

Flexi Circuit Fiber Shuffle – Interconnect Solution for Inside Chassis



Paul Yip

Product Marketing Manager



Your Optical Interconnect Solution Partner!



Introduction

- Design considerations on fiber management inside data center chassis
- **Flexi-circuit fiber shuffles – The next enabler of CPO switches and systems!**

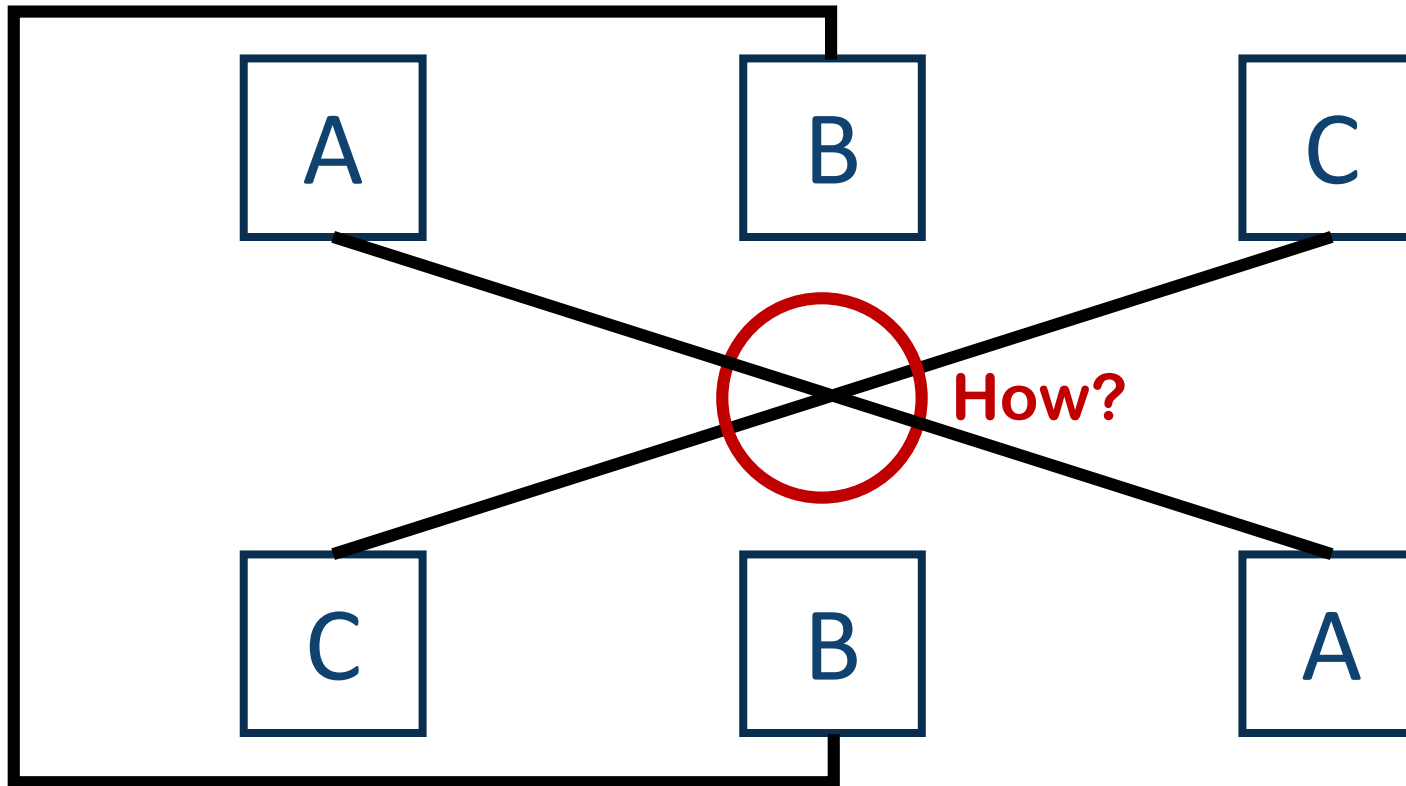
Optec Technology Limited

- Fiber optic cable assembly and interconnect solution
- Founded 2001
- COBO member since 2017



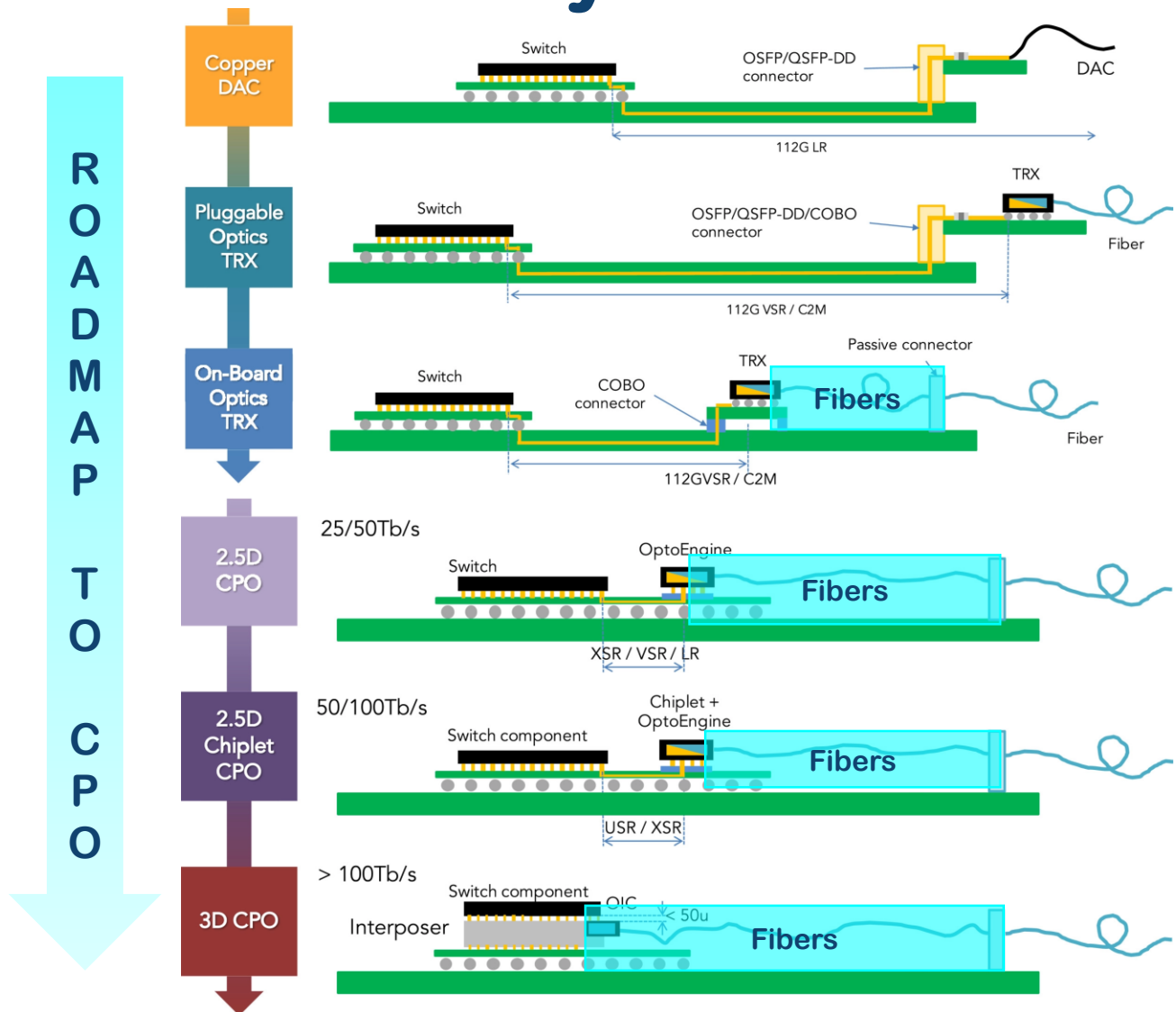
Riddle

Can you connect $A \rightarrow A$, $B \rightarrow B$, $C \rightarrow C$ without crossing lines?



Answer at the end of presentation.

Fibers in CPO System



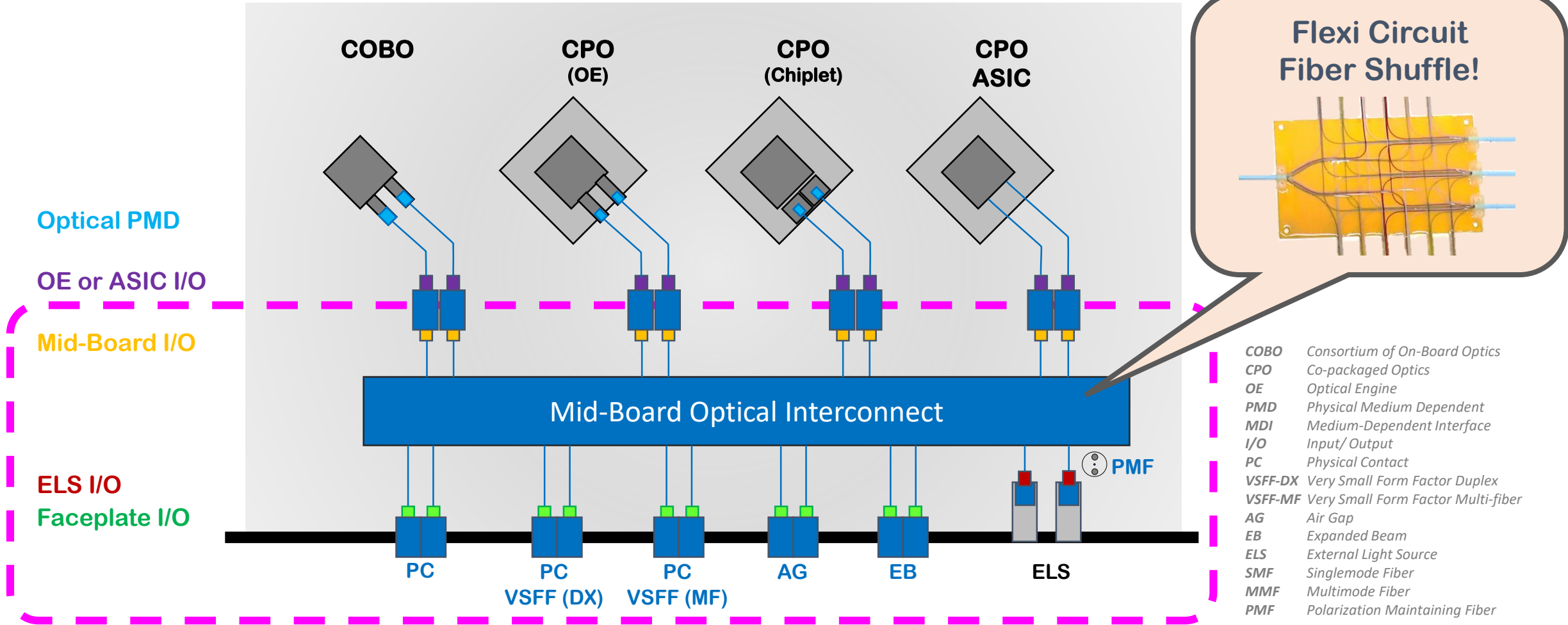
Hundreds to thousands of fibers inside a CPO system!

CPO = Co-packaged Optics

Citation:
 Minkenberg, C., Krishnaswamy, R., Zilkie, A. and Nelson, D. (2021),
 Co-packaged datacenter optics: Opportunities and challenges.
 IET Optoelectron, 15: 77-91.
<https://doi.org/10.1049/ote2.12020>

Board Level Fiber Connectivity

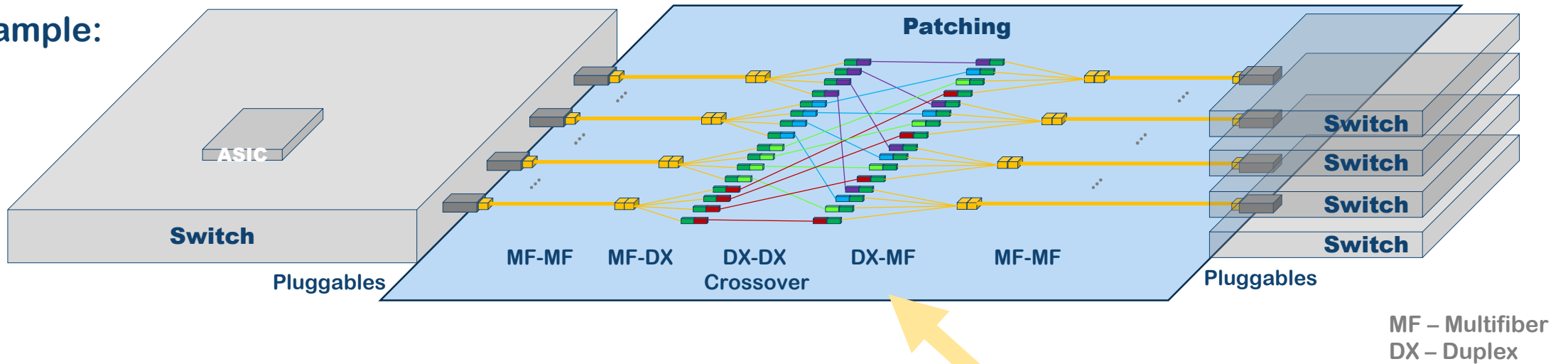
*Blue indicates where fibers exist



Conventional Patching

- Conventional Patching of Switches with Pluggables

Example:



- More connectors in the link
- More rack space required

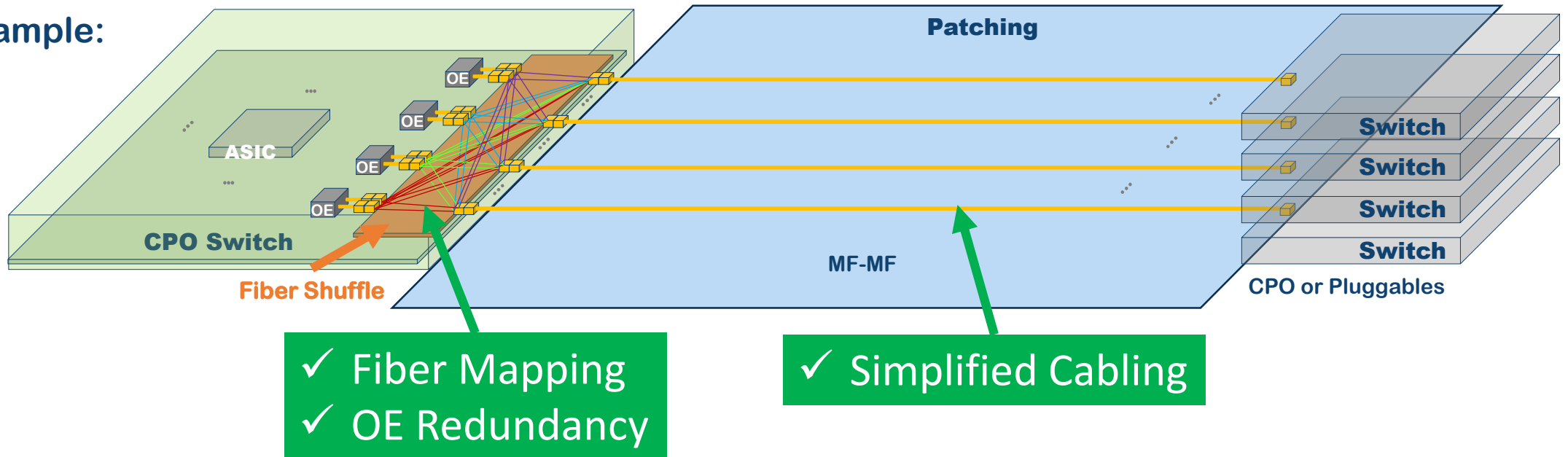
Consideration:

- Can we pre-build some or all of these patchings inside the switch?
- Too many cables for a small box?

Why Fiber Shuffle?

- Possibility of CPO switches with **fiber shuffle** built inside chassis

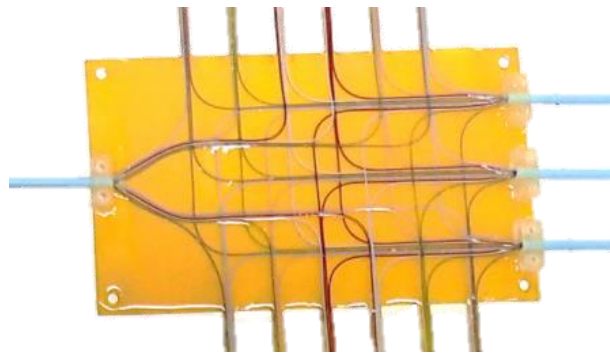
Example:



- Cross connect happens within CPO switch with optimized number of connectors per link
- Channelings are pre-configured, fabricated & tested at factory, protected in the switch box
- Simple Data Center cabling; Saves rack space and OpEx!

Fiber Shuffle

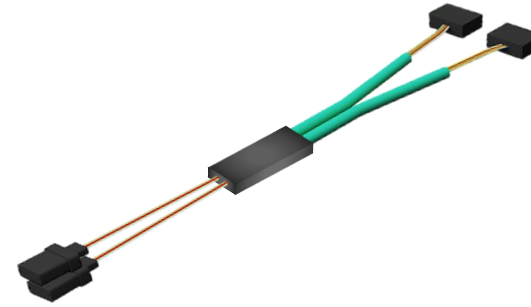
- Re-configure fiber arrangement from origin ports to destination ports
- Different types of connectors can be used within the shuffle
- It facilitates
 - Fiber mapping
 - Redundancy
- Forms of fiber shuffle



Thin Film Flexi Circuit



Box Type



Miniature

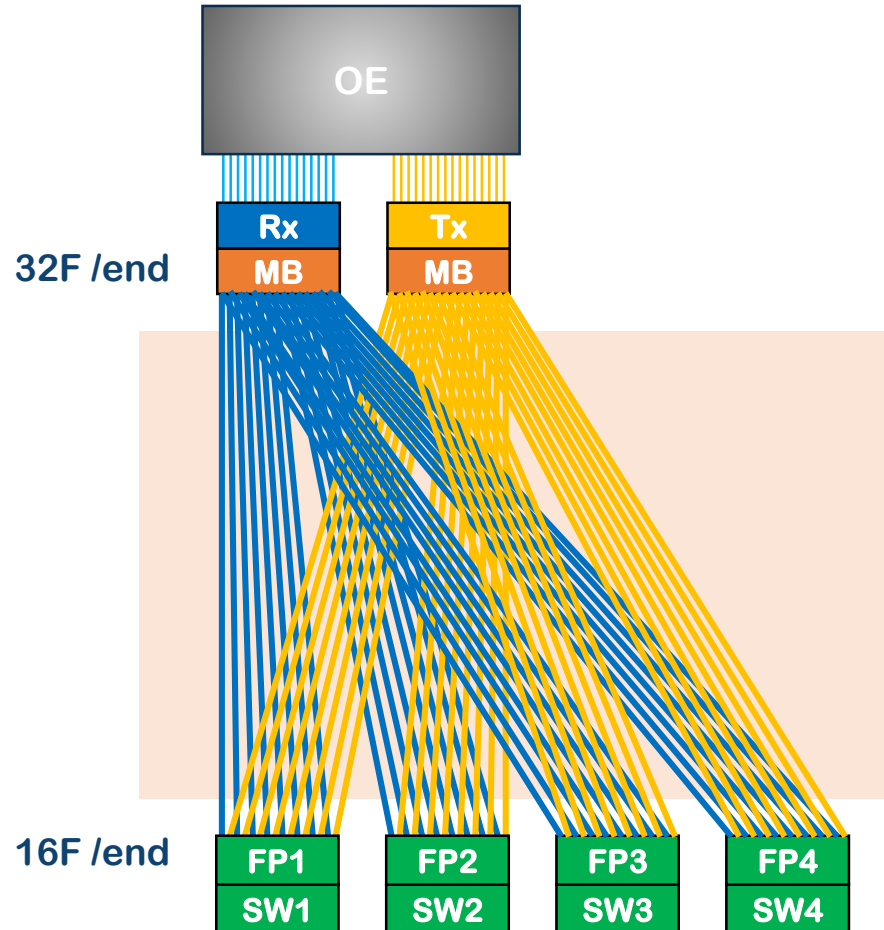
Fiber Mapping

Schematic Diagram

Fiber Mapping

Fibers from an OE is mapped out to 4x FP connectors

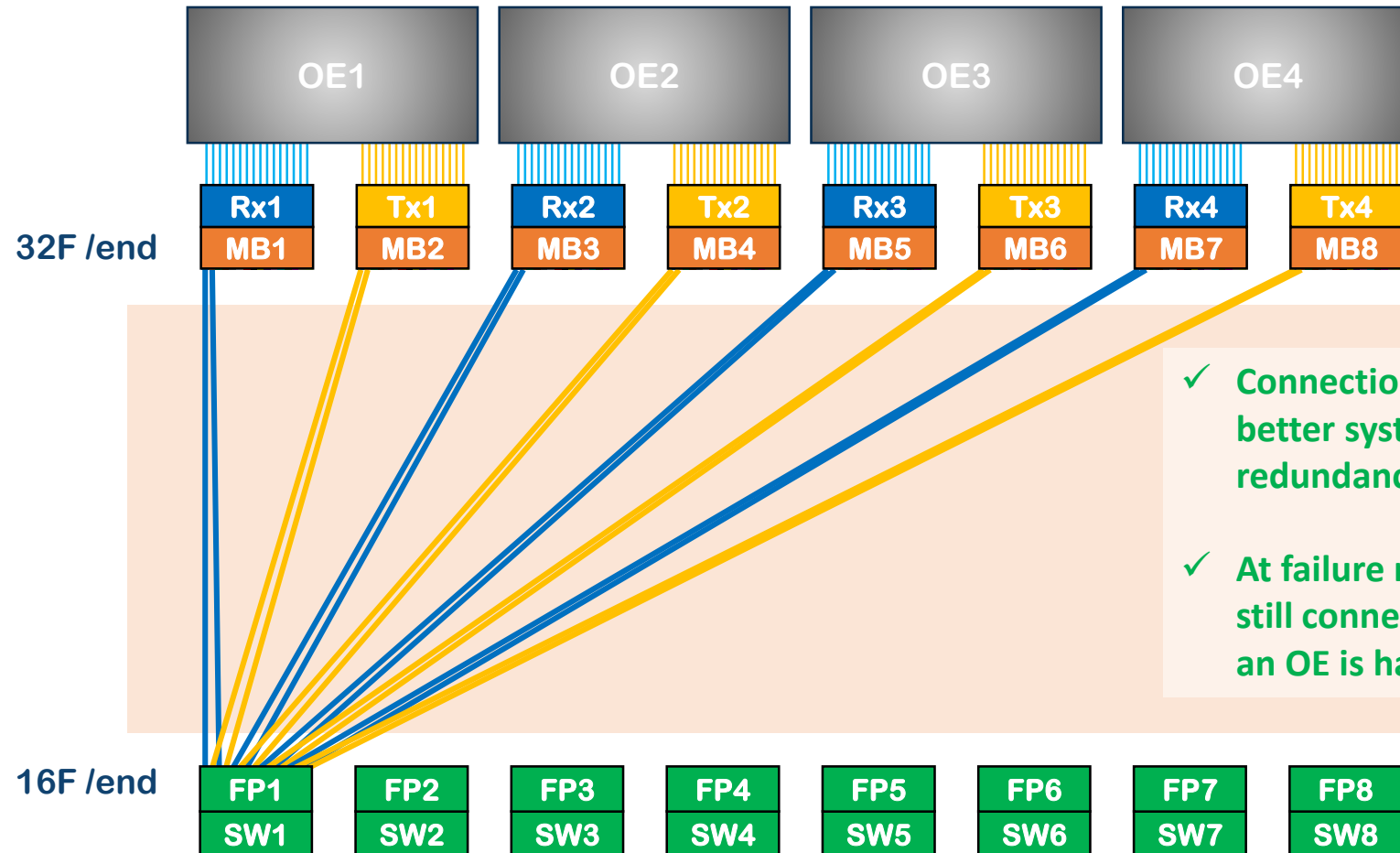
e.g.
3.2TB OE with 2 connectors
(1x32Tx +1x32Rx)
can be mapped out to
4x 800G I/O with
4x 16F (8Tx & 8Rx) connectors
at FP



- ✓ Transfer bigger granularity into smaller through Fiber mapping
- ✓ Smaller granularity means better reliability /redundancy when a I/O port or a fiber fails

OE Optical Engine
Rx Receive
Tx Transmit
MB Mid-board
FP Faceplate
SW Switch

Redundancy



OE Redundancy

Each port is connected to more than one OE

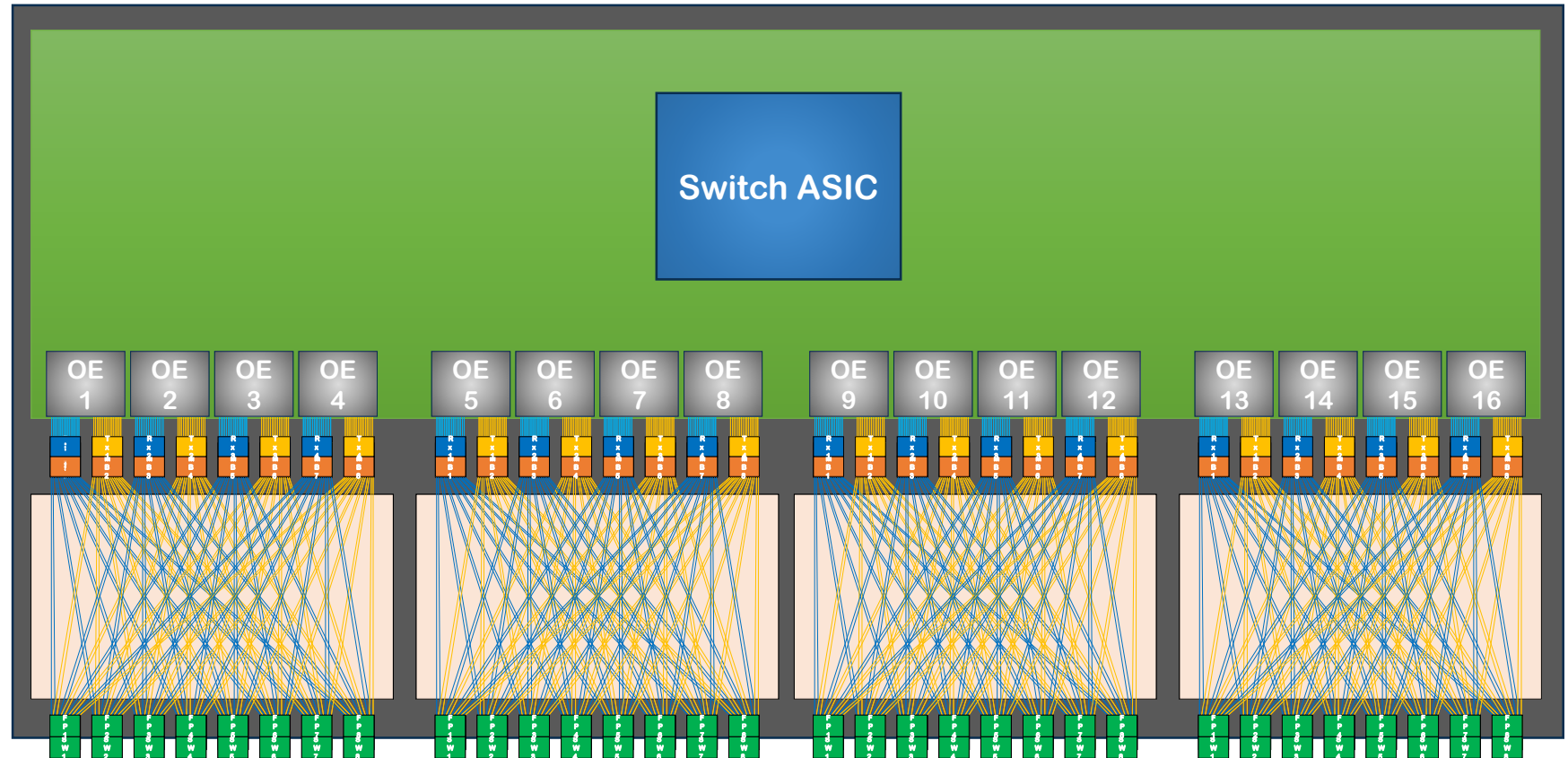
e.g.
 800G I/O with 8 lanes of 100G signals from 4 OEs
 1x16F (8Tx & 8Rx) connector at Front panel are connected to 4x OEs using 2Tx+2Rx fibers

- ✓ Connection to more OE means better system reliability /OE redundancy.
- ✓ At failure mode, an I/O port is still connected to 3x OEs when an OE is having a problem

OE Optical Engine
 Rx Receive
 Tx Transmit
 MB Mid-board
 FP Faceplate
 SW Switch

Fiber Shuffle Interconnect OE – MB - FP

Schematic Diagram



Fiber Mesh

Up to 16x OEs in a Switch.

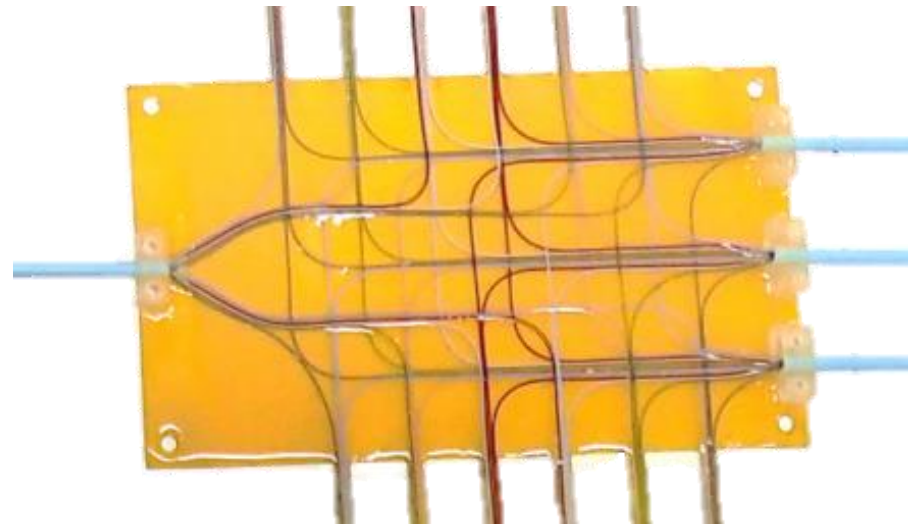
The diagram illustrates 4x OEs

Fiber Routing Concerns Within Chassis

- Highly compact space within chassis
- Cable congestions if cables are being put inside chassis
- Need a dedicated way to manage hundreds to thousands of fibers
- Airflow
- Effect of system environment to the cable assemblies long term reliability, e.g. temperature and vibration
- The form of fiber routings shall be operation friendly for chassis assembly

Flexi Circuit

- Fibers are being laminated on a flexible thin film substrate
- Fibers intersect on the thin film with optimized amount and protection
- Well controlled bending angle according to fibers min. bending radius
- Layers are stackable, allowing better fiber management



Flexi Circuit Fiber Shuffle For CPO Switch Demo

Collaborated with **USCONEC**

For **Tx / Rx** fibers,

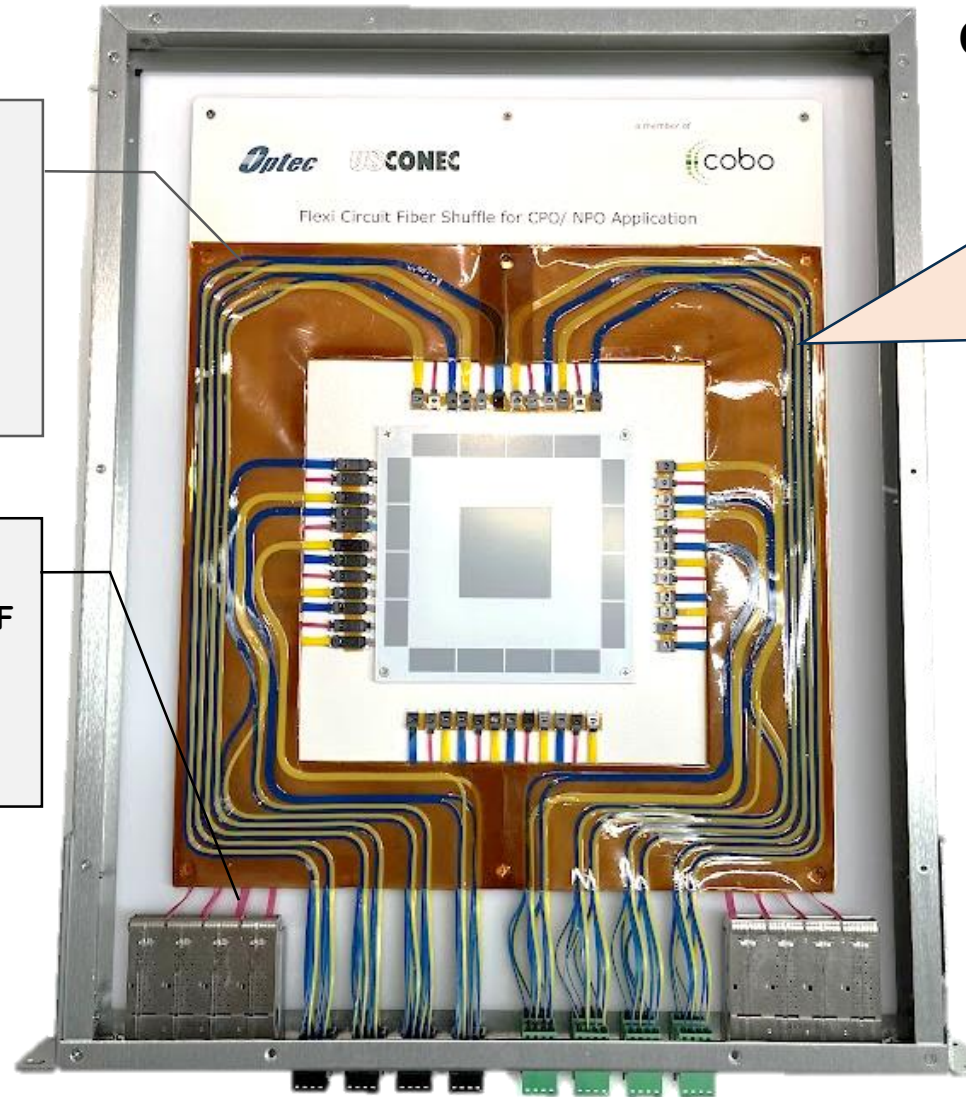
- Typical SMF count /connector: 8F, 16F, 32F
- Max number of connectors: 32
- Max SMF fiber count: 32F *32 = **1024F**

For **PMF** - ELS-OE/ASIC Interconnection,

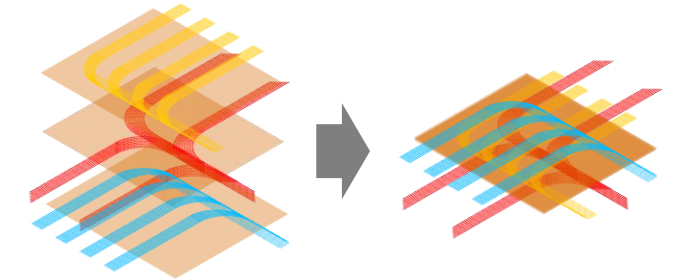
- Typical fiber count /connector: 2F, 4F, 8F
- Max number of connectors: 16
- Max fiber count: 8*16 = **128F**

Total 1152F

- Backplane Adaptor Interface for ELS (External Light Source)
- Blindmate Connector at ELS
- MMC®-16 – Very Small Form Factor MT Connector

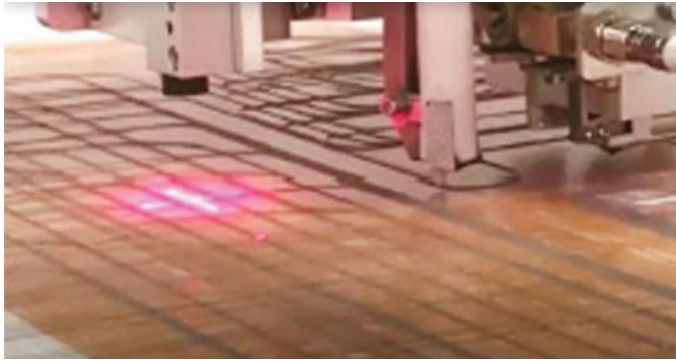


- Optical fibers being laminated on **flexible thin film** substrates
- The films are **stackable** for multi-layer design

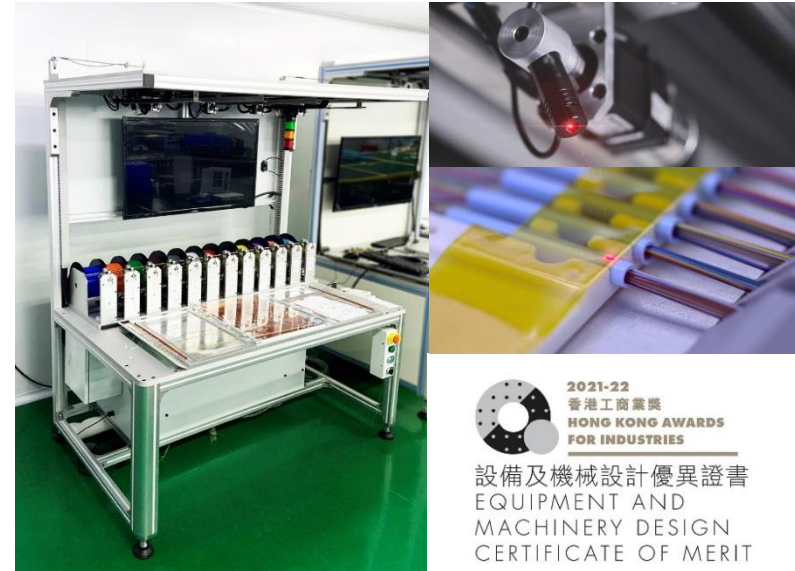


Manufacturing of Flexi-Circuit Fiber Shuffle

- Scalability
- Polarity control



Automated Fiber Laying Machine



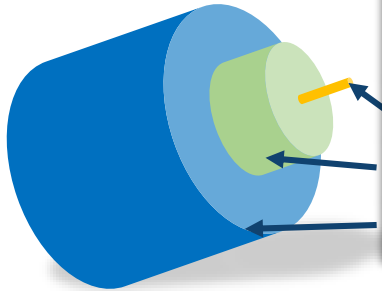
**Semi-Automated
Fiber Routing Machine**

Design Considerations of Fiber shuffle

Areas	Key Considerations			
MB – Mid-Board	Connector Interface	Connector location	Polarity	
FP – Faceplate	Connector Interface	Port Assignment	Polarity	
Fiber Type	Fiber Count	Fiber Mode	Bending Radius	Fiber OD
Shuffle Location	Preferred shuffle location	Mounting Mechanism	Fiber routing	Avoid SMT components on PCB
Other	System temperature range	Air Flow/ Cooling Method	System assembling workflow	Serviceability at failure mode

Choice of Fiber

Dimensions



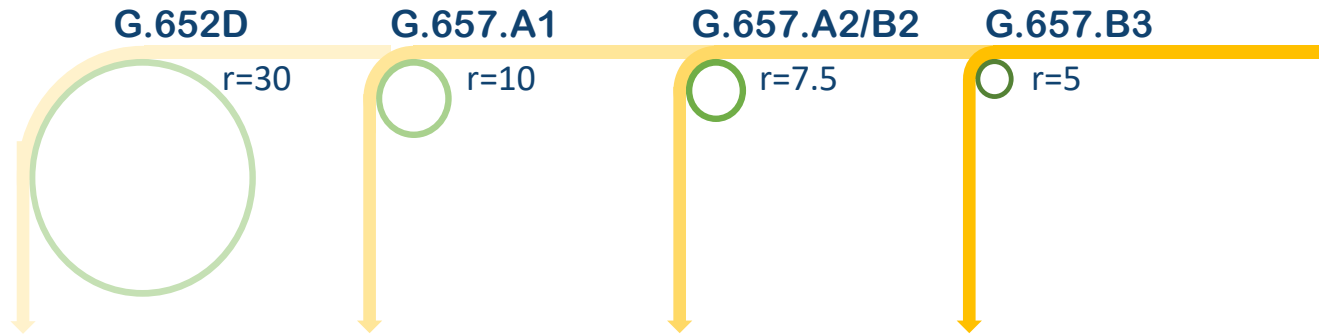
Typical Size	250um Fiber	200um Fiber	Reduced Cladding Fiber
Core	SM: 8-9um MMF (OM2-5): 50um		
Cladding	125um	125um	80um
Bare Coating	250um	200um	165um

Fiber Mode

	MMF	MMF SWDM	SMF
Fiber Type	OM2/OM3/ OM4	OM5	G652D, G657A1, A2/B2, B3
Wavelength (λ)	850, 1300nm	850~953nm	1310, 1490, 1550, 1625nm






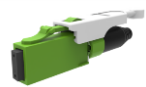




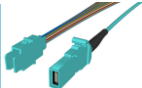

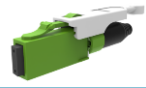

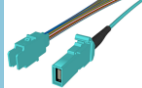
Min. Bending Radius for SMF (mm)

ITU Standard



Choice of Optical MDI at Faceplate:

Optical Media Dependent Interface

Granularity Fibers per connector	Physical Contact				Air Gap	Expanded Beam	
	Conventional		VSFF				
	2	 Duplex LC	 CS	 SN			 MDC
12	 MPO-12				 AirMT-12		
16	 MPO-16	 SN-MT 16		 MMC-16		 SN-EB	 MM MXC-1x16
24	 MPO-24				 AirMT-24		
32	 MPO-32	Roadmap					 MM-MXC-2x16

Considerations:

- Density
- Performance
- Durability
- Ease of operation
- Blind Mate possibility

Photo courtesy: US Conec Ltd; Senko Advanced Components

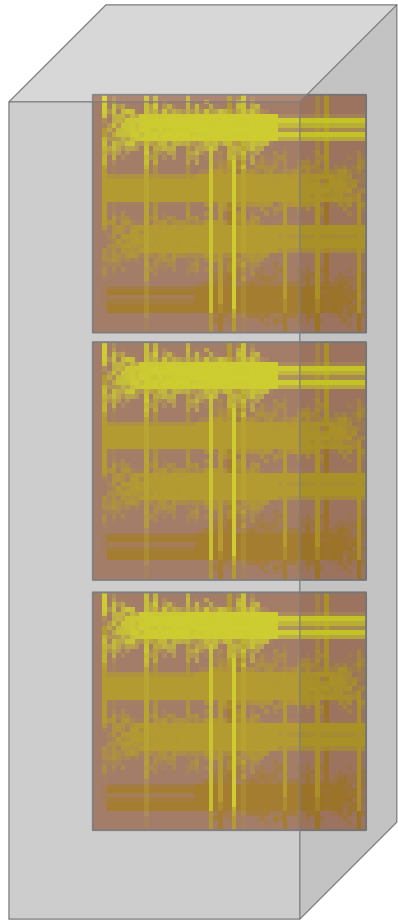
Flexi-Circuit Fiber Shuffle Demo

- Example of a few considerations
 1. To improve airflow in middle → use flexi-circuit fiber shuffle and moved connector to the side
 2. Increased density on front panel → used SN-MT connector in front panel
 3. Used 200um reduced cladding fiber (RCF) for higher density and connector consideration

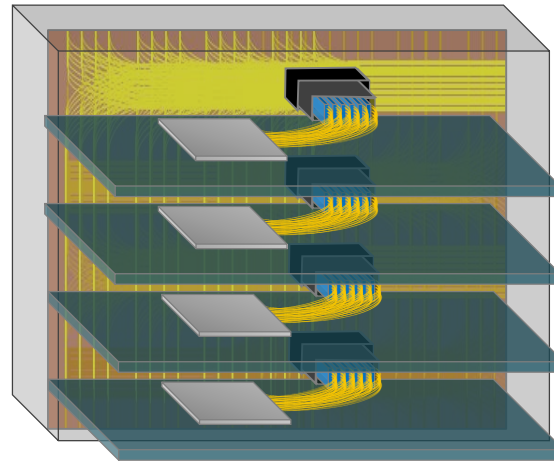


Collaborated with
RAGILE
SENKO[®]
Advanced Components

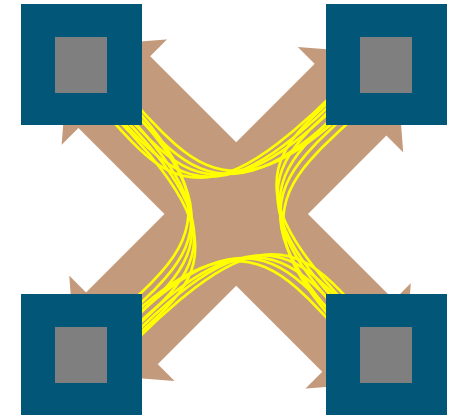
Other Applications of Flexi-Circuit Fiber Shuffle



Optical Backplane



Board-to-Card

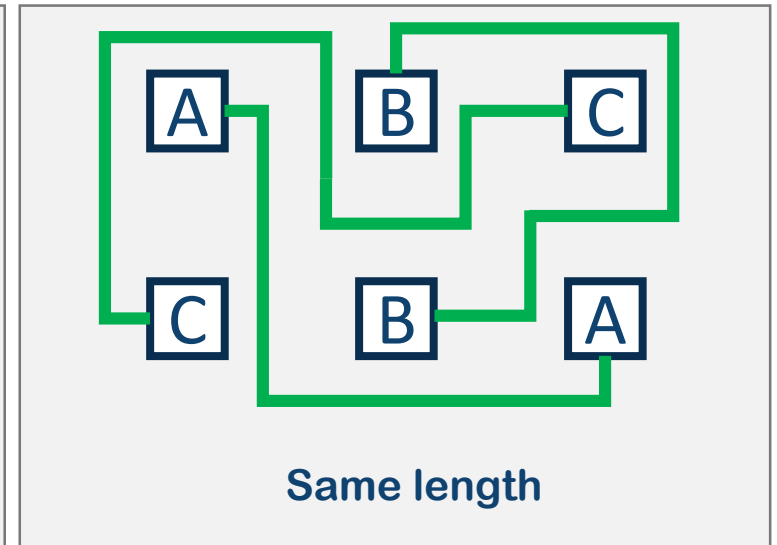
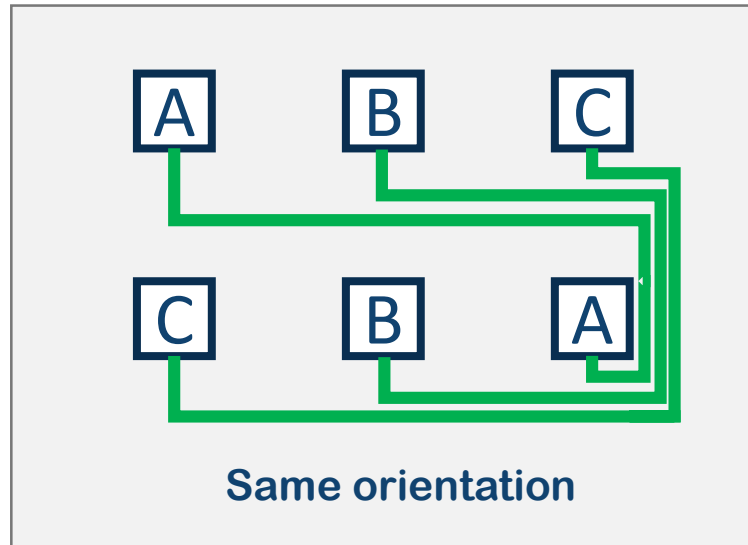
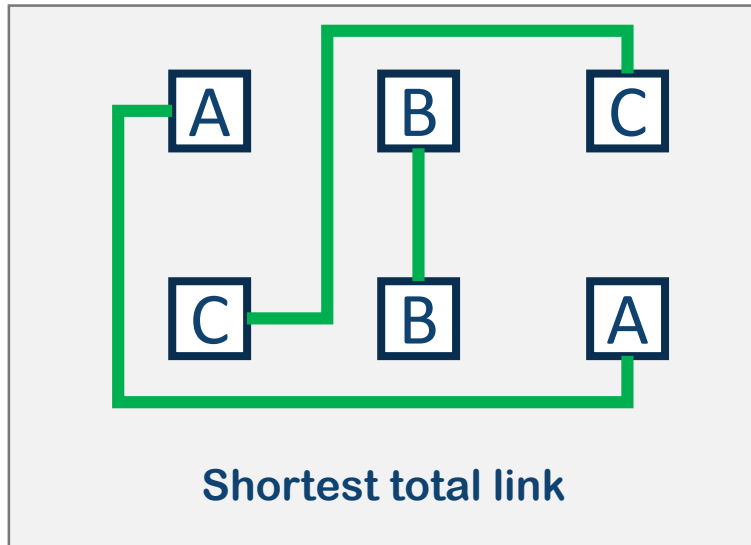


Chips-to-Chips

Riddle -

Can you connect $A \rightarrow A$, $B \rightarrow B$, $C \rightarrow C$ without crossing lines?

Just a few solutions...



Every detail means a better design
Involve Interconnect Solution Designer Earlier!

