

# Wavelength Services Delivered Another Way

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# Market Landscape

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# Wavelength / private line services

- High capacity
  - >10Gbps per service
  - Point to point
- Committed / dedicated resources from A to Z
- Organisational boundaries
  - Different organisations inside a service provider
  - Wholesale connectivity between service providers
  - Enterprise services

# Common Private Line Service Requirements

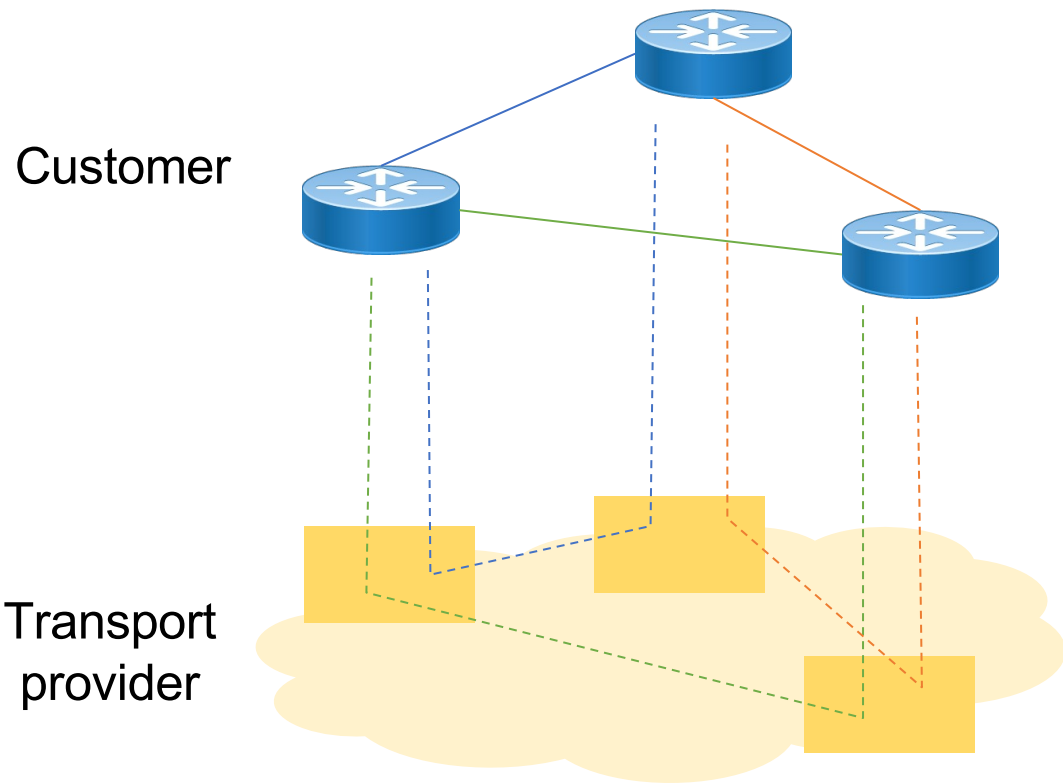
- Low cost per bit
- Assuring transport service SLAs
  - Predictable path, guaranteed bandwidth & 50msec protection
  - Low latency
  - Fault detection and notification
  - Performance monitoring
  - Transparency
- Simple operations

Note:

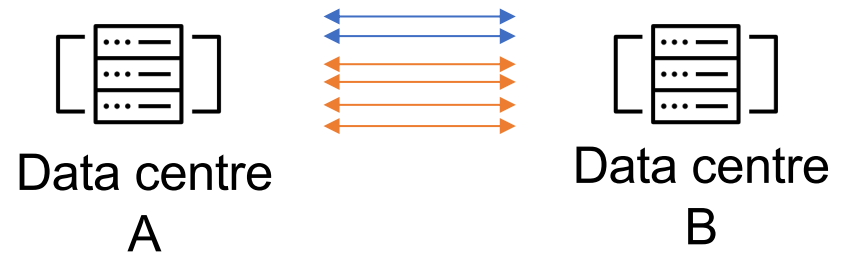
MEF 6.1 does already define most of this for ethernet services

# Typical use cases

Dedicated WAN pipes



Data center interconnect



“Cloud connect”



# Private Line Services Delivered Today

## Trans-/Muxponder point2point

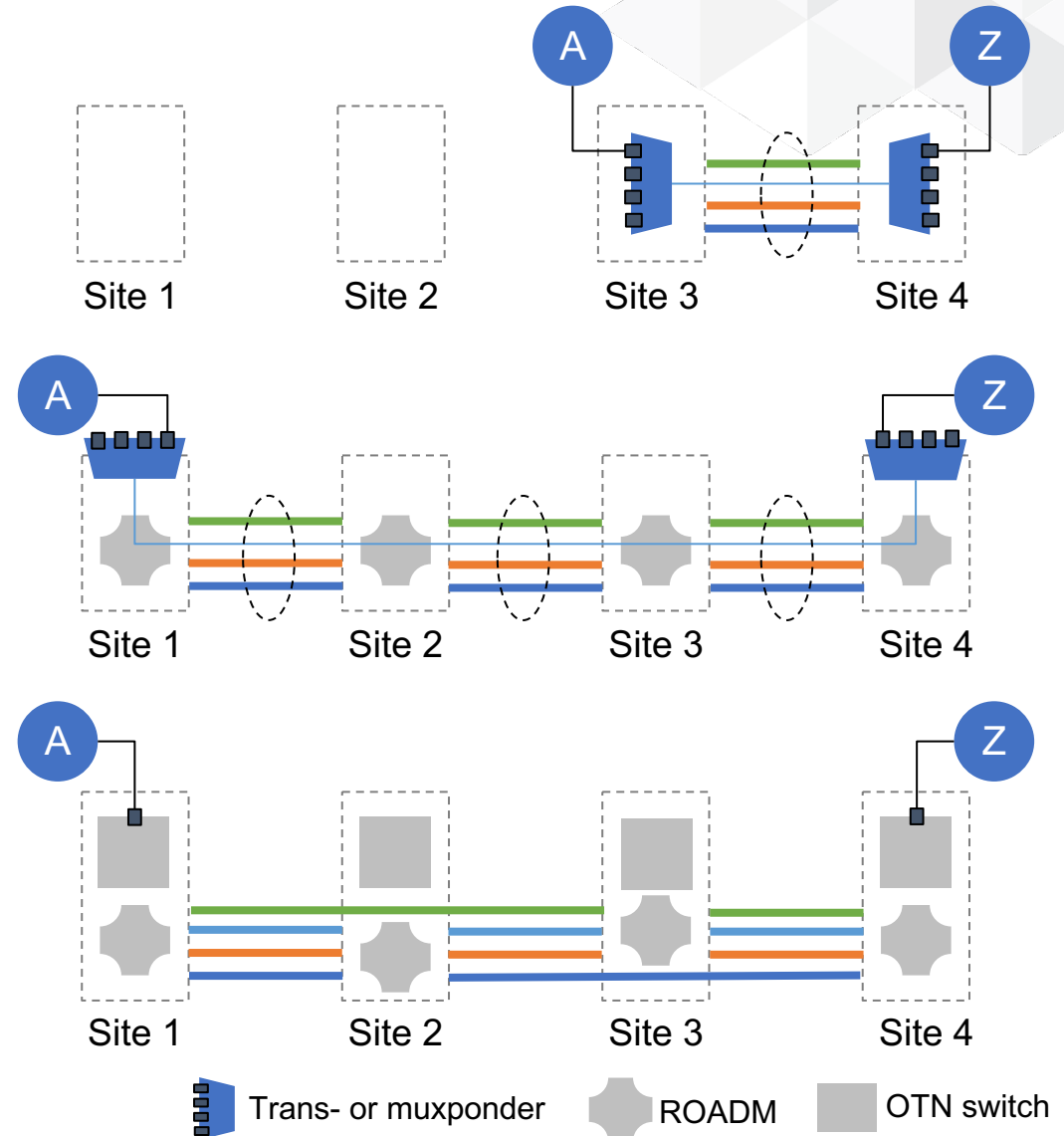
- Simple and cost effect for close-by locations

## Trans-/Muxponder across ROADMs

- Allows for greater geographic reach
- Likely bad wavelength utilization (especially for 10GE)
- Low spectral efficiency due to 100G/200G wavelength end-to-end

## Electrical switching (OTN)

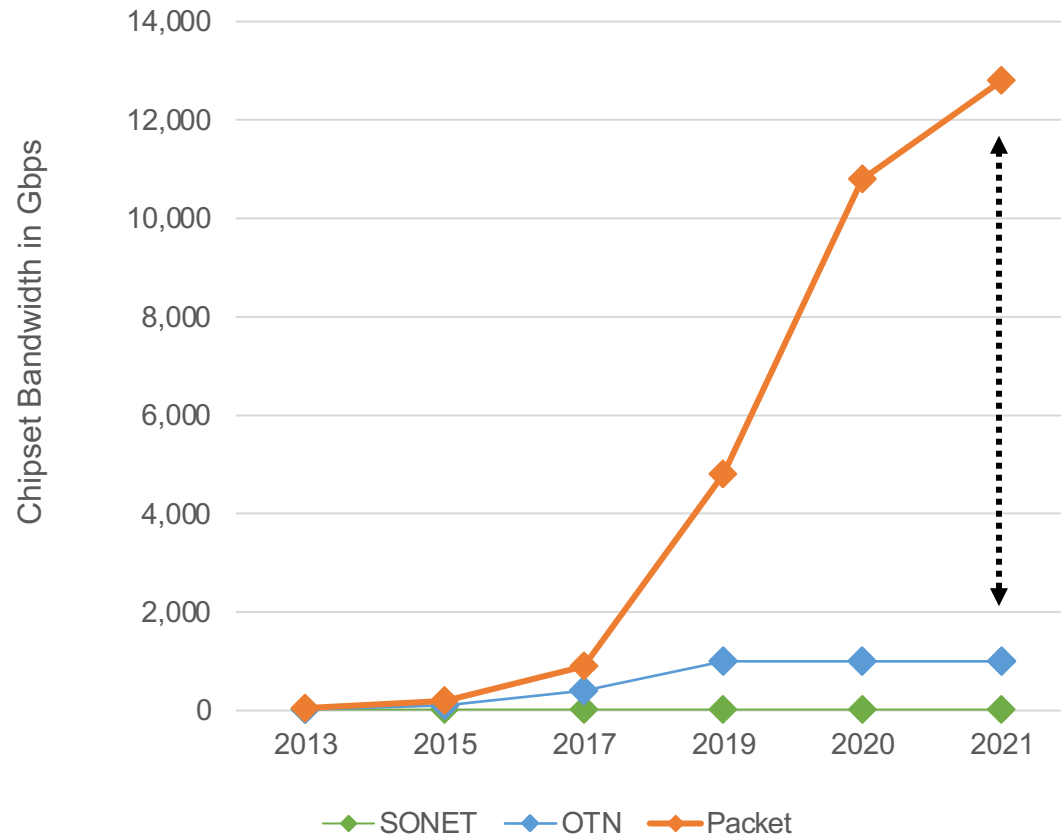
- Greater base network cost
- Efficient wavelength utilization
- Optimum spectral efficiency using wavelengths at highest possible rate (100-1.2Tbps)



# Routers are no longer small nor expensive!

Silicon evolution

Flexible router choice



- 800Gbps
- Mix of 10,25,40,50,100 and 400GE



- 12.8Tbps
- Mix of 10,25,40,100 and 400GE

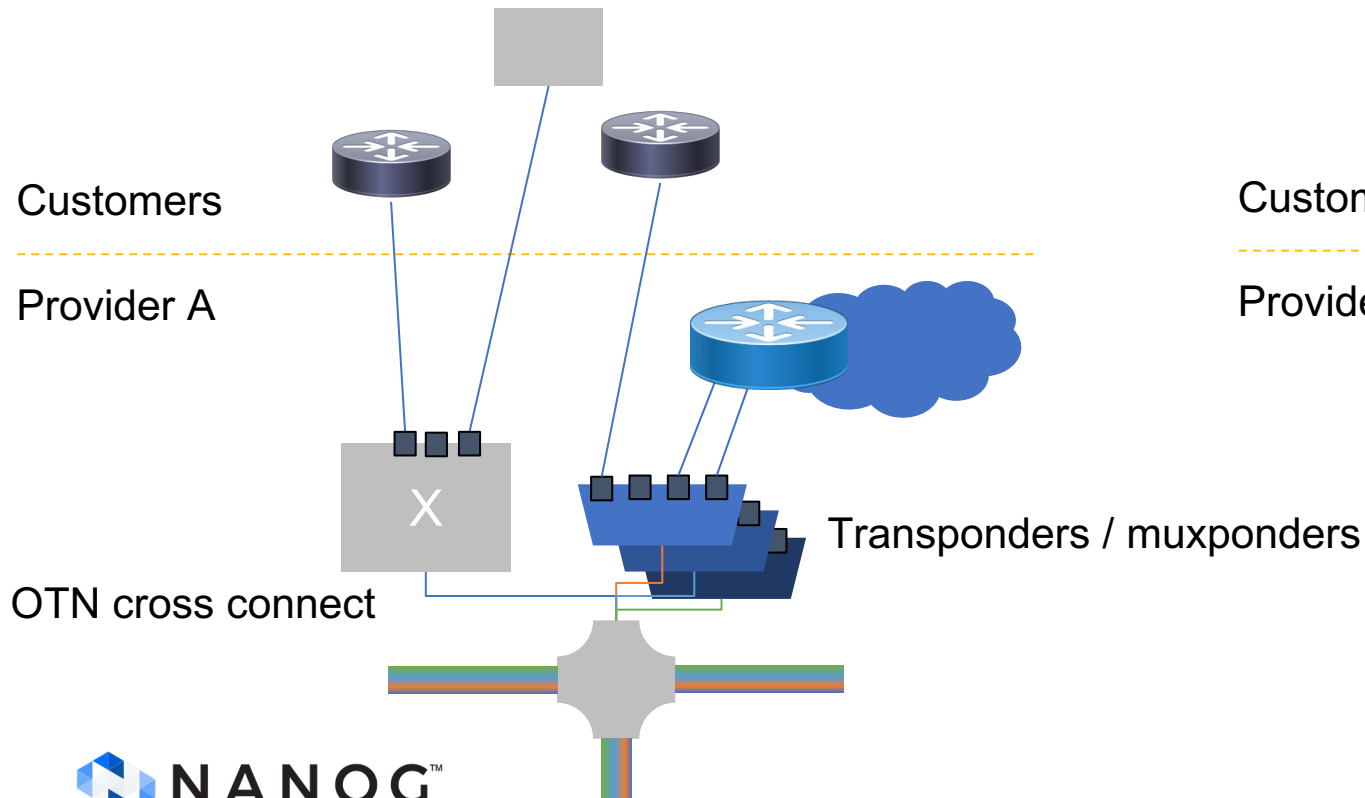


- 172.8Tbps
- Mix of 10,40,100 and 400GE

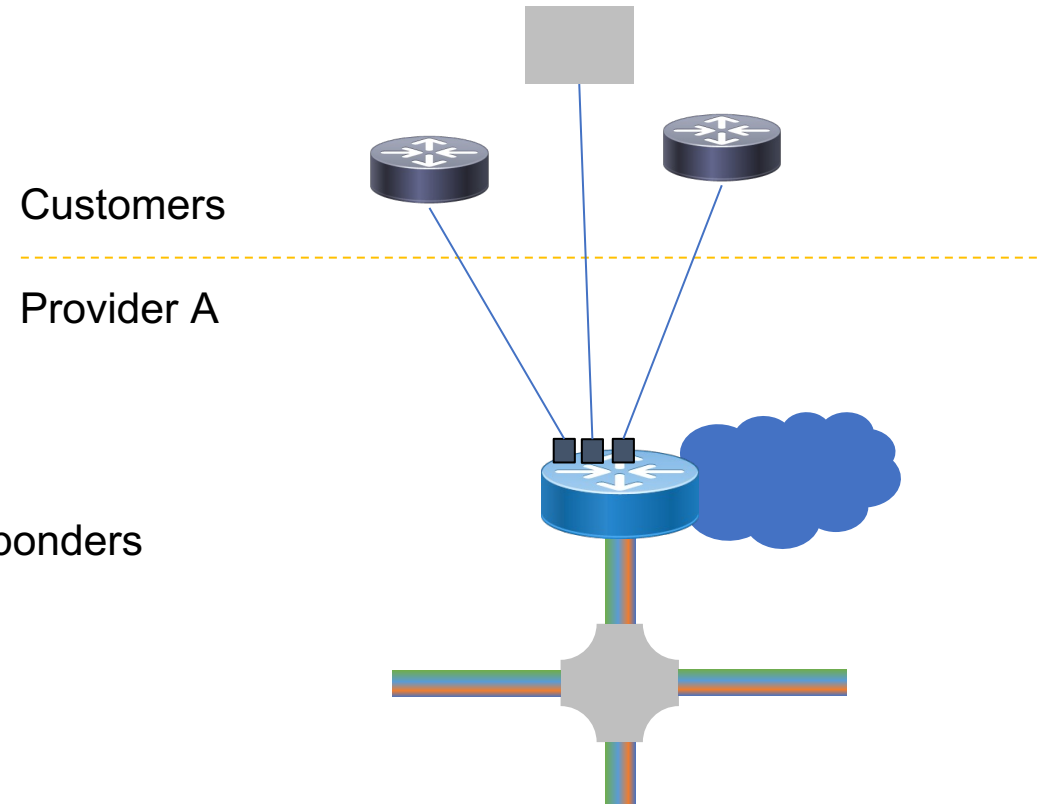


# Private Line Services Delivered Another Way

From...



... To



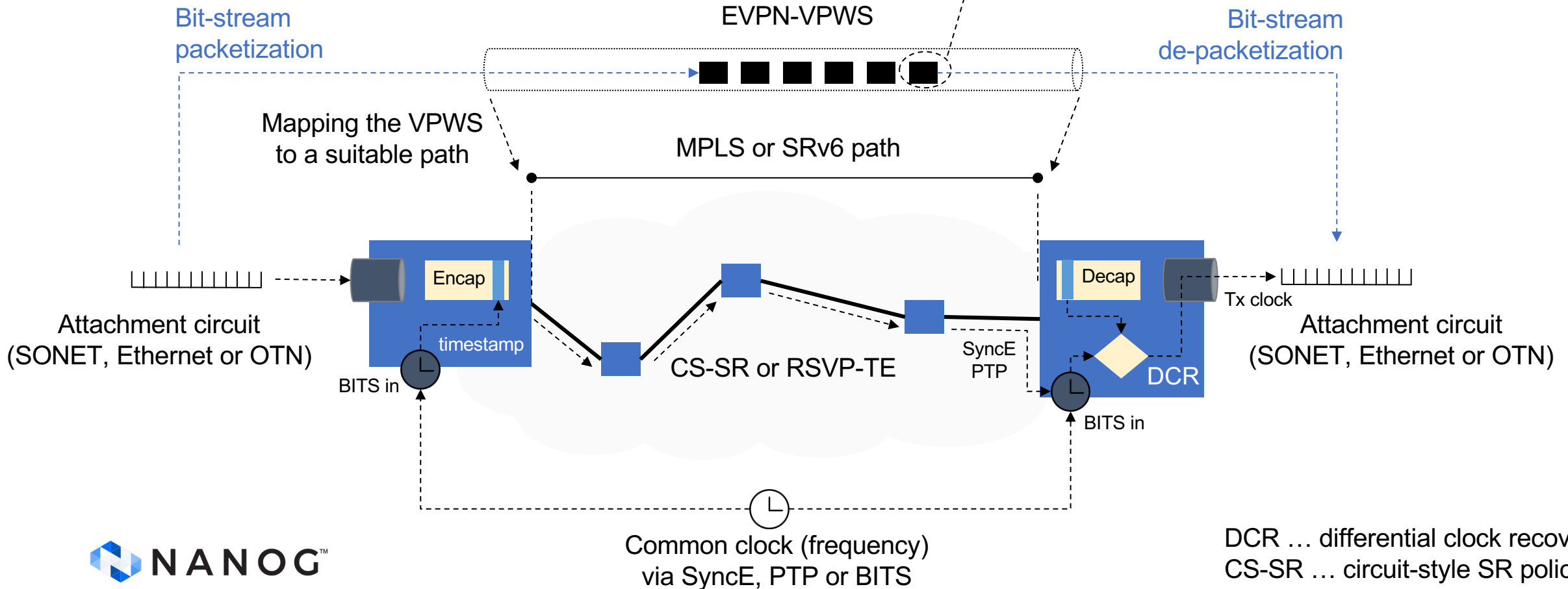


# Private Line Emulation (PLE)


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# Private Line Emulation (aka PLE)

structure agnostic emulation packet



# PLE payload types

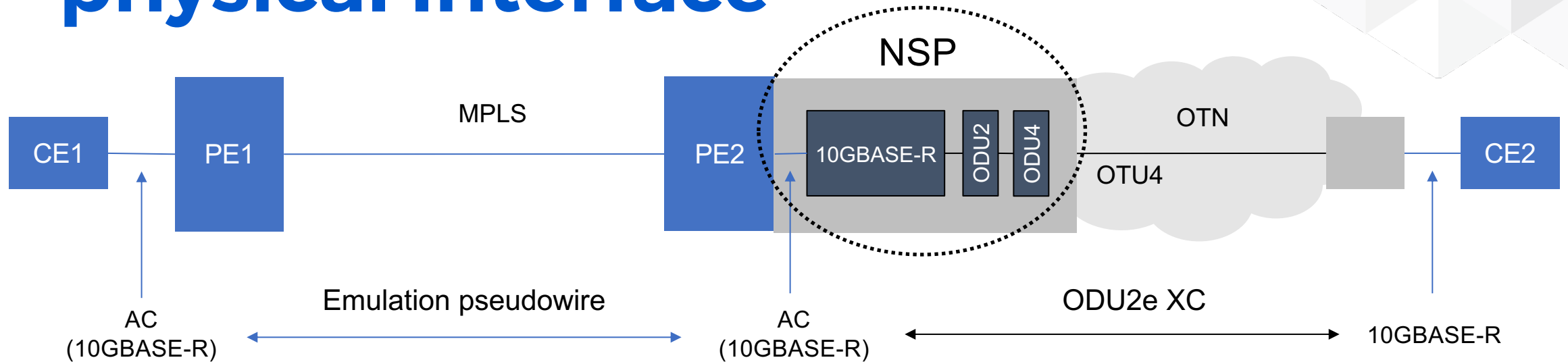


1Gbps

100Gbps

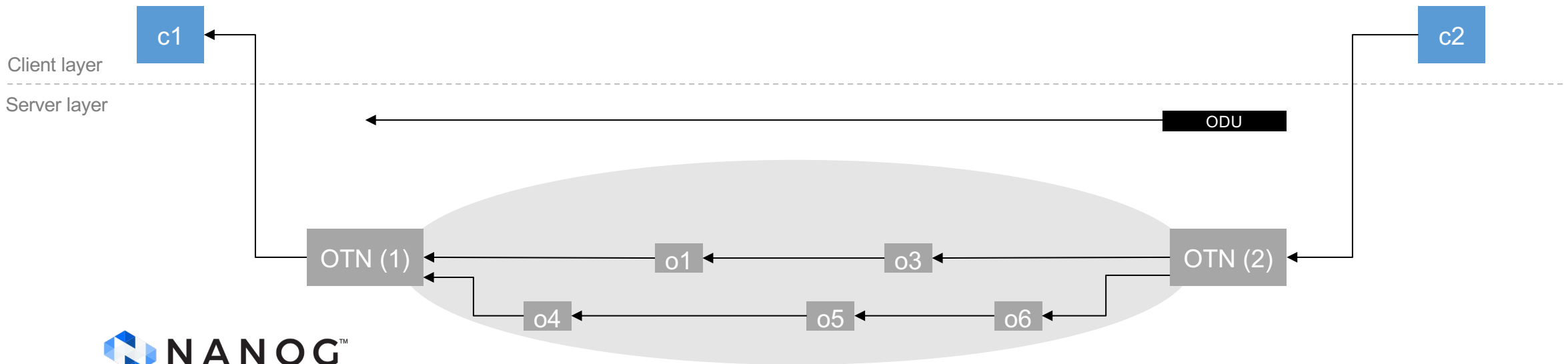
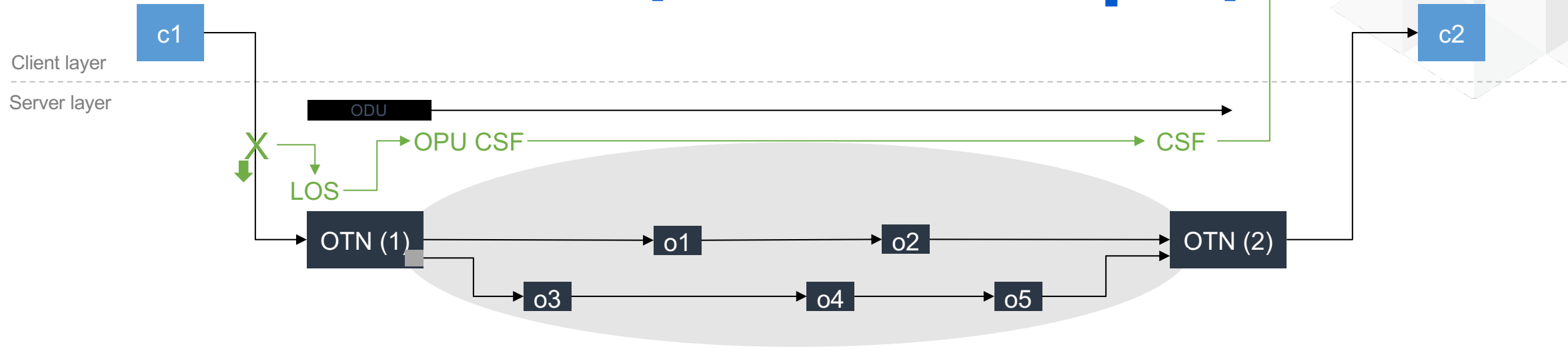
SONET/SDH	OTN	Ethernet	Fibre Channel
	ODU0	1GE	FC100
OC48/STM16	ODU1		FC200
			FC400
			FC800
OC192/STM64	ODU2/ODU2e	10GE	
			FC1600
			FC3200
	ODU4	100GE	

# Emulation is independent of the physical Interface

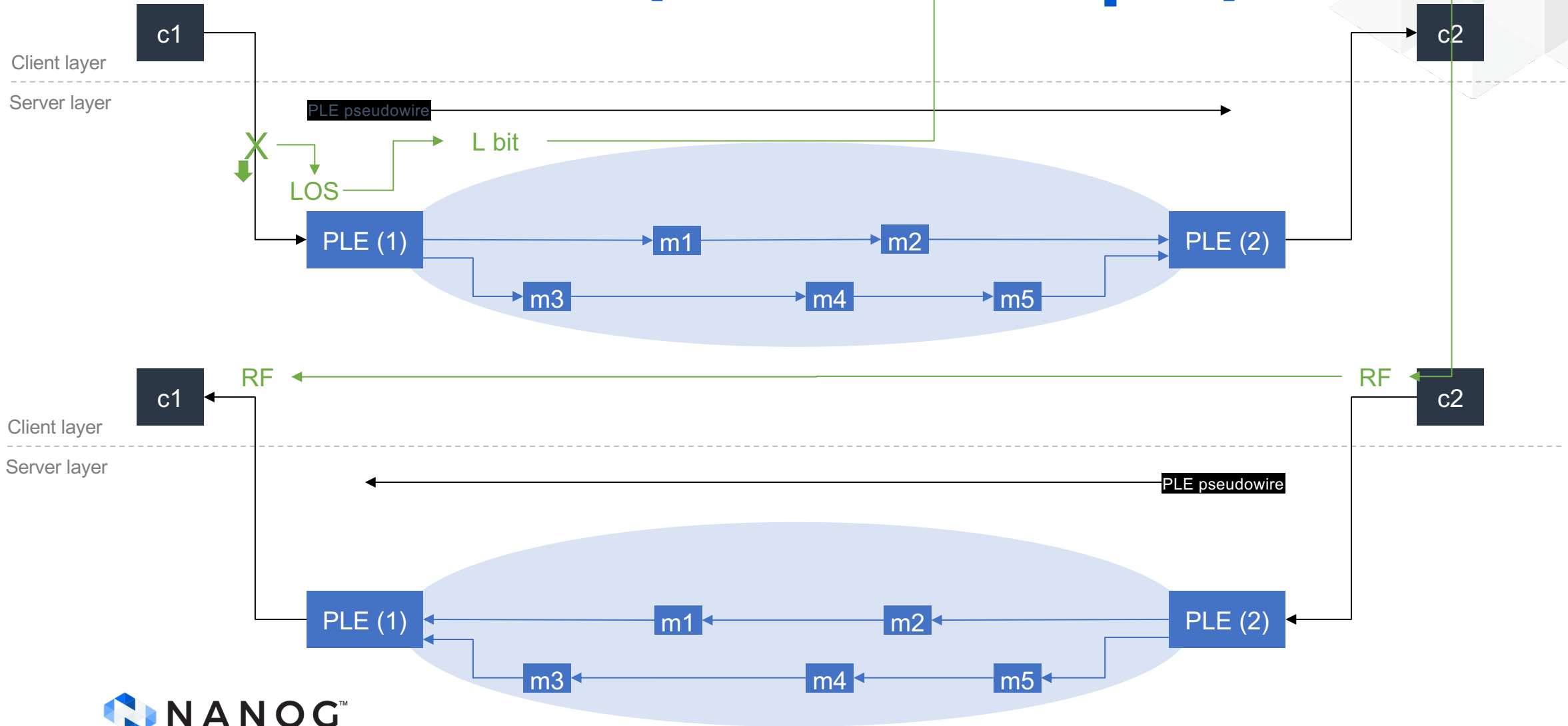


- Similar to SAToP (RFC 4553) the structure agnostic attachment circuit is independent from the physical port type
- It can either be a physical ethernet port or ODU2e mapped “logical” 10GE port inside a 100Gbps OTU4 interface extracted by the **native service processing (NSP)** function

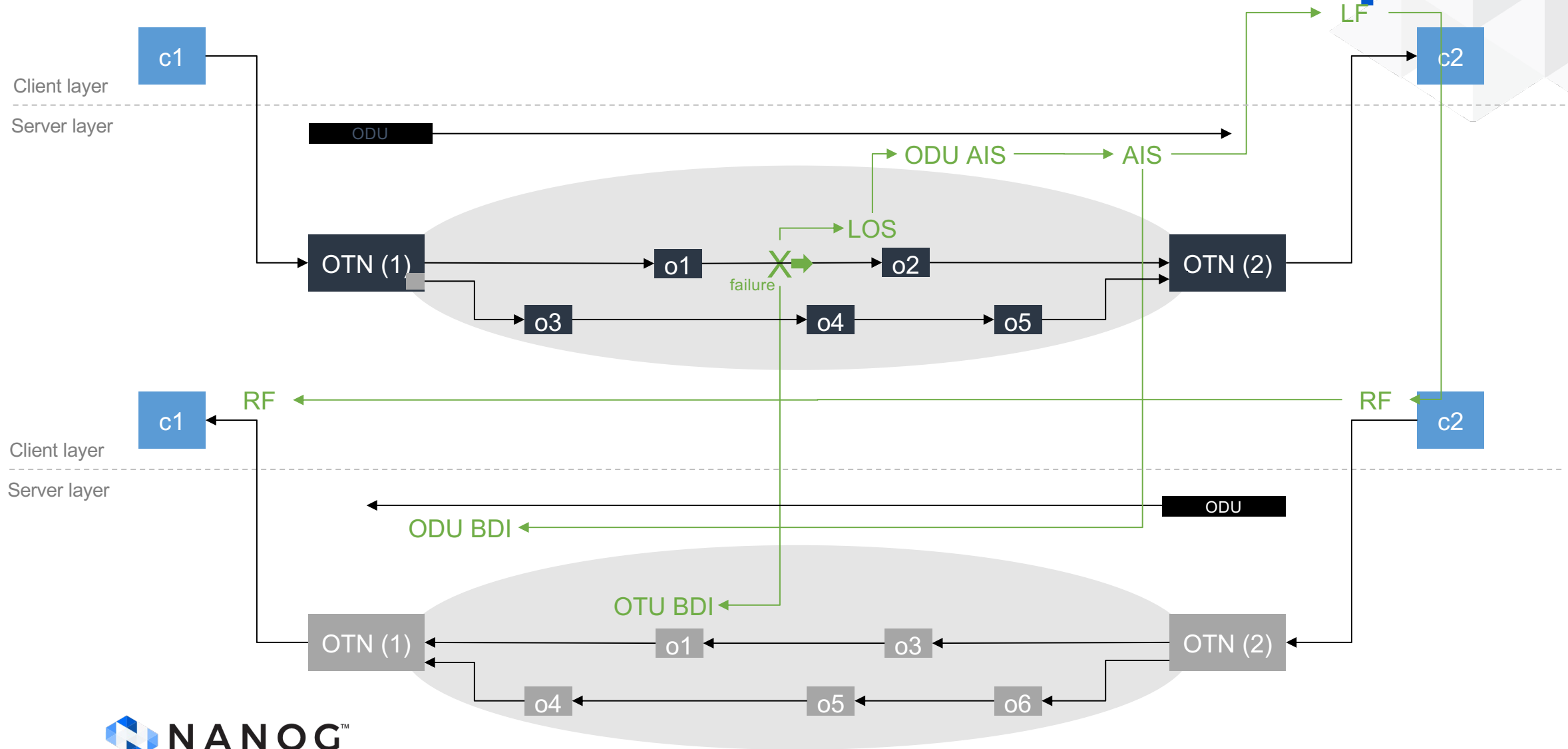
# Client failure (10GE example)



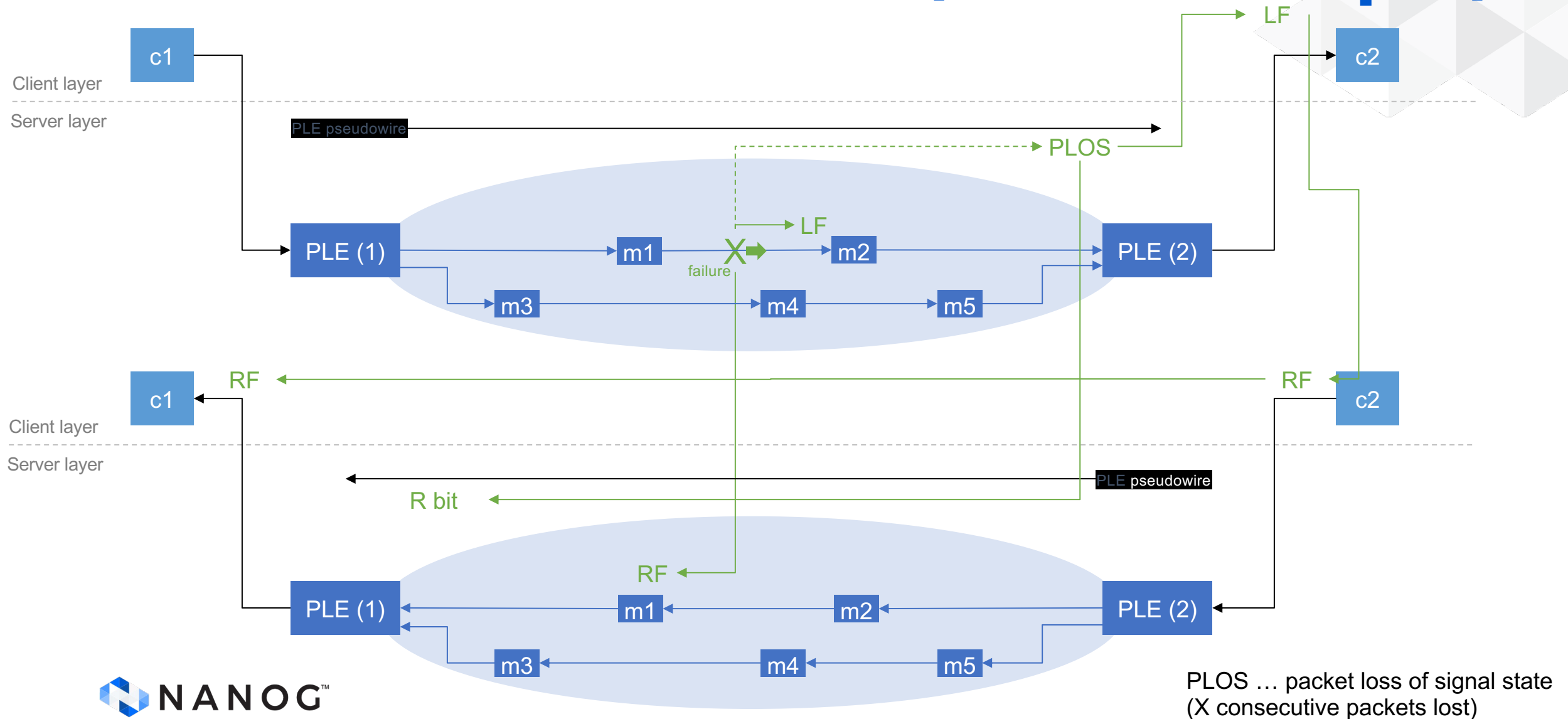
# Client failure (10GE example)



# OTN network failure (10GE example)



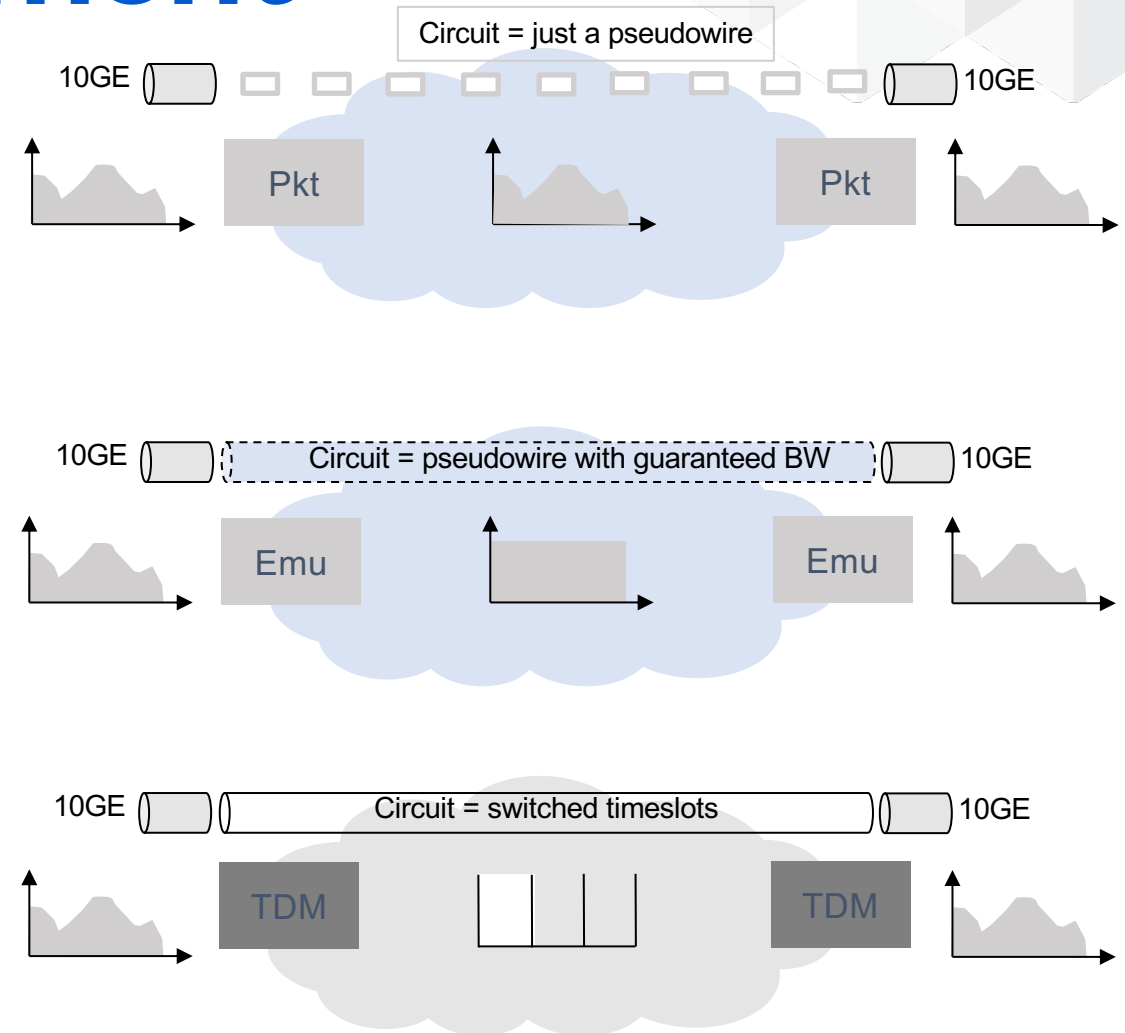
# MPLS network failure (10GE example)





# Emulation driving need for bandwidth commitment

- Native packet transport
  - Bandwidth only consumed when customer is sending data
  - Allows for multiple traffic classes and forwarding behaviors
- Emulation
  - Bit transparency
  - Constant network load
- TDM transport
  - Static timeslot allocation



# PLE Use Cases

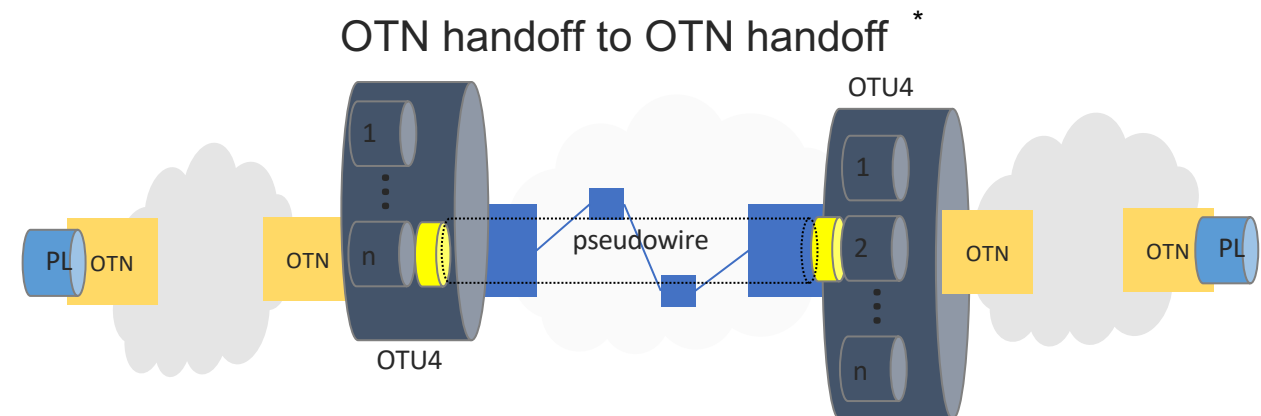
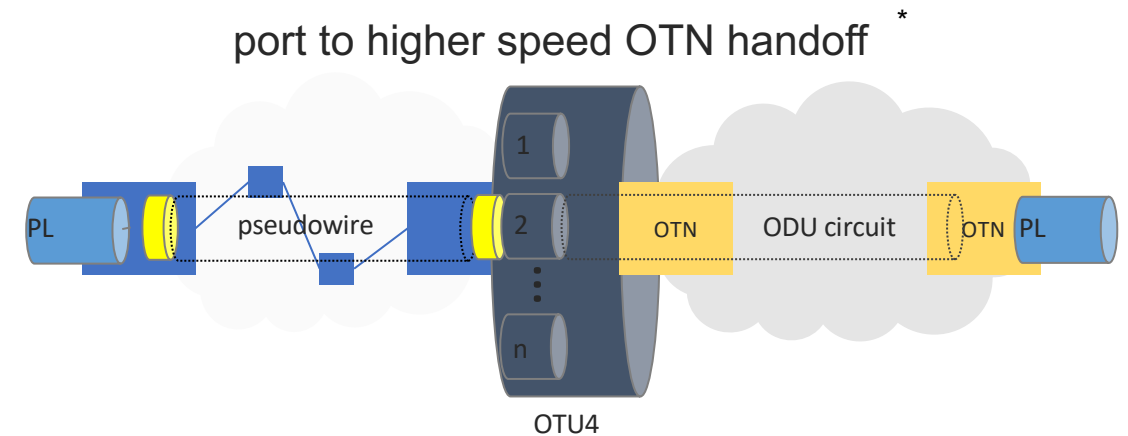
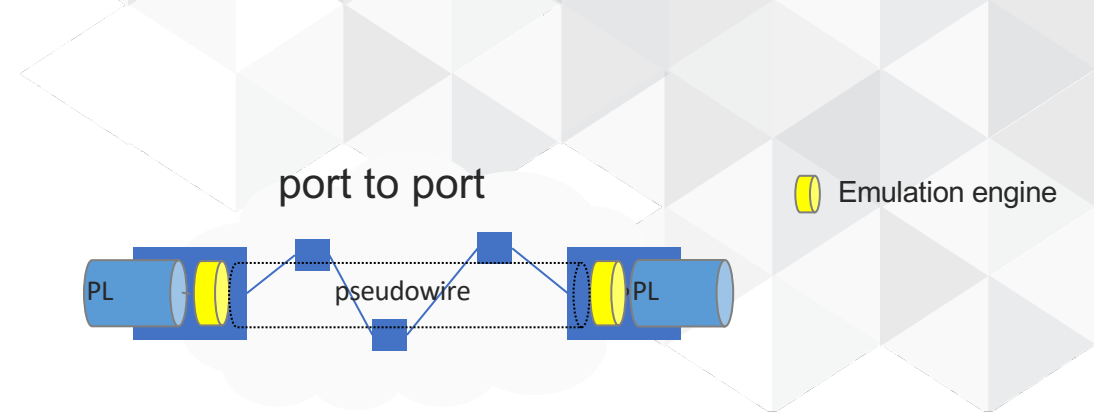
Both endpoints in the PLE domain  
simple client to client PLE PWs  
port based

One endpoint in an OTN domain

Channelized OTN interface  
OTN / PLE gateway (interworking) function  
ODU termination and native PLE transport

Both endpoints in OTN domains

Channelized OTN interface  
Transparent ODU transport



# Addressing Common Misconceptions



**Resiliency:** PLE offers more Protection and Protection Switching capabilities than traditional OTN Networks

**Transparency:** PLE is bit transparent

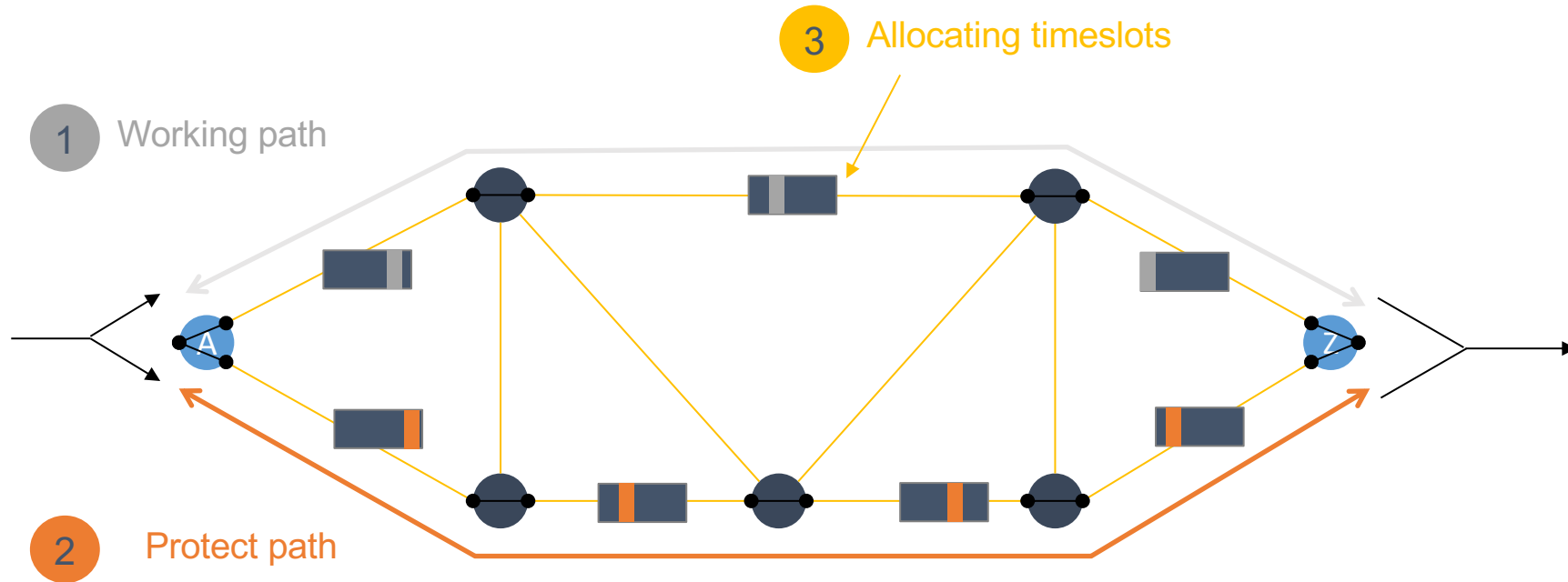
**Latency:** Router Latency are similar to traditional OTN Networks

**OAM&P:** Advanced toolsets offer broader automation, management, and

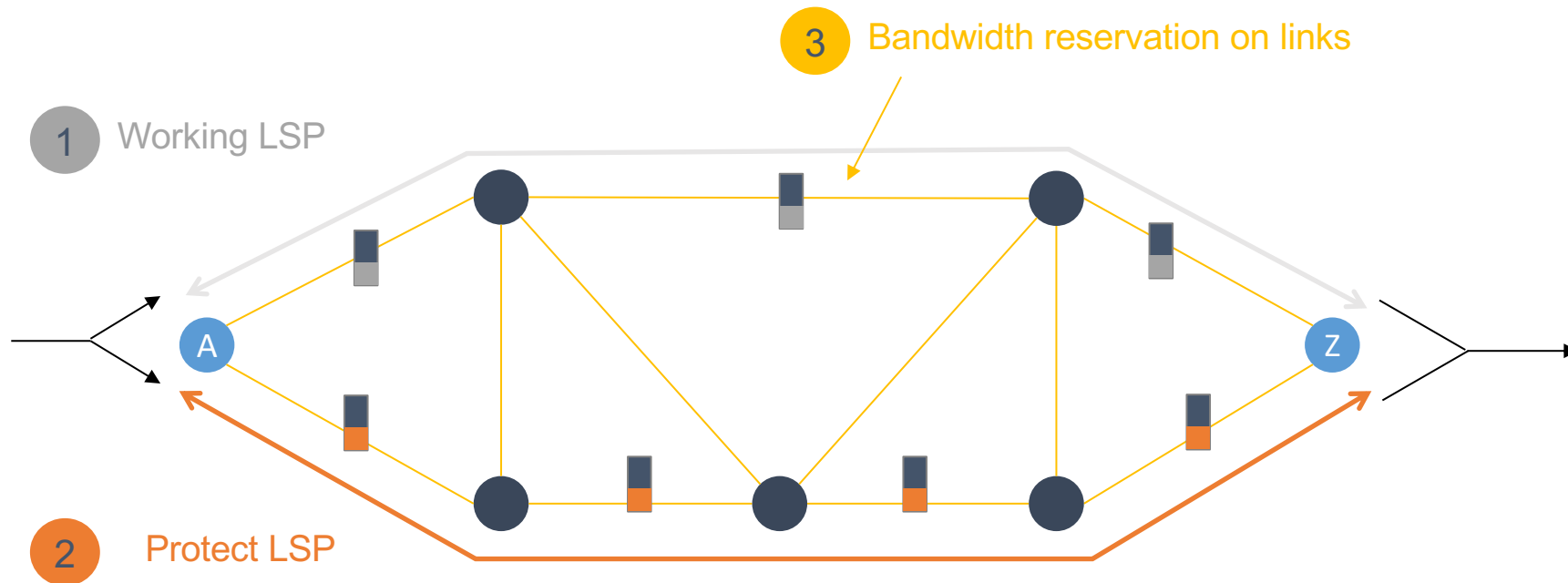
# Circuit-Style Segment Routing (CS-SR)

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# TDM = Timeslots & series of cross connects



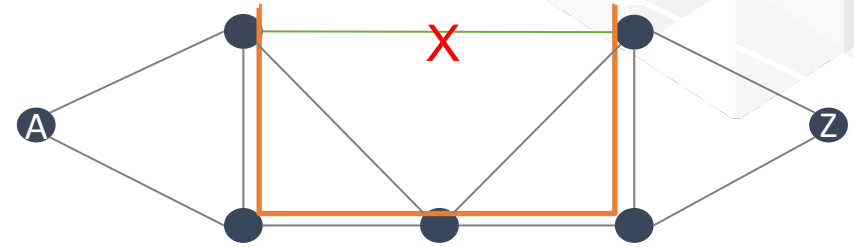
# Path protected, co-routed, bi-directional LSPs



# Why do protection schemes matter?

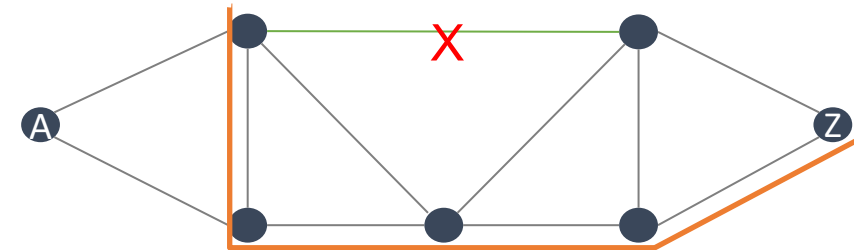
## MPLS-TE FRR

Local bypass protection, without bandwidth allocated



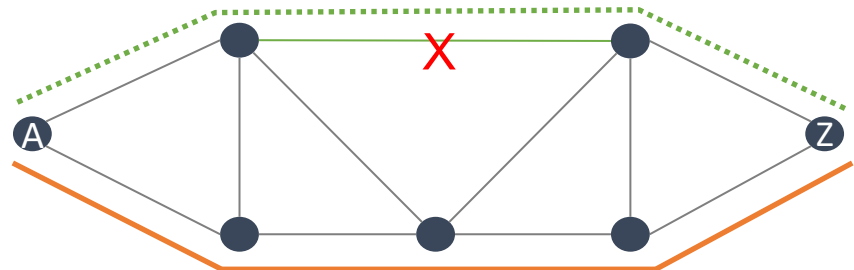
## Loop Free Alternate (LFA)

Post convergence path, without bandwidth allocated



## Path Protection

pre-allocated bandwidth end2end

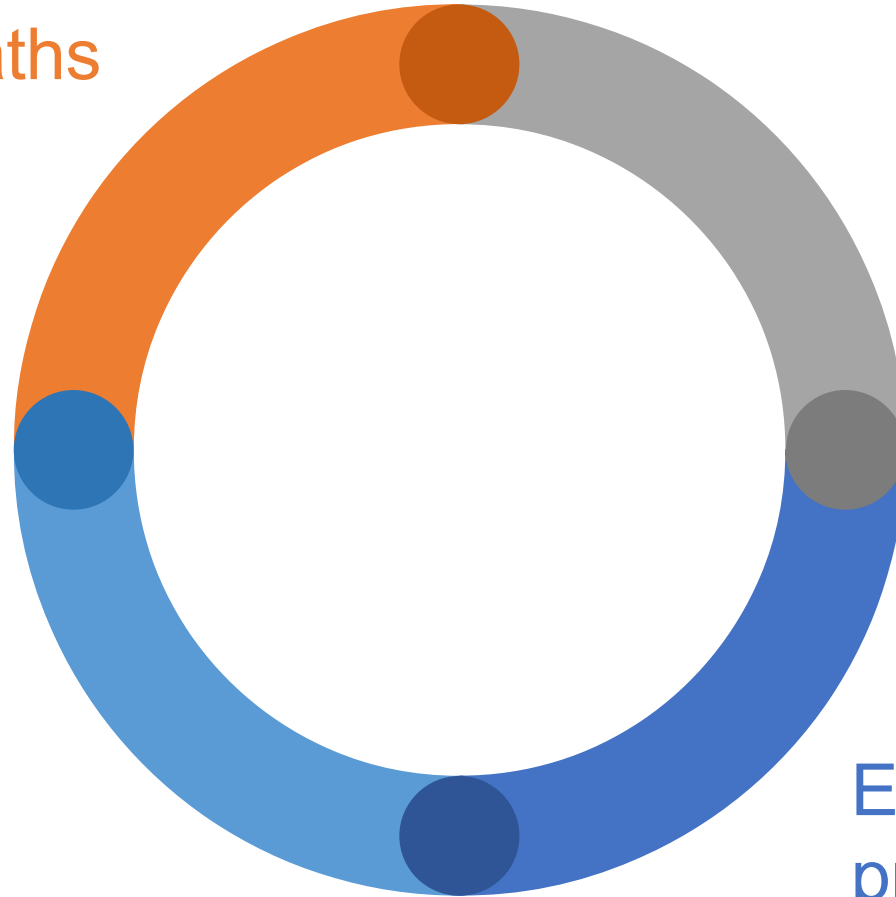


Each scheme does require a different capacity planning strategy !

# Circuit-Style Segment Routing (CS-SR)

## Traffic engineered paths

- bidirectional
- co-routed
- persistent



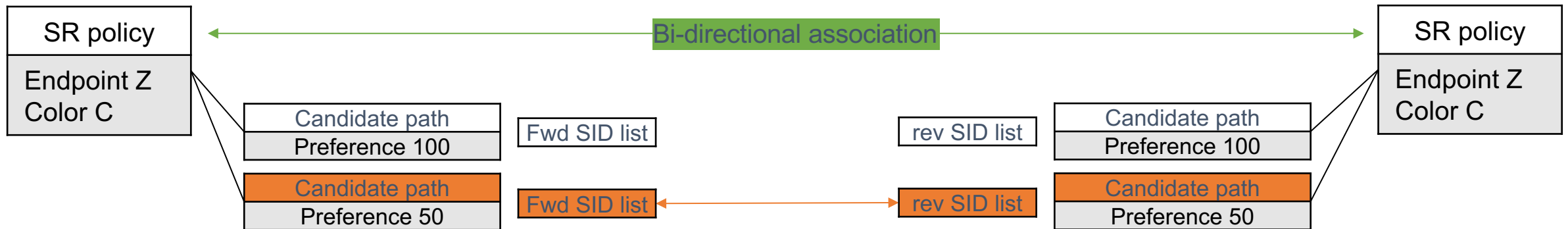
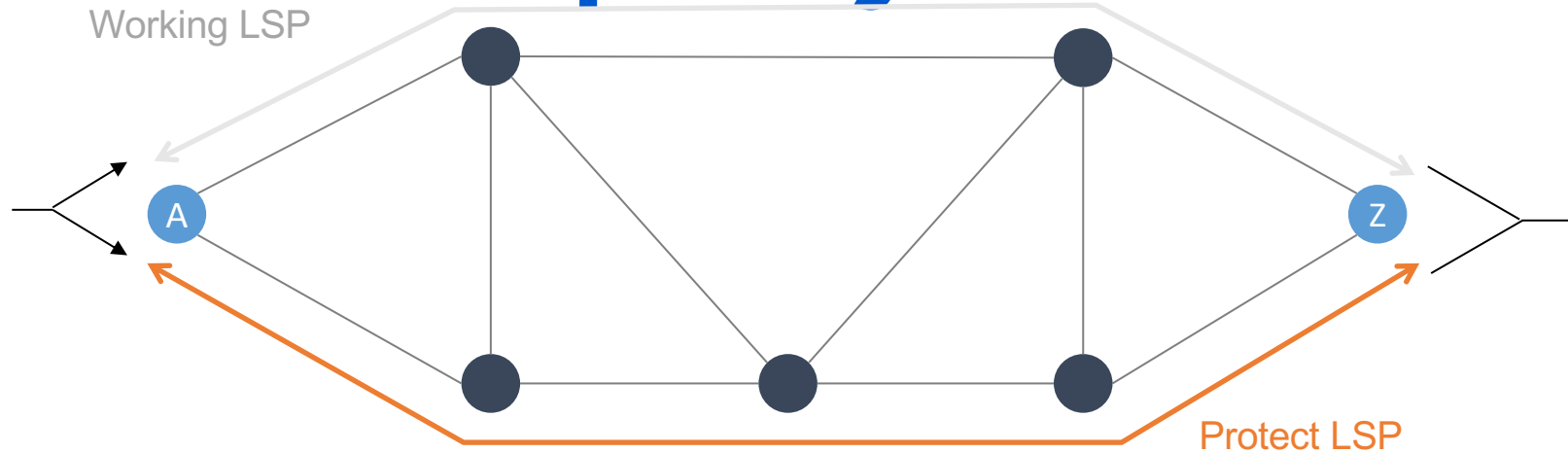
Strict bandwidth  
commitment

Path OAM

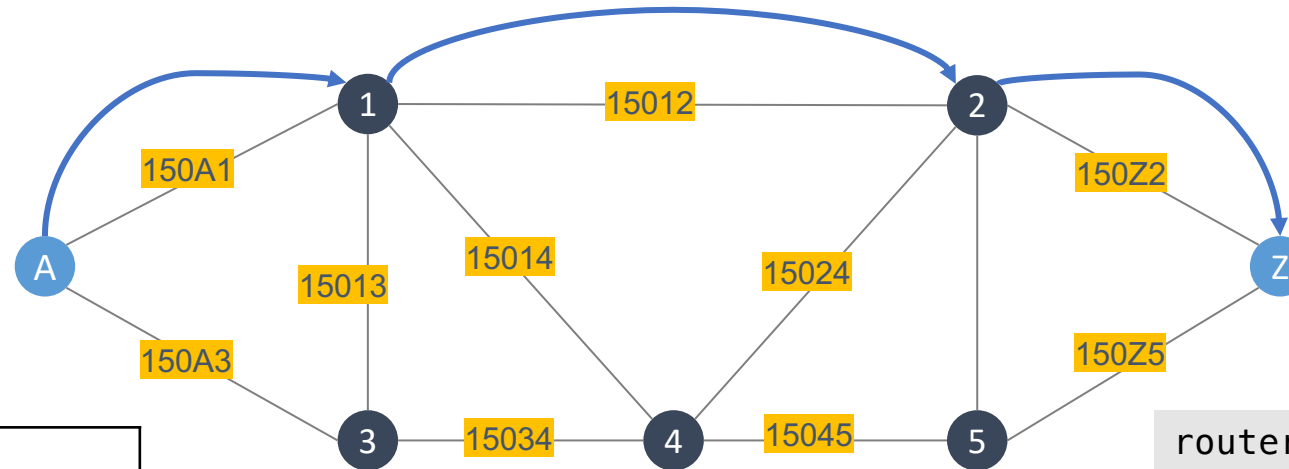
End-to-end path  
protection & restoration



# Path protected, co-routed, bi-directional SR policy



# Deterministic and persistent SR paths

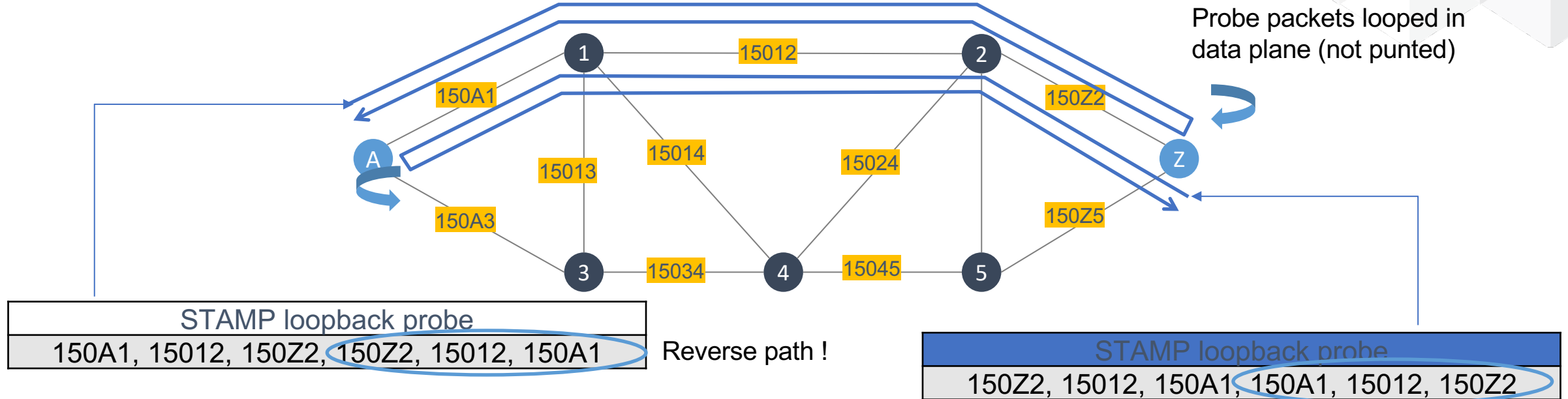


segment list
150A1, 15012, 150Z2

```
router isis core
...
interface HundredGigE0/0/2/0
...
address-family ipv4 unicast
...
adjacency-sid absolute 15012
```

- Strict list of adjacency SIDs → no ECMP
- Manual adjacency SIDs → persistent across node reloads
- Unprotected adjacency SIDs → no traffic rerouting due to TI-LFA

# Candidate path connectivity verification (liveness)



- Simple TWAMP enabling liveness and performance measurement (loss and delay)
- Candidate path is up as soon as single probe packet was received
- Candidate path is declared down when N consecutive probe packets are lost
- Due to loopback mode, also unidirectional failures are detected by both endpoints

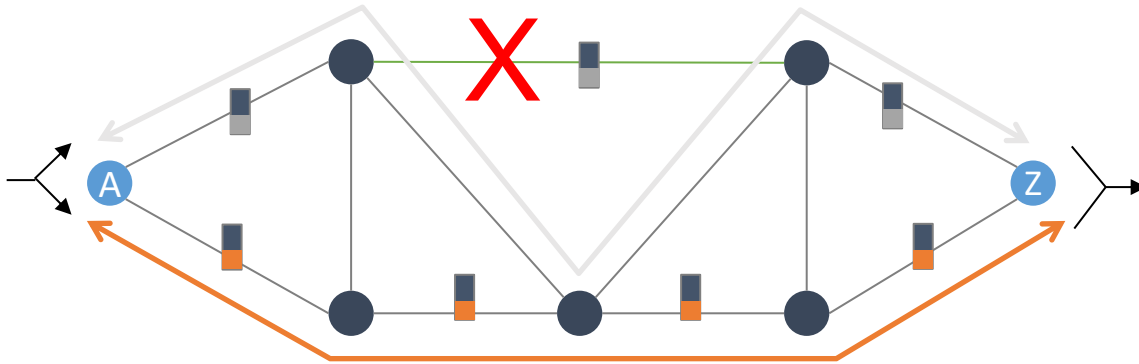
# Persistency

Classic TE behavior



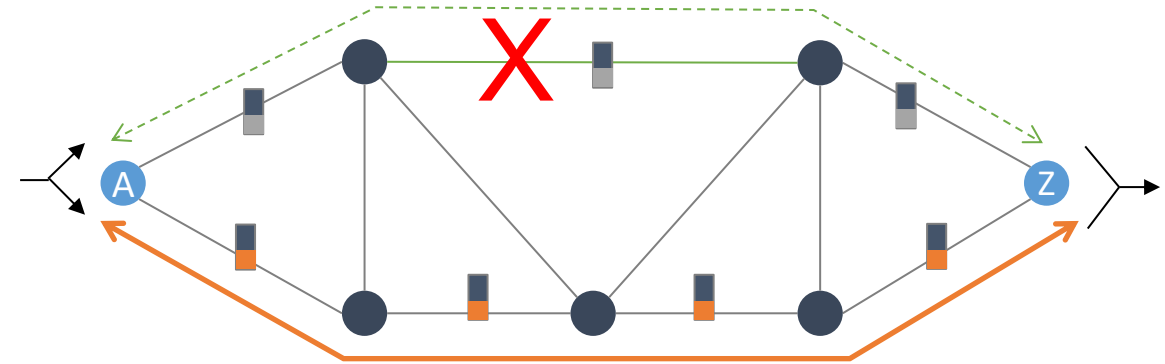
Transport expectation

1' NEW Working LSP



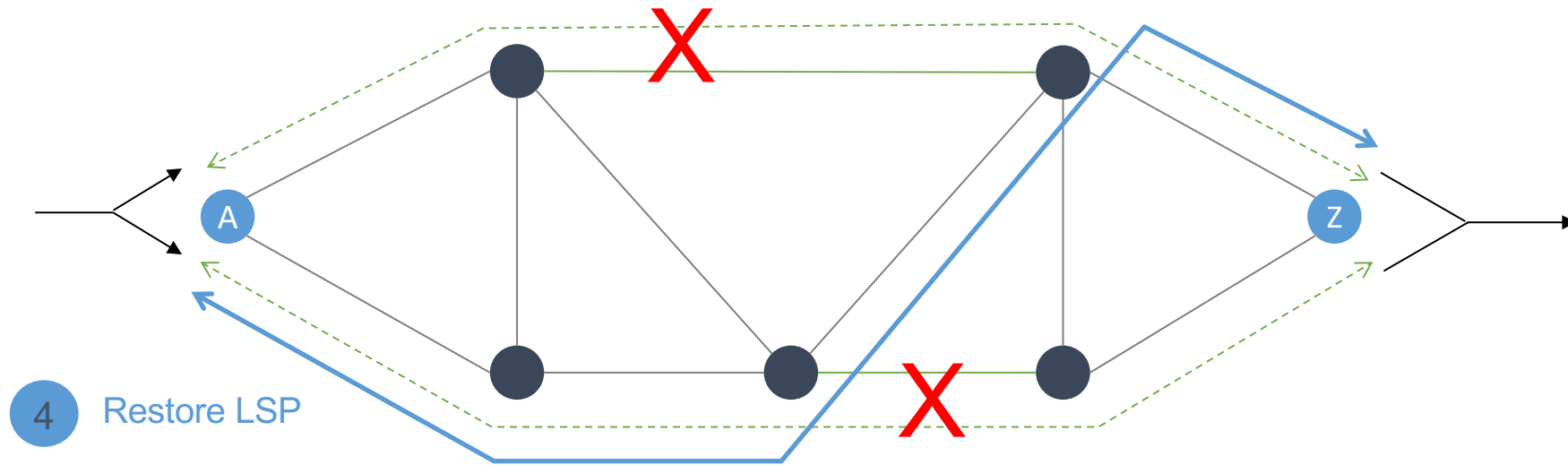
2 Protect LSP

1 Working LSP (stays DOWN)

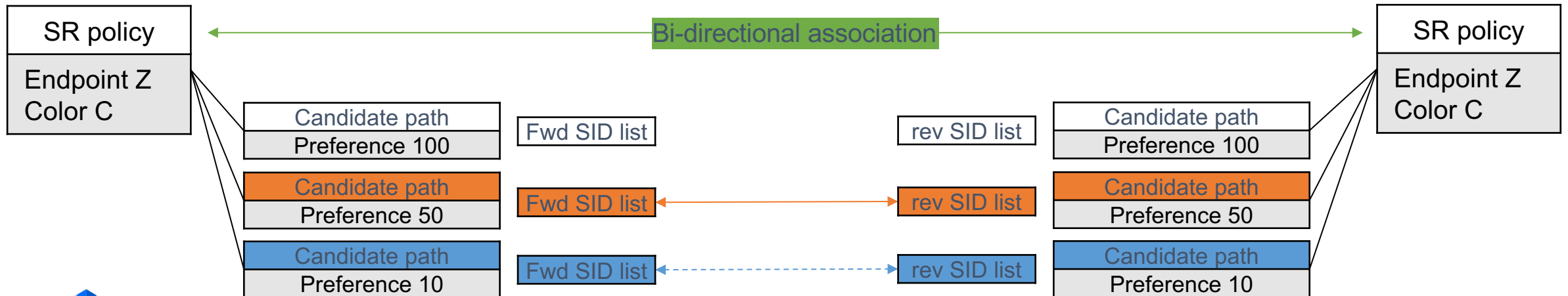
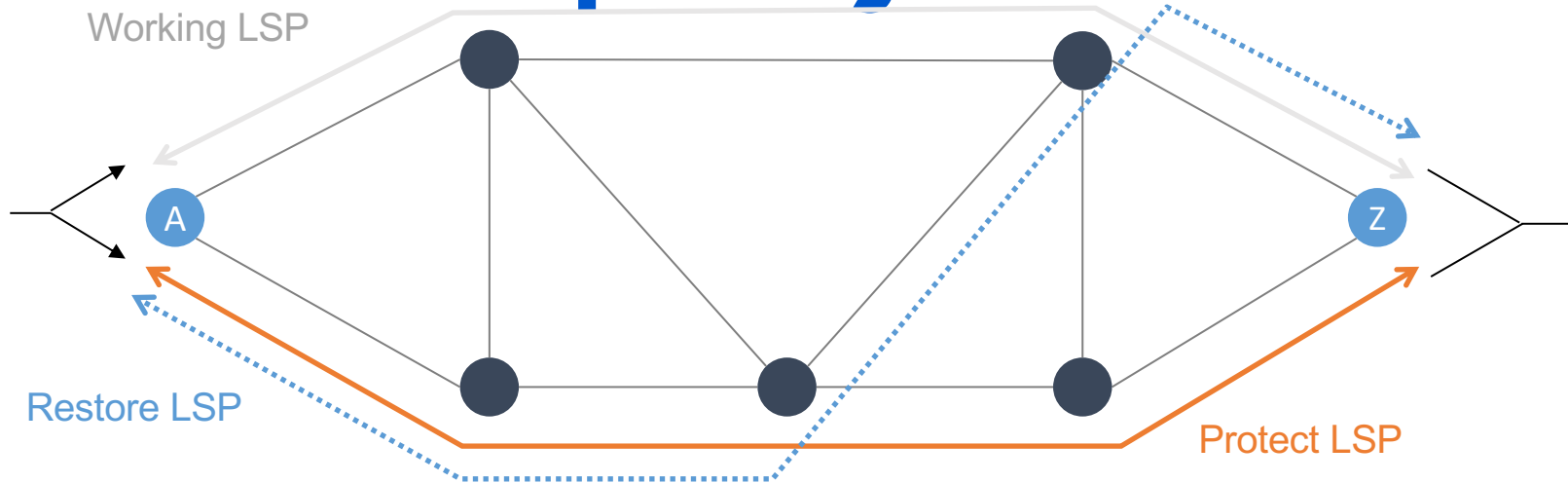


2 Protect LSP

# Restoration to handle double-failures

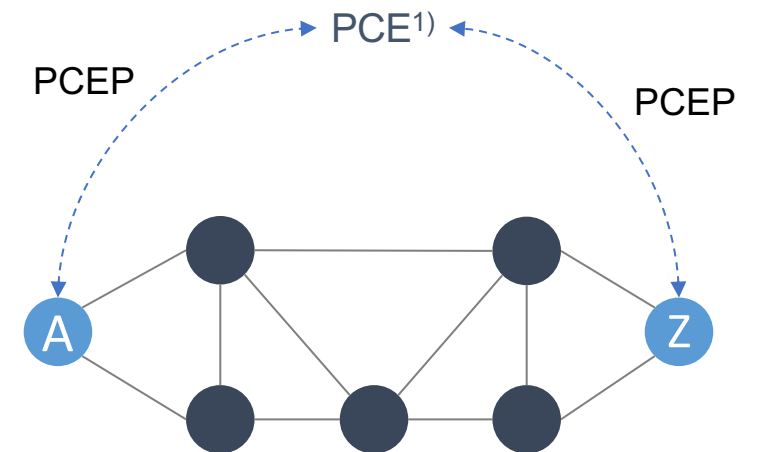
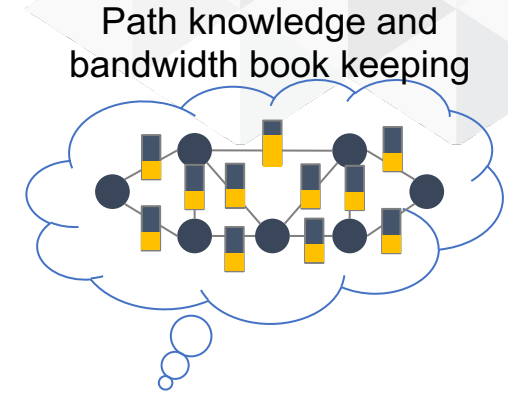


# Path protected, co-routed, bi-directional SR policy



# PCC-initiated CS-SR policy creation

- A SR policy is configured on both endpoints
- Each endpoint requests a path via PCEP from a central PCE
  - Common bi-directional association
  - Required bandwidth
  - Path constraints
- The central PCE maintains a real time view of
  - The network topology (BGP-LS)
  - All path/bandwidth requests (PCEP)



1) Cisco Crosswork Optimization Engine (COE)

# Summary

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# Putting it all into perspective

## PLE

- Bit transparent (100% control protocol transparent)
- Provider independent SyncE
- Multi-protocol (TDM, FibreChannel)
- No MTU limits

## EVPN-VPWS

- No special hardware required
- Most cost effective
- No bandwidth consumption during idle
- Limited MTU

## Circuit-style SR (CS-SR)

- Guaranteed bandwidth
- persistent, co-routed, bi-directional paths
- 1:1 End-to-end path protection and restoration

## SR

- ECMP
- TI-LFA
- Scale & Simplicity



# Thank you

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