Trends in Testing Data Center Infrastructure

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Agenda


INTRODUCTION
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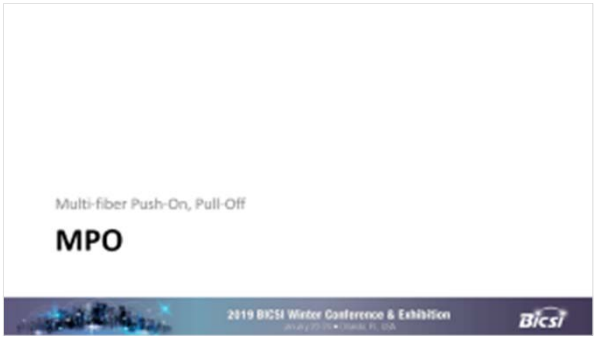
Multi-fiber Push-On, Pull-Off
MPO
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Active Optical Cables & Direct Attach Copper
AOC/DAC
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WRAP UP
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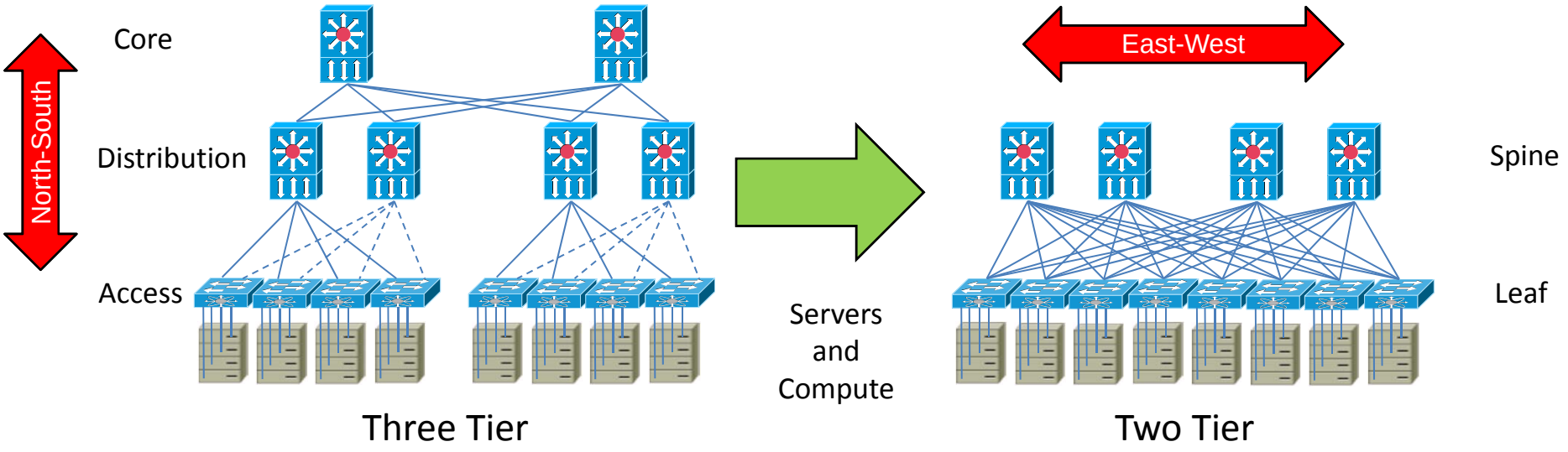
INTRODUCTION

Modern Data Center Architecture

- Historically Enterprise has been a 3-tier topology – Core, Aggregation, Access
- Cloud data center networks are 2-tier topology
  - Optimized for East-West traffic



Lanes and Speeds

- High speeds are possible by using multiple “lanes” that can be combined together into a single “pipe”
- The highest current speed for a “lane” is 50Gbps (MMF)
- Single mode and OM5 multimode allow for lanes to be different wavelengths
- OM4 and below require each lane to have its own fiber pair

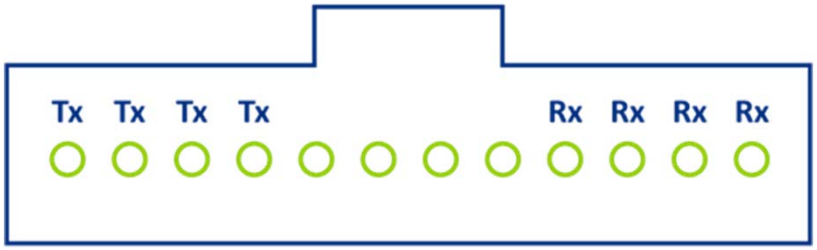
Speed per lane	# of Lanes	Resulting speed	MM Technology	SM Technology
10Gbps	1	10Gbps	10GBASE-SR	10GBASE-LX
10Gbps	4	40Gbps	40GBASE-SR4	40GBASE-LR4
10Gbps	10	100Gbps	100GBASE-SR10	
25Gbps	4	100Gbps	100GBASE-SR4	100GBASE-LR4 100G PSM4

10, 25, 50 Gbps Lanes

- IEEE802.3ba defines 10 Gbps lanes for 40/100 Gbps
- IEEE802.3bm defines 25 Gbps lanes for 100 Gbps
- IEEE802.3cd defines 50 Gbps lanes for 200 Gbps

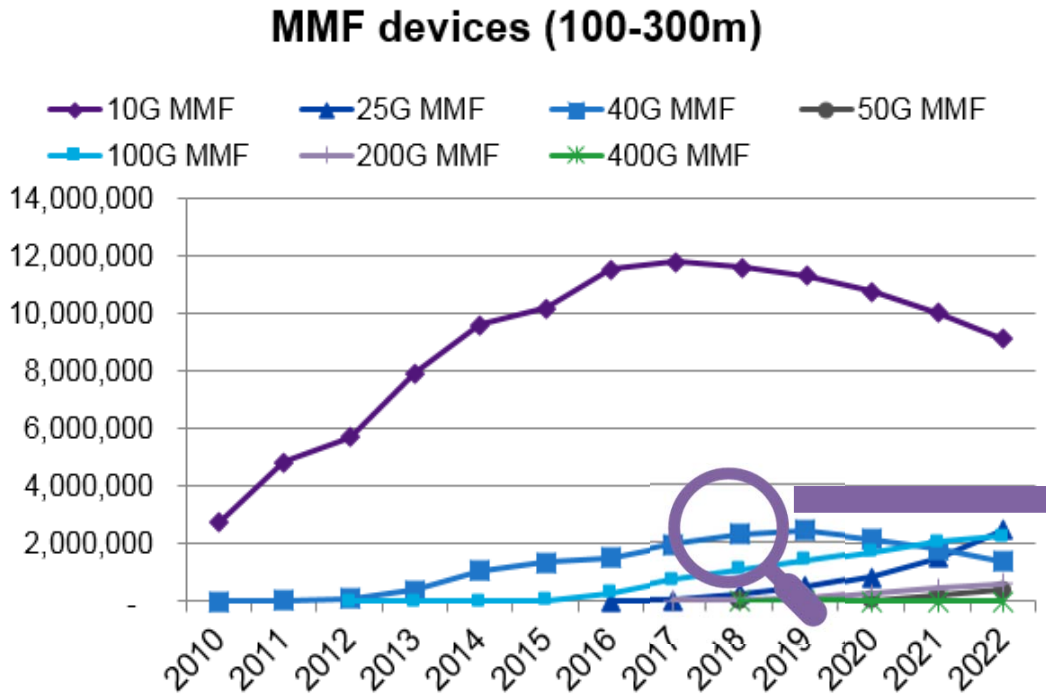
- 40GBASE-SR4, 100GBASE-SR4, and 200GBASE-SR4 use MPO connectors with 8 fibers
- Can breakout to 10, 25, 50 Gbps for servers

IEEE Std 802.3bm-2015
Amendment 3 to IEEE Std 802.3-2012: Ethernet

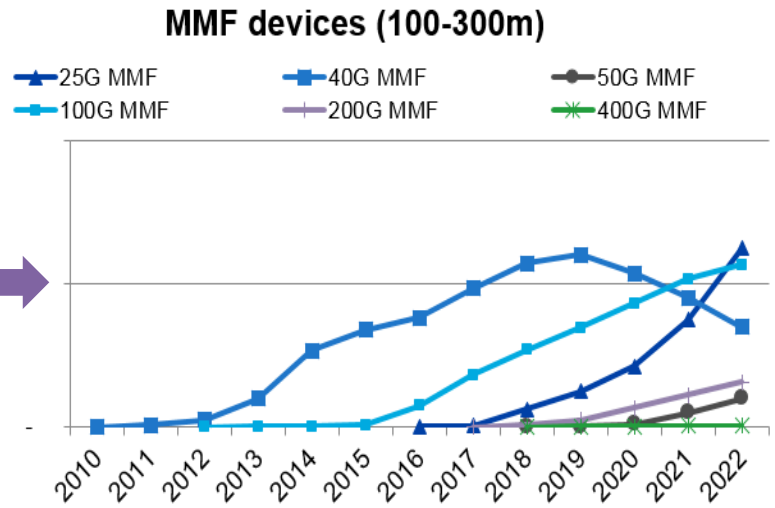


100GBASE-SR4 Optical Lane Assignments

Shipments of Multimode Pluggables



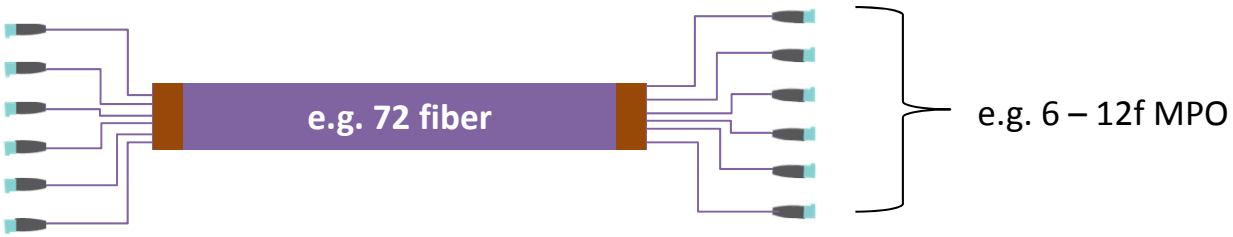
- Short reach optics shipments are led by data center requirements
- Growth primarily at 100GE and 25GE



Source: Lightcounting Ethernet Forecast March 2017

Backbones, Links, and Channels

- A **backbone** MPO cable is the foundation of the link. It is sometimes called a trunk cable.



Backbone example – 72 fiber backbone cable terminated with 6 12f MPOs

Backbones, Links, and Channels

- A **link** is the permanent connection between two locations. Typically it is the cabling between patch panels or distribution frames and can include adapter panels and cassettes. Fiber links can have connections and splices in them.

Link example – backbone cable terminated on MPO adapter panels.
Backbone could also be terminated on break-out cassettes

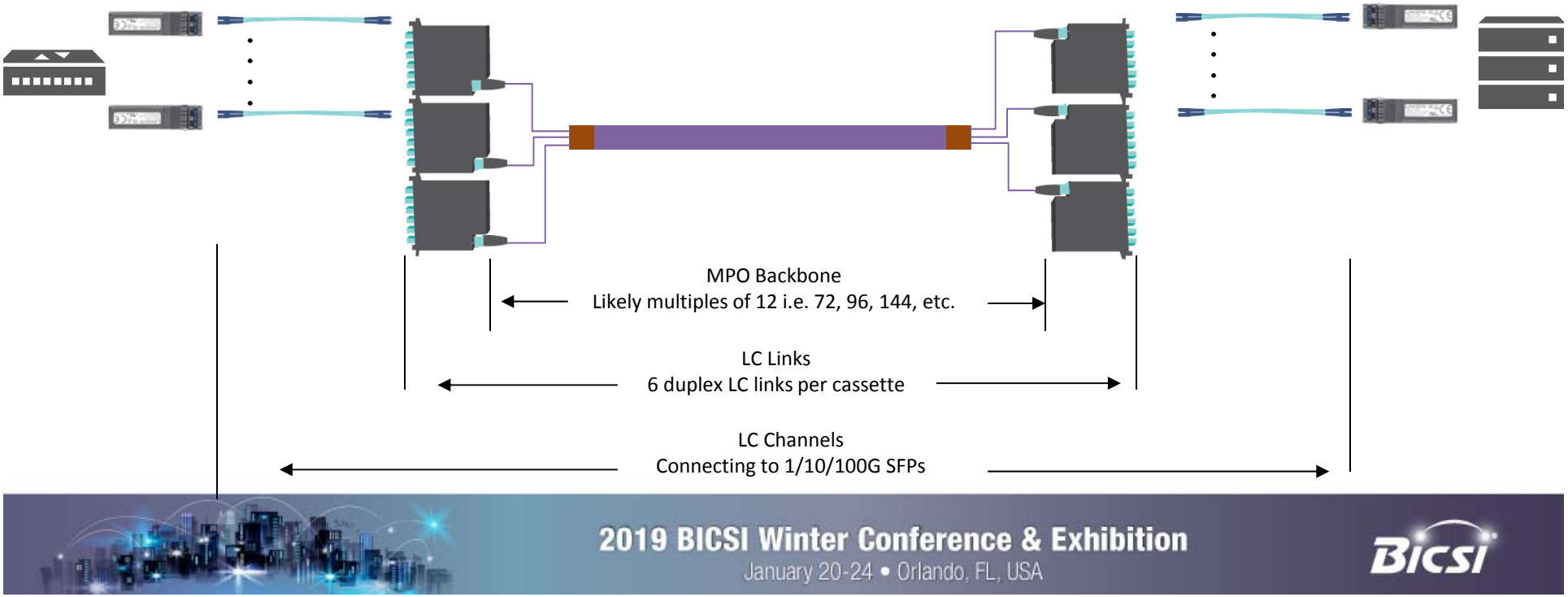
Backbones, Links, and Channels

- A **channel** is the connection between equipment. It is made up of the link plus equipment cords (patch cords) at either end of the link.

Channel example – MPO equipment cords added – 6 40/100G channels

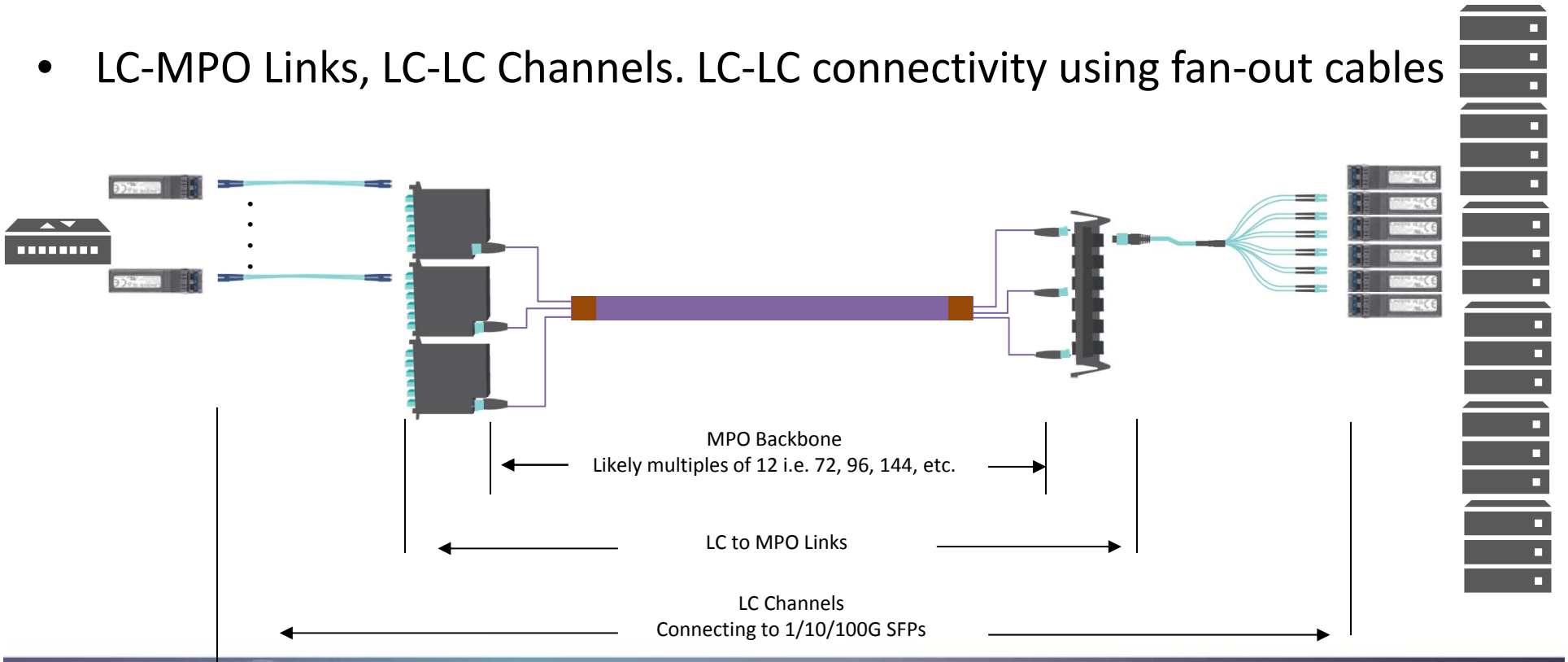
1G/10G MM Channels 1/10/100G SM Channels

- LC-LC connectivity using cassettes via LC Links and Channels



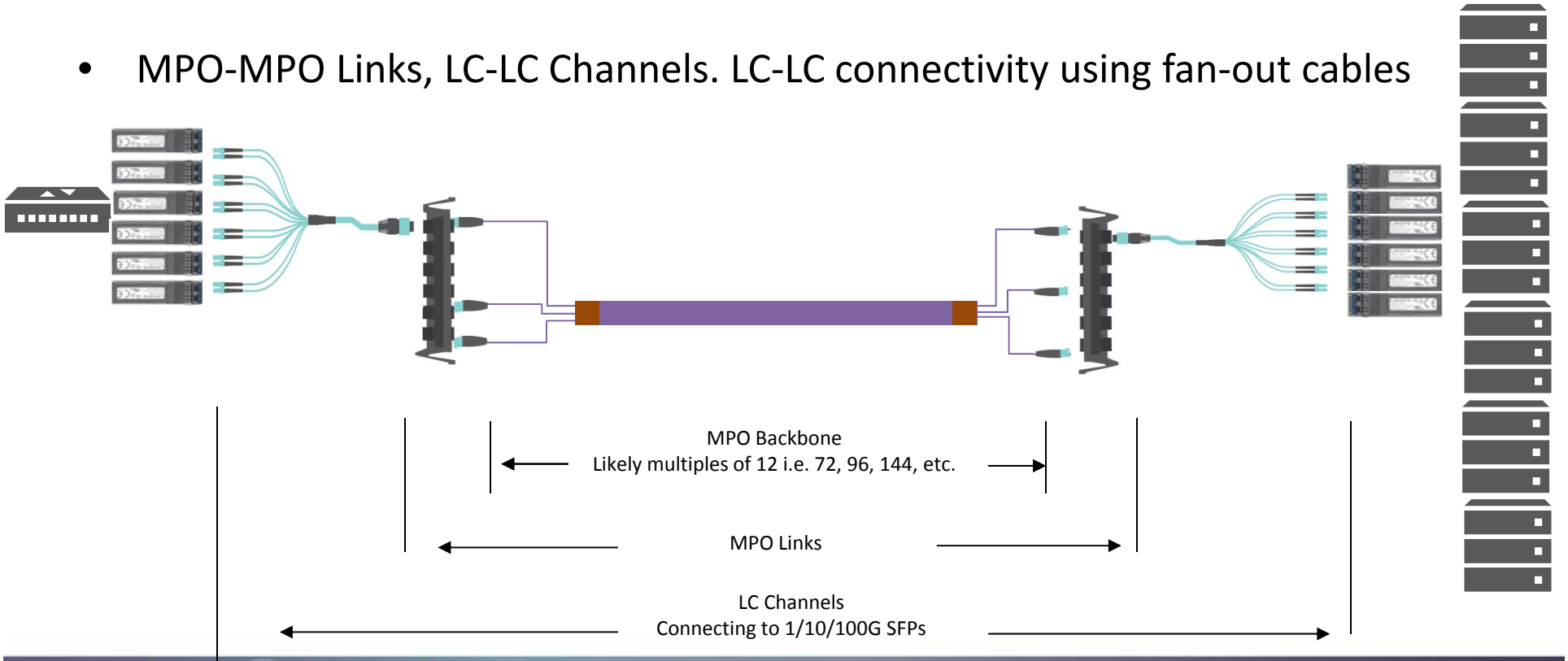
1G/10G MM Channels 1/10/100G SM Channels

- LC-MPO Links, LC-LC Channels. LC-LC connectivity using fan-out cables



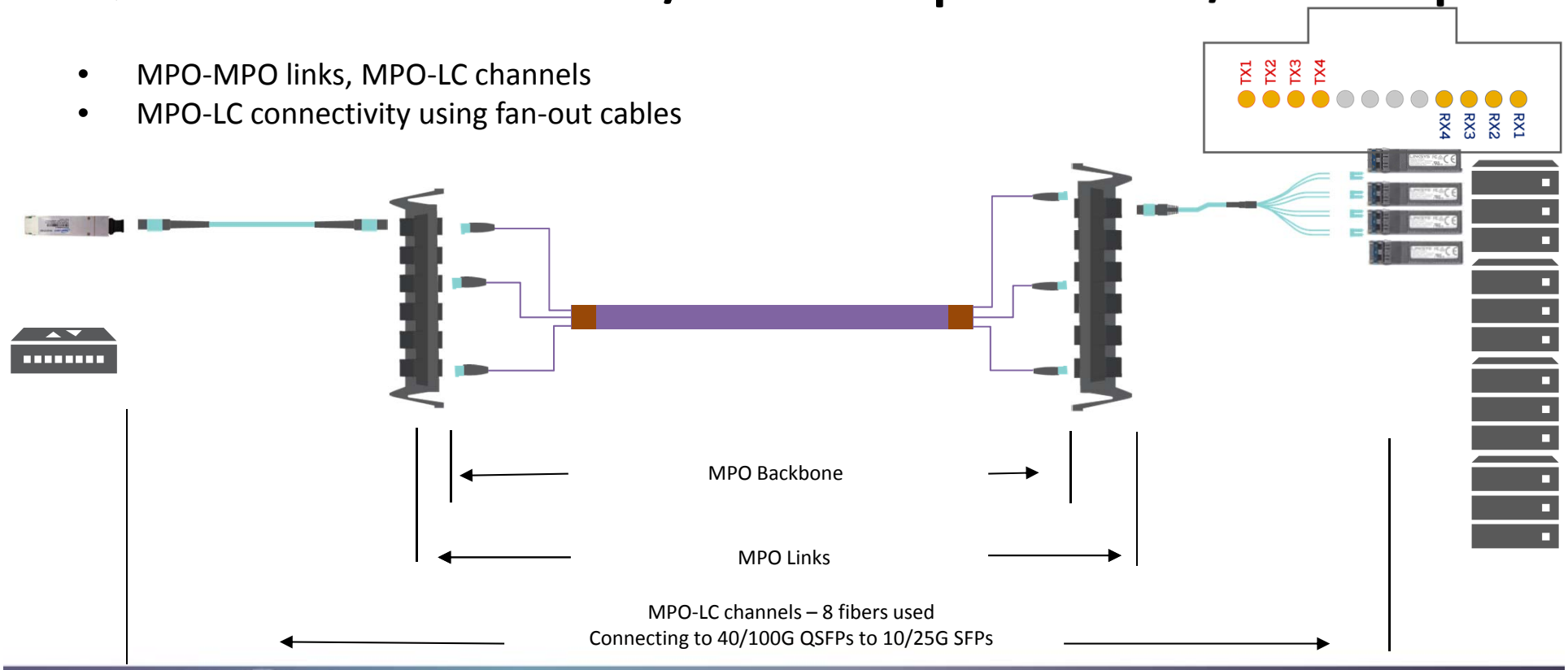
1G/10G MM Channels 1/10/100G SM Channels

- MPO-MPO Links, LC-LC Channels. LC-LC connectivity using fan-out cables



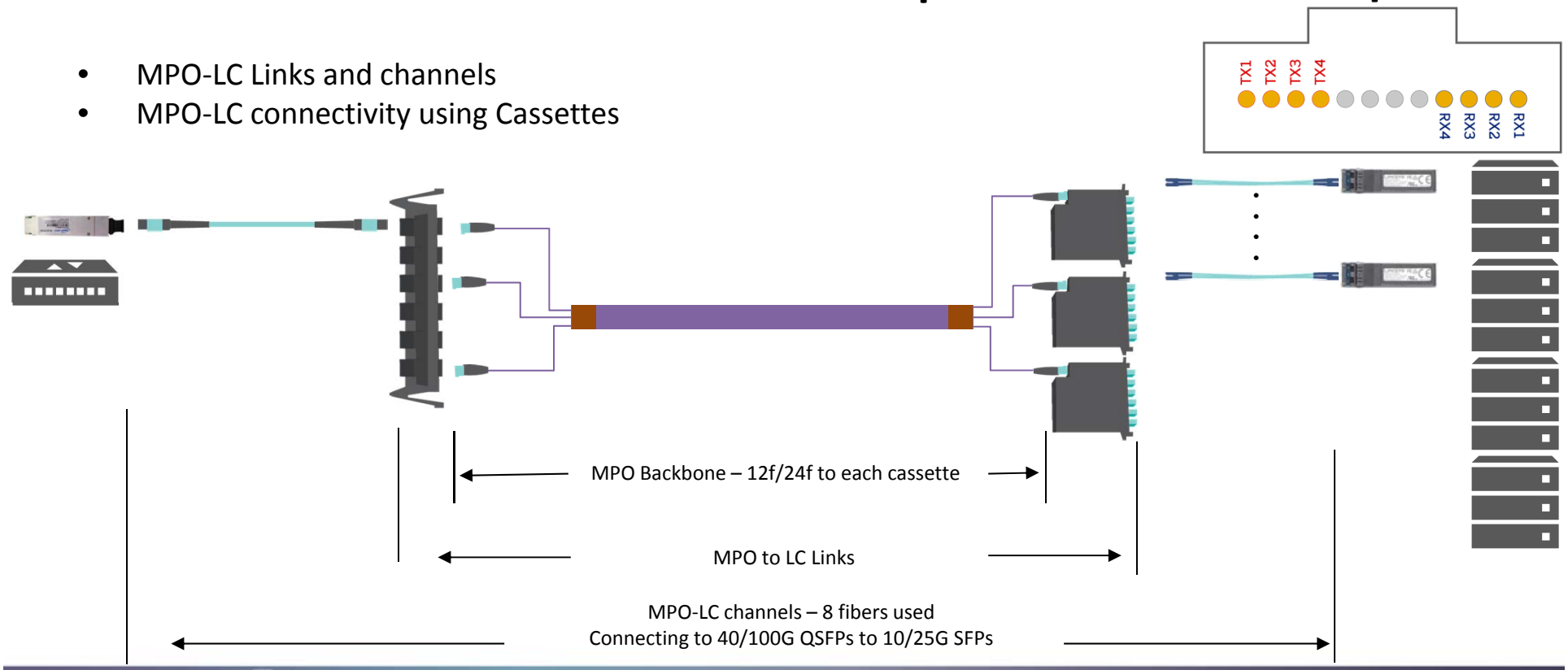
QSFP to LC for 40/100Gbps to 10/25Gbps

- MPO-MPO links, MPO-LC channels
- MPO-LC connectivity using fan-out cables



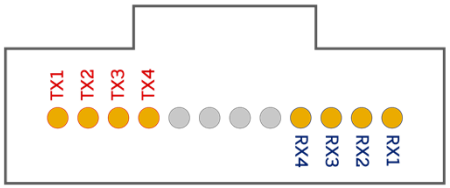
QSFP to LC for 40/100Gbps to 10/25Gbps

- MPO-LC Links and channels
- MPO-LC connectivity using Cassettes



40/100G SR4 MM, 100G PSM4 SM

- MPO Links and Channels
- MPO-MPO connectivity using Adapter Panels



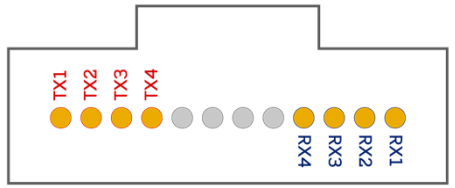
MPO Backbone
Likely multiples of 12 i.e. 72, 96, 144, etc.

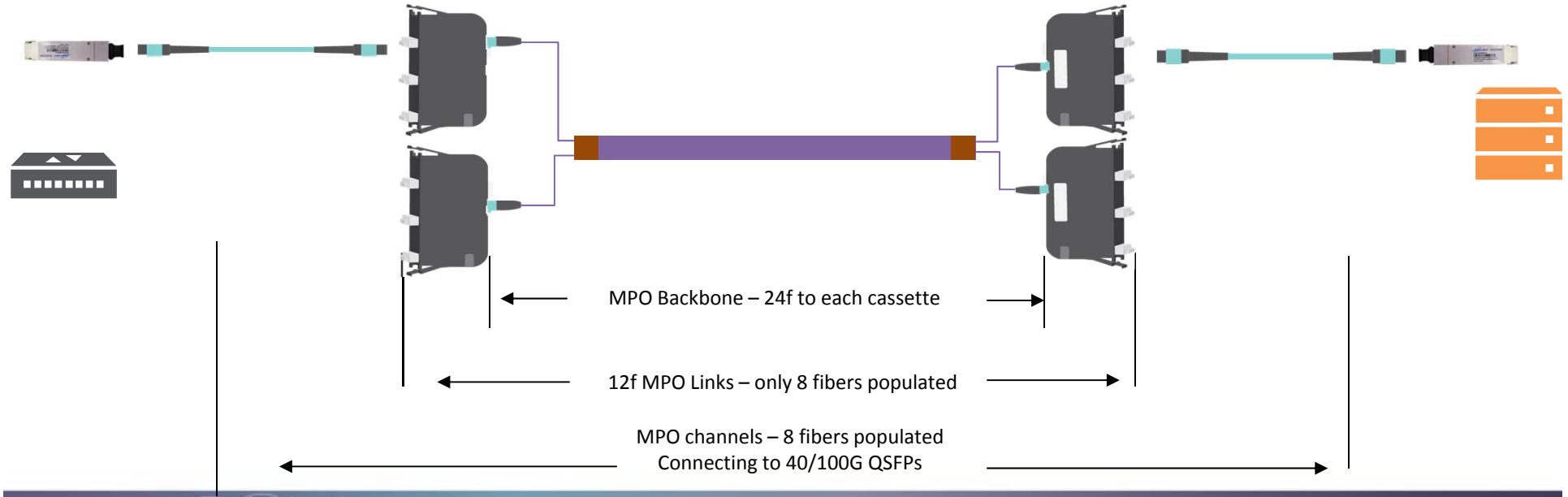
12f MPO Links

12f MPO channels
Connecting to 40/100G QSFPs

40/100G SR4 MM, 100G PSM4 SM

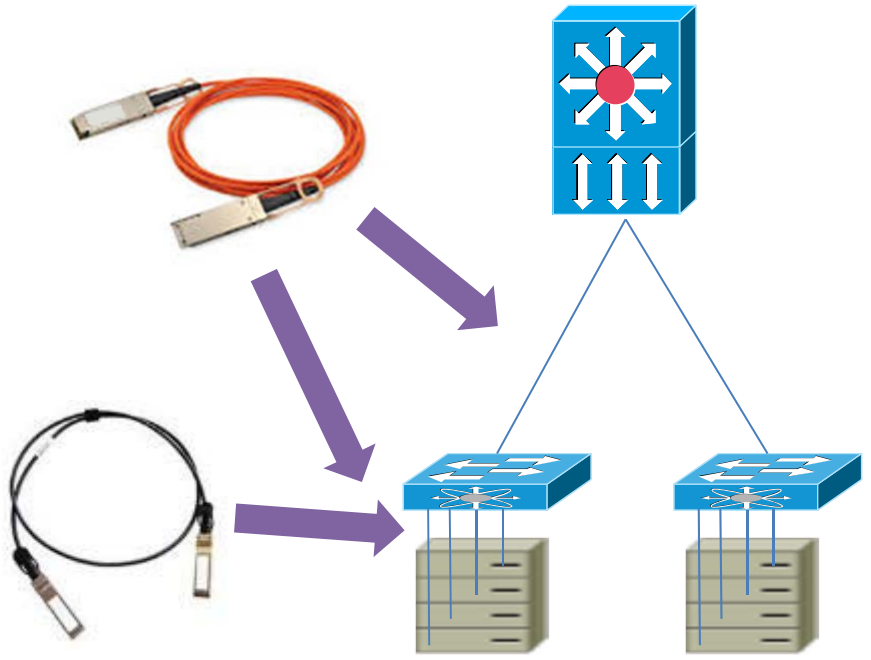
- 8f MPO links and channels
- MPO-MPO connectivity using Cassettes





Use of AOC/DAC Cables

- High-speed cables terminated with pluggable QSFPx and SFPx optics:
  - AOC: Active Optical Cables
  - DAC: Direct Attach Copper
- Fixed length cables
  - Available at multiple data rates
  - Scaling from 10Gbps up to 100Gbps
- Used in many locations including between TOR (Top of Rack)/EOR (End of Row), Leaf/Spine, and between rows



Multi-fiber Push-On, Pull-Off

MPO

TIA Standards Related to Fiber Testing

- 568.3-D – Optical fiber cabling and component standard
  - Transmission performance and test requirements in Clause 7
  - Annex E (informative) provided guidelines for field testing
  - Addendum ANSI/TIA-568.3-D-1 approved in October 2018
- ANSI/TIA-526-14-C-2015
  - Test procedures for installed multimode fiber cable plant
  - Adaptation of IEC 61280-4-1 Ed. 2.0
  - Encircled Flux for 850nm/50 micron
- ANSI/TIA-526-7-A
  - Test procedure for installed single mode fiber cable plant
  - Adoption of IEC 61280-4-2 Ed 2.0

Tests Defined in Standards

- Both ANSI/TIA and ISO/IEC standards specify two tiers of certification
  - Tier 1 (or basic): loss, length, and polarity
  - Tier 2 (or extended): Optical time domain reflectometer (OTDR)
    - An optional addition to tier 1 (basic) tests

- Fiber end-face inspection and certification is also a requirement to ensure pristine end-face condition PRIOR to mating

Simplex/Duplex vs. MPO Testing

- Existing fiber test standards do not address MPO-specific concerns
  - ANSI/TIA-526-7 and -14 describe testing fiber terminated with single ferrule connectors and are difficult to apply to multi-fiber terminated cabling
- SC 86C WG 1 released Technical Report (TR) on testing MPO
  - IEC TR 61282-15
- TIA TR42.11 released an addendum to ANSI/TIA-568.3-D that references the IEC TR
- SC 86C WG 1 is working on an MPO testing standard
  - To be published as IEC 61280-4-5

What do we test?

- Construction phase:
  - Links – equipment cords are not in place yet

- Operational phase:
  - Channels – will the CHANNEL support the application?

Many Topologies, Only 3 Test Scenarios

LC-LC Links and Channels

Tests to perform:

- Inspect all connections
- Test duplex (LC) links w/duplex OLTS

MPO-LC Links or Channels

Tests to perform:

- Inspect all connections
- Test from MPO to LC
- OR use fan-out cable and test MPO-MPO

MPO-MPO Links or Channels

Tests to perform:

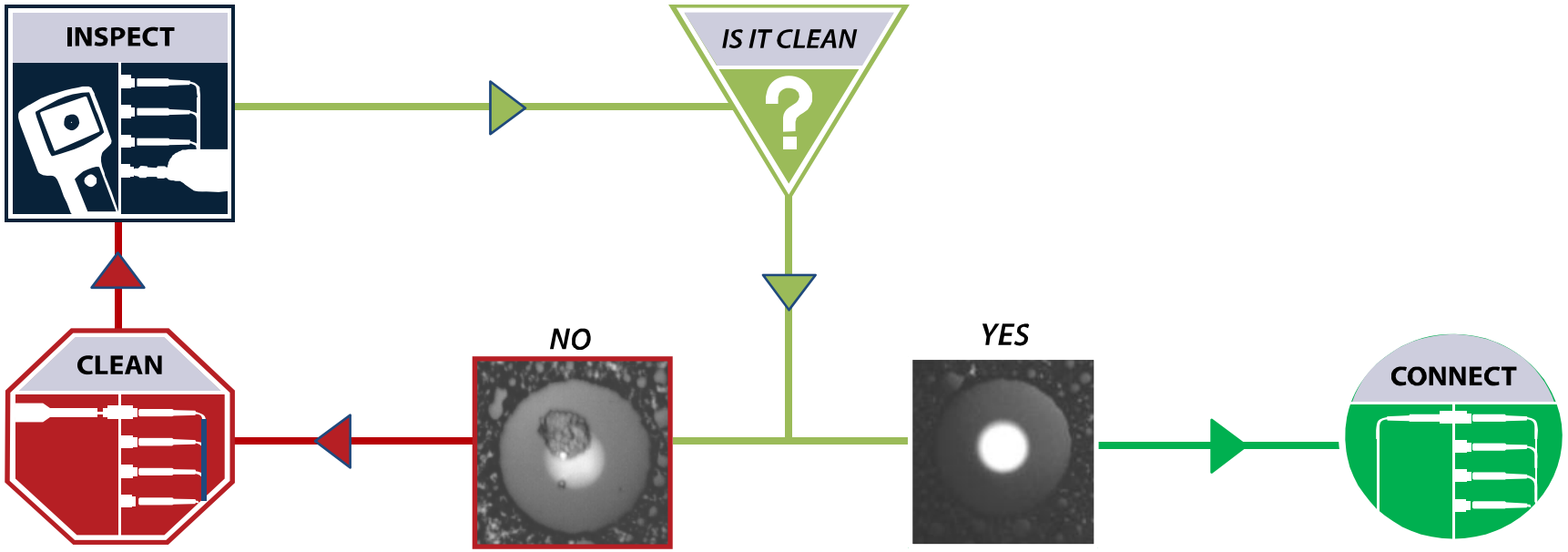
- Inspect all connections
- Test MPO links/channels

MPO Specific Test Challenges

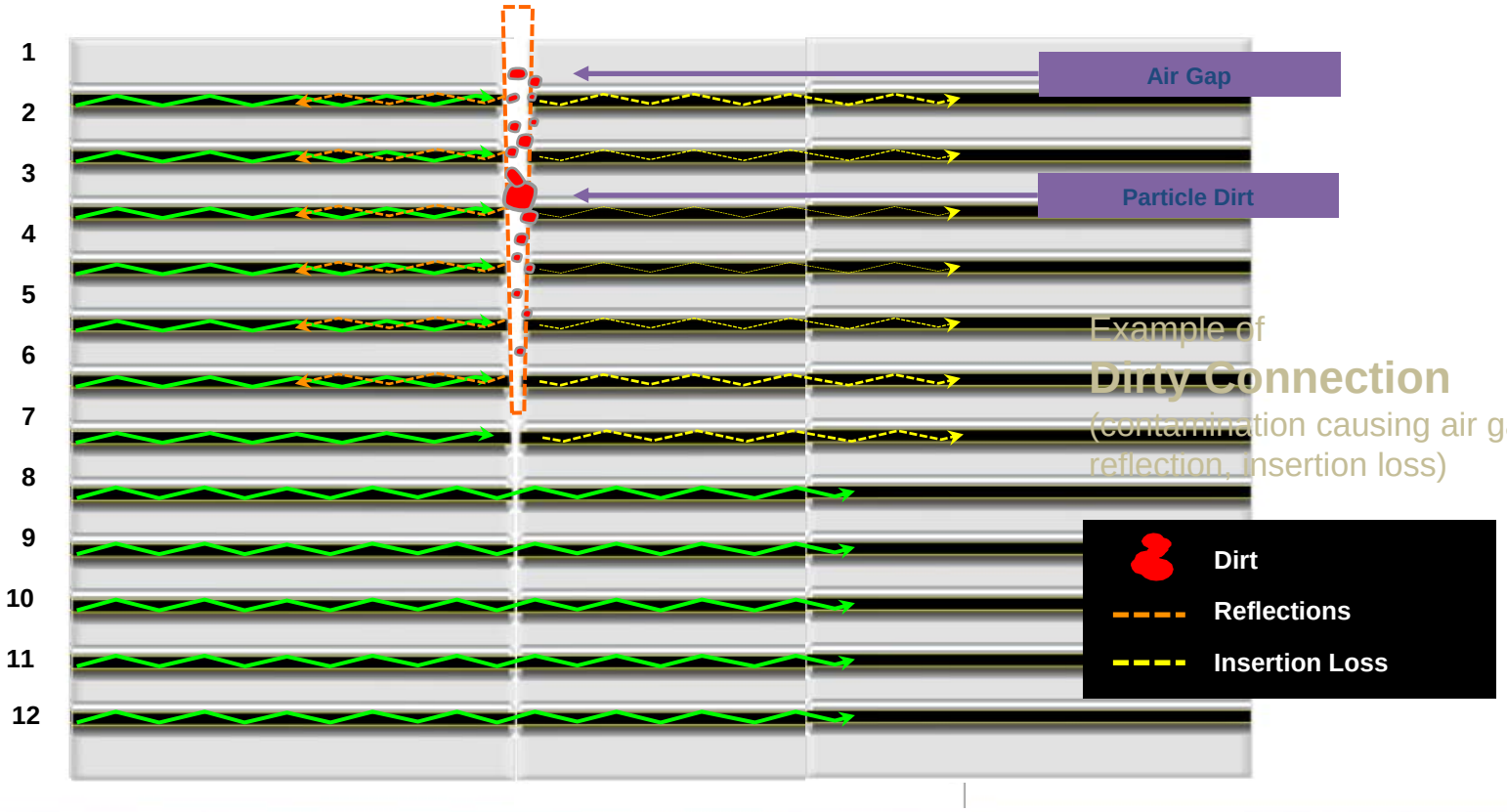
- Pinned-unpinned
  - Impact on test cords and/or reference methods
- Number of fibers used
  - 8, 12, 24
  - False failures due to missing fibers
- Polarity
  - A, B, C

Inspect Before You Connect

Follow this simple "INSPECT BEFORE YOU CONNECT" process to ensure fiber end faces are clean prior to mating connectors.



Top-view Cross Section (1–12 Fibers)



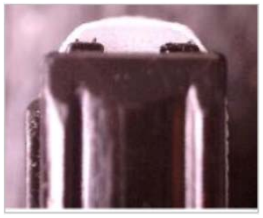
Cleaning MPO Connectors

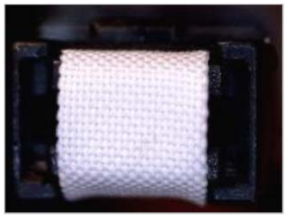
Clicker for cleaning MPO end faces

- Clickers are good for cleaning end faces during network installations
- Cleans both in adapter/cassette and patch cords
- Uses micro woven ultrasonically cut cleaning ribbon

Best Practice for Wet-Dry:

- Apply small amount of cleaning fluid to an optical grade wipe
- Touch the cleaning tip of the clicker on the wet spot on the wipe
- Do NOT apply the cleaning fluid directly to the cleaning ribbon



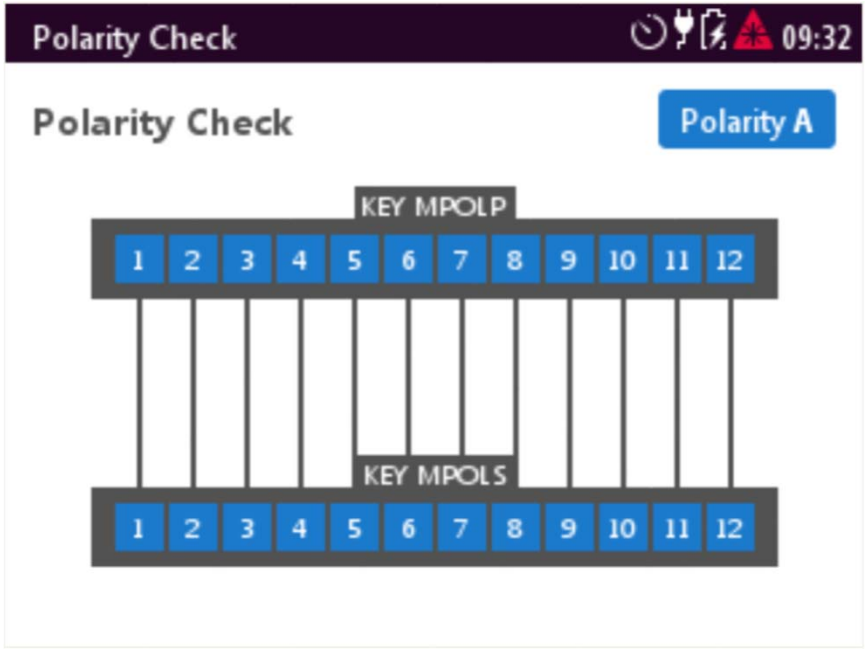


Courtesy of Sticklers

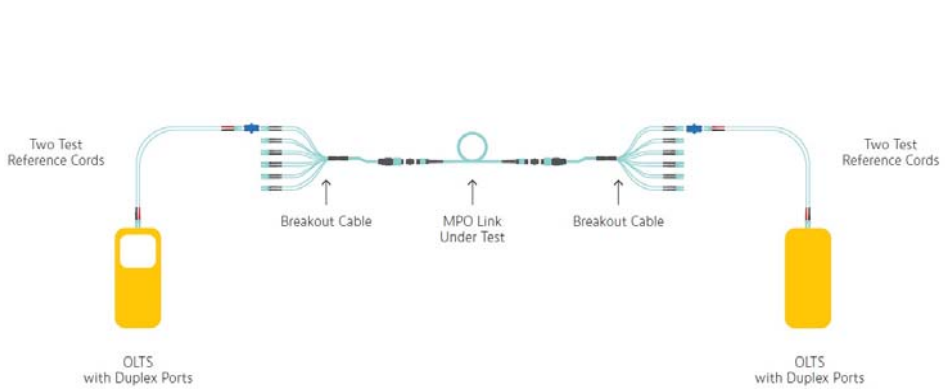
Polarity Check (aka Fiber Map)

For existing installations, the end-to-end polarity is often not known

Polarity Check tool shows the polarity of the system

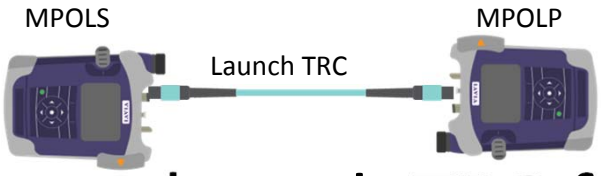


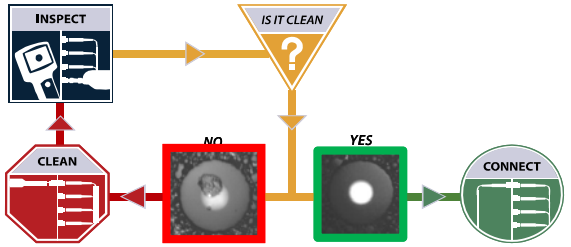
MPO Testing: OLTS vs MPOLx



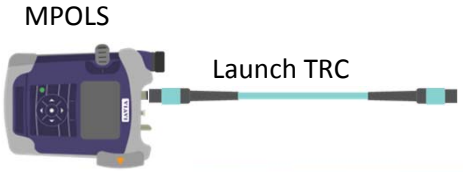
Testing MPO to LC Links

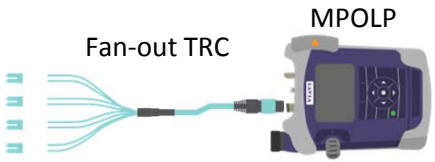
1. Set reference – One-cord between MPOLS and MPOLP





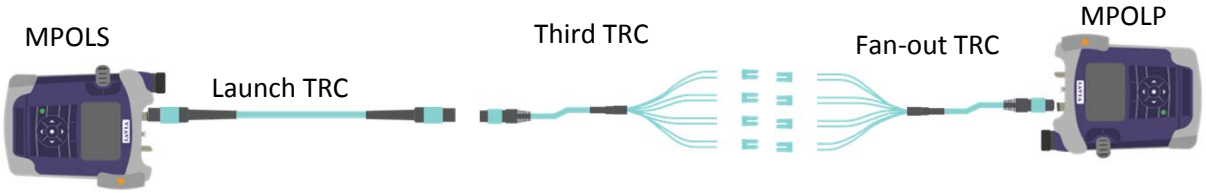
2. Disconnect launch TRC from MPOLP and add fan-out TRC



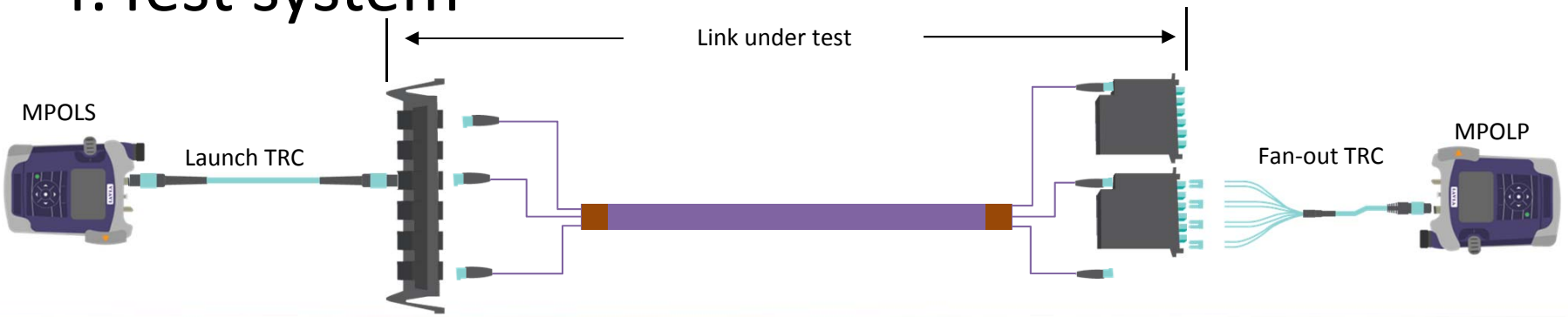


Testing MPO to LC Links

3. Verify Reference – add third cable – measure loss



4. Test system



Active Optical Cables & Direct Attach Copper

AOC/DAC

What to test in an AOC/DAC?

- Key challenge is access to dual SFP/QSFP connectors
- Main parameter of an AOC/DAC is its Bit Error Rate specification

Bit Error Rate Testing

- Can be accomplished using a stressful pattern (such as PRBS 31)
- Provide pass/fail criteria by comparing results to cable BER specification
- Key consideration is whether cable is designed to work using FEC (Forward Error Correction)

Forward Error Correction (FEC)

- Some data rates (primarily 100GE and 25GE) have a built-in error correction mechanism
  - But not 40GE or 10GE
- This reduces the effective Bit Error Rate
- Example of 100GE AOC specification:

Example of Cable Specification	Max BER	
Pre-FEC BER	10^{-6}	
Post-FEC BER	10^{-10}	FEC provided by host system

Ethernet Rate	Interface Type	FEC
100GE	PSM4 MSA	Yes
	SWDM4 Alliance	Yes
	100GBASE-SR4	Yes
	100GBASE-CR4	Yes
40GE	SWDM4 Alliance	No
	40GBASE-SR4	No
	40GBASE-CR4	No
25GE	25GBASE-SR	Yes
	25GBASE-CR	Yes
	25GBASE-CR-S	No
10GE	10GBASE-SR	No
	10GBASE-CR	No

AOC/DAC Cable Test Use Cases

1. Before Installation – 1 unit with 2 ports
   - Test multiple cables before they are laid out
   - Connect each end of the cable in a single unit

2. After cable has been installed – 2 units - 1 port per unit
   - Need 2 units to access each end of the cable for troubleshooting
   - Connect each end to a unit
   - Run test script on the first unit
   - Run Monitor/thru mode (loopback) on the 2nd unit

3. Full Ethernet test use case
   - Run any Ethernet test: BERT, IETF RFC 2544, ITU Y.1564 test suites
   - Verify throughput, latency, packet jitter, bursting at layer 2 or 3

Breakout Cable Testing

QSFP28 – multiple SFP28 (25G case)
Or
QSFP+ -- multiple SFP+ (10G case)

1. Before Installation – 1 unit with 2 ports
   Run cable test on SFP – loopback QSFP
   Repeat for more SFP endpoints

2. After cable has been installed – 2 units - 1 port per unit
   Need 2 units to access each end of the cable for troubleshooting
   Run test script on SFP terminations
   Run Monitor/thru mode (loopback) on the 2nd unit

WRAP UP

Conclusion

- Modern Data Centers present test challenges many are not used to addressing
  - MPO-based systems
    - Inspection and cleaning
    - Different topologies
  - AOC/DAC connectivity
    - No access to physical media
- There are solutions for addressing these challenges!

THANK-YOU

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