

# Operationalizing the Control Plane: *The Control Plane Toolbox*

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**Jim Jones - Alcatel-Lucent  
OIF President and  
Networking Interoperability WG Chair**



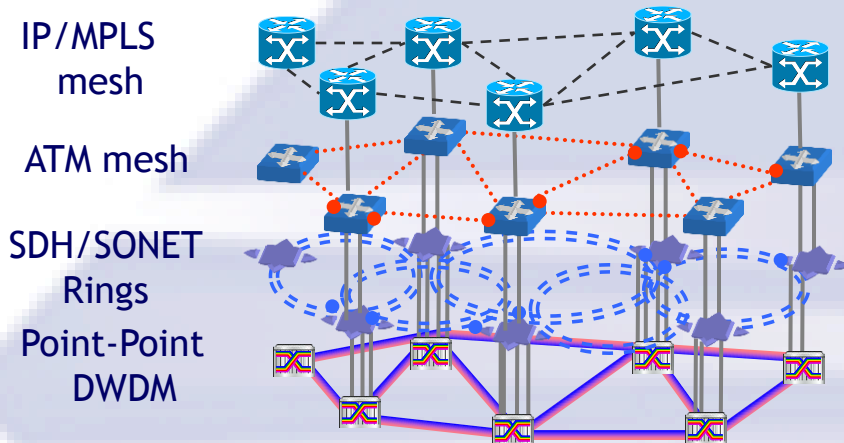
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# Optical Control Plane Goals

## The Journey Toward a Converged Network Architecture

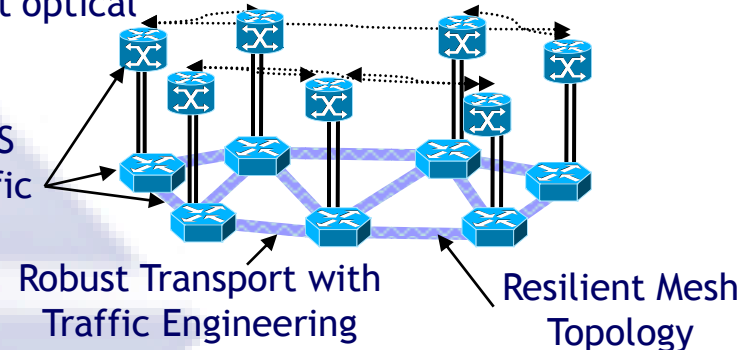
### Early 2000's



### Today

Fewer layers (client + intelligent optical layer)

Many QoS and traffic types



### The Goals

- Simplified management, automated provisioning
- Flexible and responsive to dynamic traffic demands
- Collapsed layer architecture
- Standards-based interfaces

### Observations on Today's Converged Networks

- There is no universal convergence layer (depending on the carrier, it could be Ethernet, MPLS-TP, PBB-TE, ODU,  $\lambda$ , ...)
- Even with fewer layers, today's carrier networks support diverse legacy technologies

To these goals requires

- An automatically switched optical network (ASON) architecture
- A distributed optical control plane (based on GMPLS) - for many technologies
- The right tools to make it operational in carrier networks



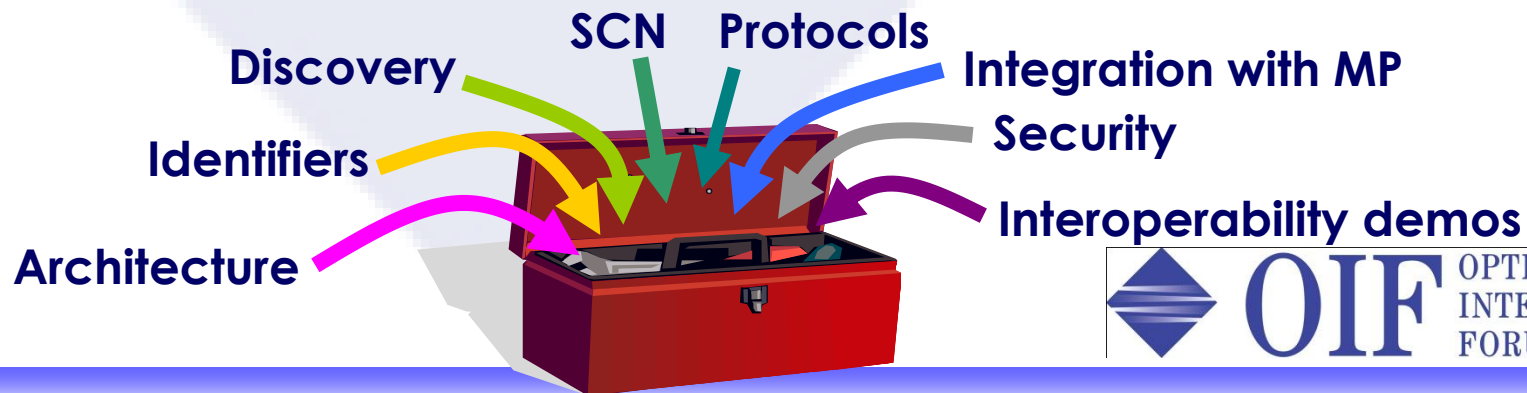
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# Operationalizing the Control Plane

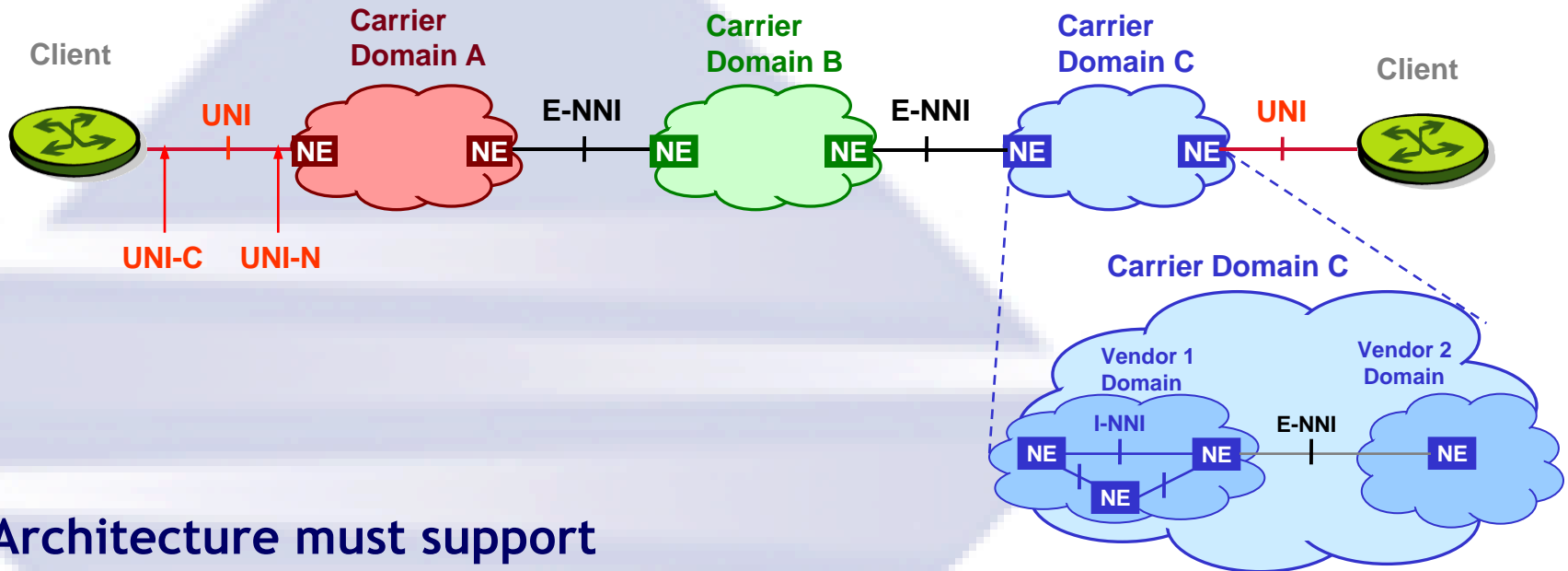
**operationalize** \ ,äp-ə-'rä-shən-ə-lîz \ v : to deploy for execution a business process at the operations level

Source: Merriam-Webster

This presentation will focus on steps that OIF and other groups are taking toward *operationalizing* the control plane: the eight essential tools in the Optical Control Plane (CP) toolbox. It will highlight how to use the tools in multi-layer networks.



# 1. Architecture *The Need*



## Architecture must support

- Heterogeneous topologies, technologies, applications and trust relationships
- Control Plane (CP)-based or Management Plane (MP)-based subnetworks
- Boundaries of policy and information sharing/hiding
- Functional independence between CP, MP, transport plane (TP) and SCN
- Any number of network layers with functional separation between them

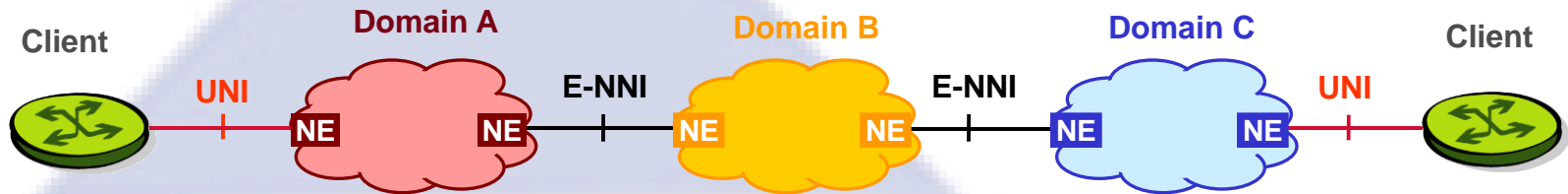


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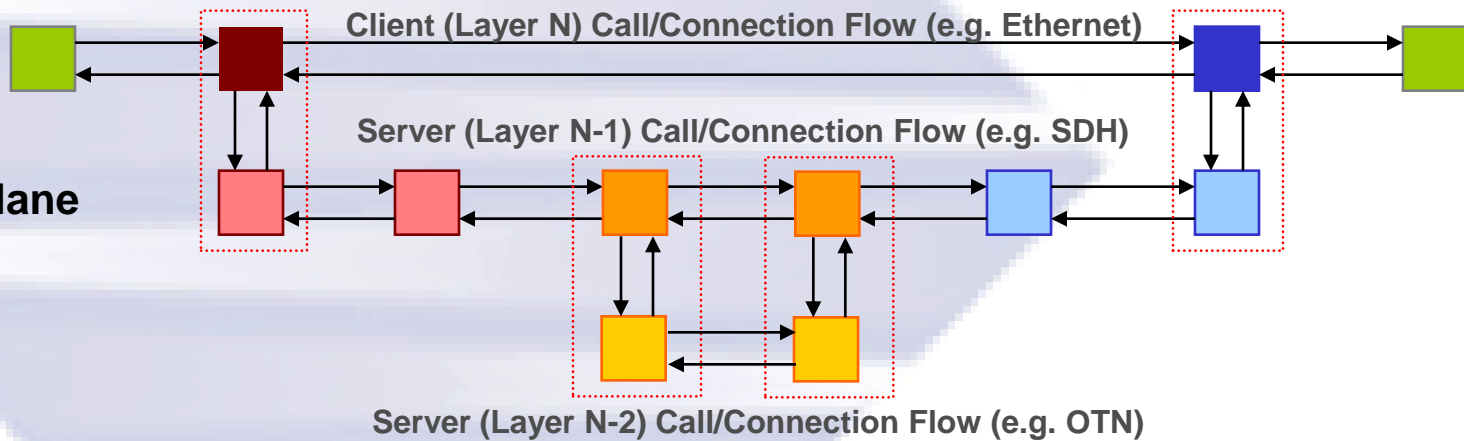
# 1. Architecture

## Multi-layer OIF/ASON Control Plane Model

### Network Topology



### Control Plane Layering



- Edge nodes typically provide layer adaptation and multi-layer control plane
- Core nodes typically operate in single server layer
- Versatile - supports only layers needed (e.g Eth-VCAT-SDH, packet over OTN)
- Server layer signaling completes before client layer signaling does
- Supports BW modification by adjusting server layers to meet demands of client



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# 1. Architecture

## *The Tools and Remaining Challenges*

### Current CP Tools

- **ASON architecture coupled with GMPLS-based CP**
  - Enables value-added services over different transport technologies
  - Supports flexible mapping (1:N, M:1, M:N) between CP and TP entities
  - Routing abstraction methods support domain models and multi-layer representations, to improve scalability and to control sharing of topology.

### Key challenges remaining

- **Completion of multi-layer, recovery and technology-specific amendments to E-NNI**



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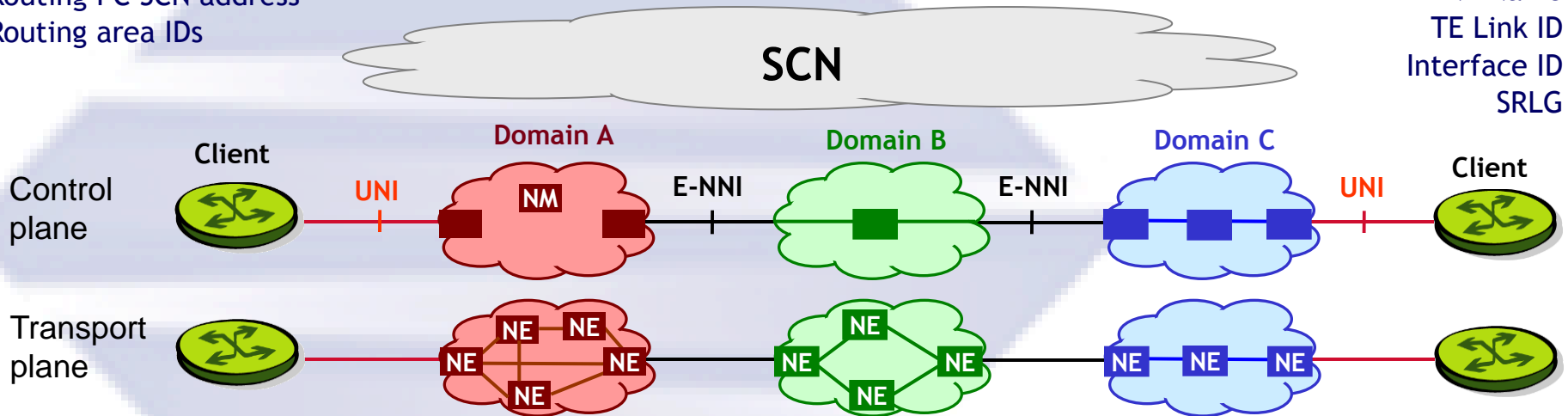
## 2. Identifiers The Need

### Control Plane/SCN IDs

Signaling Protocol Controller (PC) ID  
 Signaling PC SCN address  
 Routing Protocol Controller ID  
 Routing PC SCN address  
 Routing area IDs

### Transport Plane IDs (as viewed by the Control Plane)

Node ID  
 Logical Port ID  
 TNA Name  
 TE Link ID  
 Interface ID  
 SRLG



### Identifiers must provide

- An identity (name or address) for every entity visible to the CP
- ID uniqueness and support for various formats (IPv4, IPv6, ...)
- Note: the CP assigns other IDs dynamically (e.g. Call ID, LSP ID, Generalized Labels). The above lists cover IDs that need to be assigned for the CP to function.



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## 2. Identifiers

### *The Tools and Remaining Challenges*

#### Current CP Tools

- OIF TNA (Transport Network Assigned) Name for domain architecture
  - Supports namespace separation and network growth/merges/splits
- Carrier requirements for Control Plane IDs
  - Support for resource summarization, formatting, ID uniqueness
  - IDs primarily use IPv4 formats now, with growth to IPv6 enabled

#### Key challenges remaining

- A naming authority may be needed to administer IDs, to ensure summarization and uniqueness
- Guidelines could help for mapping IDs that are commonly used by network operators into appropriate CP IDs
- Some address resolution functions are needed at UNI and E-NNI points

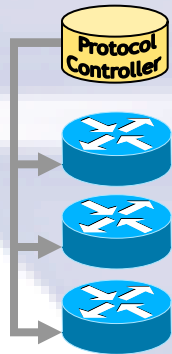


## 2. Identifiers

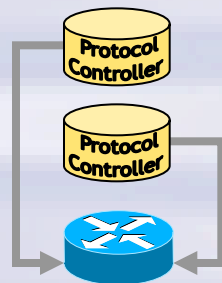
### *Flexible Mapping Examples*

- ASON allows various mappings between CP and TP entities (such as protocol controller, SCN address, TNA and node ID)
  - IDs of similar entities may differ at each layer within the same NE (if NE supports EoS, there may be distinct IDs for each entity at Ethernet, VCAT and SDH layers)
- Example of mappings that are supported by ASON (PC = Protocol Controller):

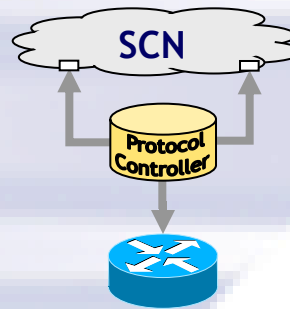
One PC controlling multiple nodes



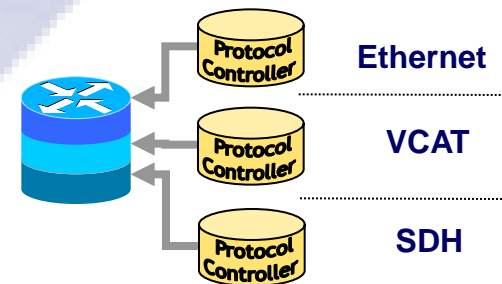
One node controlled by multiple PCs



Multiple SCN attachment points and SCN addresses



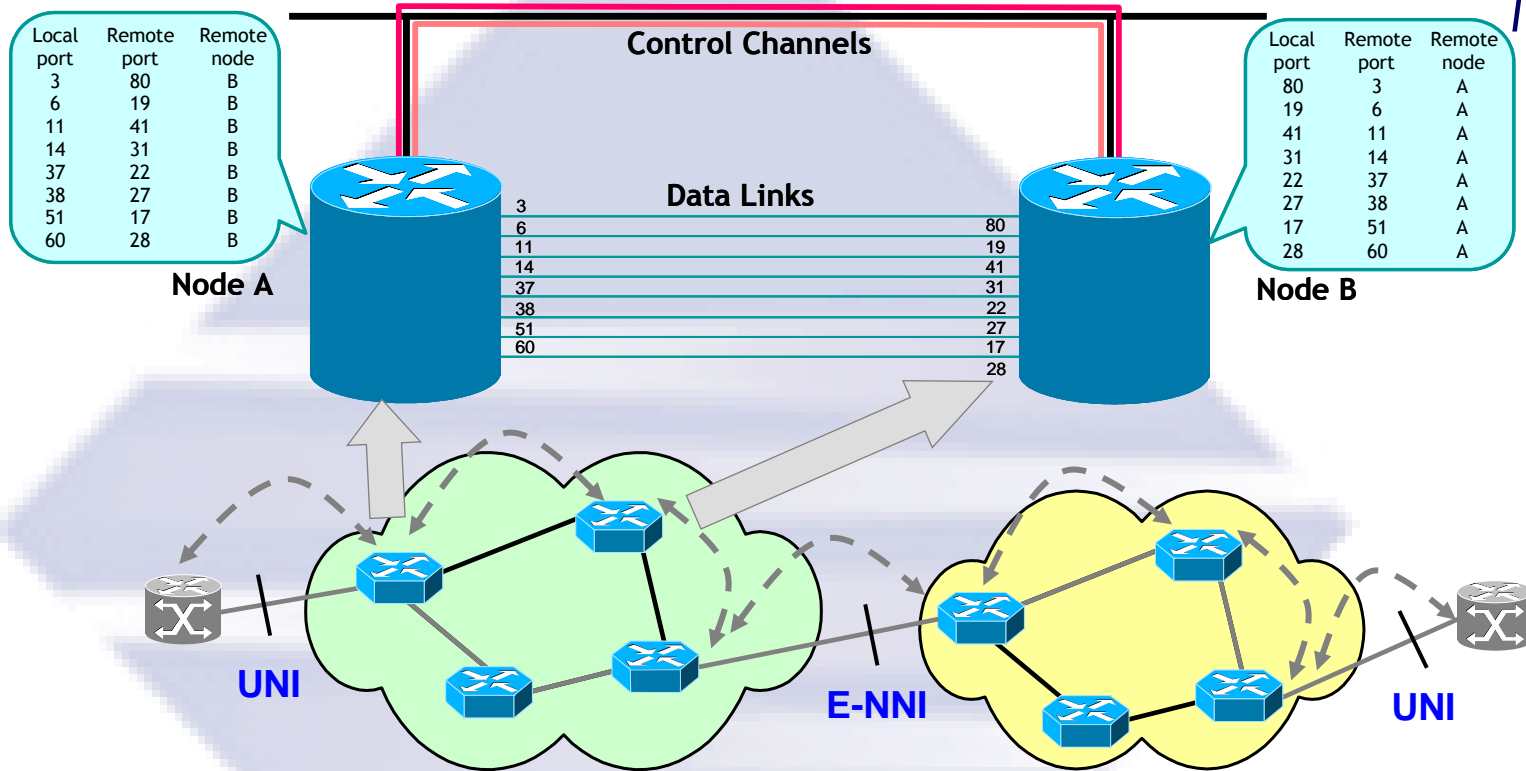
Different PCs for each layer supported



- Devices that only need 1:1 mappings may need to interface with others that support M:N
- A balance between simplicity and full generality (1:1, 1:N, M:1, M:N) is needed



# 3. Discovery The Need



- The CP must discover, or be provisioned with, the configuration and ID of its neighbors. This can provide different types of information:
  - Remote link or end-point connectivity verification
  - Transport capability exchange (service discovery)
  - Control plane resource exchange

# 3. Discovery

## *The Tools and Remaining Challenges*

### Current CP Tools

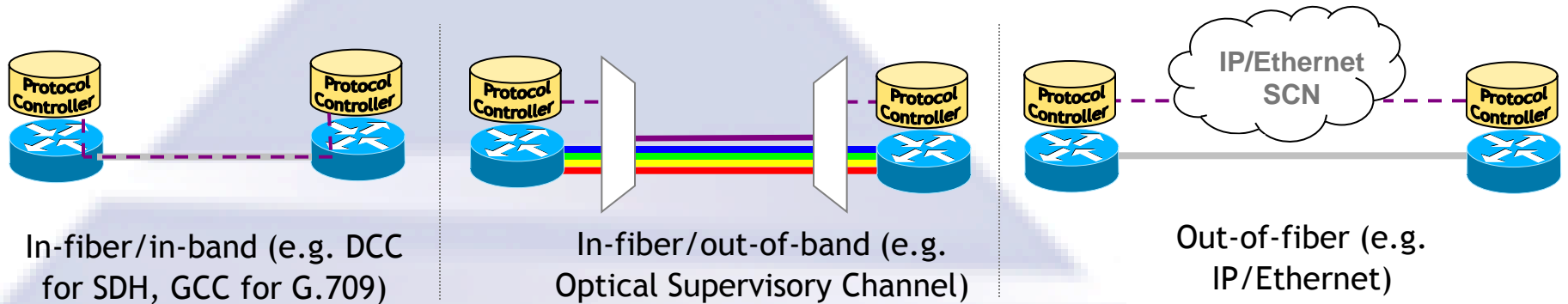
- Discovery mechanisms defined by ITU-T in G.7714 and other sources
  - Defines discovery procedures for transport entities (SDH/SONET, OTN)
- IETF Link Management Protocol (LMP)
  - Supports discovery for both in-band and out-of-band

### Key challenges remaining

- In-band mechanisms require updates as new technologies emerge
- Extension of autodiscovery capabilities continuing in G.7714.x, including transport capability exchange (service discovery)



# 4. Signaling Communications Network *The Need*



- **A Signaling Communications Network (SCN) must be established to support secure control plane communications**
  - **May be in-band or out-of-band**
  - **May consist of a single integrated SCN or multiple SCNs**
  - **SCNs may be partitioned by business, technology or layer boundaries**
  - **SCN resiliency is required**



# 4. Signaling Communications Network

## *The Tools and Remaining Challenges*

### Current CP Tools

- ITU-T G.7712 and other sources defining SCN functions
  - **Procedure, encapsulation and encryption methods defined**
- Slow protocol Ethernet PDU supporting in-band SCN with OIF OUI
  - **Avoids need for separate SCN for Ethernet bearer**
- Carriers already have experience managing SCNs in non-CP networks

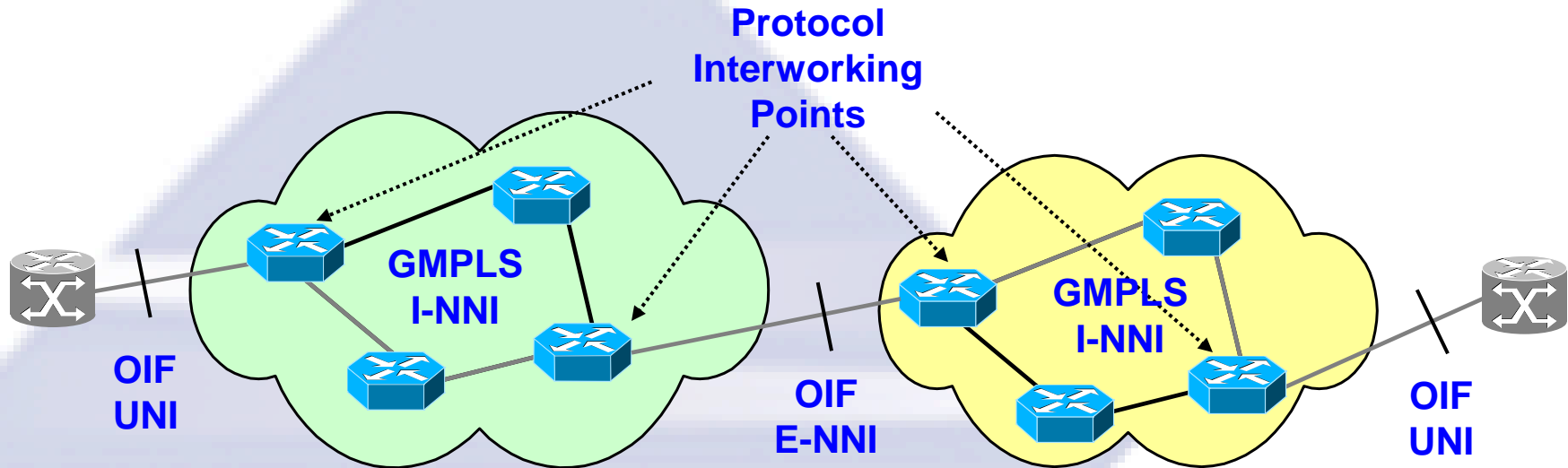
### Key challenges remaining

- Policy may limit scope of SCN across domain/carrier boundaries
- Multi-layer architecture requires SCN connectivity or forwarding gateway between remote nodes in client layer
- Use of a separate out-of-fiber IP SCN can impact the business case for deploying CP (i.e. why do I need a separate SCN for CP when I'm trying to use CP to simplify my transport network?)



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# 5. Protocols *The Need*



- **Protocols must be standardized for CP functions**
  - **Signaling** - to negotiate the allocation and release of resources needed to establish connections
  - **Routing** - to exchange topology information and choose routes for connections
  - **Link management** - to maintain control channel connectivity and support discovery procedures



# 5. Protocols

## *The Tools and Remaining Challenges*

### Current CP Tools

- OIF UNI 2.0 and E-NNI 2.0 signaling IAs, E-NNI 1.0 routing IA and foundation base of IETF RFCs and MEF/ITU-T service definitions
  - **Supporting ASON signaling, routing and discovery for SDH/SONET, Ethernet, ODUk (G.709 ed 2)**
- OIF signaling interworking spec (ASON UNI/E-NNI 1.0 to GMPLS)
  - **Interworking at UNI <-> I-NNI <-> E-NNI domain boundaries**

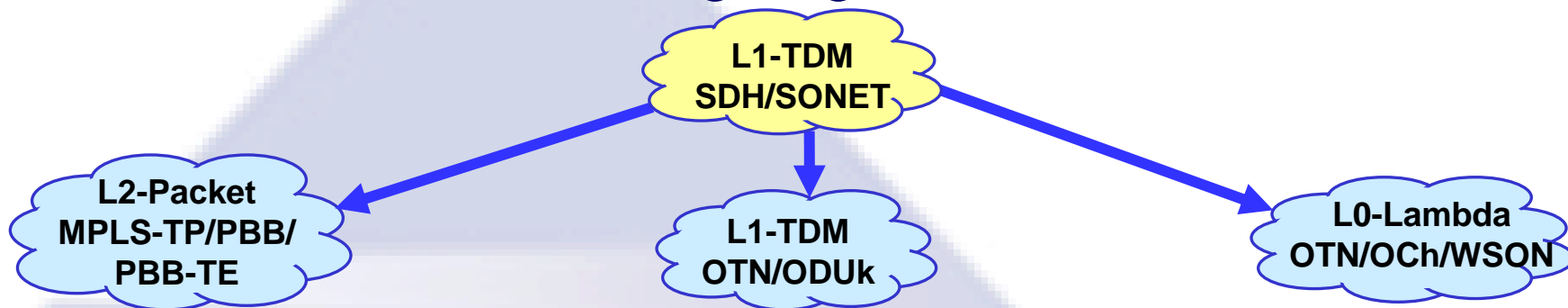
### Key challenges remaining

- Protocol extensions continue to be defined as more applications, transport technologies (e.g. packet optical, OTN (G.709 Ed 3)) and features (e.g. recovery) are developed



# 5. Protocols

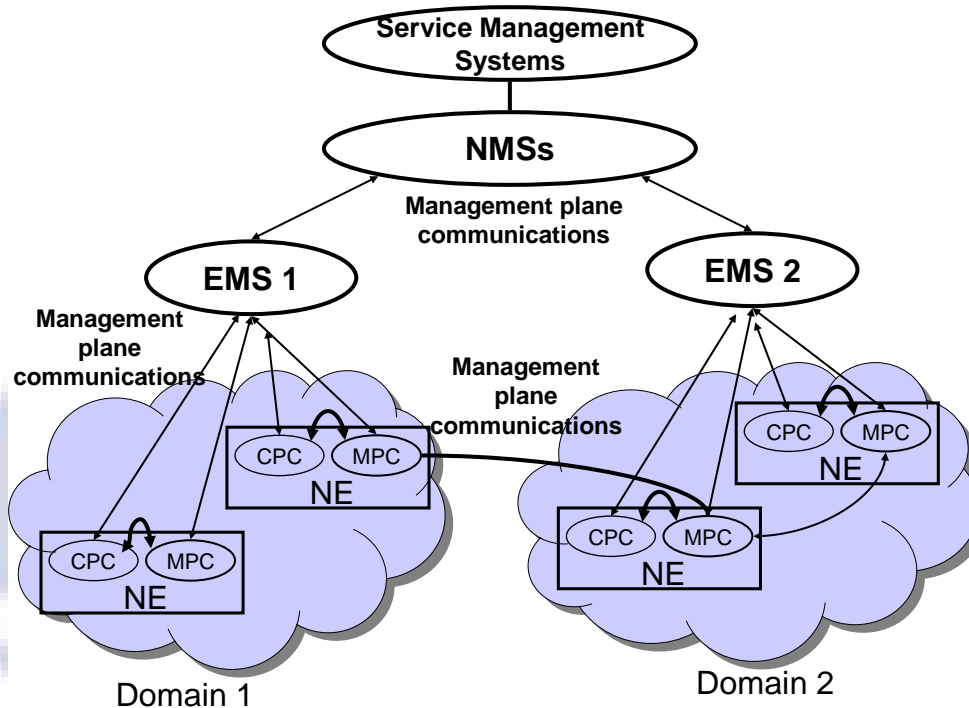
## Ongoing Protocol Enhancements



Transport Technology	Switched Entity	Key Features & Technologies	Control Plane Status	Updates in Progress
Layer 2 (Packet – MPLS-TP/PBB/PBB-TE)	Packet	Packet-based, connection-oriented, L2 transport tunnels	Control plane in work (IETF/ITU-T)	Tailoring MPLS for connection-oriented operation
Layer 1 (TDM – OTN/ODUk)	Time Slot	Optical/TDM switching at 10/40/100G rates	Defined for G.709ed2 [2003] (RFC4328, OIF UNI/E-NNI 2.0)	Update for G.709ed3 [2009] (ODU0, ODUflex, ODU4)
Layer 0 (Lambda – OTN/OCh/WSOON)	Wavelength	Photonic switching (multidegree ROADM/WSS)	Control plane in work (IETF WSOON)	$\lambda$ continuity, physical impairments, scalability

# 6. Integration with the Management Plane

## *The Need*



- MPC = Management Plane Component
- CPC = Control Plane Component

- **The CP must co-exist with - and be under the supervision of - the MP**
  - Connections controlled by CP must co-exist with those controlled by MP
  - Connections may be migrated between MP & CP control without disruption
  - MP actions may trigger a CP connection setup (Soft Permanent Connection-SPC) or reroute an existing CP connection (Soft Reroute)
  - CP supports commands and queries from the MP and reports status to MP



# 6. Integration with the Management Plane

*Typical Work Split Between MP and CP*



# 6. Integration with the Management Plane

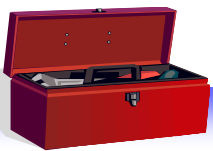
## *The Tools and Remaining Challenges*

### Current CP Tools

- ITU-T and TMF management functions including ITU-T M.3010, G.7718.x and TMF MTNM (TMF-513, TMF-608, TMF-814)
- IETF Management Information Base (MIBs)
- UNI/E-NNI requirements, allowing MP to initiate SPC

### Key challenges remaining

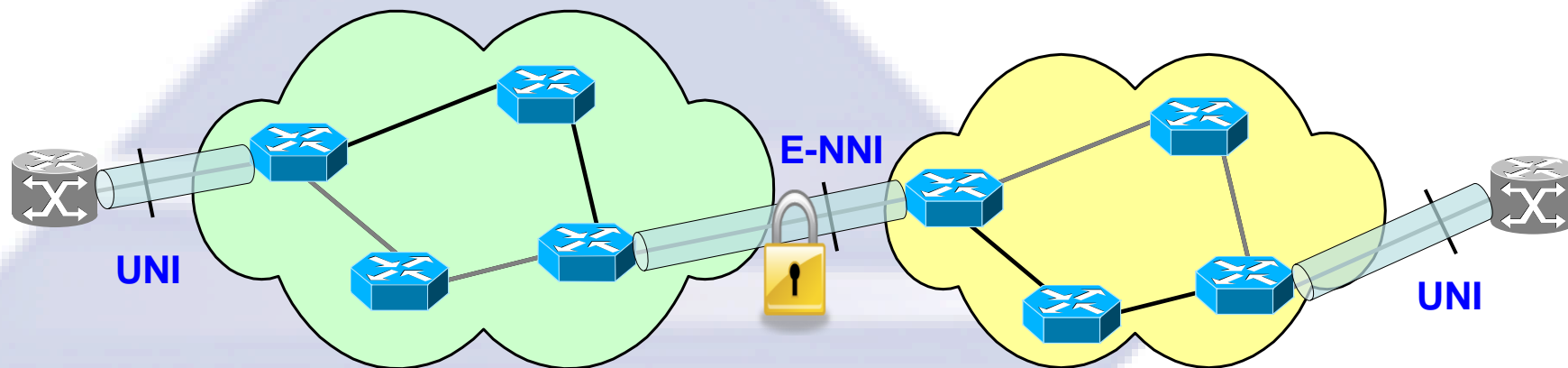
- Complete OIF project for OSS management of Control Plane
- Carrier-specific OSS investments are needed to manage the CP
- MP/CP integration, interworking and migration strategies are in work



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# 7. Control Plane Security

## *The Need*



- **Communications between CP entities and between CP/MP entities must be secure to protect against various threats**
  - **CP communications must not reveal network resource details (beyond those required for CP functions)**
  - **Potential threats must be countered, including denial of service attacks, spoofing, eavesdropping, intrusion attempts, forgery and others**
  - **Security mechanisms should be tailorable and include auditing and logging features**



# 7. Control Plane Security

## *The Tools and Remaining Challenges*

### Current CP Tools

- OIF security IAs, using the latest IETF RFCs tailored for the unique requirements of OIF UNI and E-NNI
  - Security Extension for UNI and E-NNI
  - Security for Management Interfaces to Network Elements
  - Control Plane Logging and Auditing with Syslog

### Key challenges remaining

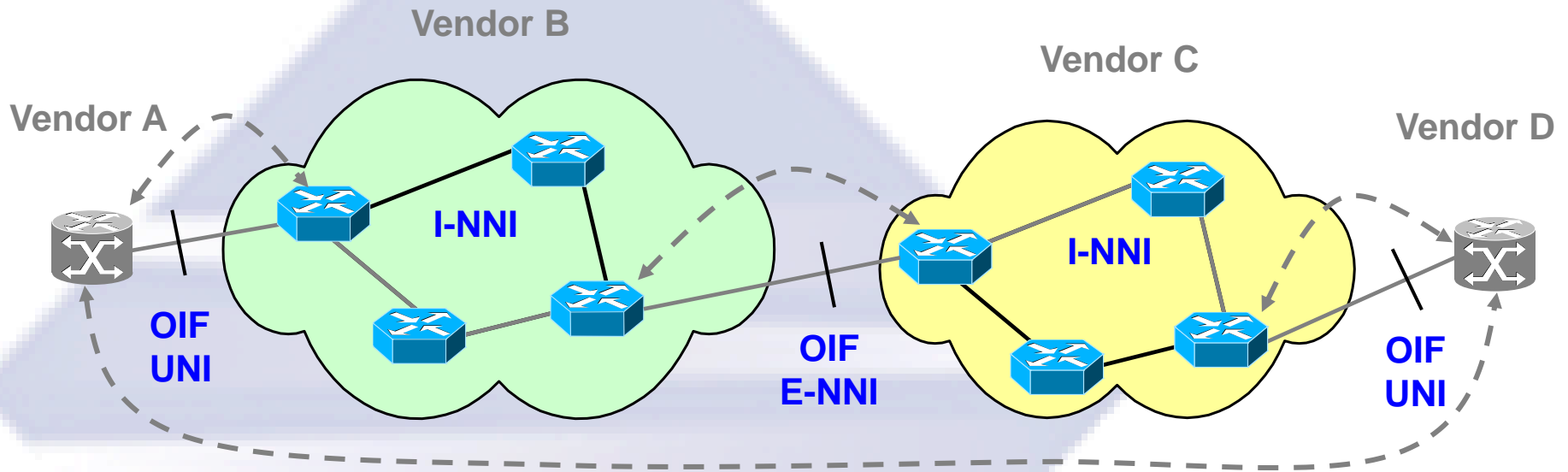
- Continue regular updates to IAs, to keep pace with evolving threats and updates in foundation RFCs
- Complete signaling-based end-to-end security IA (to complement existing segment-by-segment security IAs)



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# 8. Interoperability Demos

## *The Need*



- Interoperability testing is needed to evaluate multi-vendor interop and advance CP maturity
  - Essential stepping-stone to move CP from research labs to live networks
  - Initial exposure and feasibility demo, feedback into standards process
  - Critical tool for early detection and correction of interoperability issues - in specifications, vendor implementations and operations concepts



# 8. Interoperability Demos

## *The Tools and Remaining Challenges*

### Current CP Tools

- Experience from 6 OIF interop events - control and transport plane test methods, global SCN, test findings
- Continued planning for next OIF interop event
- Test efforts of groups including UNH, Isocore, EANTC, MEF and others

### Key challenges remaining

- Planning of future interop test efforts, with finite resources
- Focus on proving out new features in definition phase or IAs near completion?
- On-going smaller-scale tests or less frequent large event?
  - **Many candidate features and technologies are on the horizon - which ones to test?**



# Control Plane Toolbox Summary

- **Operationalizing the Control Plane (deploying CP as a business process at the operations level) requires a full set of tools**
  - **A robust set of tools exists today from OIF IAs, and many other tools come from ITU-T, IETF, TMF, MEF**
  - **Additional work is needed to continue advancing the CP - both in feature content and operational aspects**
  - **Future development of CP and related tools must align with business needs and operational realities of service providers**

