



Interworking and Operational Considerations for Deployment of the GMPLS Technology

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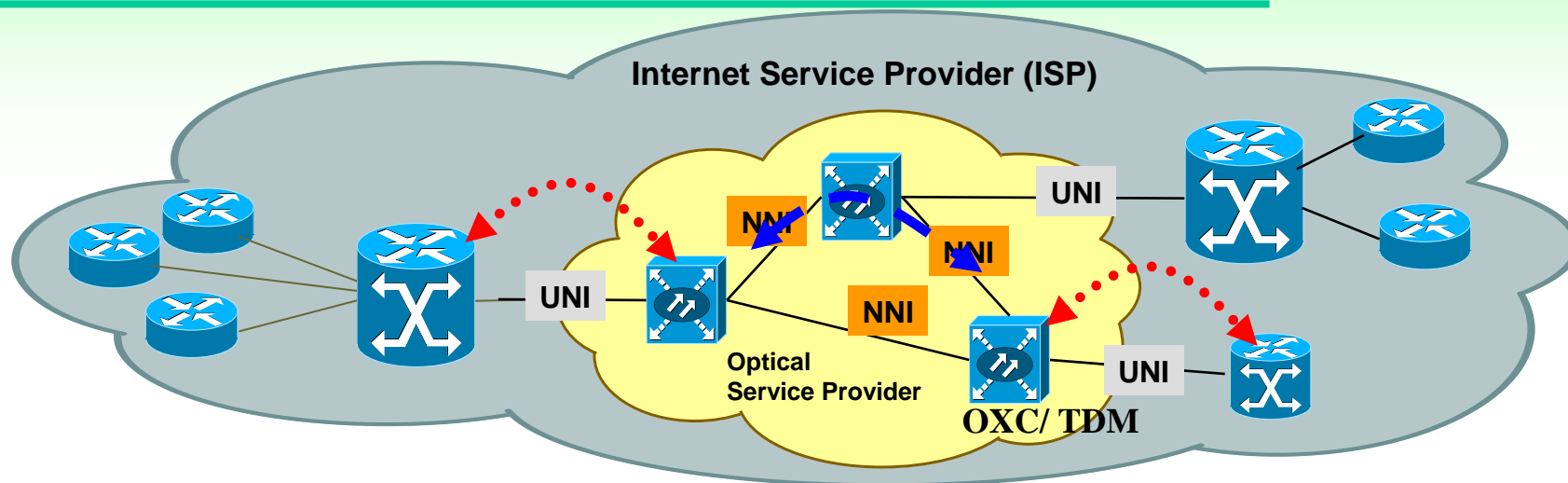
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Agenda

- Overview of the Service Models
- MPLS/ GMPLS Signaling interworking
- Static vs. Signaling Triggered Dynamic FA-LSPs
- MPLS/ GMPLS LSP Priority Mapping
- Service Migration Aspects

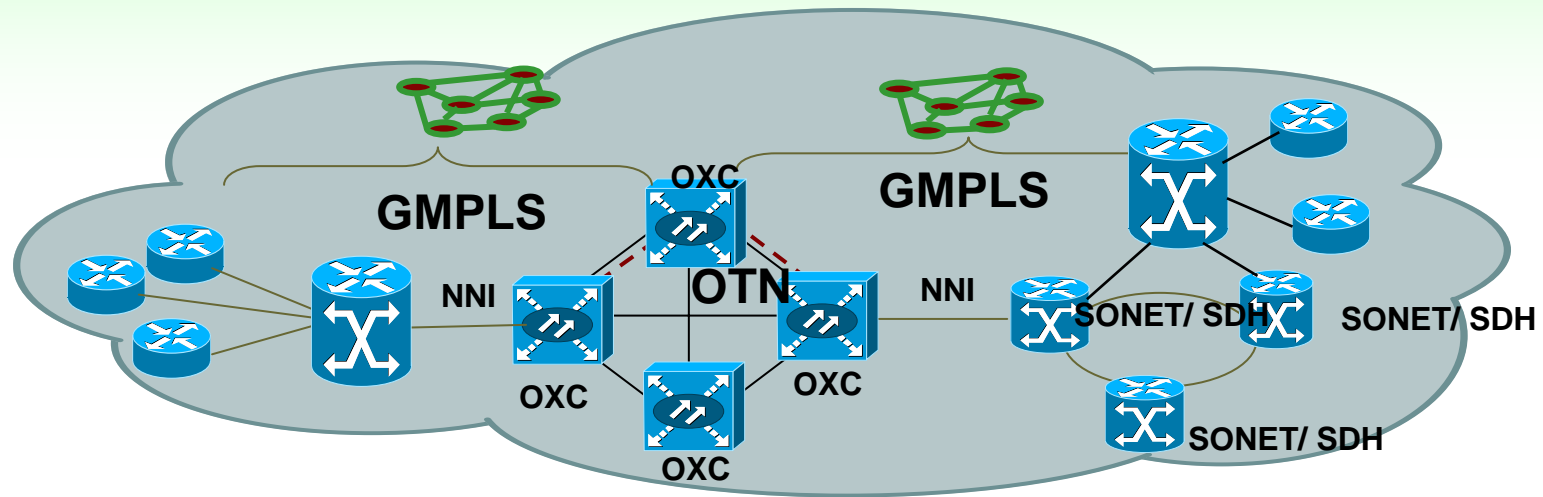
Overview of the Service Models: Overlay Model



- **Two Administrative Domains**
 - Optical Transport Network (OTN)
 - Internet Service Provider (ISP)
- **No Exchange of Routing/Topology Information between OTN and Client Networks**
 - Routers do not see optical transport topology and vice-versa.

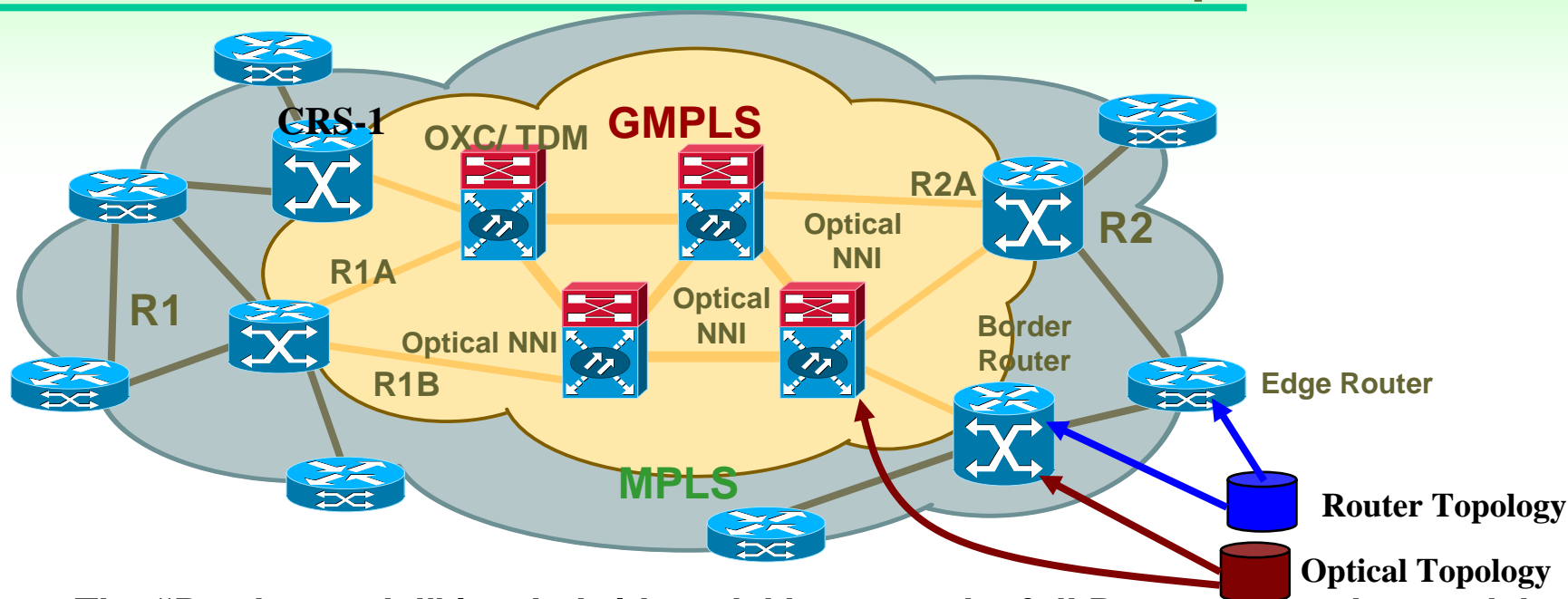
ISP Requests Circuits via UNI Interface

Overview of the Service Models: Full Peer Model



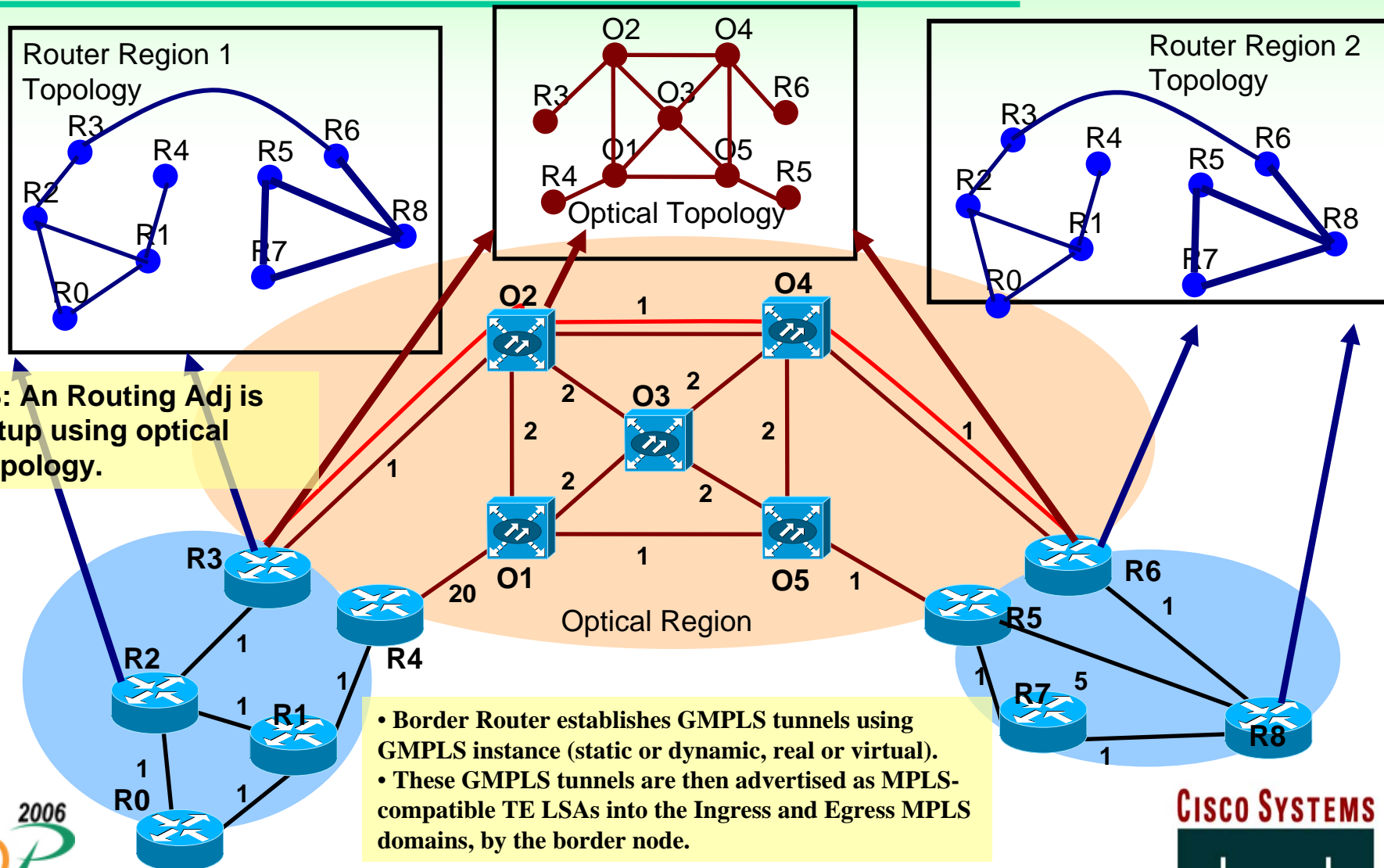
- **Routers and Optical Transport Nodes in same network - act as peers**
- **Single instance of a control plane for addressing, routing, signaling, etc.**
- **More efficient interaction between IP and OTN nodes for faster provisioning and optimal path selection.**
- **Applicable to single administrative domain.**

Overview of the Service Models: Border Peer Model - A Sweet Spot

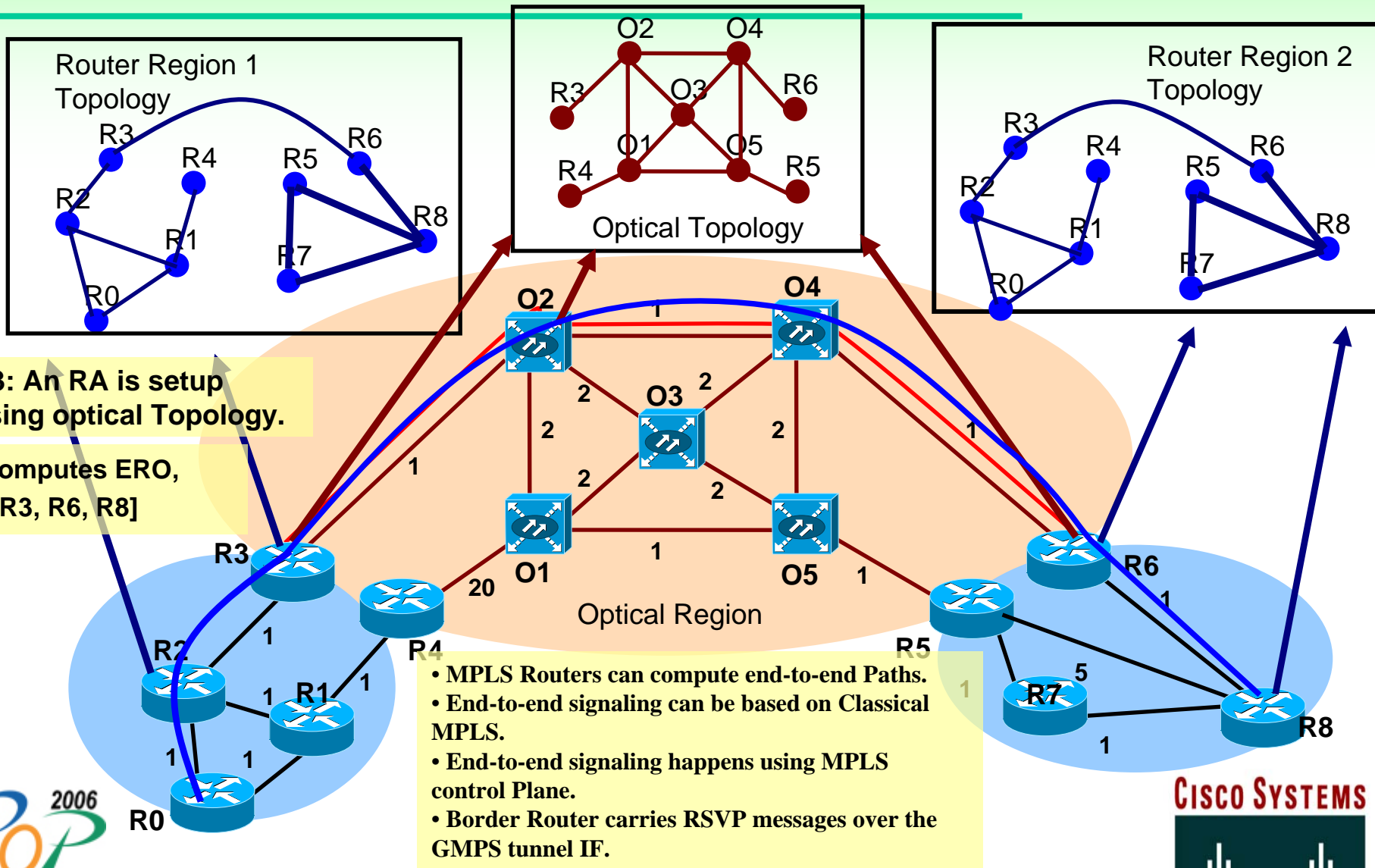


- The “Border model” is a hybrid model between the full Peer and Overlay models.
- Border Routers receive routing information from the optical devices as well as routers.
- Border router keeps the optical and router domain topology information in separate routing tables.
- No routing information from the router region is carried into the optical region.

MPLS/ GMPLS Signaling Interworking: Routing Interworking



MPLS/ GMPLS Signaling Interworking: Signaling Interworking



Static vs. Signaling Triggered Dynamic FA-LSPs: Definitions

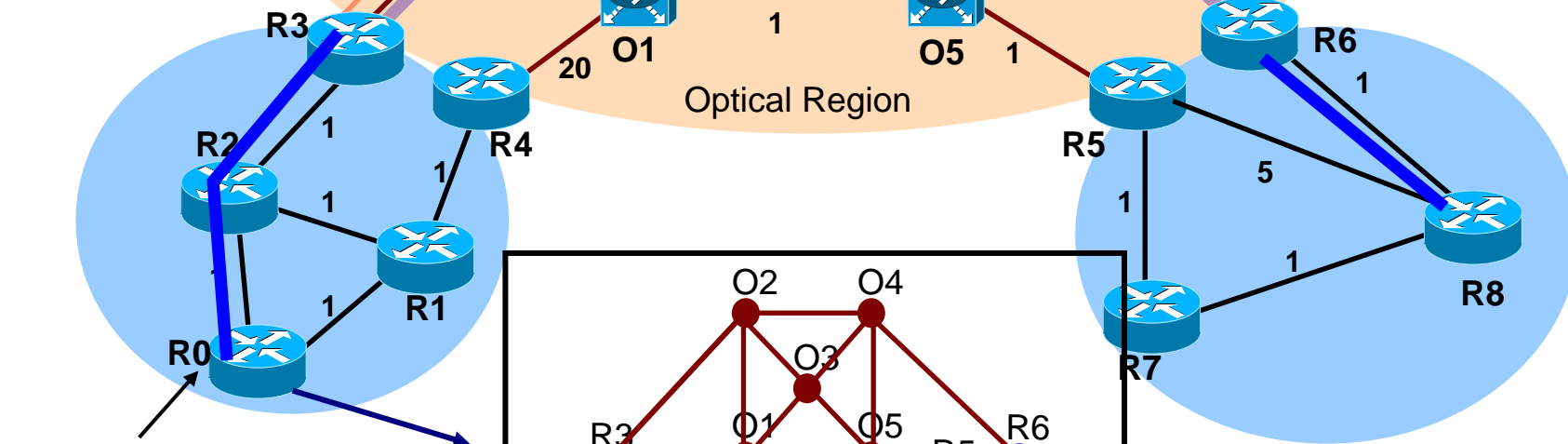
- MPLS Signaling Triggered (aka Dynamic)
 - When MPLS LSP setup can trigger a GMPLS LSP.
- Non-MPLS Signaling Triggered (aka Static)
 - When GMPLS LSP setup cannot be triggered by MPLS LSP setup request.
 - Decision to establish new LSPs are made either by the operator or automatically.
 - If MPLS LSP setup request cannot be satisfied by existing FA-LSPs, it is rejected.

MPLS Signaling Triggered Setup in Full Peer Model

Once GMPLS LSP is setup, R3 continues with MPLS LSP Setup (Path over the PSC LSP).

Based on contents of ERO, R3 signals setup for GMPLS LSP.

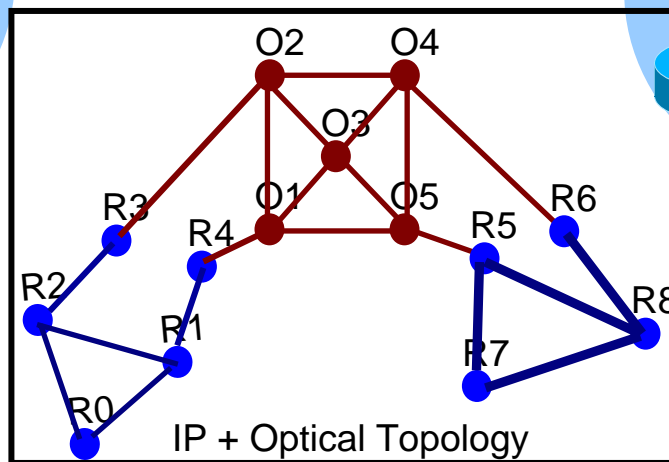
R6 continues setup of the MPLS LSP based on ERO contents.



R0 computes a complete heterogeneous Path.

Path message:

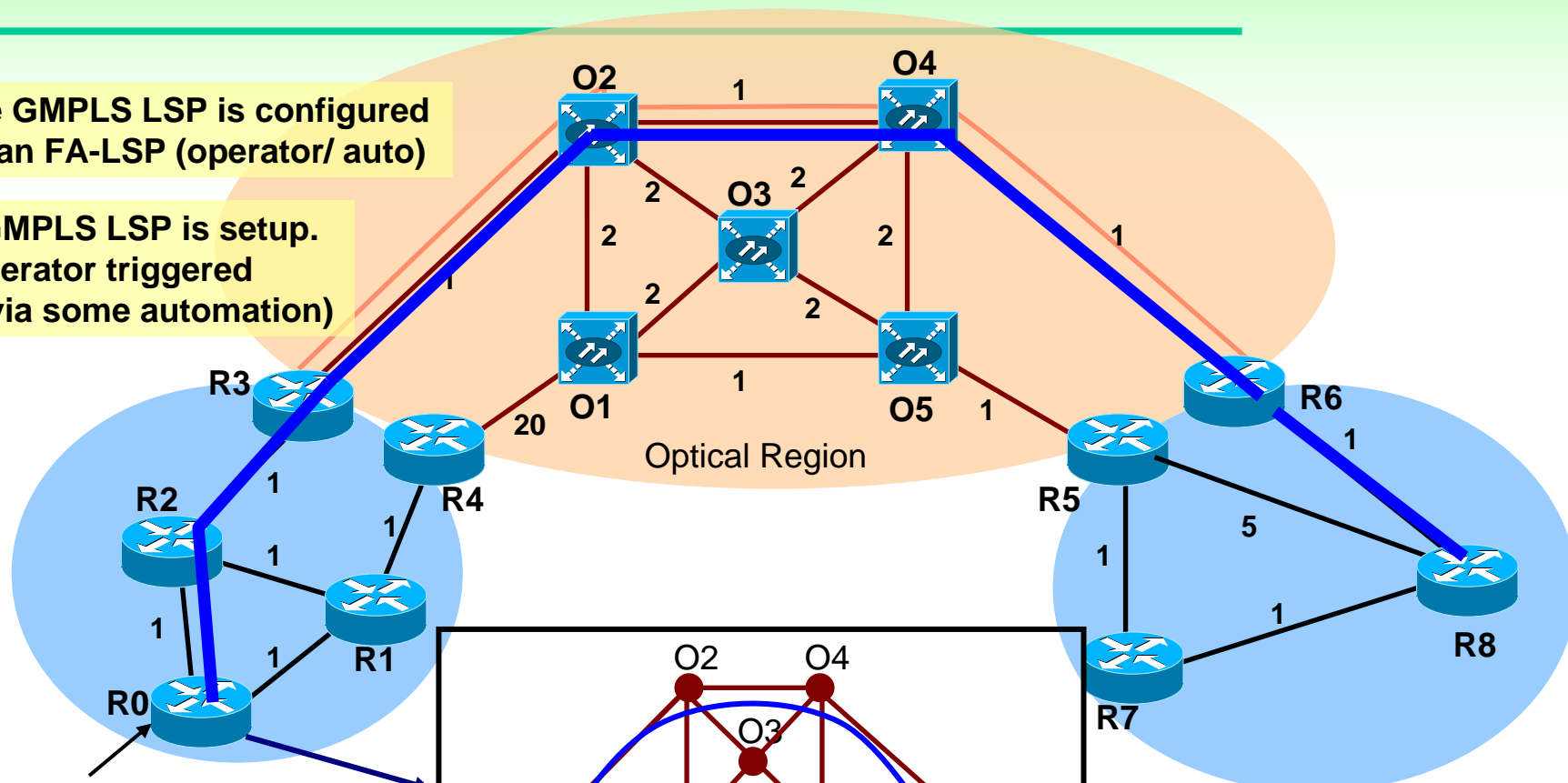
ERO: [R2, R3, O2, O4, R6, R8]



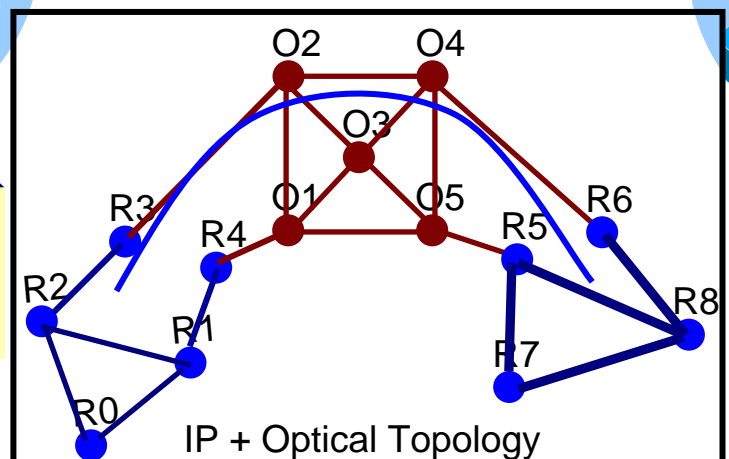
Non-MPLS Signaling Triggered Setup in Full Peer Model

The GMPLS LSP is configured As an FA-LSP (operator/ auto)

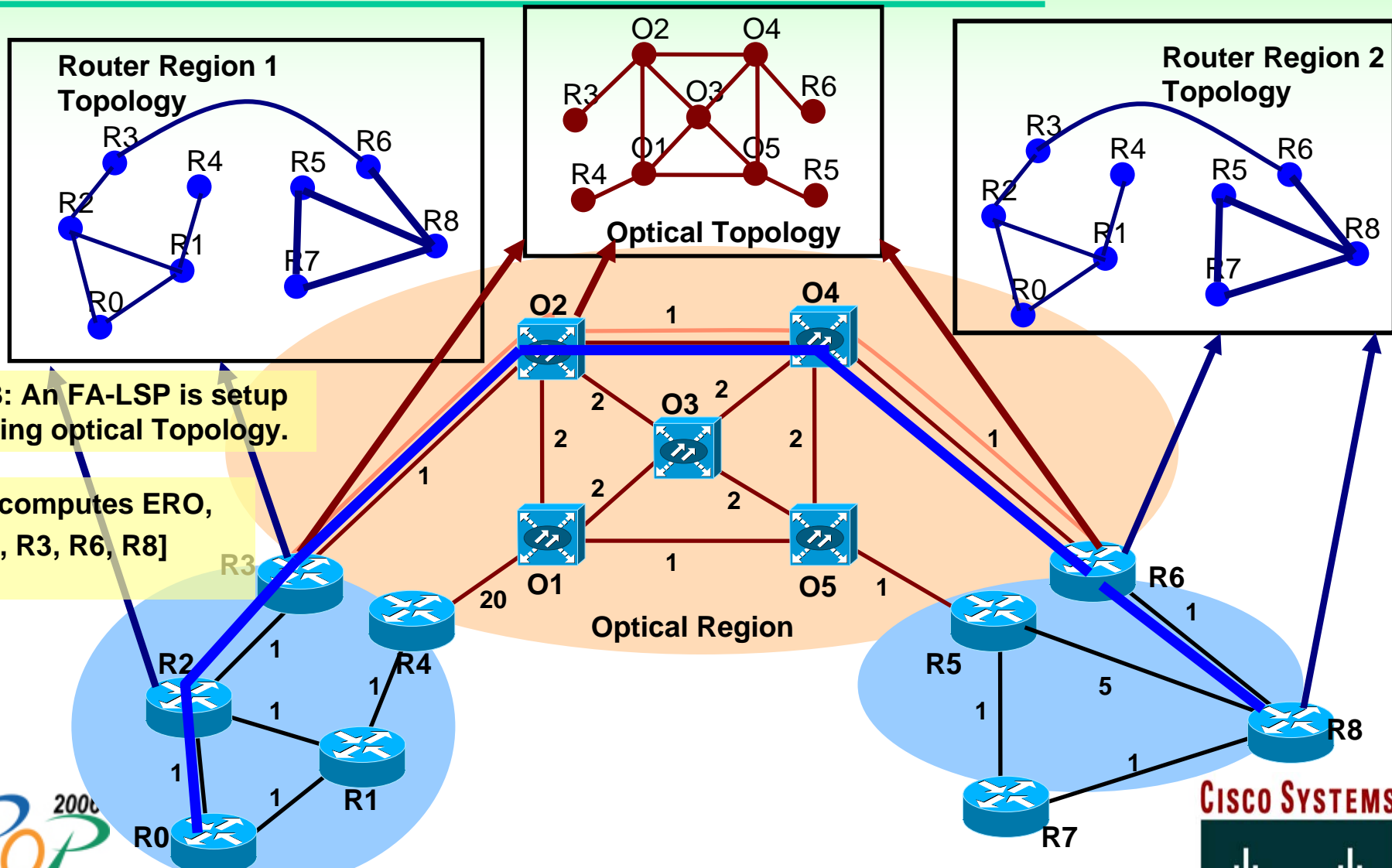
A GMPLS LSP is setup. (Operator triggered or via some automation)



R0 computes a complete Homogeneous Path.
Path msg: ERO: [R2, R3, R6,



Non-MPLS Signaling Triggered Setup in Border Peer Model



R3: An FA-LSP is setup using optical Topology.

R0 computes ERO, [R2, R3, R6, R8]

MPLS Signaling Triggered Setup in Border Peer Model

This procedure is equally applicable to inter-area and inter-AS case

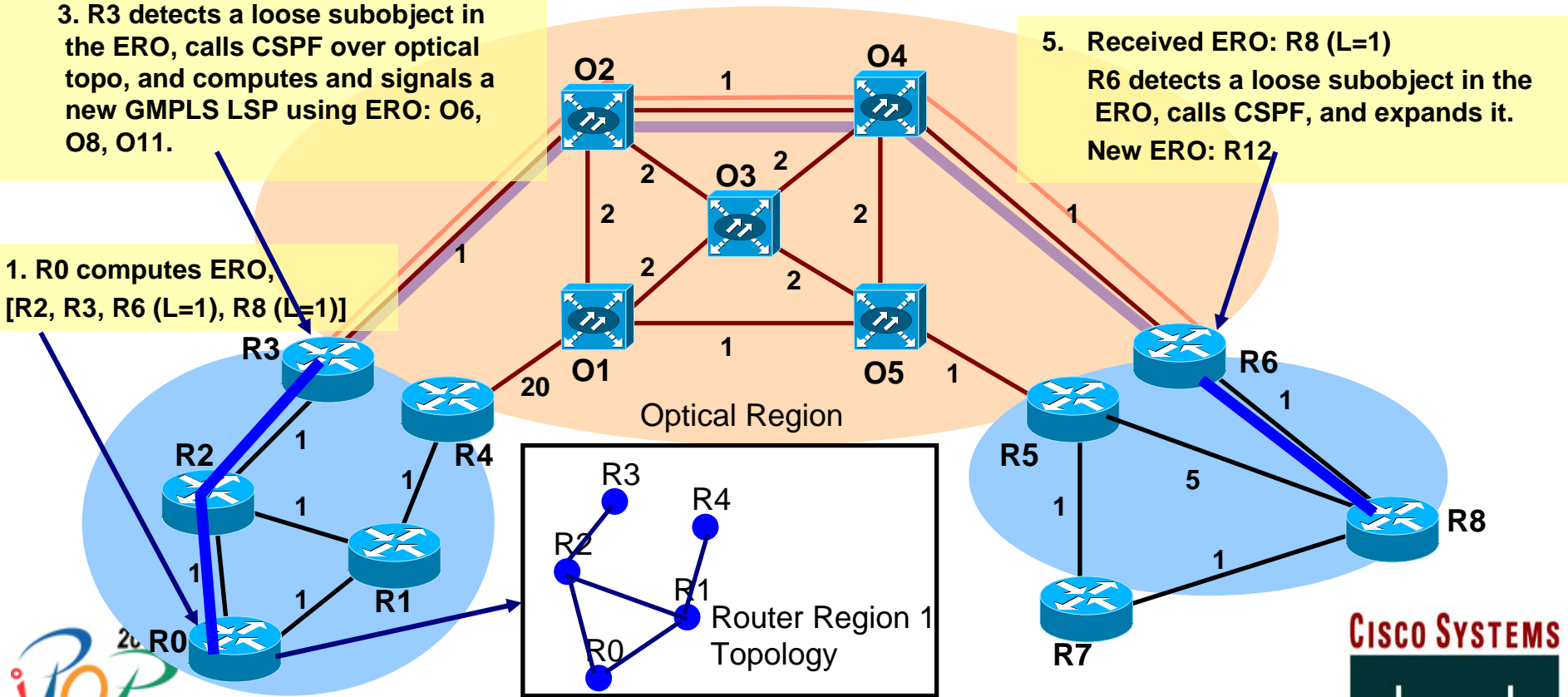
4. Once GMPLS LSP is setup, R3 continues with MPLS LSP setup by sending ERO: R6, R8 (L=1), over GMPLS LSP (PSC)

2. Received ERO: R6 (L=1), R8 (L=1)

3. R3 detects a loose subobject in the ERO, calls CSPF over optical topo, and computes and signals a new GMPLS LSP using ERO: O6, O8, O11.

5. Received ERO: R8 (L=1)
R6 detects a loose subobject in the ERO, calls CSPF, and expands it.
New ERO: R12

1. R0 computes ERO, [R2, R3, R6 (L=1), R8 (L=1)]



Static Vs. Dynamic Options:

Bandwidth Fragmentation vs. Config/ Management Burden Tradeoffs

Dynamic Signaling

- Larger number of LSPs (unless we aggregate)
- Greater bandwidth fragmentation, as GMPLS LSPs are only available in discrete bandwidth levels.
- Saturation of control channels (w/o O-LSPs)
- Issue of bandwidth usage in reverse direction
 - Still requires some Traffic Engineering

Static Config

- More configuration burden
- Requires off-line tools for Traffic Engineering.

Bandwidth Fragmentation vs. config/ management burden tradeoffs



Question: How can we address limitation of the Static Version?

Auto-mesh Feature & FA-LSP Creation

- **Auto-mesh Features:**

- Auto-mesh provides a way to automatically set up a mesh of TE LSPs.

- Two steps involved in the process:

- The automatic discovery of every member of the mesh
 - The automatic set up of TE LSPs using a TE template

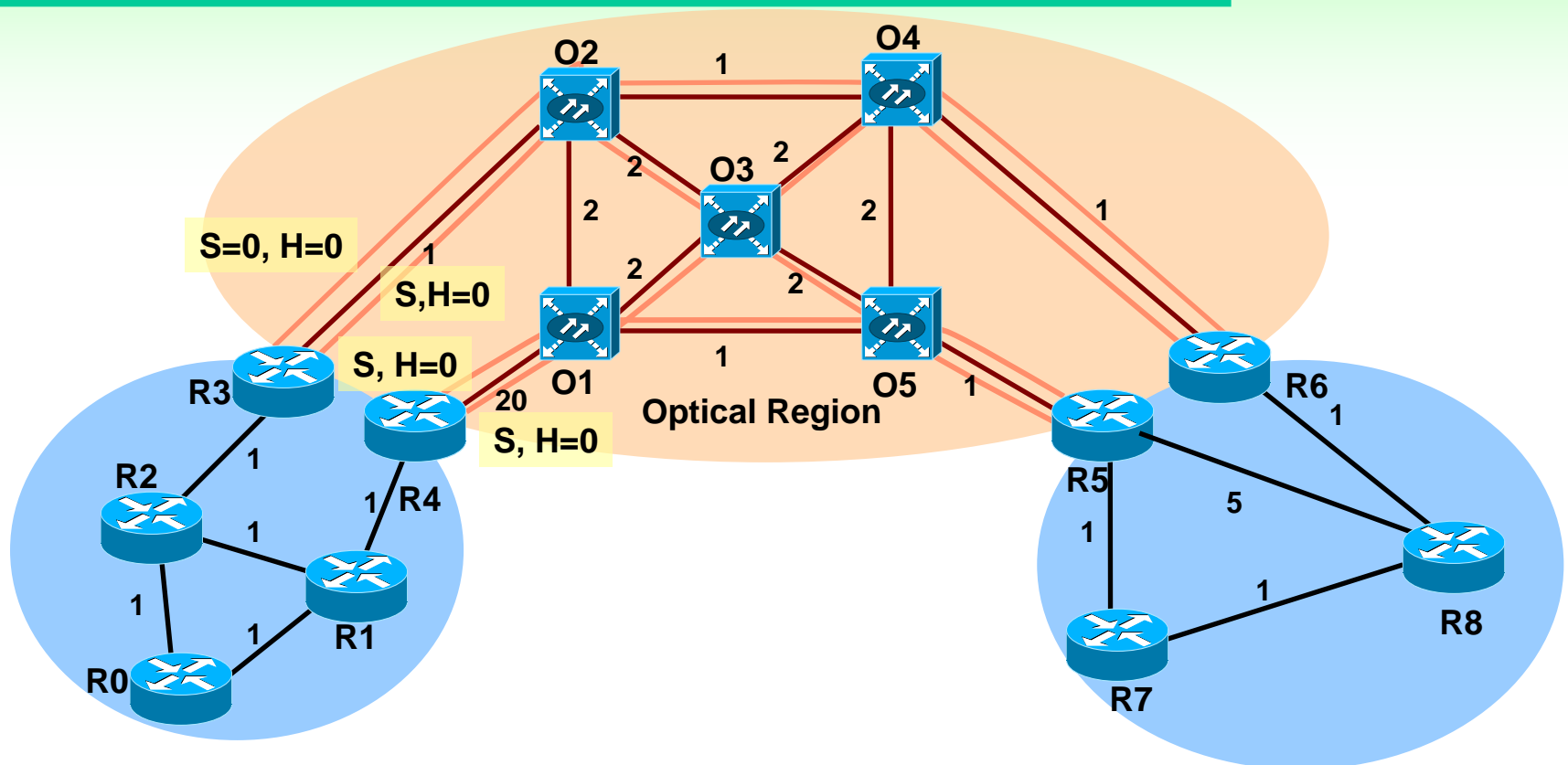
- **FA-LSP Creation:**

- Data links (Forwarding Adjacencies) in Static version may be created through:

- Operator configuration
 - Based on traffic measurements/modeling:
 - At the router or by an off-line tool
 - Basis for bandwidth on-demand

MPLS/ GMPLS LSP Priority Mapping

Priority Mapping: No Priority Management in GMPLS core

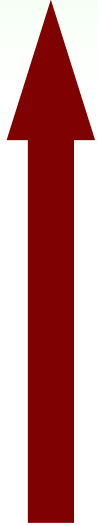


- Create all GMPLS LSPs are the same setup and hold priority.
 - Let MPLS routers take care of preemption.
 - This is what we do currently with the optical transport networks.
- $O(N^2)$ GMPLS LSPs, where N represents number of border Routers

MPLS/ GMPLS LSP Priority Mapping

Priority Mapping Options and Tradeoffs

Bandwidth Fragmentation



- **Exact Match**
 - GMPLS LSP Priority = MPLS LSP Priority.
- **Exact or better Priority**
 - GMPLS LSP Priority \leq MPLS LSP Priority.
- **Dynamic Priority for GMPLS LSP**
 - GMPLS LSP Priority = min (MPLS LSP Priority).
- **Any to Any Mapping Matrix Configured**
- **No Priority Management in GMPLS core**



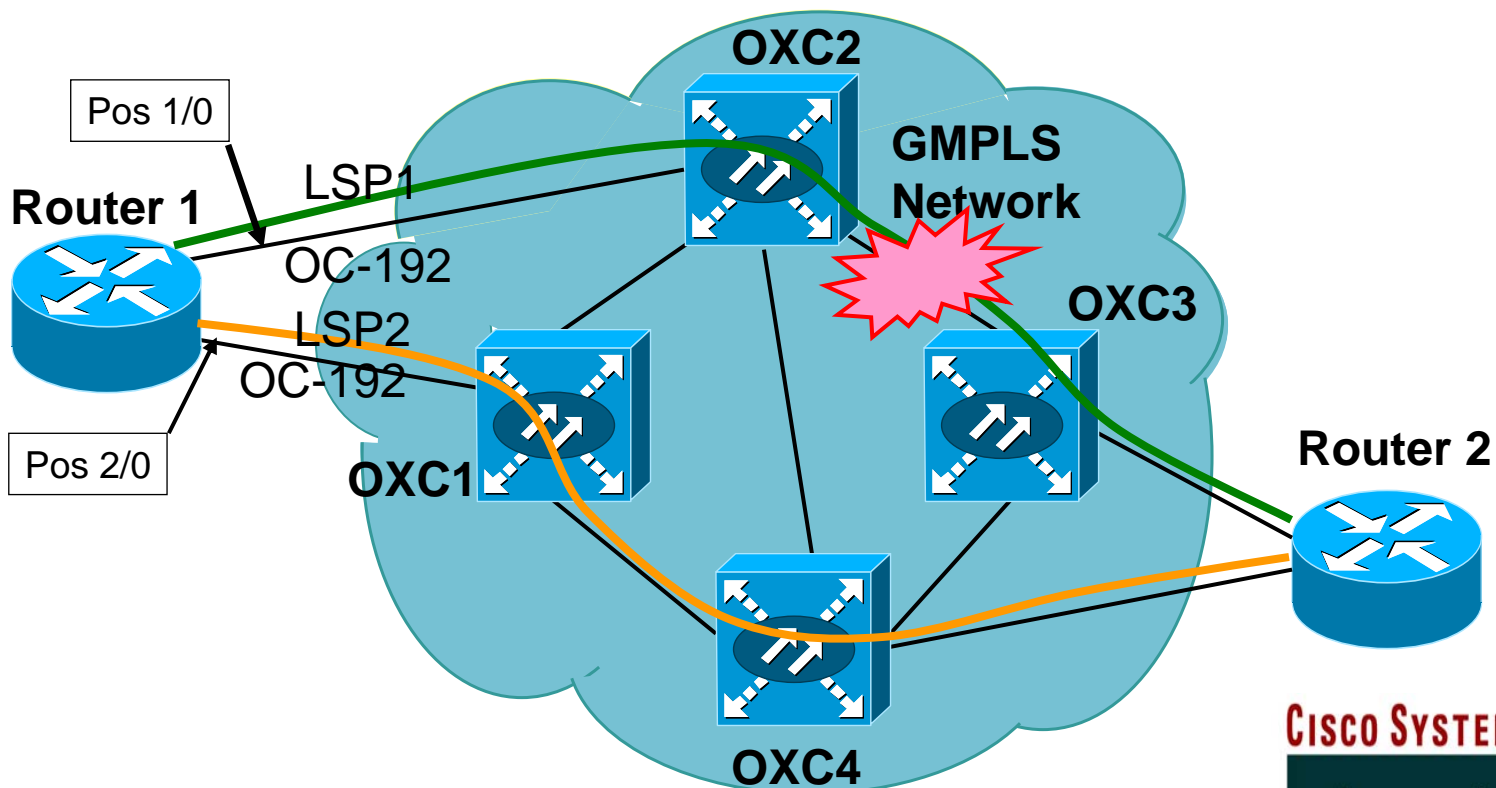
Benefit of Priority Management
in GMPLS Core

We need to understand these trade-off a little better to see benefit of providing priority management in GMPLS Networks

These tradeoffs hint that best option is to have customers configure the mapping option/ function.

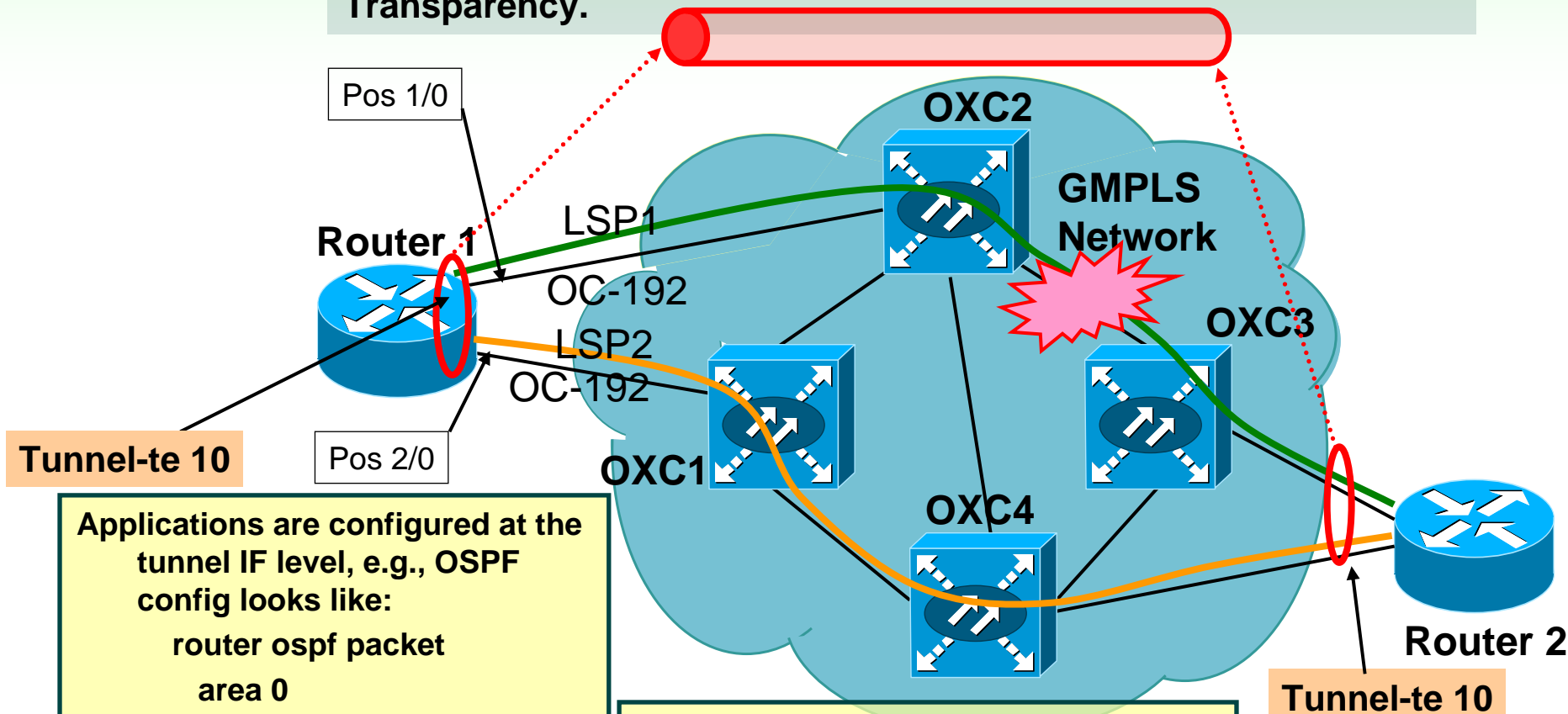
Service Migration Aspects Migrating and Managing Services over GMPLS Network

- In a GMPLS network, LSPs can be rerouted on the fly to use a different Egress physical Interface.
 - Due to failure in optical network (protection and restoration)
 - Re-optimization



Service Migration Aspects L3 Transparency: Running Services over Tunnel IF vs Physical IF (Restoration Case)

Tunnel Interface acting as a “logical Interface” and providing L3 Transparency.



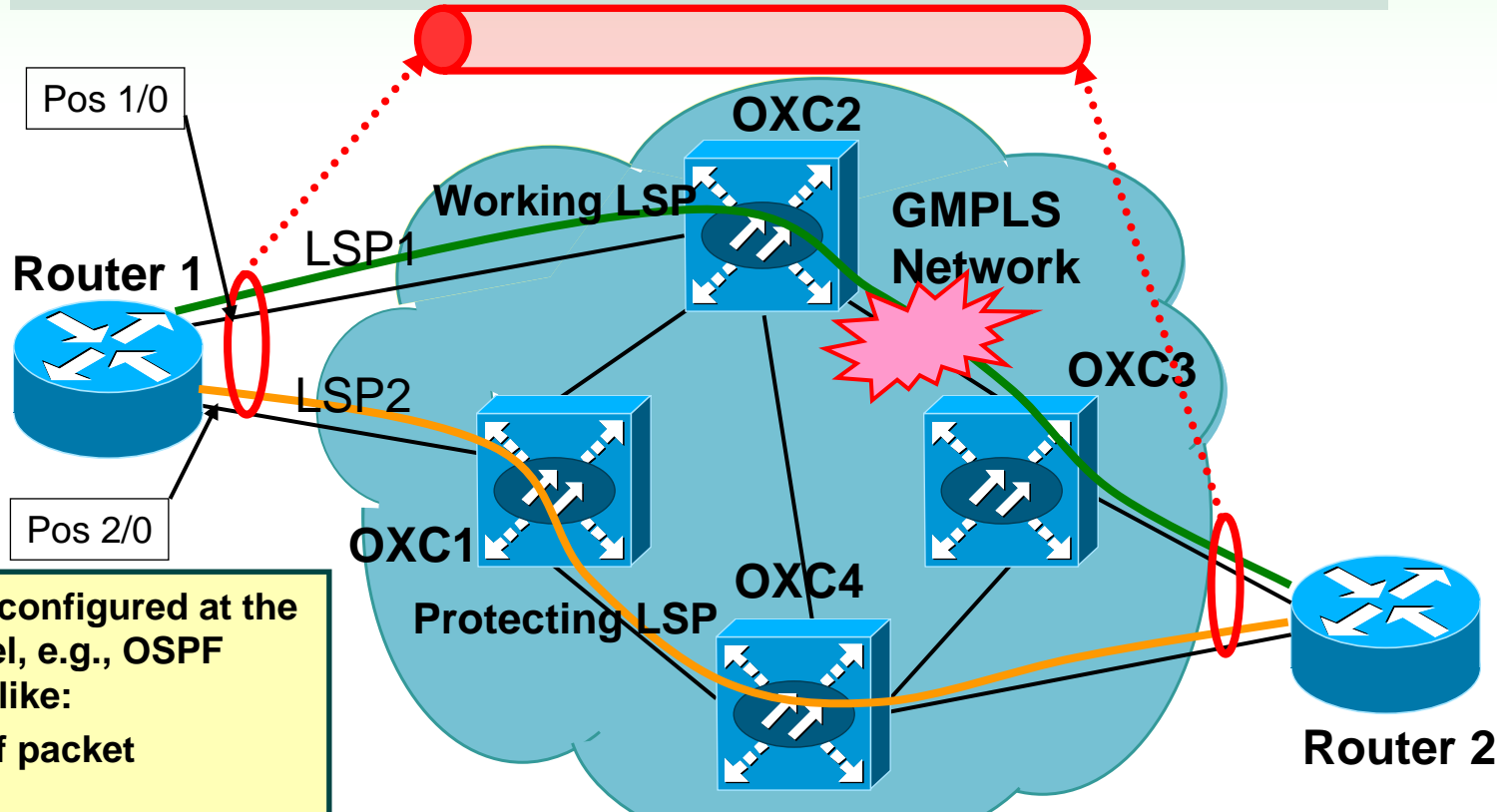
Applications are configured at the tunnel IF level, e.g., OSPF config looks like:

```
router ospf packet
area 0
interface tunnel-te10
```

In a GMPLS controlled OTN environment, applications need to be boot strapped, if configured at physical IF level.

Service Migration Aspects L3 Transparency: Running Services over the Tunnel IF vs Physical IF (Protection Case)

Tunnel Interface (tunnel-te 10), acting as a “logical Interface” and providing L3 Transparency.



Applications are configured at the tunnel IF level, e.g., OSPF config looks like:

```
router ospf packet  
area 0  
interface tunnel-te10
```

If applications are configured at the physical IF level, they need to be boot strapped upon switchover, defeating the purpose of protection.

Q & A

CISCO SYSTEMS



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