Demystifying Enterprise Fiber Networks

Adrian Young
Leviton Network Solutions

In This Session

- Multimode fiber types – distance matters
- How many fibers do I need for my application?
  - 2, 4, 8, 12, 16, 24 or 32?
- Current/Future IEEE and non-IEEE applications
  - Will my existing fiber plant support these?
- Connectivity choices and conversion cassettes

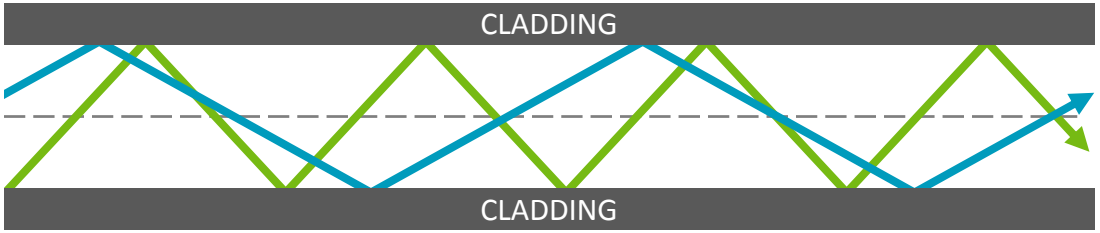
Fiber Types

Distance matters

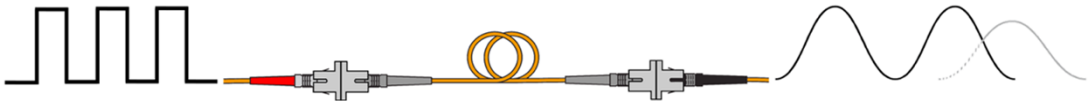
Which multimode fiber do you have or choose?

Designation	Effective Modal Bandwidth @ 850 nm (MHz.km)
OM1	200
OM2	500
OM3	2,000
OM4	4,700
OM5	4,700

- With multimode, there are many modes (paths) of light
- The modes travel down the cable at different speeds



- A pulse of light will spread as it travels down the cable
- The longer the fiber, the more spreading (dispersion)



Which multimode fiber do you have or choose?


Duplex LC


Duplex LC

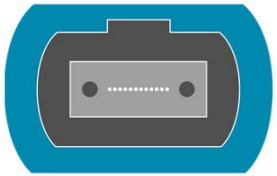

MPO


MPO

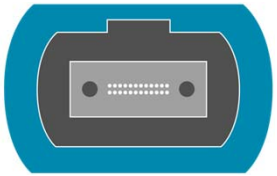
Designation	Effective Modal Bandwidth @ 850 nm (MHz.km)	1000BASE-SX		10GBASE-SR		40GBASE-SR4		100GBASE-SR4	
		Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet
FDDI	160	225	738	26	85	—	—	—	—
OM1	200	275	902	33	108				
OM2	500	550	1,808	82	269				
OM3	2,000	860	2,822	300	984	100	328	70	230
OM4	4,700	860	2,822	400	1,312	150	492	100	328
OM5									

The Multi Push On (MPO) connector

- Also referred to as MTP®
  - MTP is a registered trademark of US Conec
  - MTPs are compliant with IEC Standard 61754-7 and TIA 604-5 – Type MPO
  - Typically provides better performance than standard MPOs



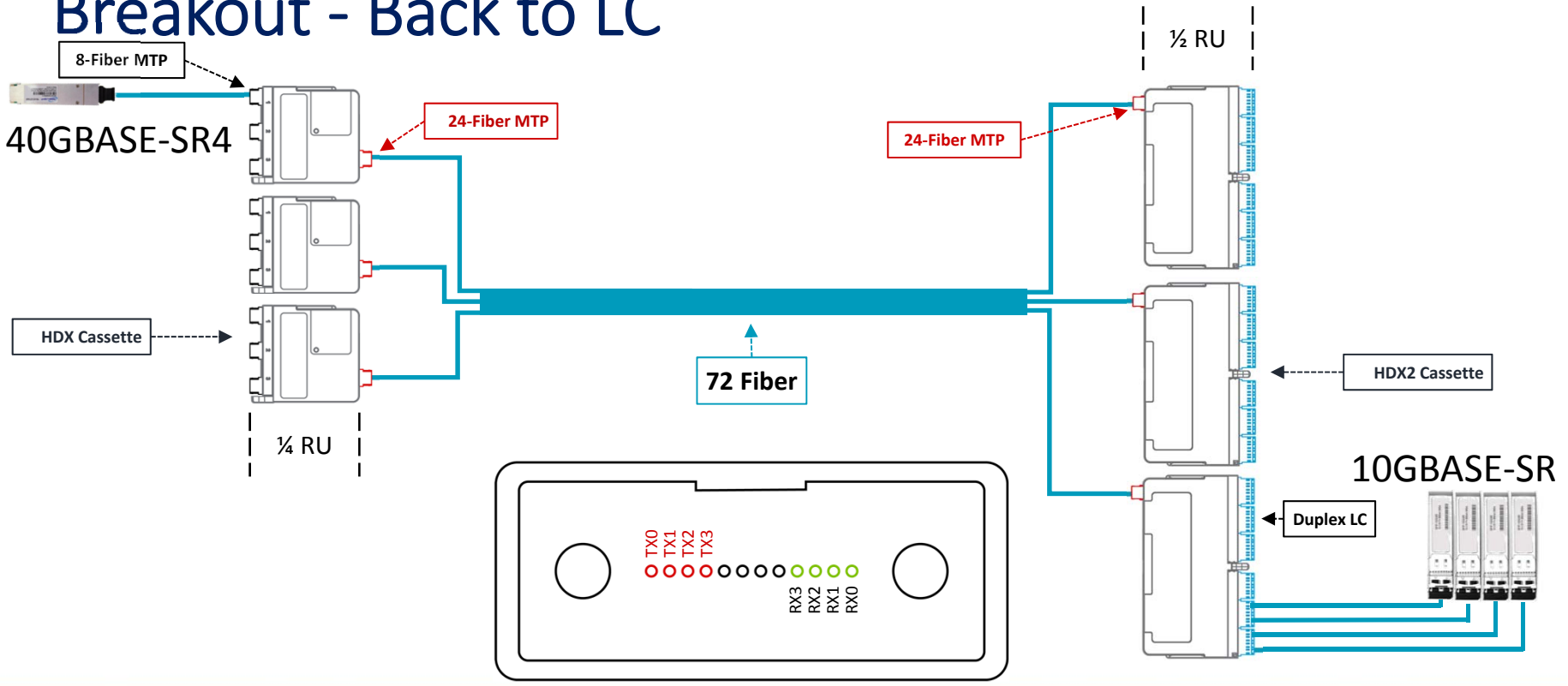
12 Fiber



24 Fiber

MTP trunk cables can support traditional LC duplex transceivers with the addition of breakout cassettes

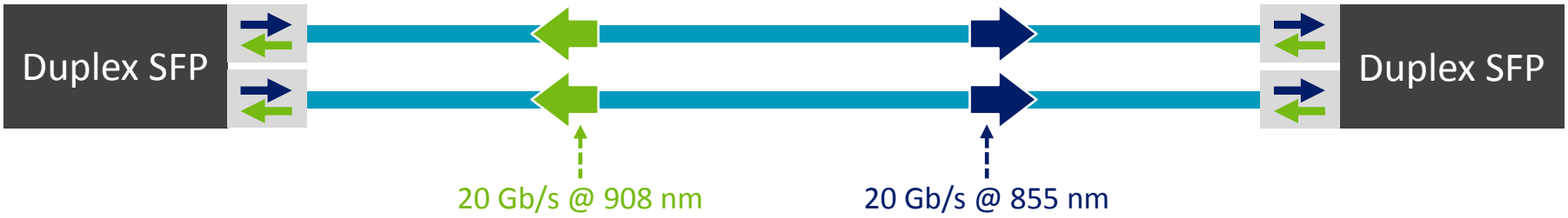
Breakout - Back to LC



Do I have to replace my links with MPO?

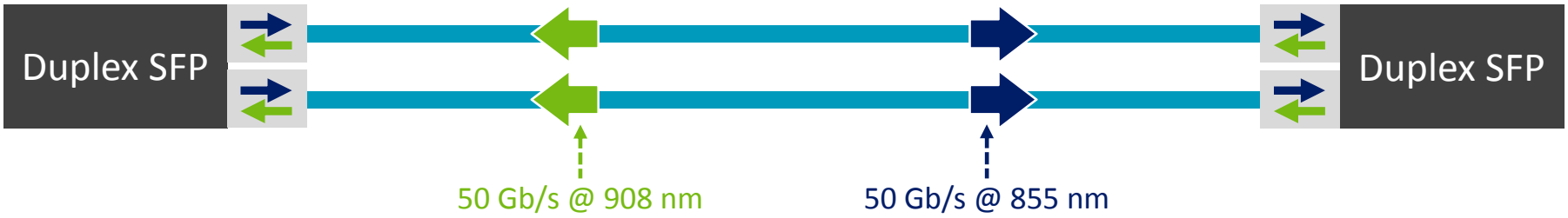
Don't forget to tell them there is no break out option

- There are 40 Gb/s solutions than run over duplex links today
- QSFP-40G-SR-BD
  - 30 m over OM2, 100 m over OM3 and 150 m over OM4
  - Transmits and receives on the same fiber using two wavelengths



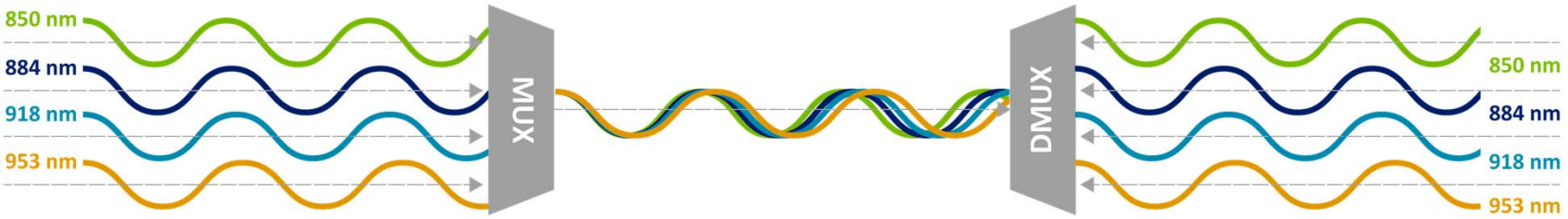
Do I have to replace my links with MPO?

- There are 100 Gb/s solutions than run over duplex links today
- QSFP-100G-SR-BD
  - 70 m over OM3, 100 m over OM4 and 150 m over OM5
  - Transmits and receives on the same fiber using two wavelengths

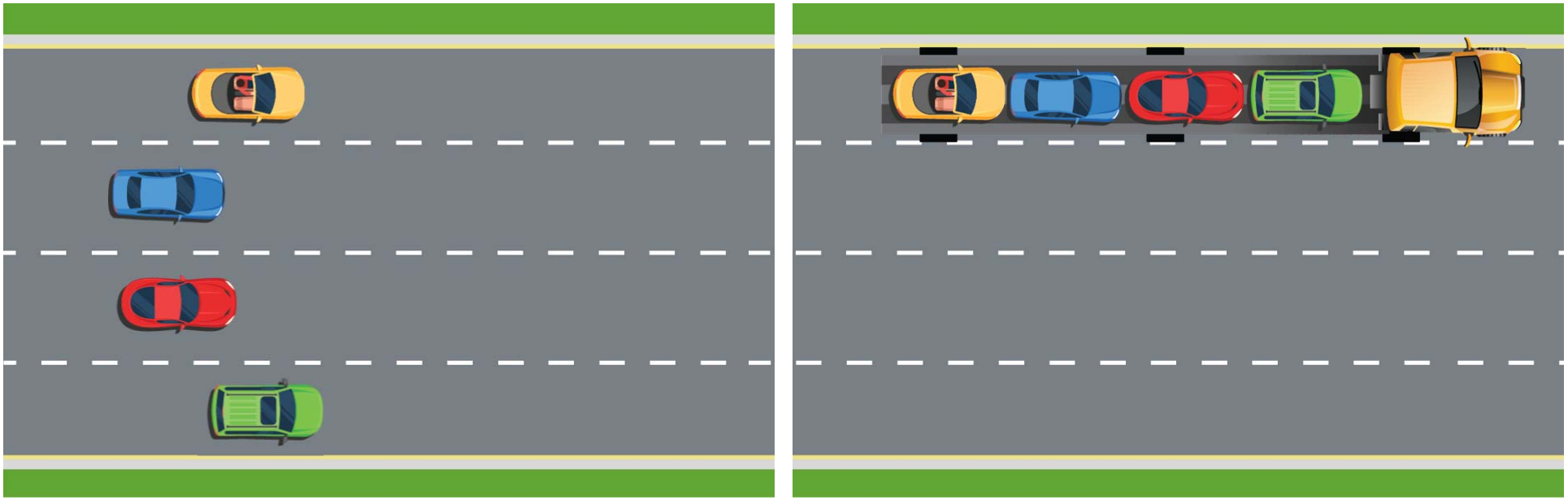


Short Wave Division Multiplexing (SWDM4)

- Transmitting four wavelengths on a single multimode fiber

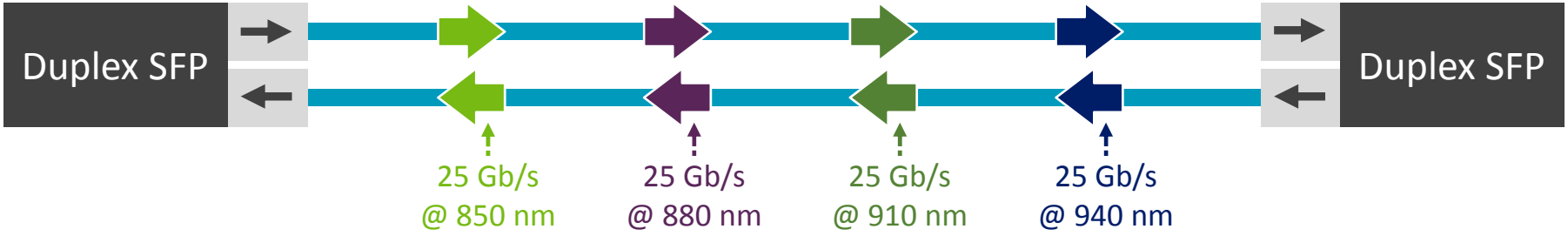


SR4 vs. SWDM4



Do I have to replace my links with MPO?

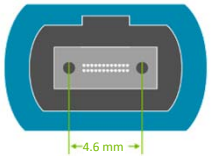
- There are 100 Gb/s solutions than run over duplex links today
- QSFP-100G-SWDM4
  - 70 m (OM3), 100 m (OM4) & 150 m (OM5), transmitting on four wavelengths



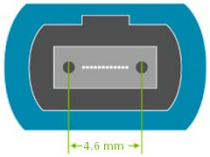
Future multimode IEEE Ethernet applications

Application	OM3		OM4		OM5		Fiber Count	Connector Type
	Meters	Feet	Meters	Feet	Meters	Feet		
50GBASE-SR	70	230	100	328	100	328	2	LC
200GBASE-SR4					100	328	8	MPO[1]
400GBASE-SR4.2*					150	492	8	MPO[1]
400GBASE-SR8					100	328	16	MPO[2 or 3]
400GBASE-SR16					100	328	32	MPO[4]

MPO[1]
12 Fiber

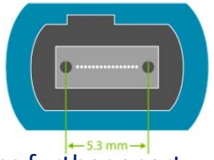


MPO[2]
24 Fiber



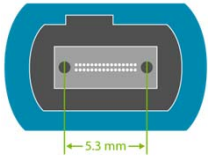
Offset Key

MPO[3]
16 Fiber



Pins further apart

MPO[4]
32 Fiber

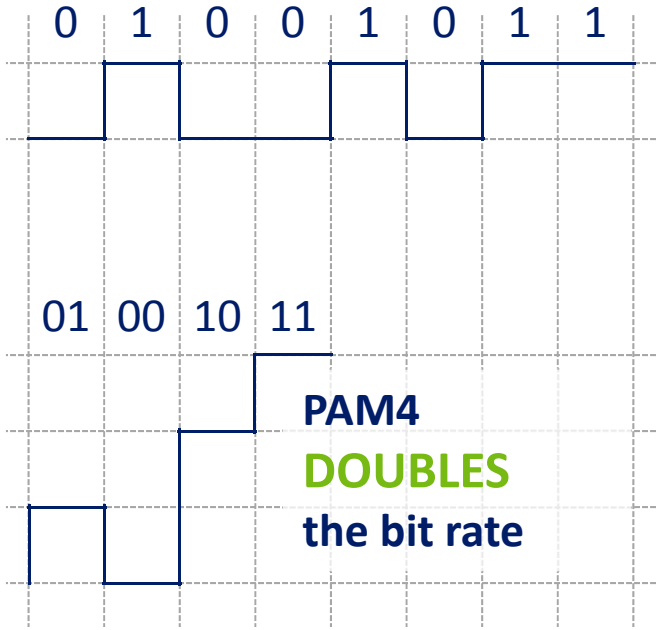


* Draft IEEE 802.3cm target distances

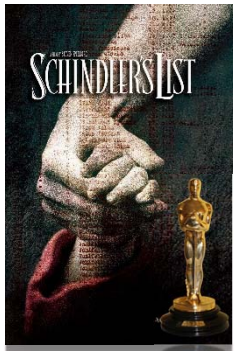
PAM4 - squeezing every bit out of the fiber

Non
Return
Zero

Pulse
Amplitude
Modulation
4 Levels



Reduction in supported lengths (multimode)



1994 100 Mb/s

2,000 m (6561 ft.)

Schindler's List

1998 1000 Mb/s

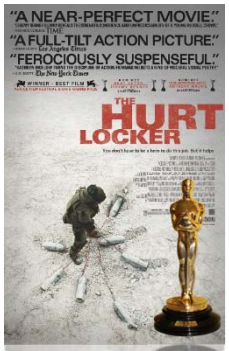
550 m (1805 ft.)

Titanic

2002 10 Gb/s

300 m (984 ft.)

A Beautiful Mind



2010 40 Gb/s

150 m (492 ft.)

The Hurt Locker

2015 100 Gb/s

100 m (328 ft.)

Birdman

Future Single-mode IEEE Ethernet Applications

Application	OS1a/OS2		PAM4	WDM	Fiber Count	Connector Type
	Meters	Feet				
50GBASE-FR	2,000	6,561	Yes	No	2	LC
50GBASE-LR	10,000	32,736	Yes	No	2	LC
100GBASE-DR	500	1,640	Yes	No	2	LC
200GBASE-DR4	500	1,640	Yes	No	8	MPO
200GBASE-FR4	2,000	6,561	Yes	4	2	LC
200GBASE-LR4	10,000	32,736	Yes	4	2	LC
400GBASE-DR4	500	1,640	Yes	No	8	MPO
400GBASE-FR8	2,000	6,561	Yes	8	2	LC
400GBASE-LR8	10,000	32,736	Yes	8	2	LC

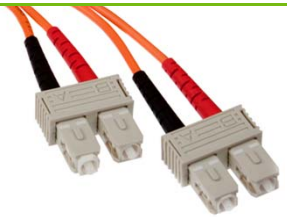
Connectivity Options

Termination options

Transceiver Fiber Interfaces

Most common SC, LC, and MPO

1000BASE-SX GBIC
(SC)



1000BASE-SX SFP
(LC)

10GBASE-SR SFP
(LC)

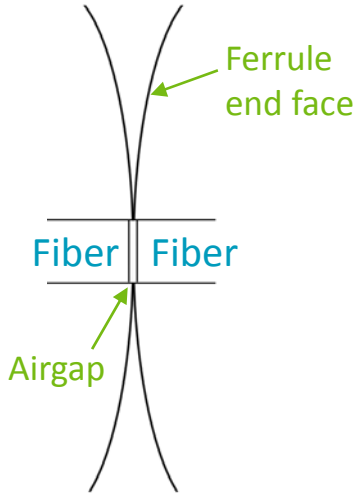
40GBASE-SR4 QSFP+
(MPO)

SC/LC Termination Options

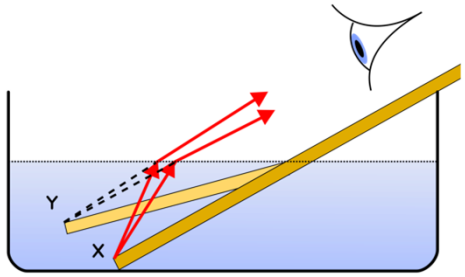
- Field Polish
  - Ideal for smaller installations
  - Craft sensitive
  - Labor costs a consideration
  - Consumables
    - Polishing paper
  - Concerns meeting updated TIA single-mode return loss (reflectance) requirements of 35 dB

Reflectance (return loss)

- This is the reflection of light back into the transceiver
- Most common cause is the airgap between connectors
  - Polishing the ceramic end face can result in an undercut
  - When two connectors are mated,
    there is small airgap between them
  - Bigger the airgap, Worse the return loss (reflectance)
- With higher speeds, now a concern in the enterprise



Further Minimizing Return Loss (reflectance)



- Put an 8-degree angle on the end face
- Any reflected light is forced into the cladding
- Angled Physical Contact connector (APC)
- APC connector housing is green
  - Avoids mixing PC and APC connectors

- Concatenated links (many connections) can result in optical return loss issues if return loss (reflectance) is not controlled
- IEEE 802.3cd (in progress) specifying discrete reflectance

Sensitive to Reflectance (return loss)

100GBASE-DR Maximum channel insertion loss (dB)		Number of connections where the reflectance is between -45 and -55 dB								
		0	1	2	3	4	5	6	7	8
Number of connections where the reflectance is between -35 and -45 dB	0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	**3.0**
	1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	2	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9
	3	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	—
	4	2.8	2.8	2.8	2.8	2.7	2.7	2.7	—	—
	5	2.8	2.8	2.7	2.7	2.7	2.6	—	—	—
	6	2.6	2.6	—	—	—	—	—	—	—

- Let's take an example link containing four LC/MTP cassettes
  - Single-mode MTPs are APC, so there will be four of those (typically better than -55 dB)
  - The four LCs are factory polished (typically better than -50 dB)
  - We have no connections between -35 dB and -45 dB
  - So our allowable loss will be **3.0 dB**

Sensitive to Reflectance (return loss)

100GBASE-DR Maximum channel insertion loss (dB)		Number of connections where the reflectance is between -45 and -55 dB								
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of connections where the reflectance is between -35 and -45 dB	**0**	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
	2	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9
	3	2.9	2.9	2.9	2.9	2.9	2.8	2.8	2.8	—
	4	2.8	2.8	2.8	2.8	**2.7**	2.7	2.7	—	—
	5	2.8	2.8	2.7	2.7	2.7	2.6	—	—	—
	6	2.6	2.6	—	—	—	—	—	—	—

- Let's take another of a example link containing four LC/MTP cassettes
  - Single-mode MTPs are APC, so there will be four of those (typically better than -55 dB)
  - The four LCs are factory polished (typically better than -50 dB)
  - Future performance could be between -35 dB and -45 dB
  - So our allowable loss will be **2.7 dB**, not 3.0 dB

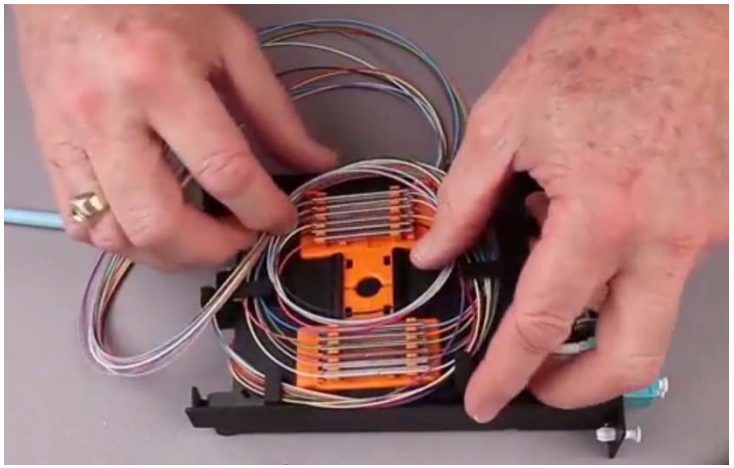
SC/LC Termination Options

- Mechanical splice
  - Faster termination than field polish
  - Less craft sensitive
  - Factory polished end faces
  - Better insertion loss
  - Better return loss (reflectance)
  - Less consumables
    - No polishing papers
  - Precision cleaver required

SC/LC Termination Options

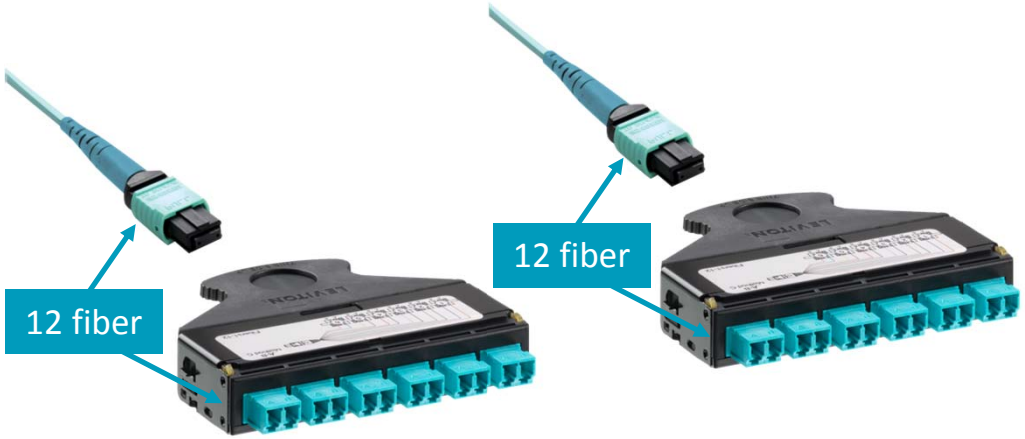
- Pigtail – Fusion Splice
  - Factory polished connectors
    - Excellent insertion/return loss
  - Precision cleaver and splicer required

  - Skill in dressing splice trays

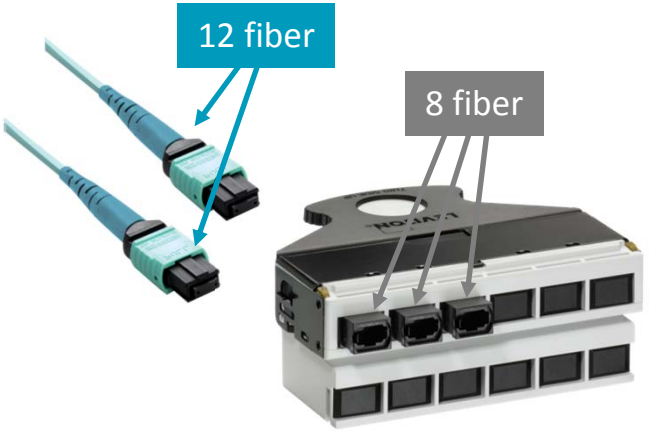


12 Fiber Multi-Push On (MPO) Connector

With an MPO trunk cable, you get to choose interface connector



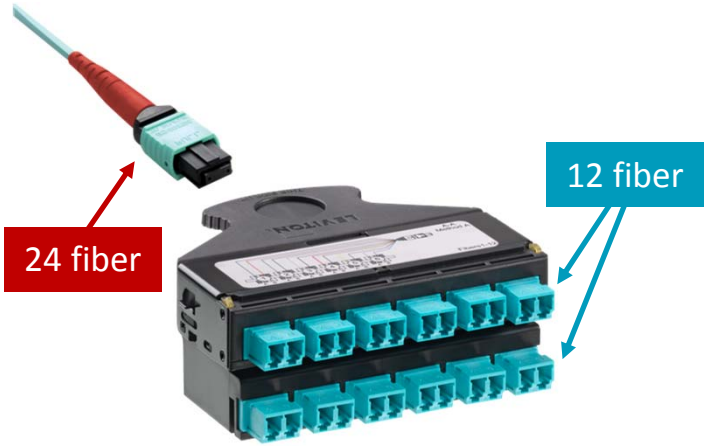
1000BASE-SX or 10GBASE-SR



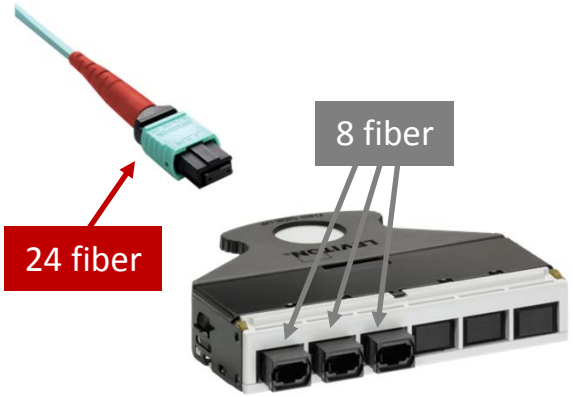
40GBASE-SR4, 100GBASE-SR4, 200GBASE-SR4, 400GBASE-SR4.2

24 Fiber Multi-Push On (MPO) Connector

With an MPO trunk cable, you get to choose interface connector



1000BASE-SX or 10GBASE-SR



40GBASE-SR4, 100GBASE-SR4, 200GBASE-SR4, 400GBASE-SR4.2

Takeaways

- Keep links under 100 m (328 ft.) for new OM4 multimode installs
- Proprietary technologies to reuse existing duplex links now available
- OM5 offers an advantage over OM3/4 for SWDM/BiDi only
- Field polished single-mode connectors may not support ≥100 Gb/s
- Concatenated single-mode links may benefit from APC connectors
- MPO trunk cables offer flexibility and performance
- 24-fiber multimode MPO cables cover you from 100 Mb/s to 400 Gb/s
- Interest in single-mode increasing due to historical length reductions

Thank You