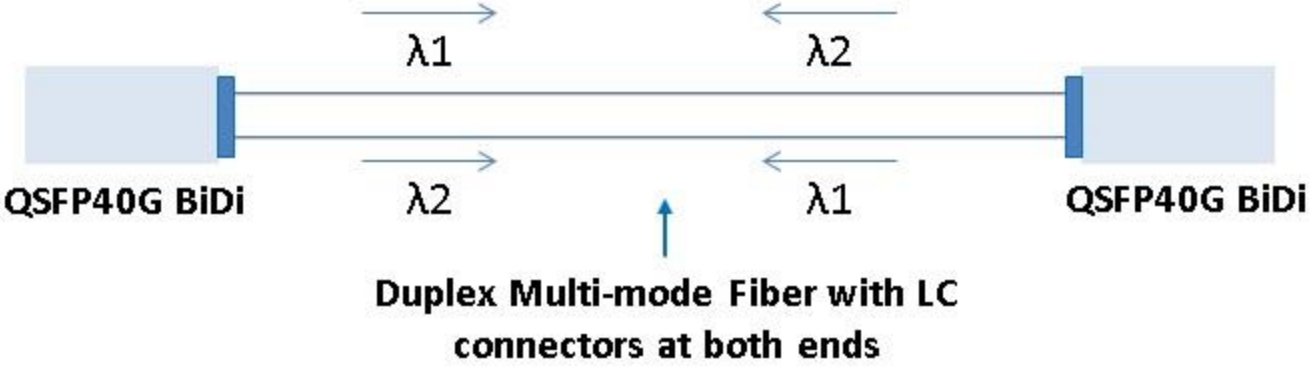
- Short reach transceiver with 2 channels of 20G, each transmitted and received over a multi-mode fibre
- 100m with OM3 grade fibre
- Electrical interface: IEEE 802.3ba Compliant
- Power consumption < 3.5w
- Use of duplex multimode fibre allows customers to migrate from 10G to 40G with minimal capital investment
- QSFP-BIDI to QSFP-BIDI connection only – No interoperability support with QSFP-SR4 or 10G SR
- Cisco exclusive transceiver

QSFP+ SKU	Center Wavelength (nm)	Cable Type	Cable Distance (m)
QSFP-40G-SR-BD	850nm	LC Duplex	100m (OM3) 125m (OM4)

Cable Type	Core Size (Micron)	Modal Bandwidth (MHz*Km)	Cable Distance	Comments
MMF	50.00	500 (OM2)	30m	
		2000 (OM3)	100m	Connector loss budget for OM3 Fibre is 1.5dB
		4700 (OM4)	125m	Connector loss budget for OM4 Fibre is 1.0dB (Engineered Link)
		OM4+	150m	Connector loss budget for OM4+ Fibre is 1.0dB (Engineered Link) Reference OM4+ Fibre: Panduit Signature Core Fibre: http://www.panduit.com/en/signature-core

QSFP40G BiDi

- 100m short reach QSFP with LC Duplex connector
- Enables Re-use of existing Duplex Fibre infrastructure
- Saves Cost on Fibre (Use only 2 fibre strands instead of 8 strands for SR4/CSR4)



* QSFP40G BiDi is a proprietary solution and will not inter-operate with any other interface

10G Fibre Infrastructure Reuse: BiDi vs SR4

10G Optical Link

Jumper cable | Patch Panel | Trunk Cabling (100m) | Patch Panel | Jumper cable

40G Optical Link with BiDi

Jumper Cable | Patch panel | Trunk Cabling (100m) | Patch panel | Jumper Cable

40 GbE BiDi
Reuse 10G SR fibre infrastructure?

YES

40G Optical Link with SR4

Jumper cable | Patch Panel | Trunk cabling (100m) | Patch Panel | Jumper cable

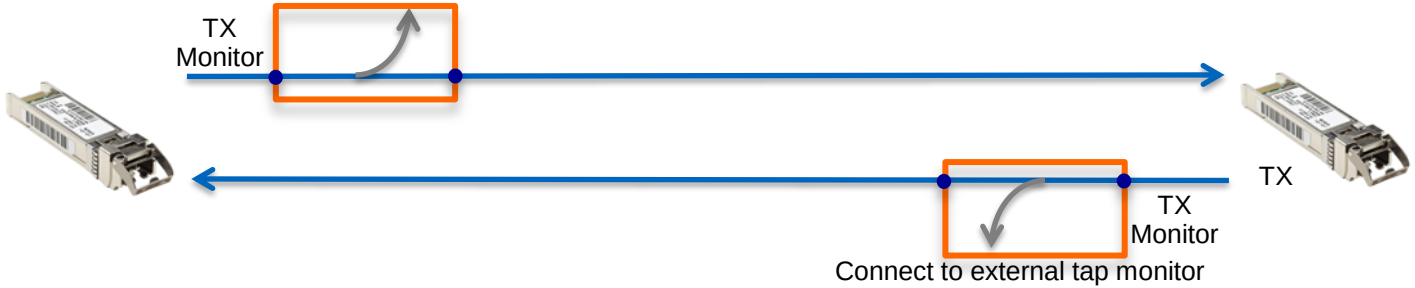
40GbE SR4
Reuse 10G SR fibre infrastructure?

NO

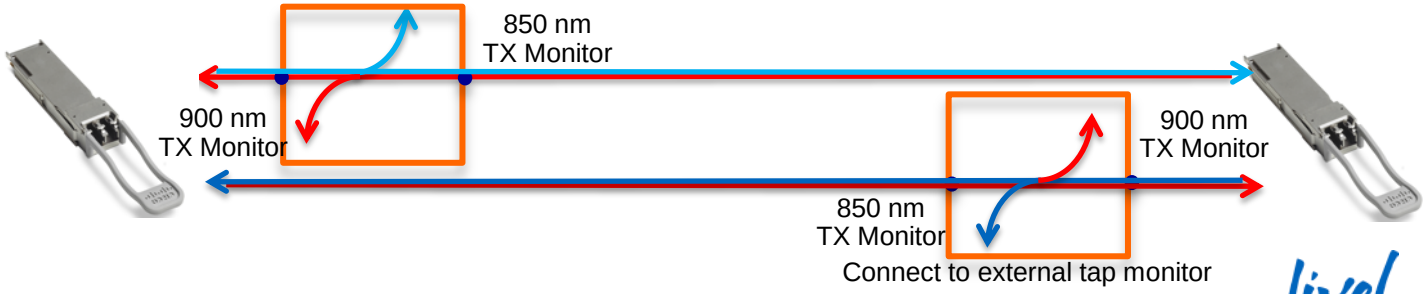
Optical Monitoring with a BiDi Optic

- QSFP BiDi optics does not include Digital Optical Monitoring
- External tap monitoring is feasible for a BiDi*, and similar to 10G SR
  - Use 2x2 splitters for BiDi rather than 1x2 splitter for 10G SR or other uni-directional links
  - Neither 10G SR nor the 40G BiDi have link budget allocation for external tap monitoring
  - Link margins are used to determine if external monitoring is feasible

10G SR Tap Monitoring



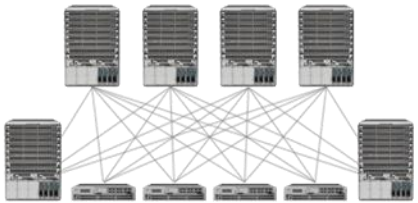
40G BiDi Tap Monitoring

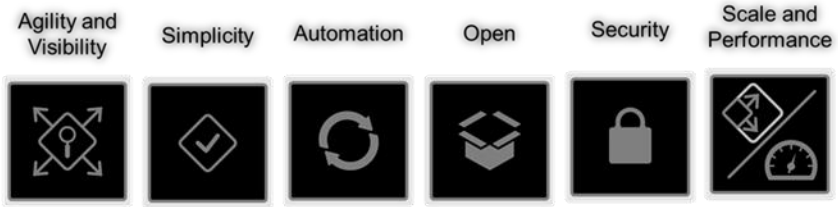


*Work in progress to determine feasibility and limitations of external tap monitoring with 40G BiDi

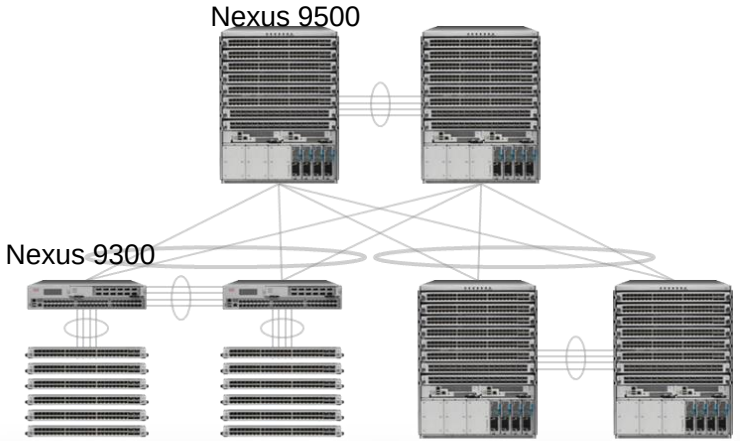
ACI / NXOS Fabric w/BiDi

APPLICATION CENTRIC INFRASTRUCTURE





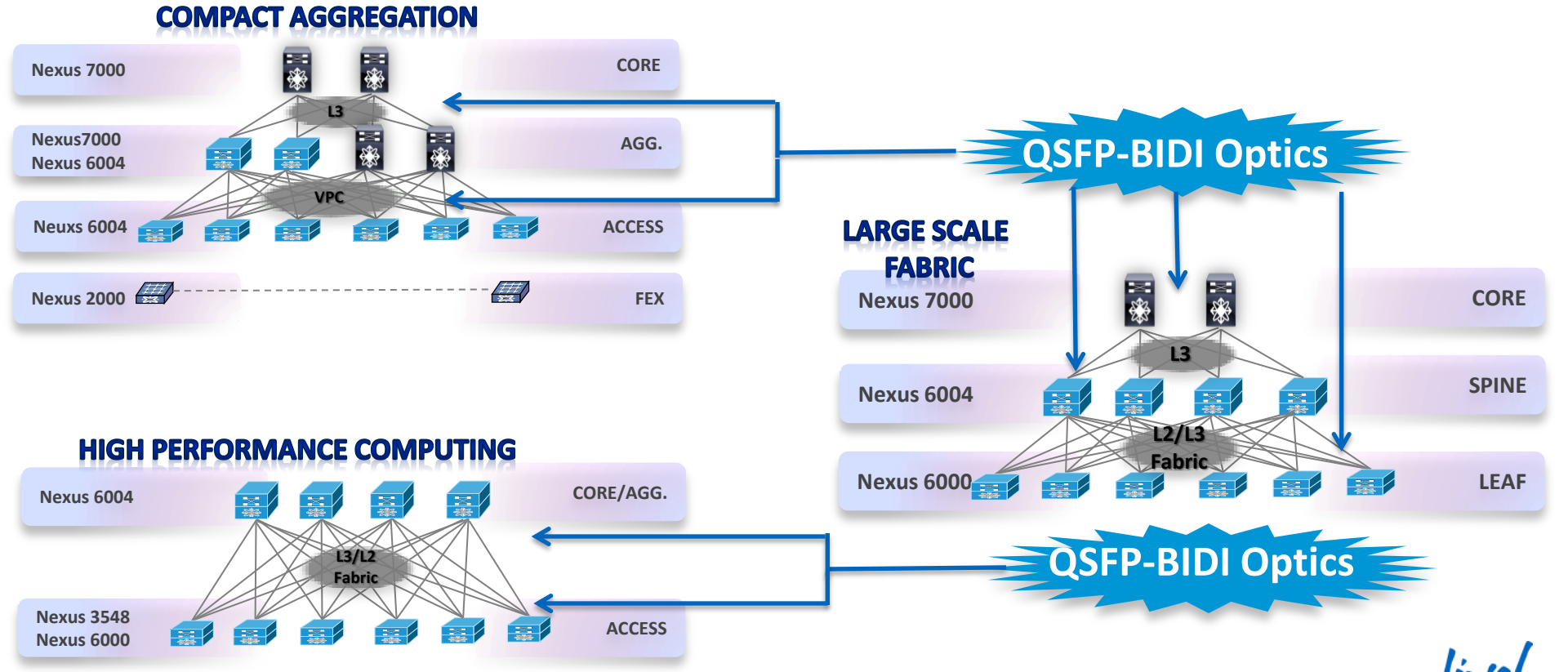
ENHANCED NX-OS



PROGRAMABILITY—40 GigE—PRICE/PERFORMANCE

Existing Network Model

QSFP40G BiDi: Targeted Solutions

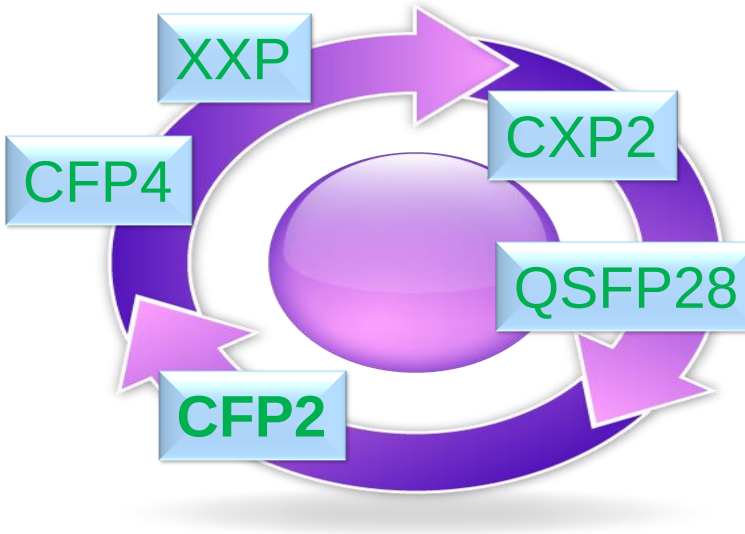


100G Transceivers and Cables

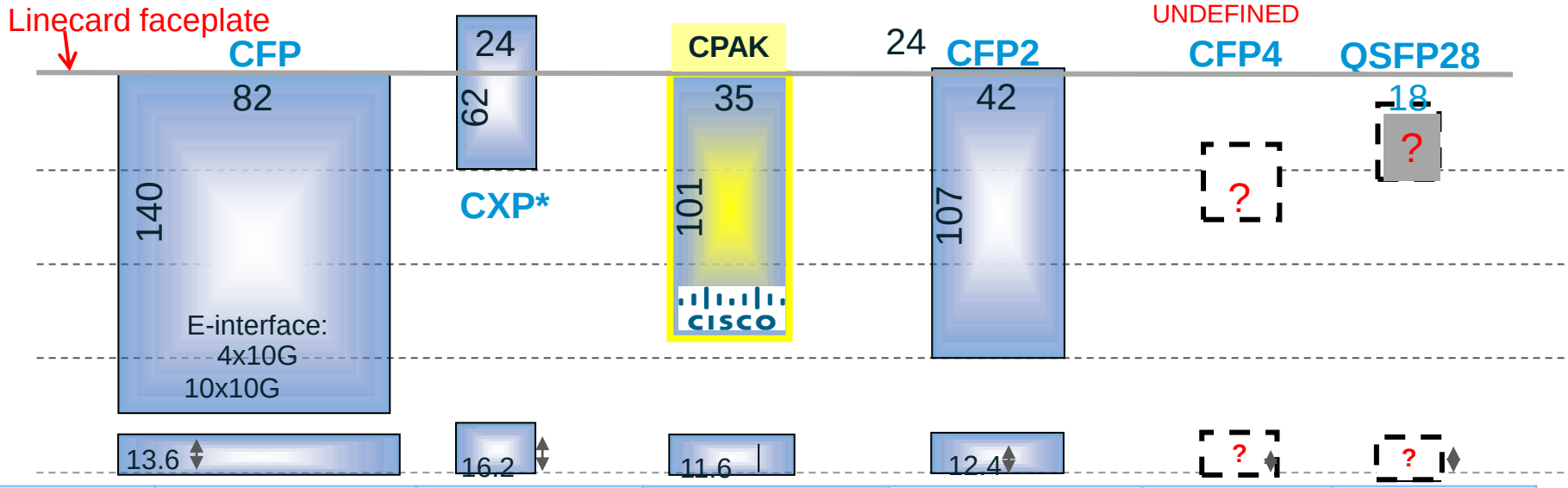
Next Gen 100G Form Factor

- Multiple Form Factors for 40GE & 100GE
- Multiple new reaches being discussed at the NextGen IEEE Optics Study group
  - Forces unique linecards for 10GE, 40GE & 100GE
- Removes economies of scale due to form factor proliferation

Next Gen Form Factor Merry-Go-Round



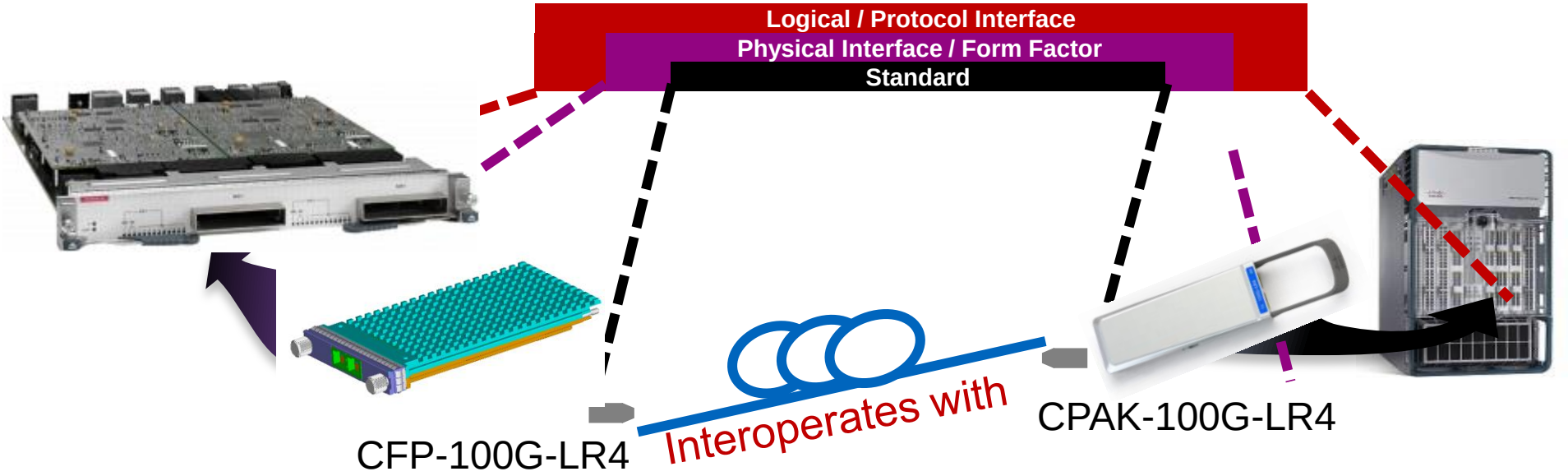
100G Module Form Factors Evolution



Power	**≤ 32 W**	**≤ 4 W? Only multimode**	**< 7.5 W For CPAK portfolio**	**≤ 8 or 12 W?**	**≤ 5 W??**	**≤ 3.5 W??**

The technology that enables Cisco CPAK is ……. CMOS Photonics

IEEE Physical Interface Standard Interoperability



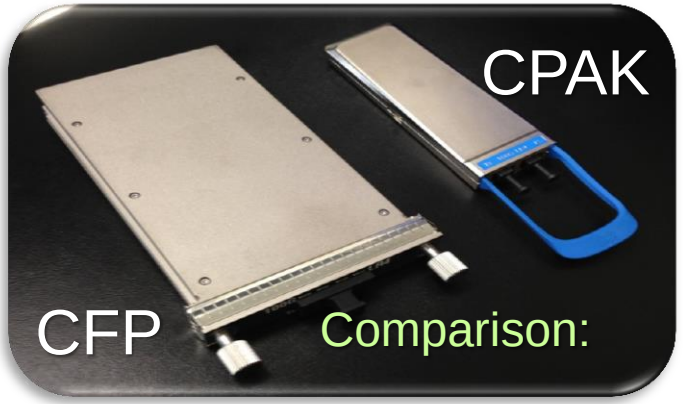
CPAK™: 100G Transceiver Innovation

Breaking Through the Capacity Brick Wall

- **Industry's first CMOS Photonic Solution**
- CMOS Photonics – Light processing in Silicon!
- 70% size reduction, 70% power reduction
- IEEE Standards based
  - OTU4 compliant

10 CPAKs = 1 Terabit

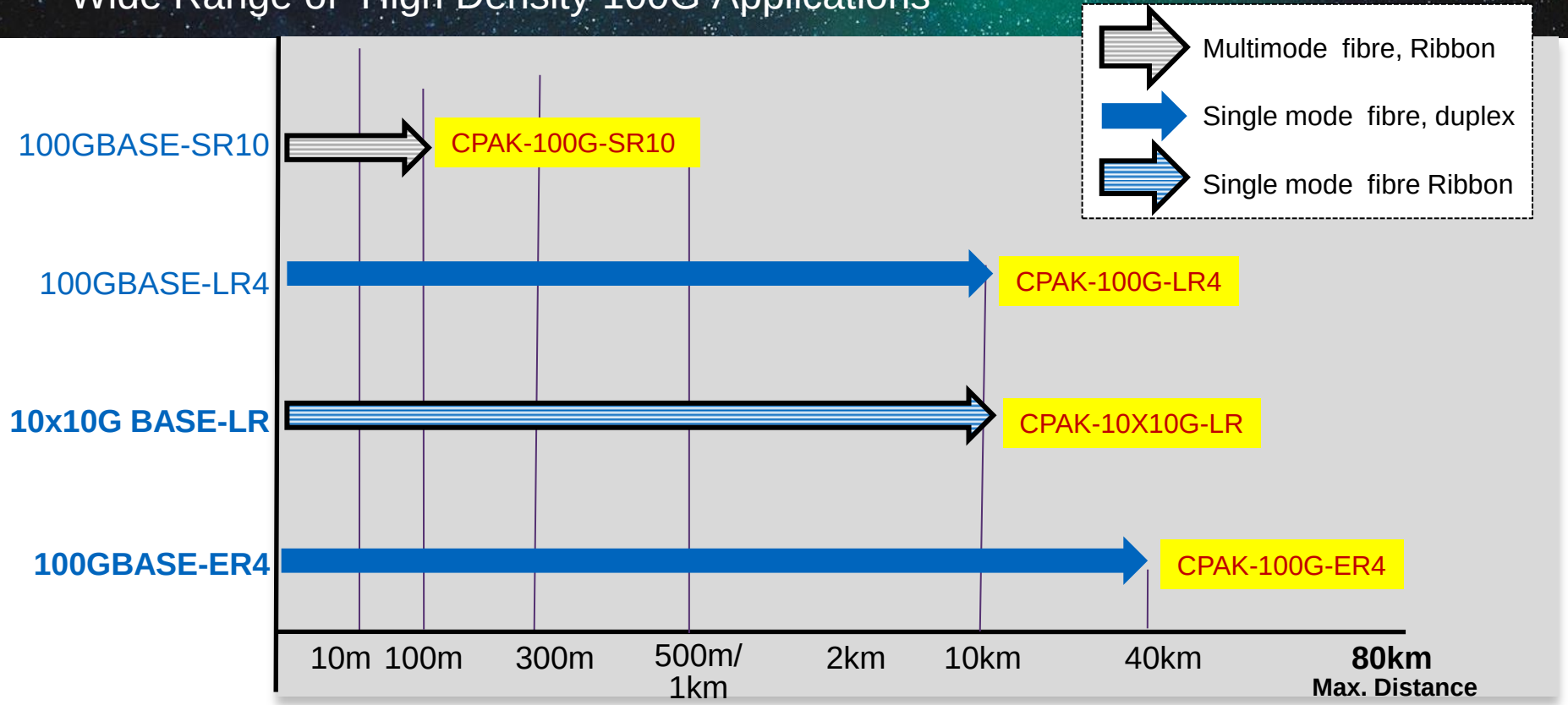
1 Terabit for <



CPAK is the smallest 100G form-factor capable of supporting the full range of IEEE reaches available.

Cisco CPAK100G Portfolio

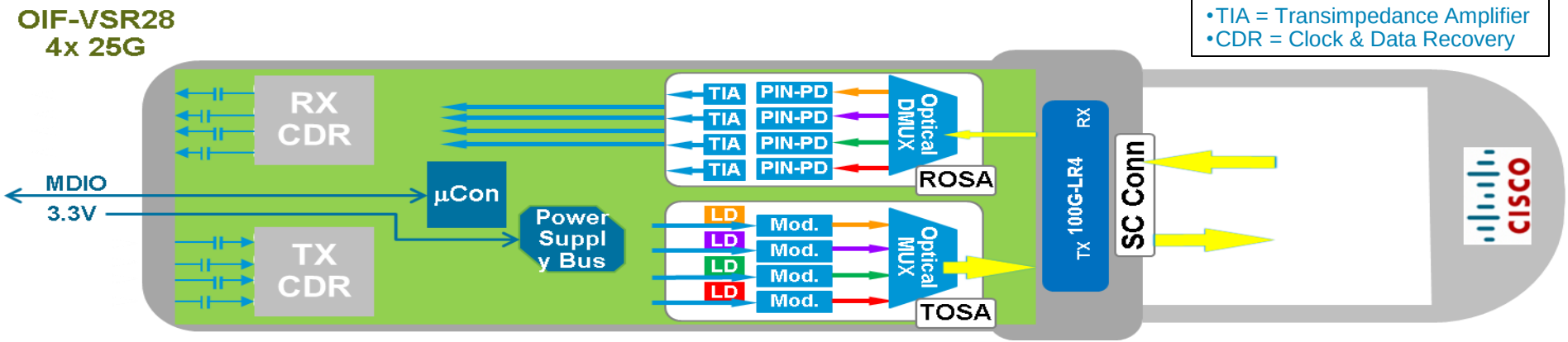
Wide Range of High Density 100G Applications



Cisco is enabling 100G connectivity on Cisco switches, routers and transport

100GE: CPAK100G-LR4 for 10 km

KEY
- LD = Laser Diode
- PD = Photo Diode
- Mod. = Modulator
- TIA = Transimpedance Amplifier
- CDR = Clock & Data Recovery



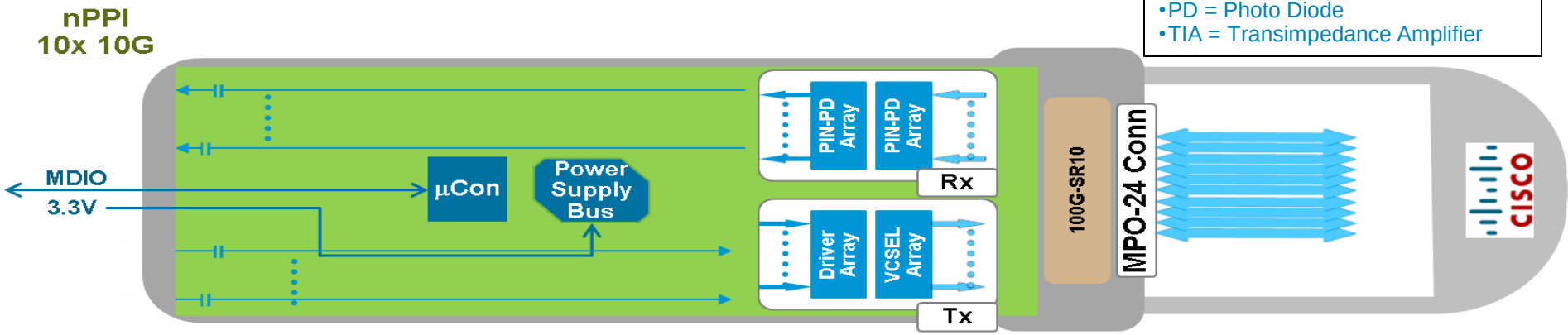
FEATURES

- IEEE 100GE Compliance
- Embedded optical Mux/Dmux
- Si Photonics for low power consumption
- Up to 10 km reach on SMF

Key Specs	CPAK100G-LR4
Standard	100GBASE-LR4
Connector	SC
Reach	≤ 10 km
Fibre	Single Mode
Power Consumption	≤ 7.5 W
Dimensions	101 x 35 x 12 mm

100GE: CPAK100G-SR10 for 100 m

KEY
- VCSEL= Vertical Surface Emitting Laser
- PD = Photo Diode
- TIA = Transimpedance Amplifier



FEATURES

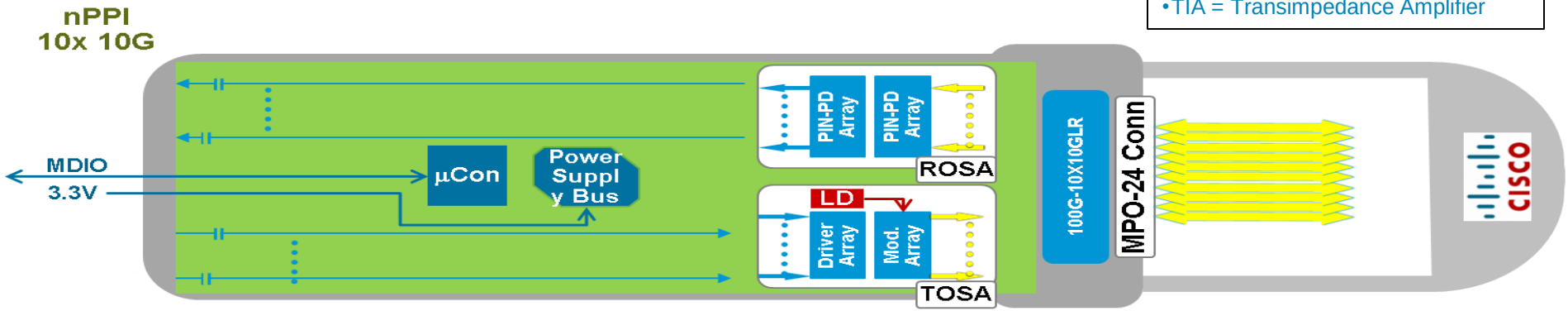
- IEEE 100GE Compliance
- Configurable to run in 10x10GSR mode
- Configurable to run in 2x40GSR4 mode
- Up to 100 m reach on MMF OM3
  - Up to 150 m reach on MMF OM4

Key Specs	CPAK100G-SR10
Standard	100GBASE-SR10
Connector	MPO-24
Reach	OM3: ≤ 100 m OM4: ≤ 150 m
Fibre	Multi Mode
Power Consumption	*tbd*
Dimensions	101 x 35 x 12 mm

CPAK-10X10-LR for 10 km

10G Density

KEY
- VCSEL= Vertical Surface Emitting Laser
- PD = Photo Diode
- TIA = Transimpedance Amplifier



FEATURES

- IEEE 100GE Compliance
- CMOS Photonics for low power consumption
- Up to 10 km reach on SMF

Key Specs	CPAK100G-10X10GLR
Standard	10GBASE-LR
Connector	MPO-24
Reach	≤ 10 km
Fibre	Single Mode
Power Consumption	*<5W*
Dimensions	101 x 35 x 12 mm

100GE: CPAK-100G Portfolio Leveraging Silicon Photonics

Key Specs	CPAK100G- **10X10GLR**
Standard	10GBASE-LR
Connector	MPO-24
Reach	≤ 10 km
Fibre	Single Mode
Power Consumption	*<5W*
Features	Configurable to run in 10x10GLR or 2x(4x10GLR) mode

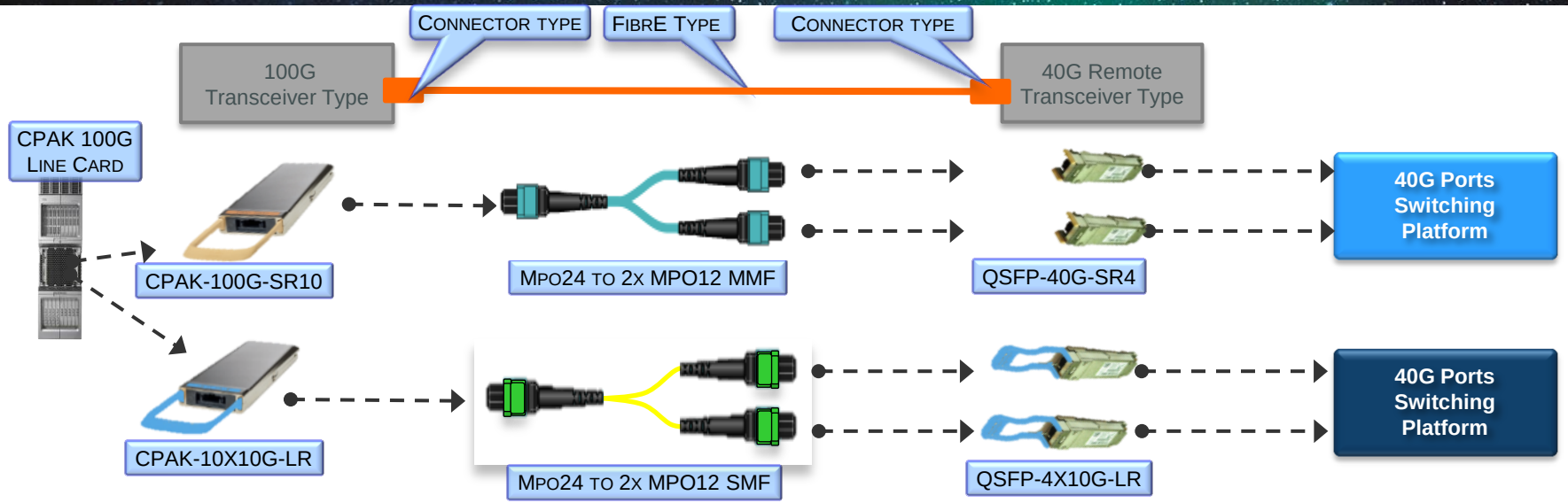
Key Specs	CPAK100G-LR4
Standard	100GBASE-LR4
Connector	SC
Reach	≤ 10 km
Fibre	Single Mode
Power Consumption	≤ 7.5 W
Features	Up to 10 km reach on SMF

Key Specs	CPAK100G-ER4
Standard	100GBASE-ER4
Connector	SC
Reach	≤ 40 km
Fibre	Single Mode
Power Consumption	*< 7.5W*
Features	Up to 40 km reach on SMF

Key Specs	CPAK100G-SR10
Standard	100GBASE-SR10
Connector	MPO-24
Reach	OM3: ≤ 100 m OM4: ≤ 150 m
Fibre	Multi Mode
Power Consumption	≤ 4.5 W
Features	Configurable to run in 10x10GSR or 2x40GSR4 mode

40G Interconnect Scenarios to Cisco CPAK 100G Ports

Using breakout cables to provide 40G connectivity to Cisco CPAK 100G ports



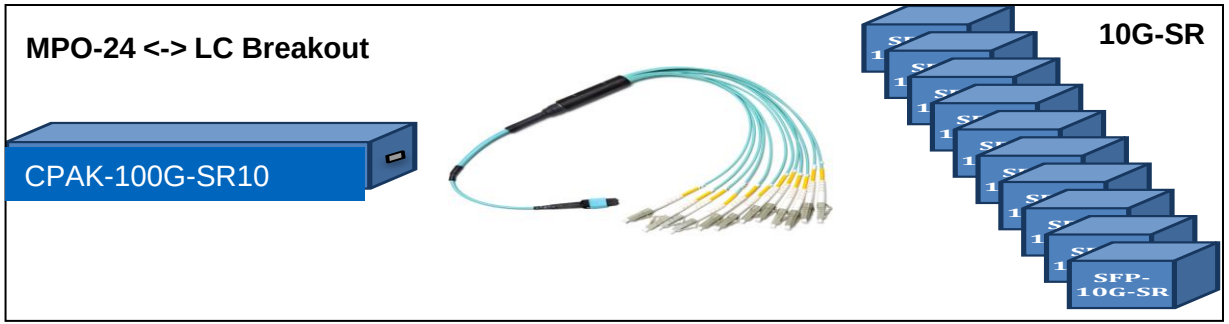
100G Line Card	Pluggable Module	CPAK Optical Connector / Fibre Type	Reach	Remote Optical Connector	Remote Transceiver
Edge Router **Carrier Router**	CPAK-100G-SR10	MPO-24 / (OM3/4)	<100m-OM3 / <150m-OM4	MPO-12	QSFP-40G-SR4
Switching Platform	CPAK-10X10G-LR	MPO-24 / (SMF)	<10km	MPO-12	QSFP-4X10G-LR

10G/40G/100G Connectivity

Sample Configurations for Multimode Fibre

100GE Interconnect Options

10GE Interconnect Options

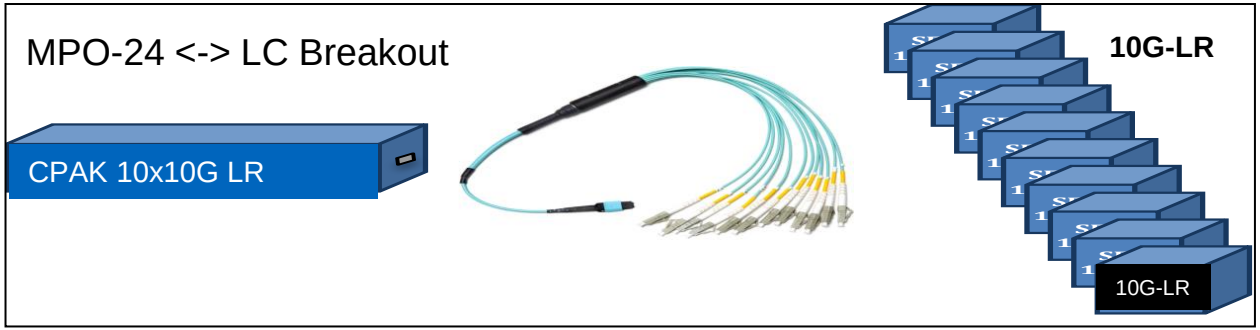


40GE Interconnect Options

10G/40G/100G Connectivity

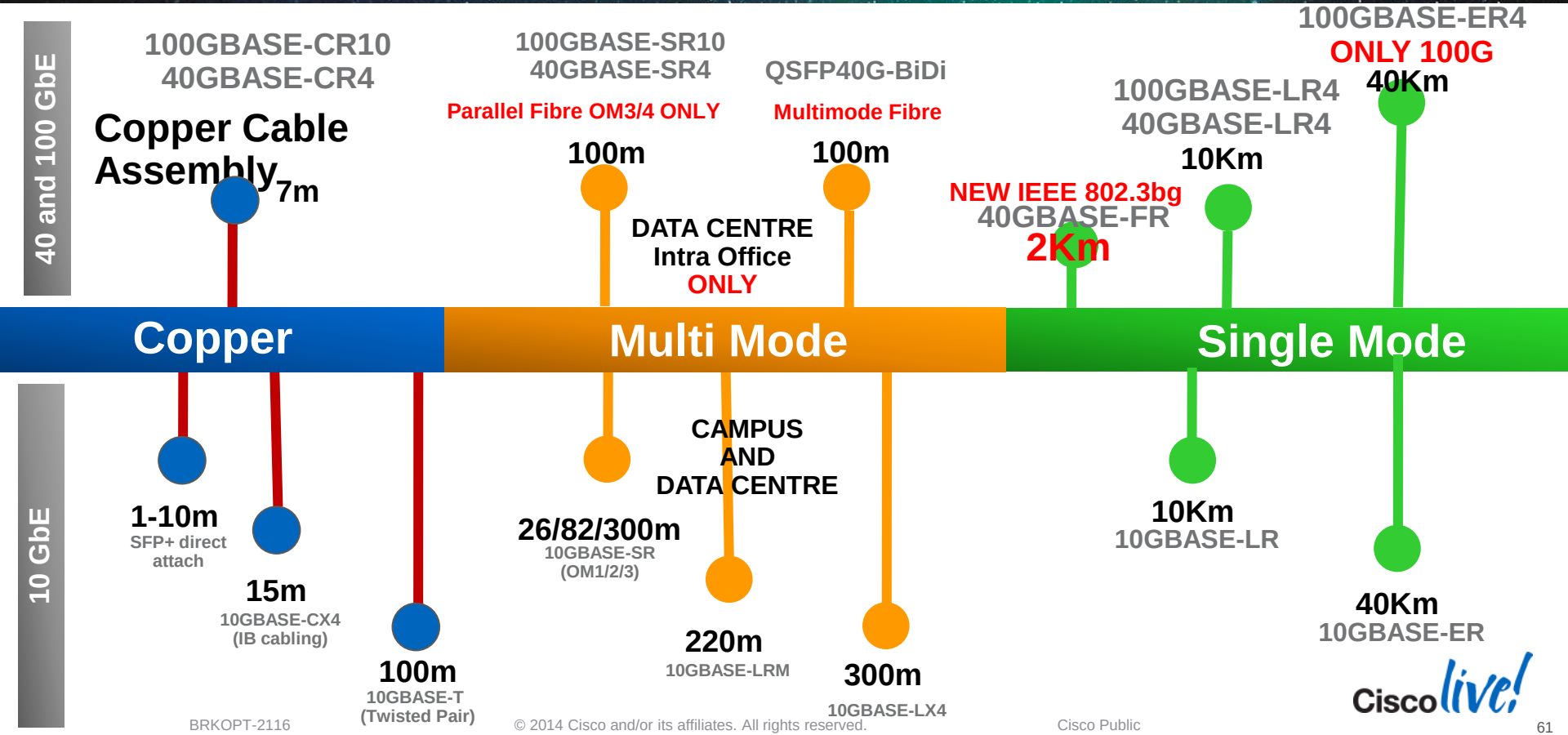
Sample Configurations for Singlemode Fibre

10GE Interconnect Options



10GE Interconnect Options

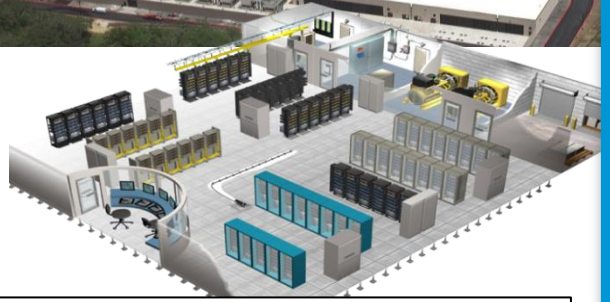
Typical Client Signal Reach Summary



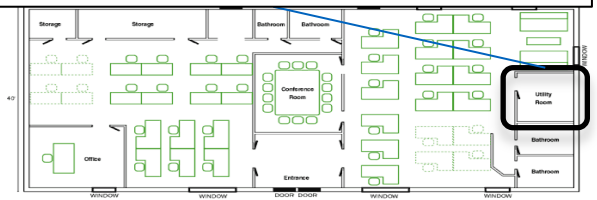
40GE and 100GE Impact on DC Fabric

Scaling to Higher Speeds: Larger Buildings

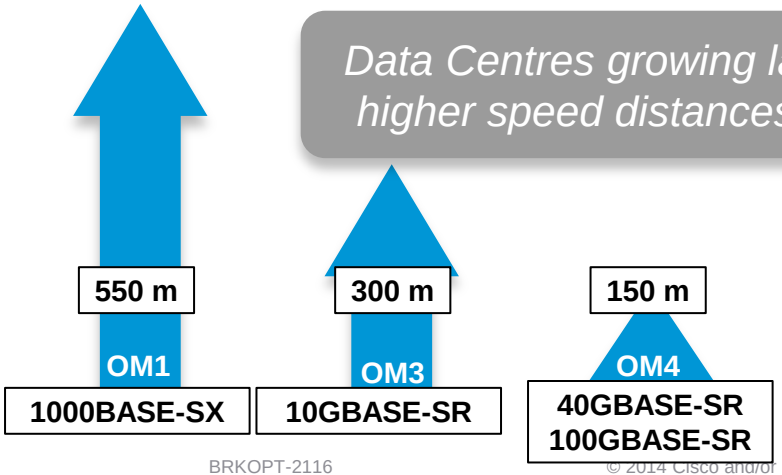
- **Physical scaling of data centres**
- Mapping Topology to Infrastructure
- Cabling complexity
- Standards & Interop
- Form Factors

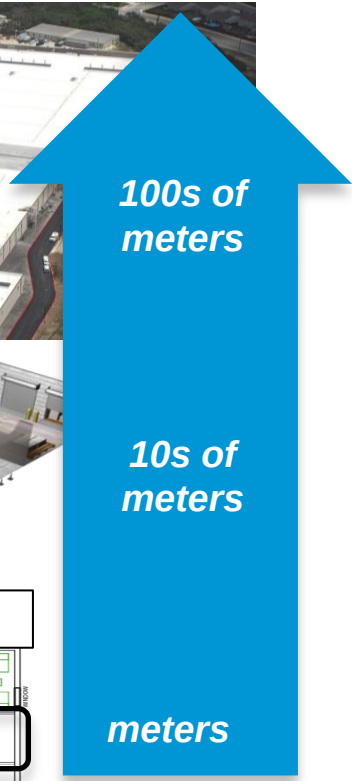


Data centres squeezed in utility room

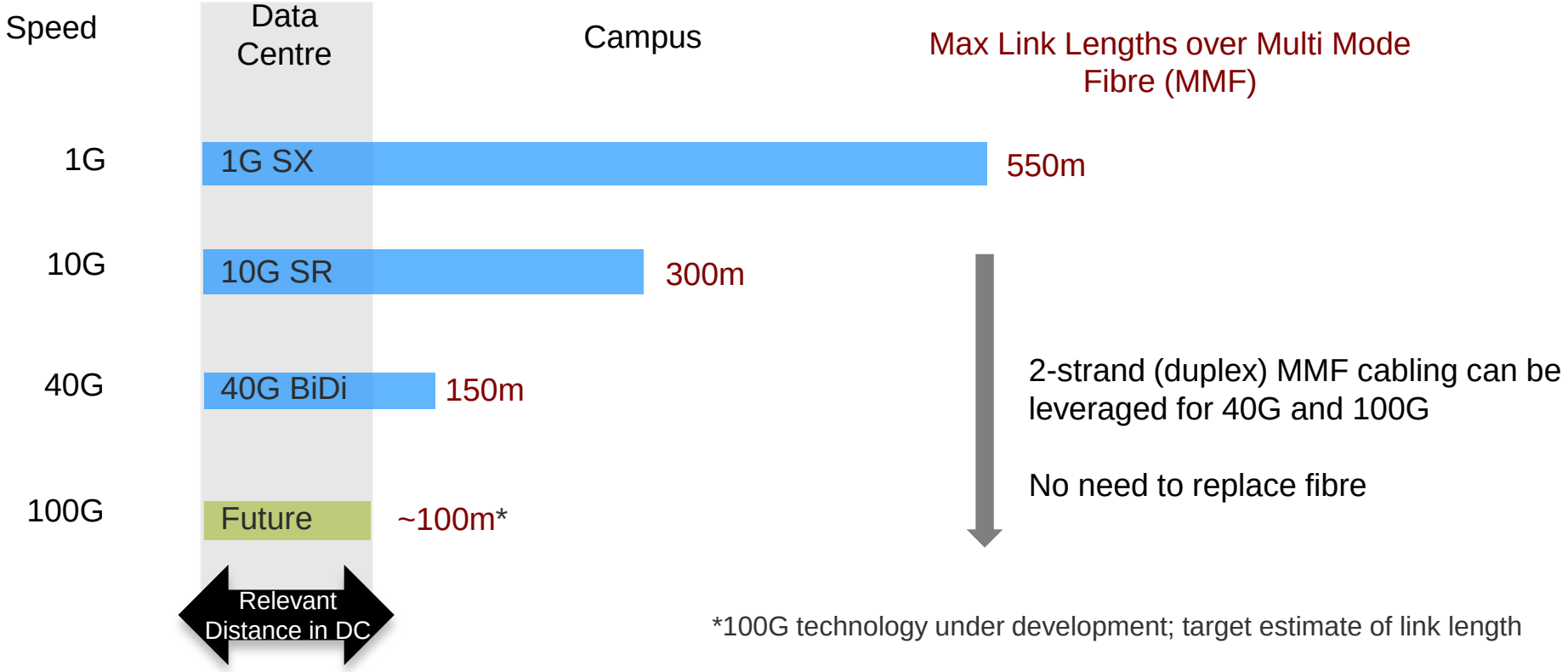


Data Centres growing larger as higher speed distances shrink



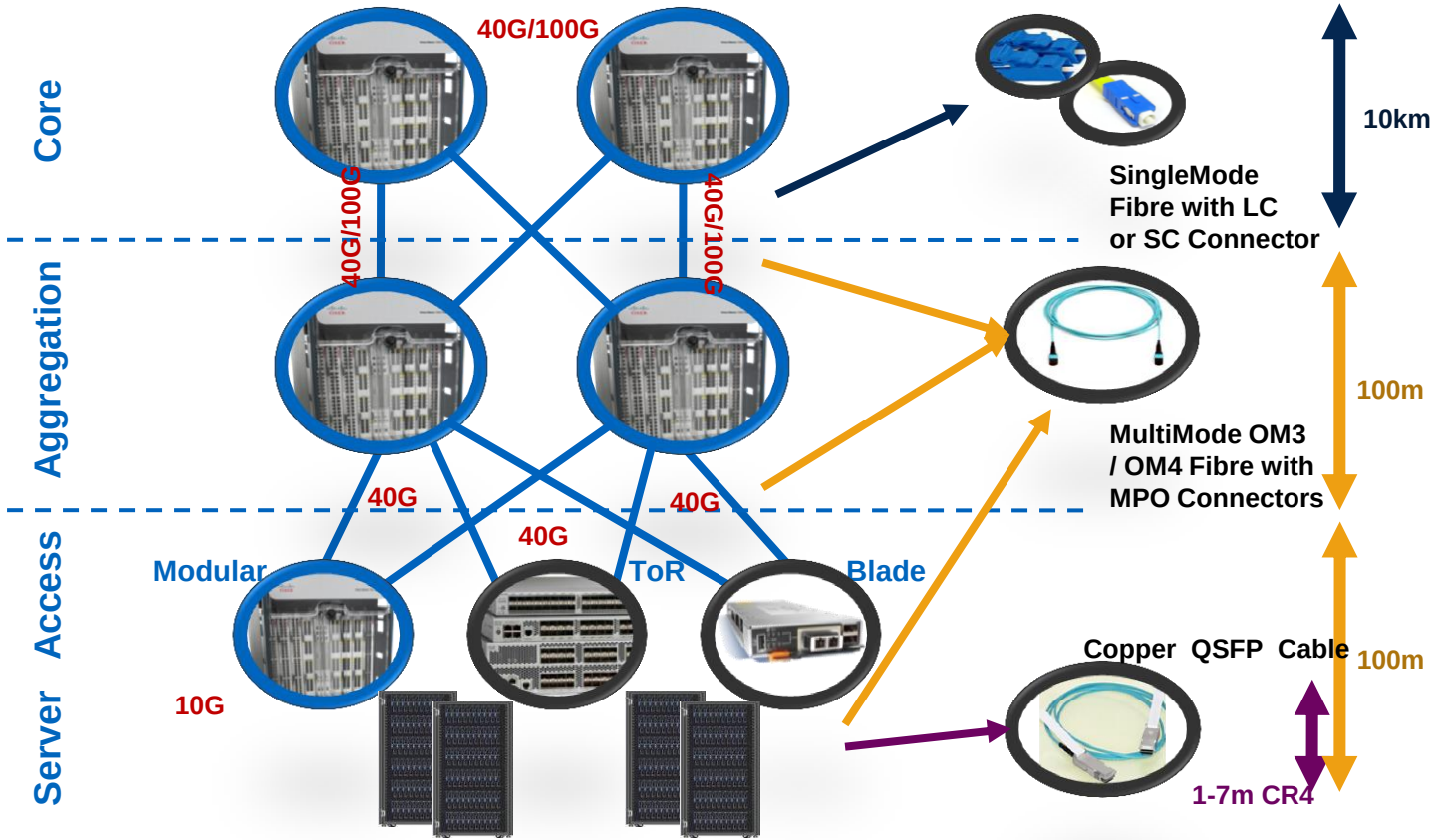


Multimode Fibre is FORWARD and BACKWARD Compatible

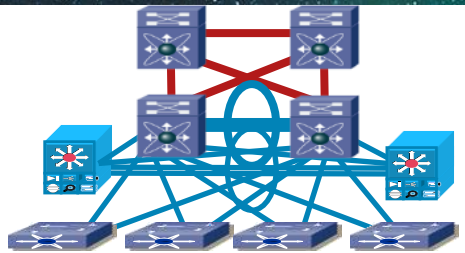


*100G technology under development; target estimate of link length

40G/100G Data Centre Deployment

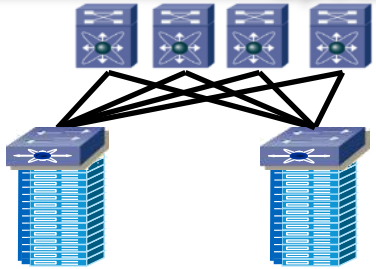


Data Centre Architecture
Trends & Application



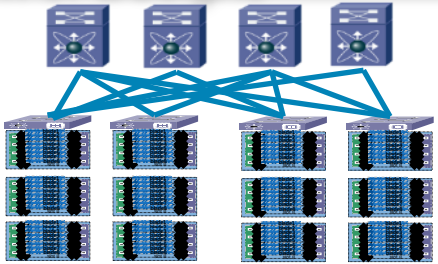
Ultra Low Latency (CoLo)

- High Frequency Trading
- Layer 3 & Multicast
- No Virtualisation
- Limited Physical Scale
- 10G edge moving to 40G
- CLOS in larger LL environments



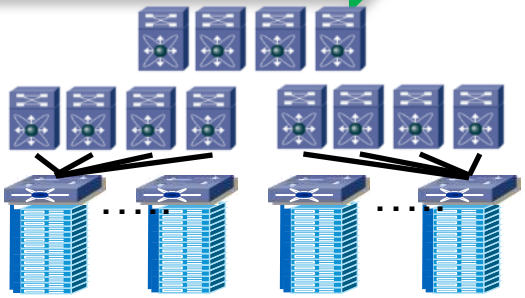
HPC/GRID

- Layer 3 & Layer 2
- No Virtualisation
- iWARP & RCoE
- 10G moving to 40G



Virtualized Data Centre

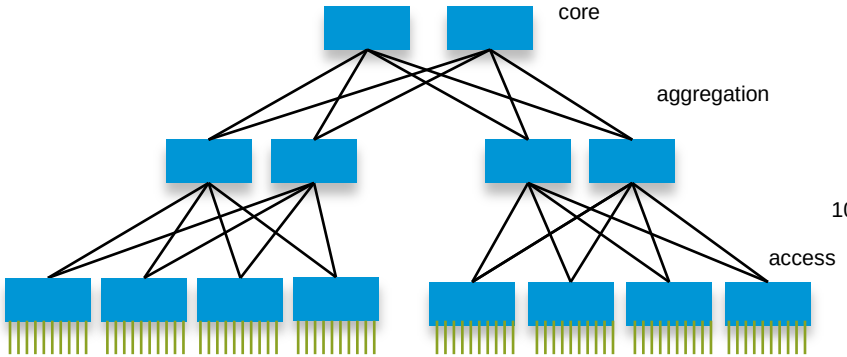
- SP and Enterprise
- Hypervisor Virtualization
- Shared infrastructure Heterogenous
- 1G Edge moving to 10G
- Workload anywhere

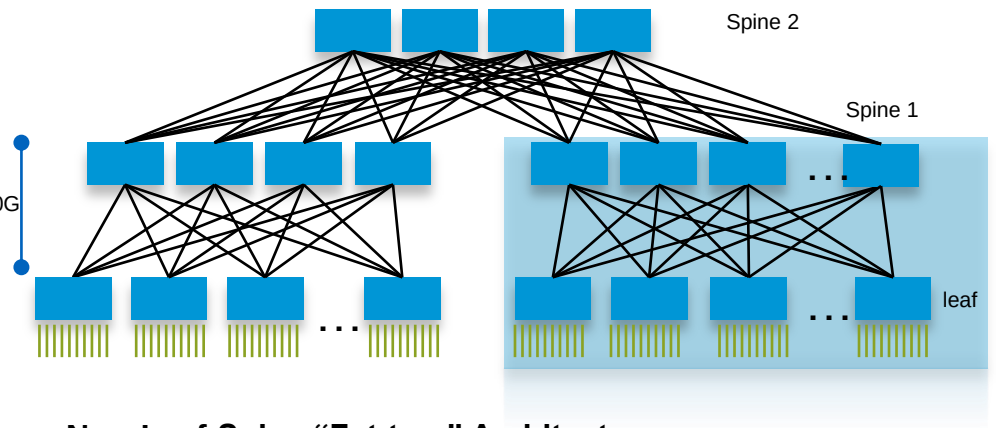


MSDC

- Layer 3 Edge (iBGP, ISIS)
- 1000's of racks
- Homogeneous Environment
- No Hypervisor virtualisation
- 1G edge moving to 10G

DC Architecture Evolution





Traditional tree-based architecture

Optimised for N-S traffic

Over-subscription in access, aggregation and core

port-channels to aggregation STP, MLAG

Conceded with 1G to 10G hosts

New Leaf-Spine "Fat-tree" Architecture

Optimised for E-W traffic (still valid for N-S traffic)

Increased availability n+1; & scale, add/remove nodes quickly

Over-subscription only in access, 1:1 to spine

Higher ports counts in Agg/spine-Core! to connect Each leaf each spine in cluster

Concede with 10/40 GE transition

Major Impact on Electronics I/O and Interconnect

Optics Improving Application Performance

Leaf-Spine DC Fabric

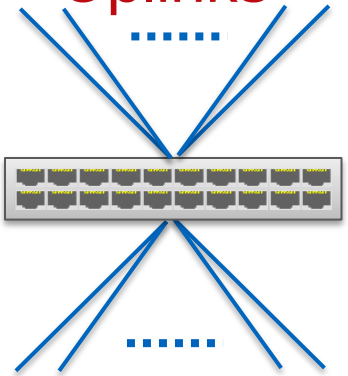
Approximates ideal output-queued switch

- How close is Leaf-Spine to ideal OQ switch?
- What impacts its performance?
  - Link speeds, oversubscription, buffering

Impact of Link Speed

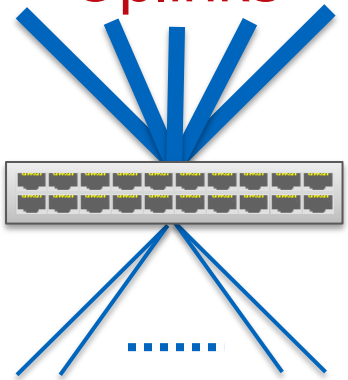
Three non-oversubscribed topologies:

20x10Gbps Uplinks



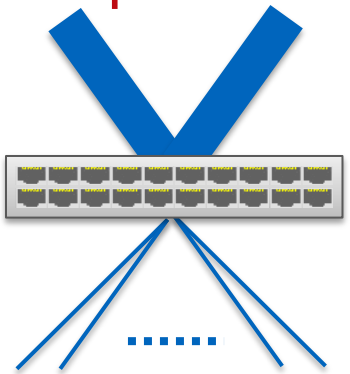
20x10Gbps Downlinks

5x40Gbps Uplinks



20x10Gbps Downlinks

2x100Gbps Uplinks



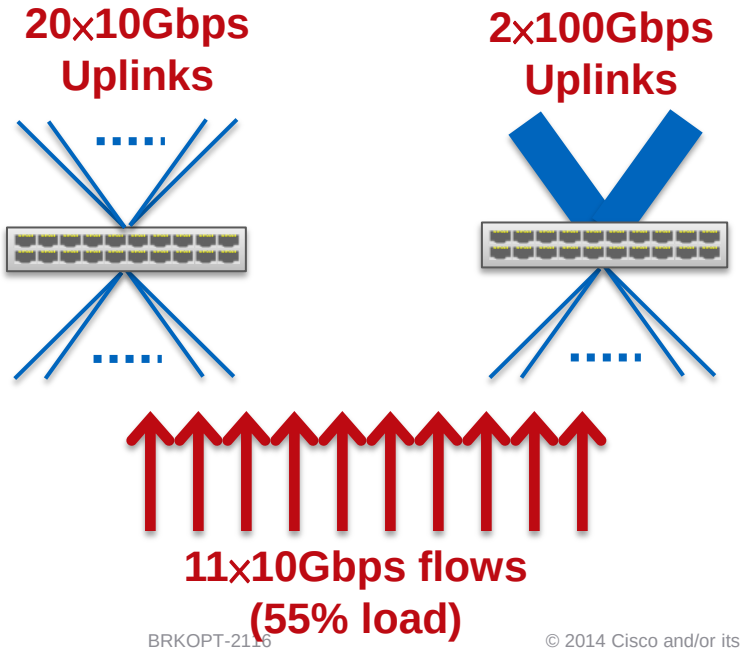
20x10Gbps Downlinks

Impact of Link Speed

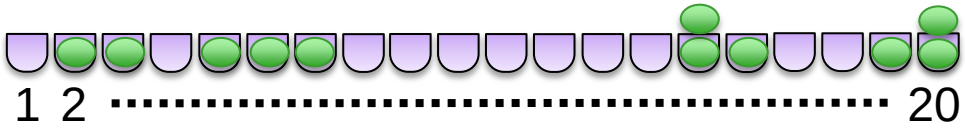
- 40/100Gbps fabric: ~ same FCT as OQ
- 10Gbps fabric: FCT up 40% worse than OQ

Intuition

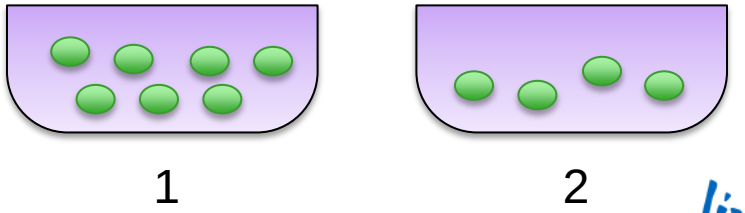
Higher speed links improve ECMP efficiency



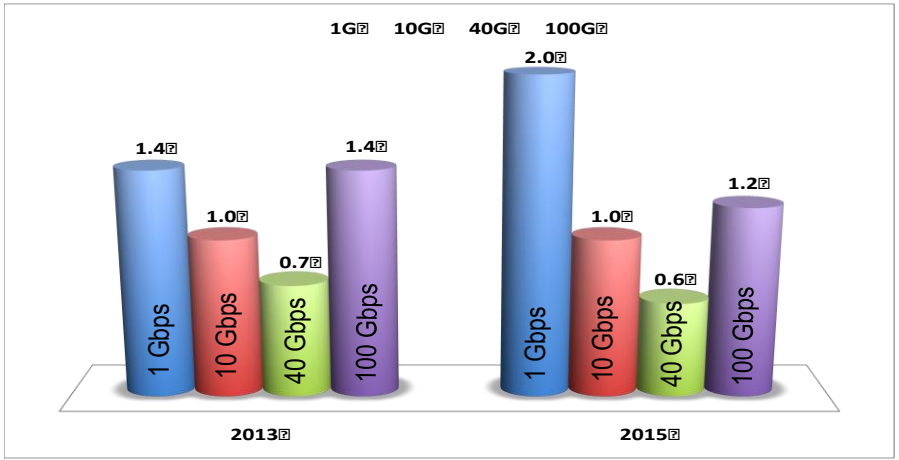
Prob of 100% throughput = 3.27%



Prob of 100% throughput = 99.95%



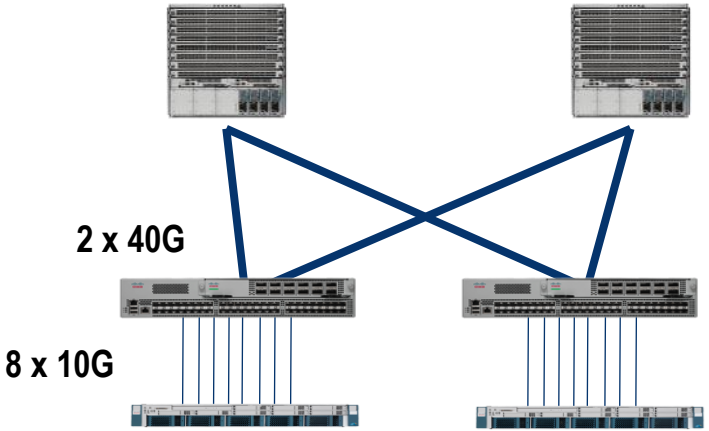
Why a 40G Fabric?



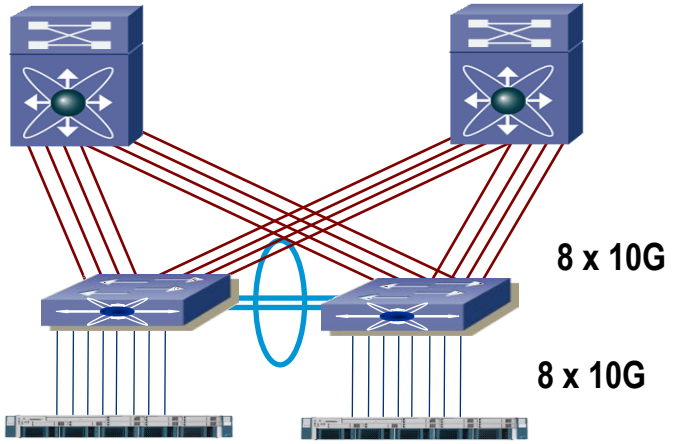
- Optimal Fabric Capacity and Cost
  - 40G provides the optimal cost point currently
  - Speed-up (higher speed transport than edge ports) necessary to achieve effective throughput in a switching network
  - 100G support (Future)

- 40G BiDi Optics
  - QSFP pluggable, MSA compliant
  - Dual LC Connector
  - Support for 100m on OM3 and 125m+ on OM4
  - TX/RX on 2 wavelength @ 20G each

Design Considerations
Increased BW Utilisation due to 40G speedup



Expected Max Effective Throughput = 86.33%



Expected Max Effective Throughput = 65.6%

Network Switching Designs have leveraged an uplink speed ups to avoid hashing collisions to the provide effective utilisation of available capacity

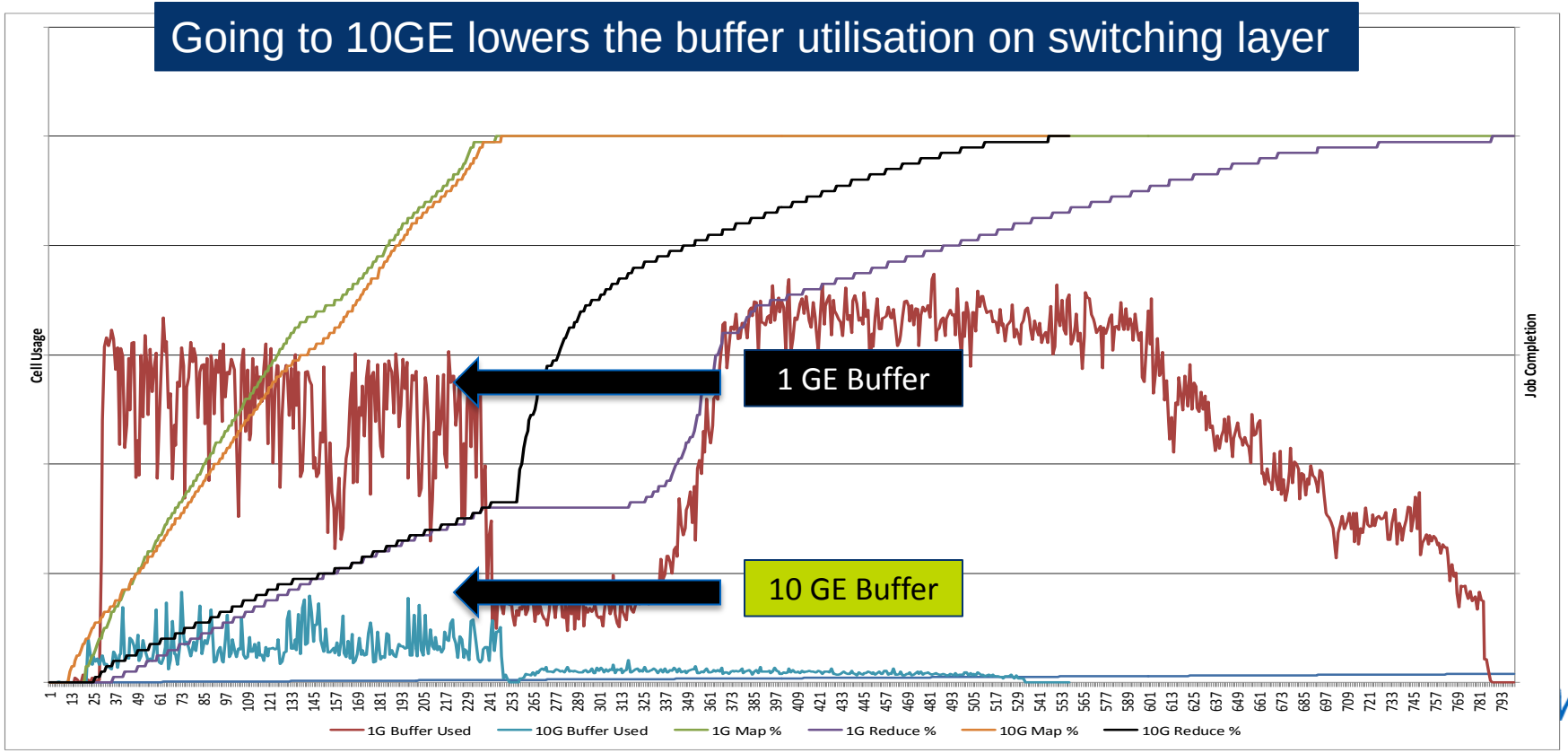
*A speedup of 40G on uplinks for 10G attached servers results in Flow Completion Times that are ~12–40% lower than that of a 10G fabric**

Without a speed up the capacity of the infrastructure will be diminished

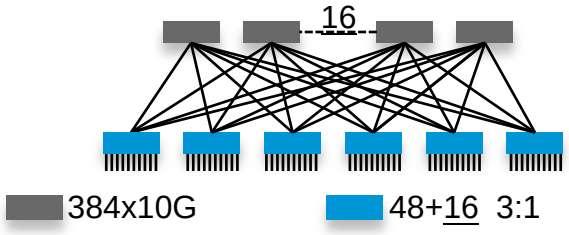
- *http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6627738*

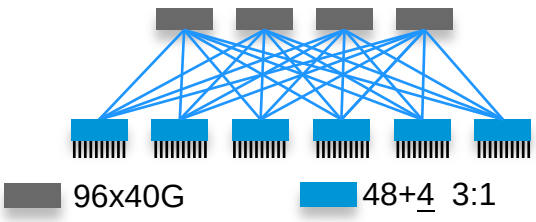
What About the Buffer Use and the Link Speed?

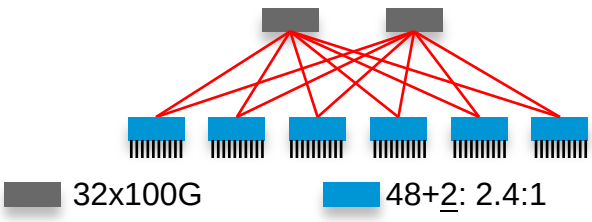
- High speed (1G – 10G and 10G – 40G) reduces the average buffer limitation



Optics Density Affects Fabric Scale

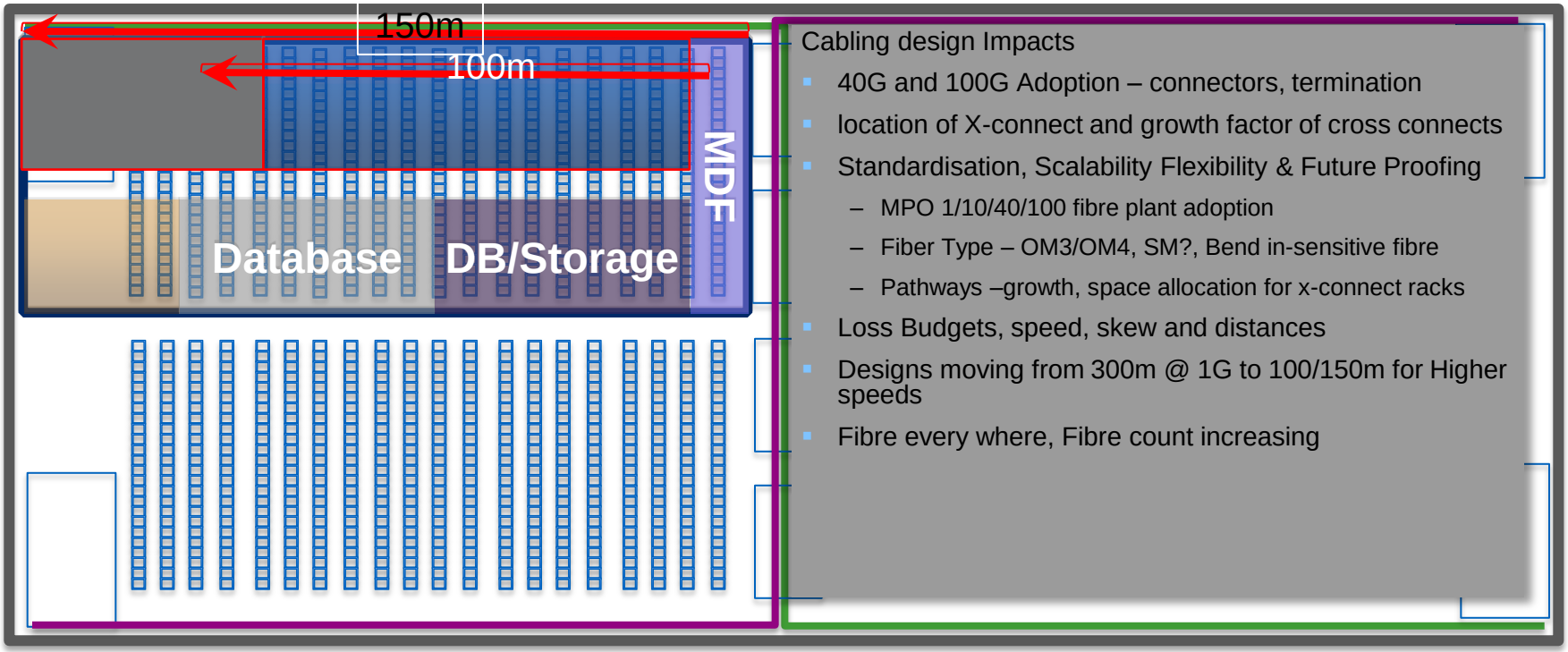






	10G		40G		100G	
Spine	384x16	384x32	96x4	96x8	32x100	32x100
Leaf	48+16 3:1	32+32 1:1	48+4 3:1	32+8 1:1	48+2 2.4:1	32+4 .8:1

Scaling the Network
Mapping Topology to Infrastructure

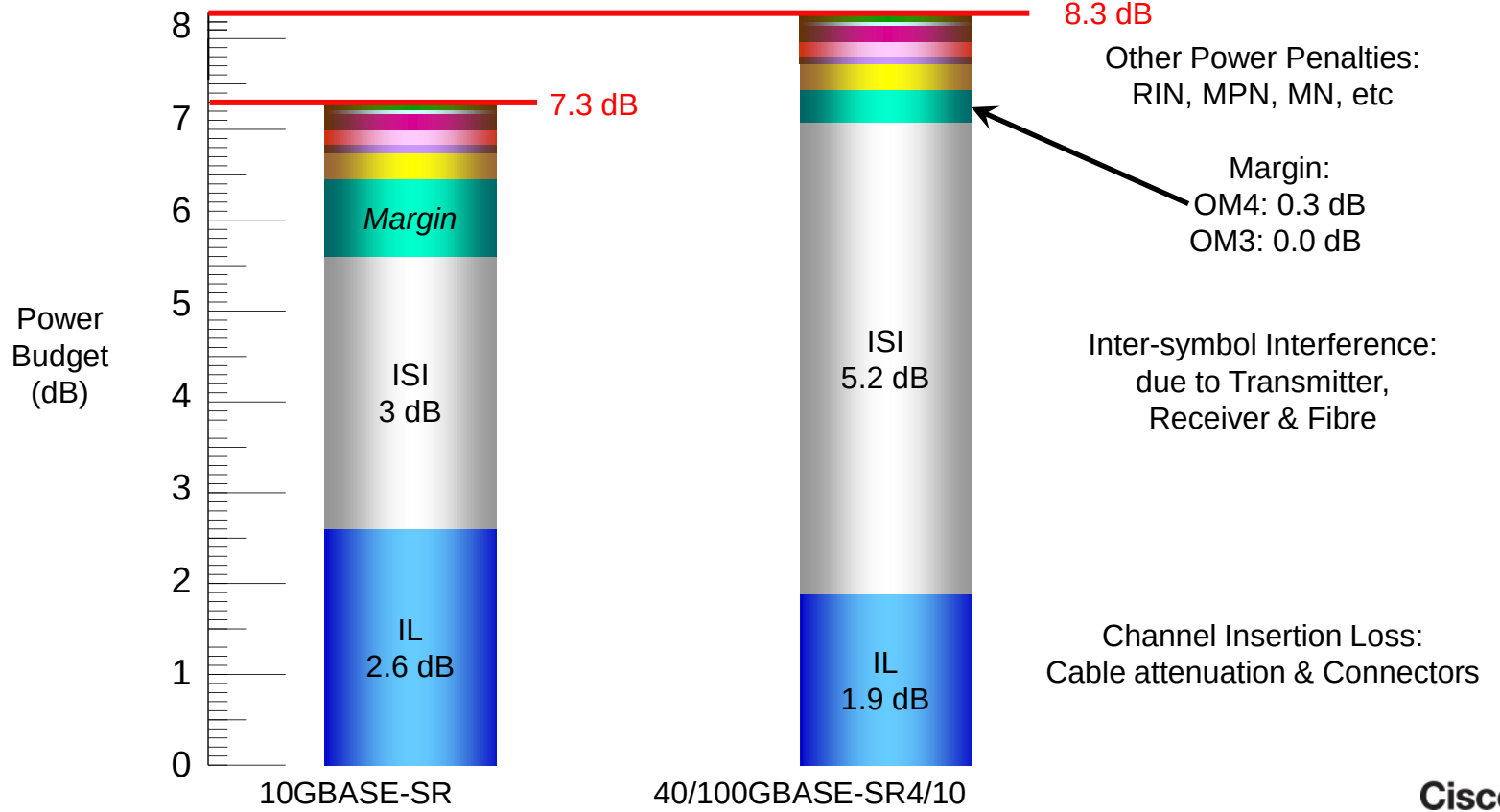


Cabling design Impacts

- 40G and 100G Adoption – connectors, termination
- location of X-connect and growth factor of cross connects
- Standardisation, Scalability Flexibility & Future Proofing
  - MPO 1/10/40/100 fibre plant adoption
  - Fiber Type – OM3/OM4, SM?, Bend in-sensitive fibre
  - Pathways –growth, space allocation for x-connect racks
- Loss Budgets, speed, skew and distances
- Designs moving from 300m @ 1G to 100/150m for Higher speeds
- Fibre every where, Fibre count increasing

Fibre runs up to 2 kM corner to corner

10G and 40/100G Ethernet Power Budgets



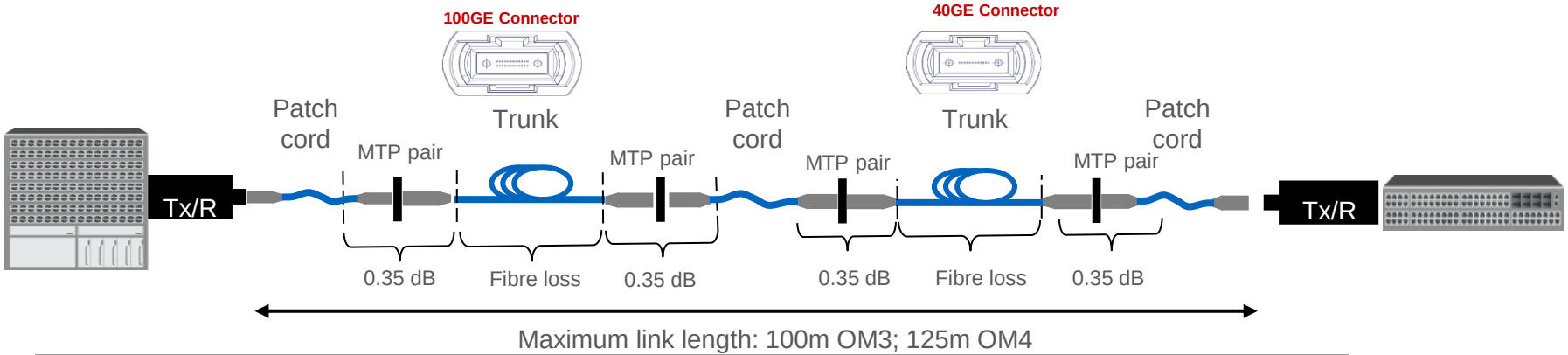
Migration to 40G and 100G

Requires more careful planning with channel parametres...

	Fibre Type	No. fibres	Max. link length, m	Max. Channel insertion loss, dB	Connector type	Skew, ns
10 GbE	OM3	2	300	2.6	LC	
40 GbE	OM3 OM4	8	100 125	1.9	MTP	79
100 GbE	OM3 OM4	20	100 125	1.9	MTP	79

FCoE will operate over these Ethernet channel parameters

Fibre Channel standards, current and draft, lie within these channel parameters



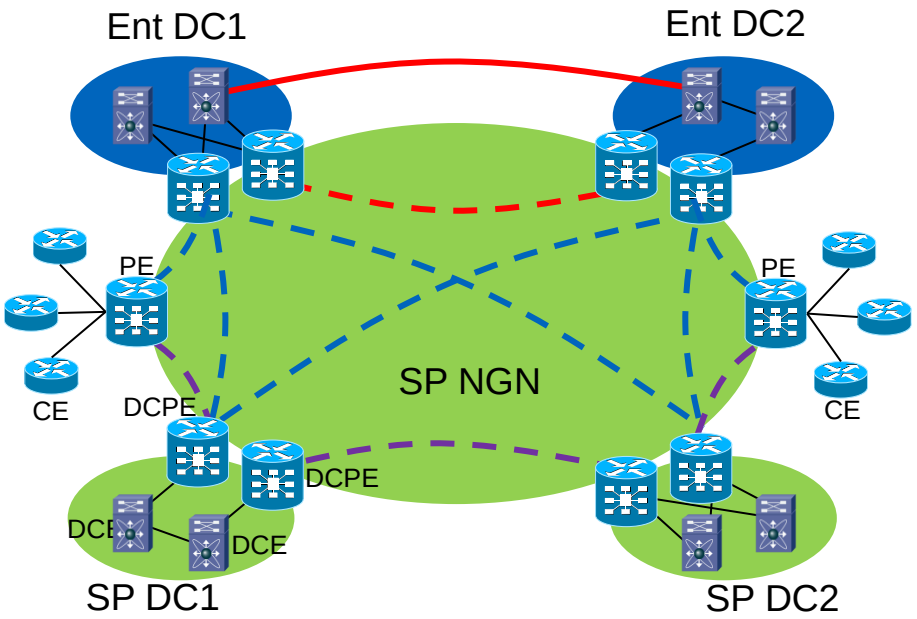
Low-Loss MPO\MTP connectors allow for one cross-connect with 40/100G systems, e.g. EDA to MDA to EDA

Data Centre Cabling Architecture Considerations

- Employ a main cross-connect at a MDA, for best management, scalability and growth
- Network architecture must support 100m (OM3) or 150m (OM4) link lengths to enable upgrade to 40G/100GE
- Plan for future device optics density and reach
- Build a 10G network using trunk cables terminated with 12f /24f MTP connectors
  - Use MTP-LC break-out modules for 10G circuits
- Use low loss connectors (<0.35dB/fibre) to enable MDA
- Allocate rack space for orderly fibre count growth and network device interface scale
- Build cable tray capacity to accommodate double or triple number of trunk cables (note 4x or 10x increase in fibre count does not imply same increase in cable count
- Plan for future high density 10G server access to be addressed by 40/100GE break out cables

40GE/100GE and Beyond Intra DC Consideration

Inter-DC Connectivity in the Cloud-era
More than DCI



- Enterprise Data Centre inter-connect
- Enterprise Data Centre to Provider Data Centre
- Provider Data Centre to Provider Data Centre

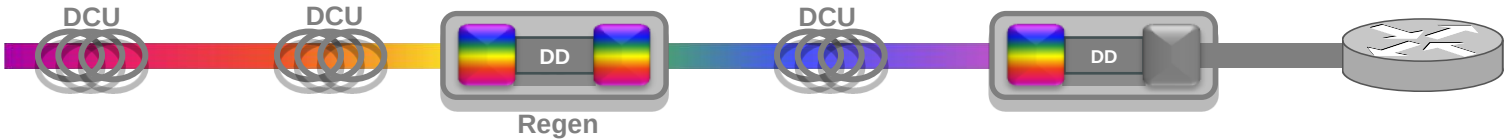
"DCI" with varying NGN requirements:

- Multiple 100G needs
- Higher Density Interconnect in metro
- Intra DC architecture extend beyond metro

100G Technology
Coherent Detection

Direct Detection

- Must correct for impairments in the physical domain (insert DCU's)
- Forced to live with non-correctable impairments via network design (limit distance, regenerate, adjust channel spacing)
- Dumb detection (OOK), no Digital Signal Processing, only FEC



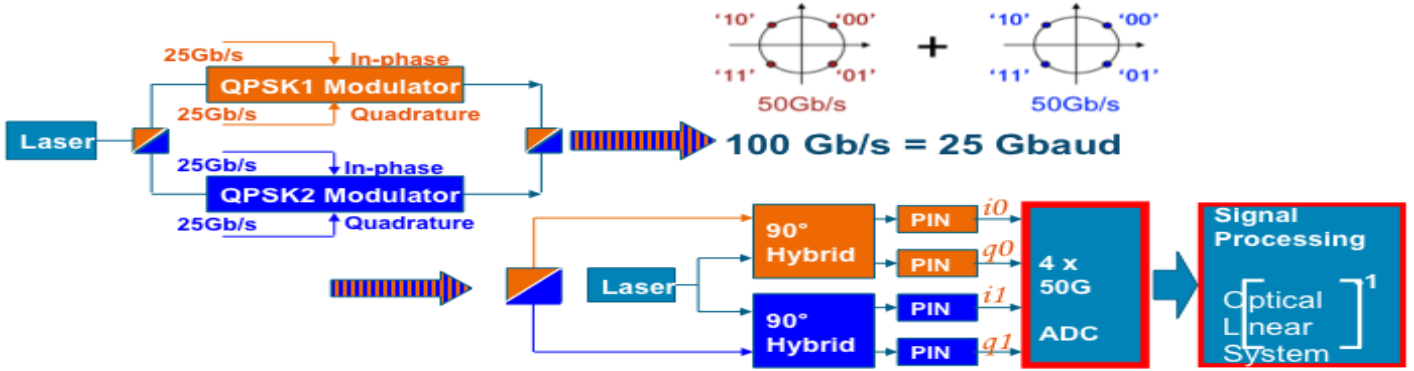
Coherent Detection

- Moves impairment correction from the optical domain into the digital domain
- Allows for digital correction of impairments (powerful DSP) vs. physical correction of impairments (DCU's). Adds advanced FEC.
- Massive performance improvements over Direct Detection.

100G DWDM Optics – CP-DQPSK

Coherent Detection and Post-Processing

100G PM-QPSK – At and / or exceeds 10Gig System Performance



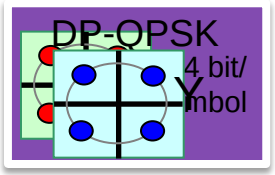
Four mutually orthogonal (“independent”) signals allow to recover the four bits transmitted in each symbol, if linear signal processing is applied

- 40G Lessons Learned
  - No standard implementation; Multiple Mod Schemes – ODB, CS-RZ,DPSK, DQPSK, PM-QPSK, DRZ, etc…
- 100Gig
  - Industry consolidation around common modulation
  - Use for 40/100G transmission

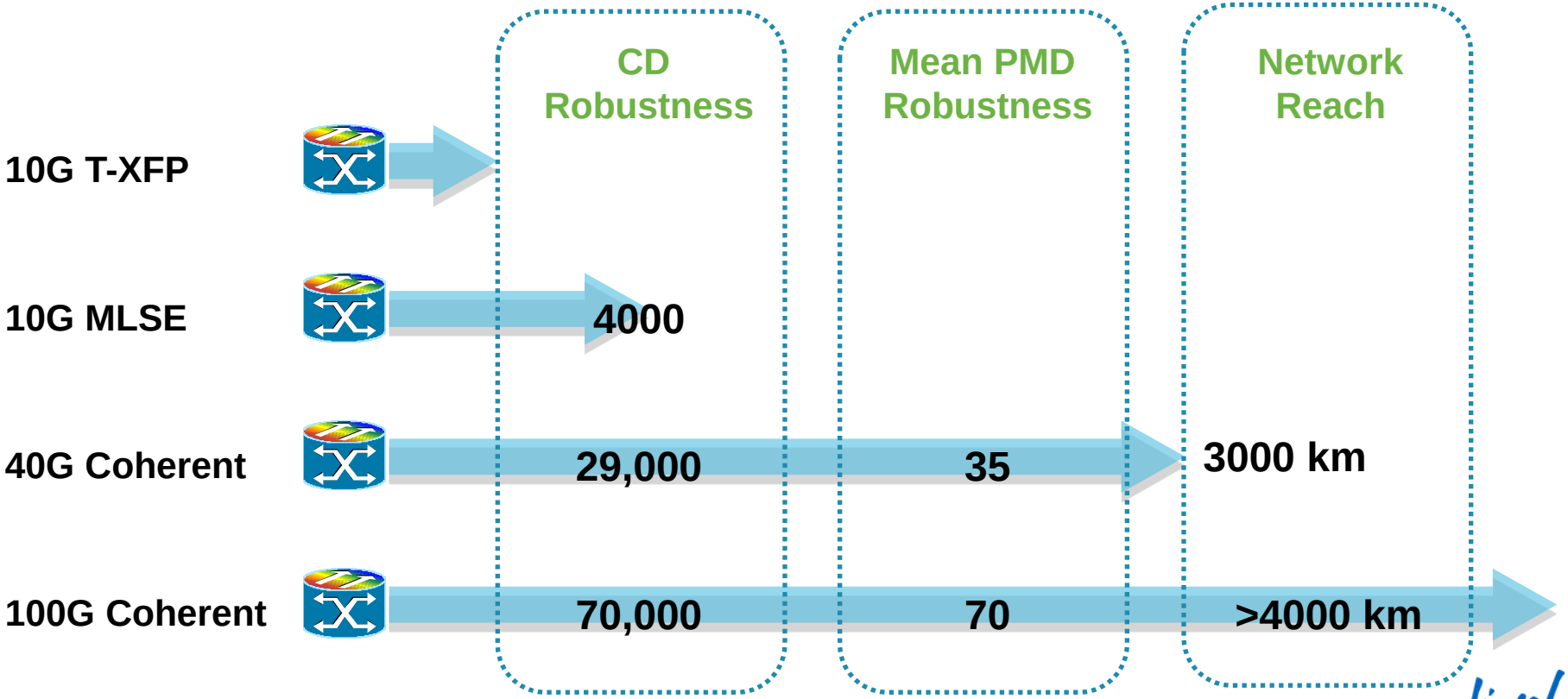
- RX Laser serves as Local Oscillator to provide a polarisation and phase reference
- Coherent receiver with Signal Processing:
  - Synchronises to carrier frequency and phase
  - Compensates CD and PMD
- Benfits: ~3bB better noise tolerance

  ~2x distance;
  - Can compensate for huge amount of

  Dispersion (>200x more tha convetions

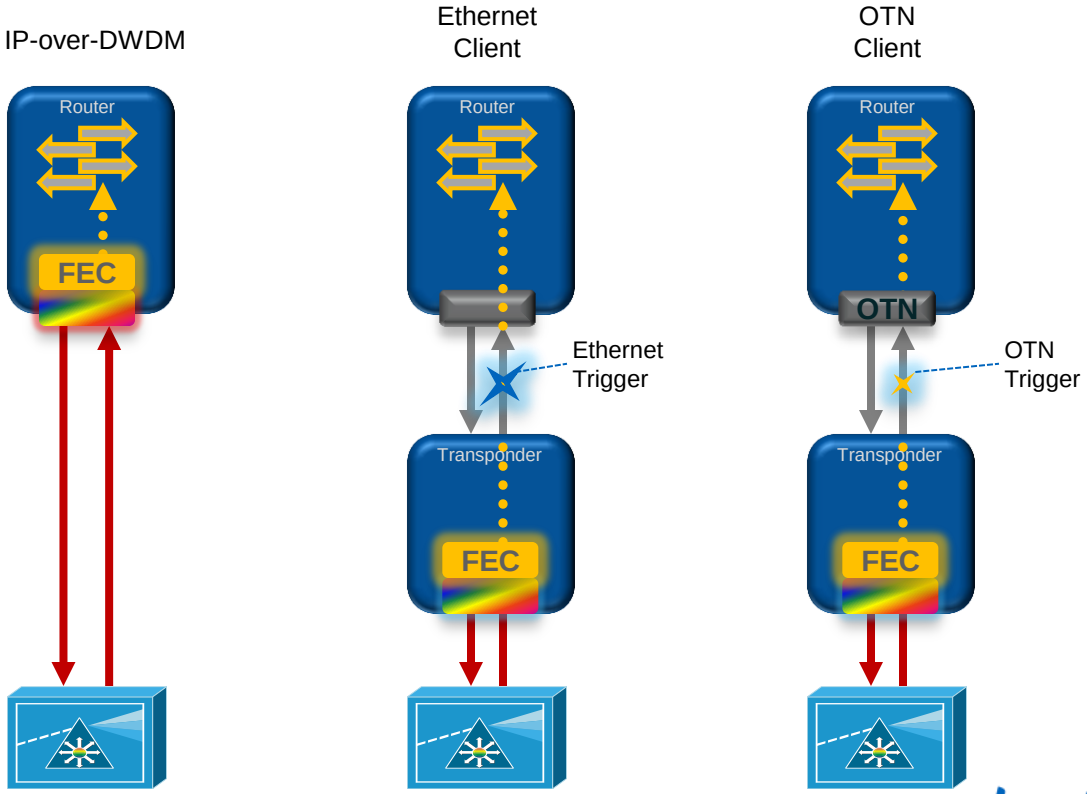


100G Coherent
Dramatic Performance



High Speed Client Implementations
Interface Independent Functionality

- **IP-over-DWDM**
  - Pre-FEC error threshold is monitored directly by router
  - RP initiates fast re-route based on internal trigger directly from PLIM
- **Gray Client - Ethernet**
  - Pre-FEC error threshold is monitored by transponder
  - Ethernet trigger is generated by transponder and sent to router which initiates fast re-route
- **Gray Client - OTN**
  - Pre-FEC error threshold is monitored by transponder
  - OTN PF-FDI trigger is generated by transponder and sent to router which initiates fast re-route
  - OTN interface monitors end-to-end path






Summary

Summary

Multimode OM3 duplex fibre for:

- <100m links, for 40G* and 100G
- No change from the current 10G fiber infrastructure

Multimode OM4+ duplex fibre** for:

- 100-150m links, for 40G and 100G

Single mode duplex fibre for:

- >150m links, for 40G and 100G

BiDi innovation enables dual fibre forward and backward compatibility for high speed interfaces on MMF

*125m supported

** New version of OM4 fibre for 150m

Summary

- Transition infrastructure to duplex fibre for lower overall cost
- Balance choice of optics with cost, reach, power and packaging
- Move to high speed optics in the DC fabric improves application performance
- CMOS photonics enables enable new generation of SM optics (CPAK) and beyond
- Move to SM backbone in DC will require low cost short reach SM optics
- Evolution of high speed optics will enable flexible bandwidth, increased system performance, drive network architecture and facilities consideration
- Cisco continues to invest and lead the industry in optics innovation to drive to lower cost structure.

DEMO TITLE

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