Intelligent Optical Control Plane

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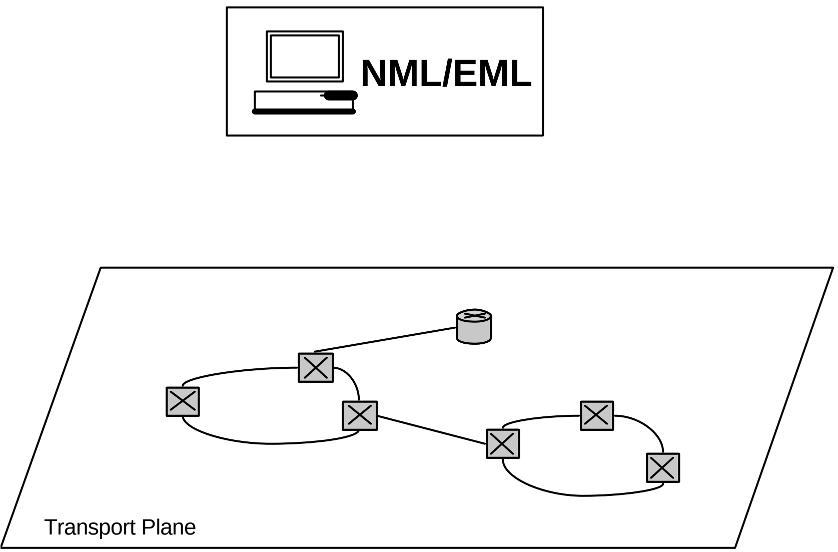
Outline

- Optical Control Plane – What is it
- Operator Drivers for Optical Control Plane
- Requirements of Intelligent Control Plane
- Control Plane Applications
- Standards for Intelligent Control Plane
- Co-Existence with Traditional Networks

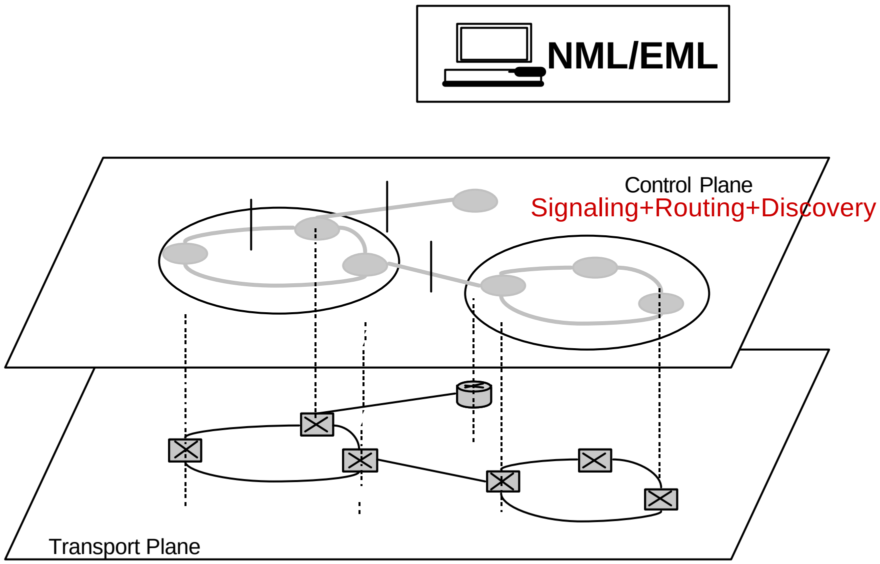
Optical Control Plane: What Is It?

Traditional Transport Network



- Centralized management (FCAPS) at NMS
- Centralized database at NMS
- No Intelligence at NE
- Inventory and circuit information is provisioned via NML
- Circuit design is an NML function
- Connection setup/teardown – Slow (Human Operator via the Management Plane)

Transport Network w. Intelligent Control Plane



- Configuration management is moved from NMS to control plane
- Distributed database at NE
- Intelligence at NE
- Inventory and circuit information is self-discovered and flowed-back to the EML/NML
- Circuit design occurs via NE independently of the NML
- Connection setup/teardown – Fast (Automate via the Control Plane)

Operator Drivers For Optical Control Plane

- Accuracy Of Network Database And Improved Utilization Of Network Resources
- Improved Multi-Vendor Interworking
- Change Of Operation Environment From Existing OS
  - **Reduced Network Costs (CapEx)**
    - Better network efficiency than SONET rings
      >>Meshed topology & Mesh restoration
  - **Reduced Operation Costs (OpEx)**
    - Reduced cost of provisioning
    - Reduced provisioning time
      >> Automatic provisioning
  - **New service and revenue opportunities**
    - Broad range of differentiated services
      >>Flexibility
    - Bandwidth On Demand
      >> Fast provisioning
    - OVPN (Optical Virtual Private Network)

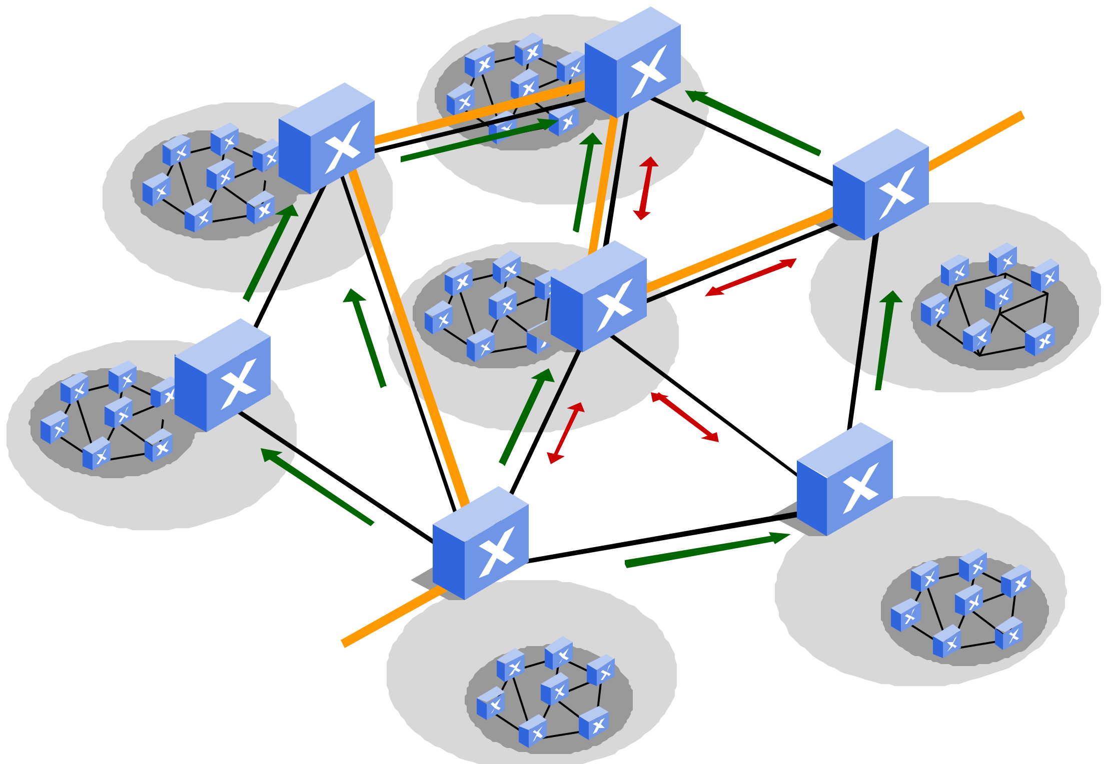
What Makes an Intelligent Control Plane?

There are two elements to an intelligent control plane:

- Intrinsic awareness of network resources
  - Network topology
  - Inventory management
    - Commissioned/de-commissioned port units
    - Available bandwidth (e.g. time-slots)
- Intrinsic service activation
  - The network knows how to optimally route circuits in the network

Control Plane Enabled Intelligent Network Elements

Example of an I-NNI



How it works:

0. Each Network Element (NE) auto discovers its port-to-port nearest neighbor adjacencies

1. Each NE floods the network domain with Link State Advertisements (LSA) containing NE adjacencies

2. Each NE uses LSA's to build a view of the network database (at least once every 30 minutes)

3. The network database is used to create "lowest cost" path between endpoints

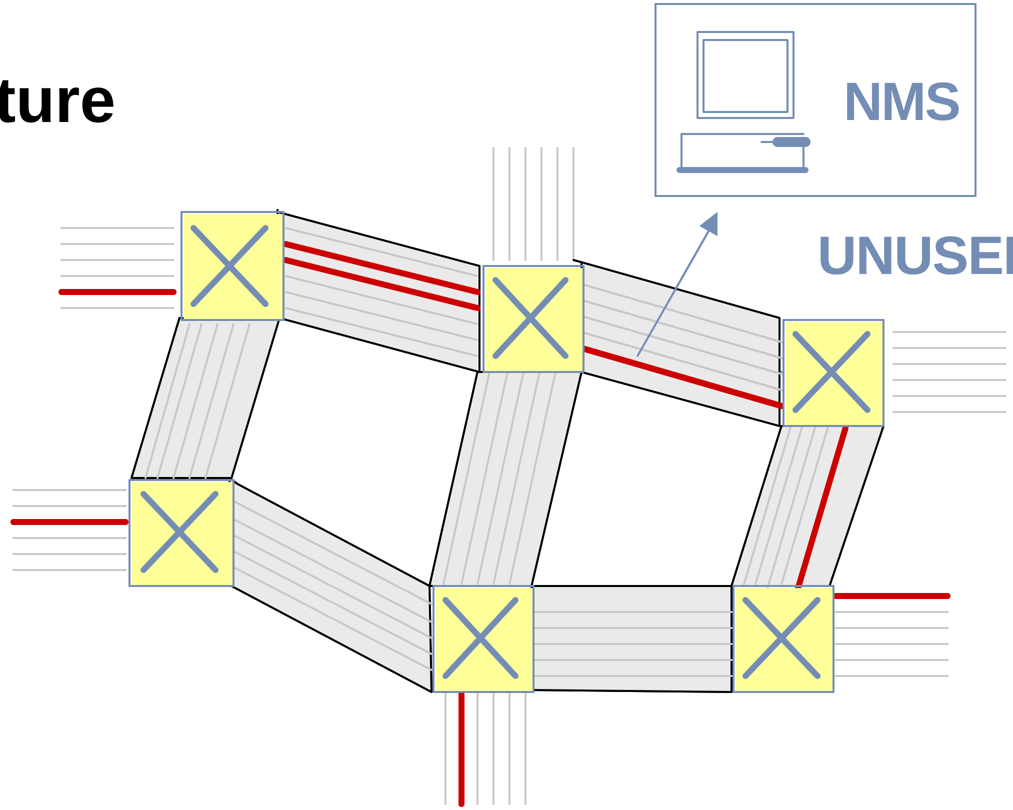
An automatic, self-optimizing network

Network Auto Discovery
Connection Management
Auto-reroute shared mesh restoration
Capacity Management

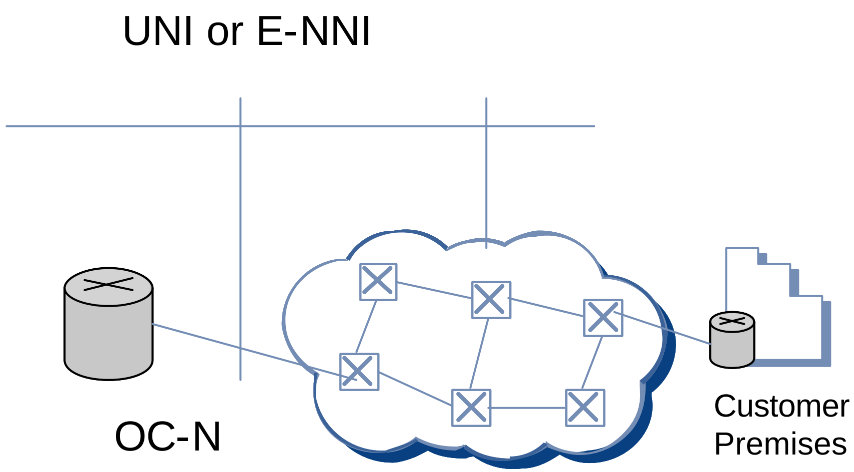
Control Plane Applications (1)

Accurate resource management in churn situations

- **Applicable to mature networks**



Control Plane Applications (2)

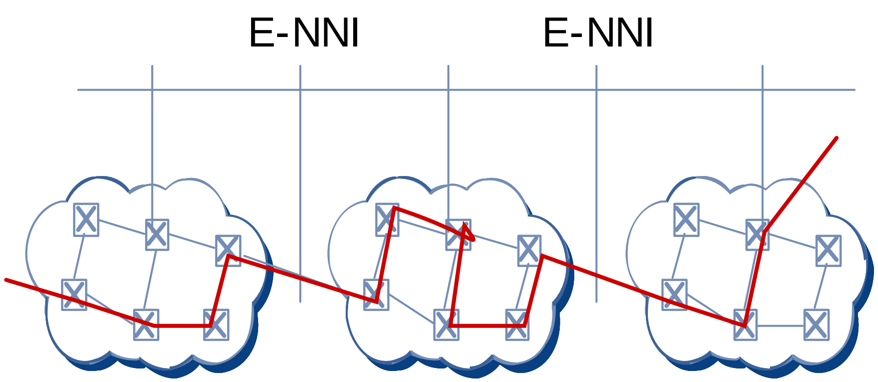


Rapid Provisioning of TDM slots

Data organization uses UNI or E-NNI to commission/de-commission customer access service

Automated Cross Domain Provisioning

E-NNI is used for multi domain (even multi-carrier) connection management



Control Plane Applications (3)

- Mesh Networks
  - Operational Simplicity
  - Bandwidth Savings
  - Increased Reliability (Restoration On Top Of Protection)
  - Service Differentiation
- Bandwidth On Demand / “Dynamic Optical Networks”
  - Traffic Patterns, Call Rates, Holding Times?
  - Subscribers (Number, Distribution)?
  - Growth Rates?
- “Optical Virtual Private Networks” Via OMS Are An Alternative Solution.

Standards

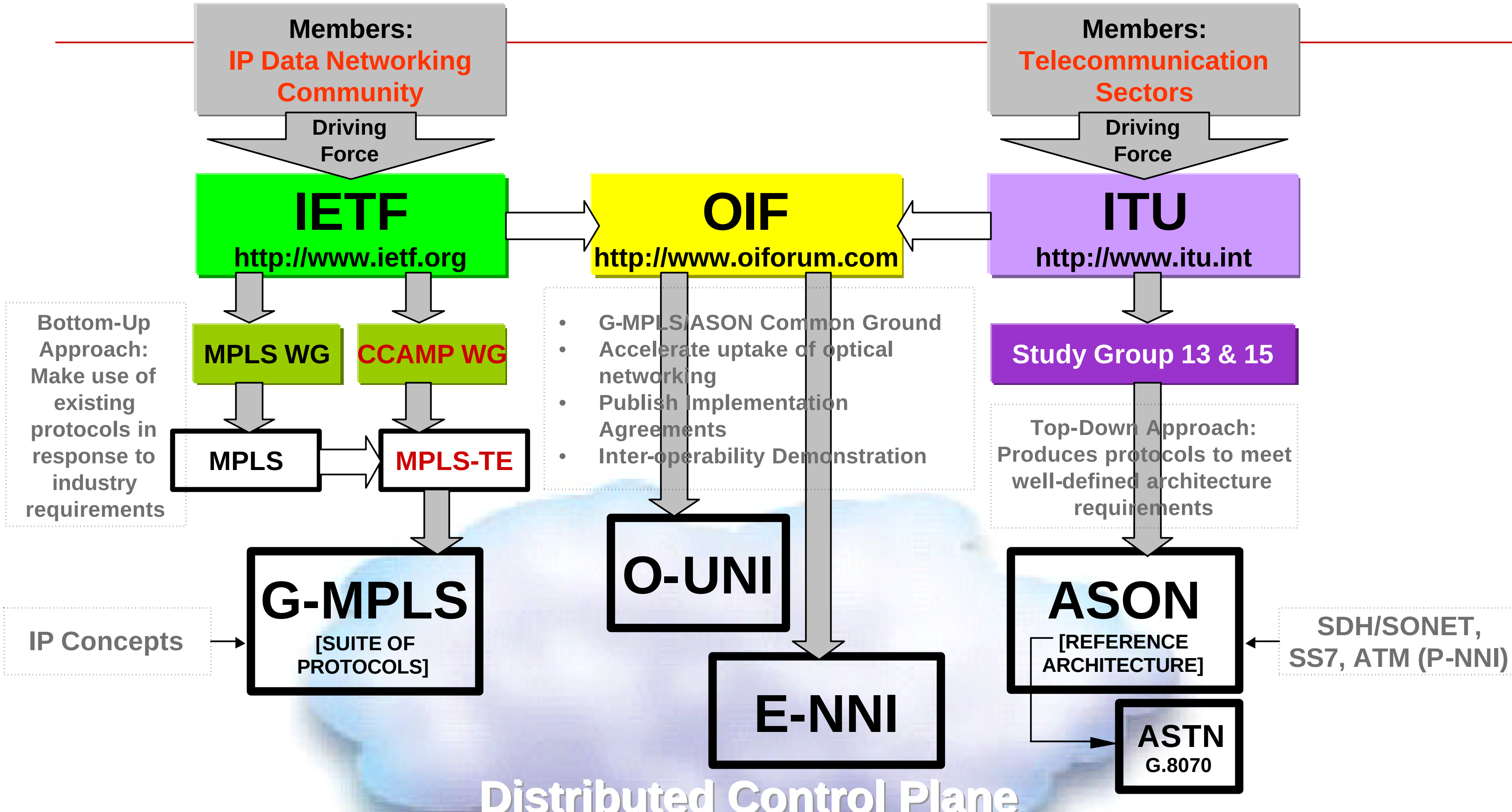
Three Standard Groups

1. IETF’s GMPLS: Mostly driven by data (protocol view) focused entities. Requires proprietary protocol extensions to support heterogeneous networks
2. ITU-T’s ASON/GMPLS: More Practical Approach for transport networks, especially for multi-vendor/operator domains, heterogeneous networks
3. OIF: Details options in ITU-T Standards. Inter-working testing between largest suppliers & operators (Mostly Our Main Customers)

=> Go With ITU-T/OIF Implementation!

But: Some Strongly Data Oriented Operators / Organizations May Not Be In Line With ITU-T/OIF

Introduction – Global Standardization Work on the Distributed Control Plane



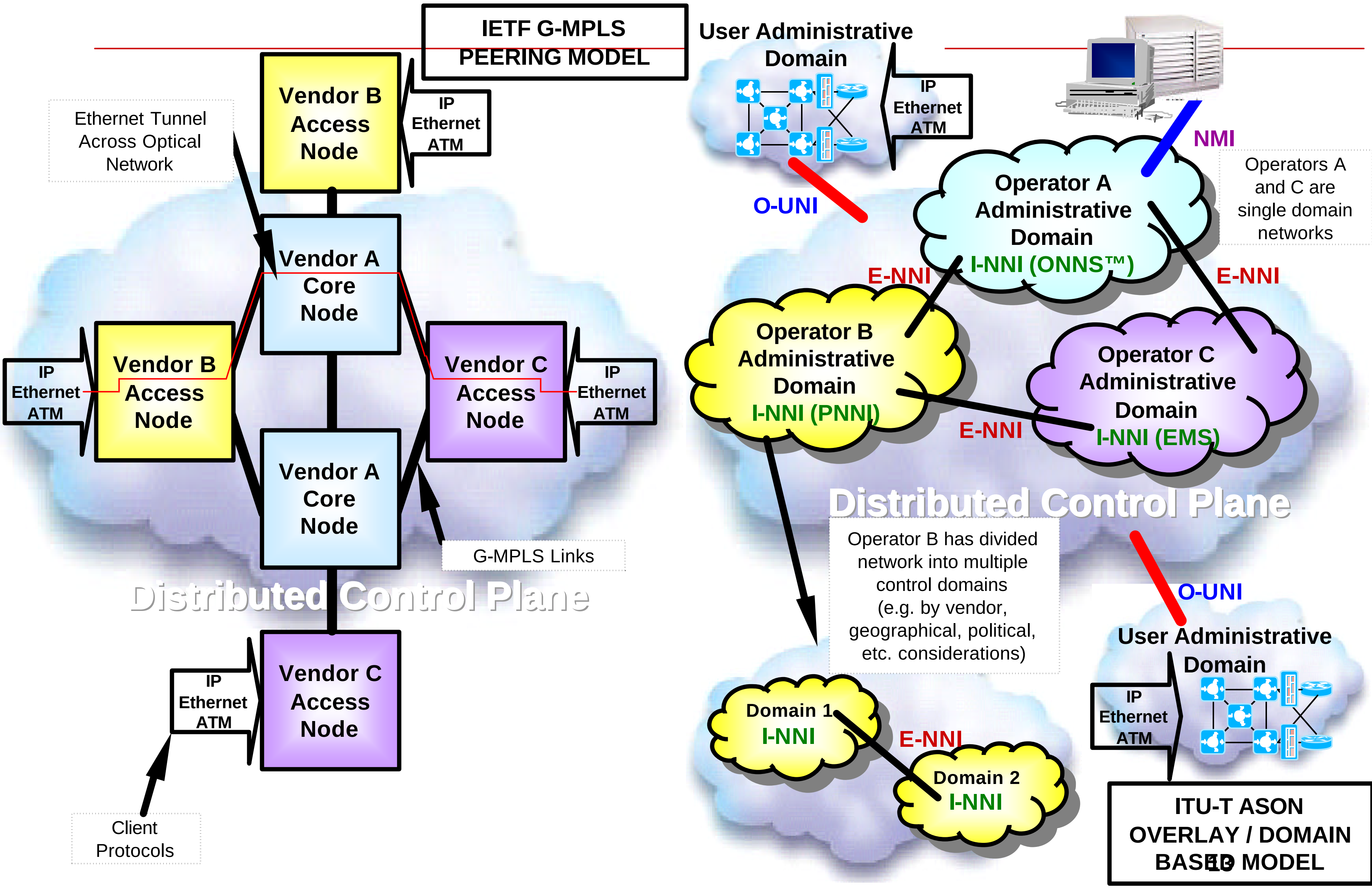
IETF	Internet Engineering Task Force
MPLS	Multi-Protocol Label Switching
CCAMP	Common Control and Management Plane
MPLS-TE	Multi-Protocol Label Switching – Traffic Engineering
G-MPLS	Generalized Multi-Protocol Label Switching

ITU	International Telecommunication Union
ASON	Automatically Switched Optical Networks
OIF	Optical Internetworking Forum
O-UNI	Optical User Network Interface
E-NNI	External Network Node Interface

Introduction – ASON Signaling Protocols Specifications

- **User Network Interface (UNI)**: Operations between end-user and service provider administrative / control domains
  - ⇨ **OIF O-UNI:**
    - Addresses the client/user signaling – i.e. The call management portion
    - Based on GMPLS signaling extensions / modifications to support O-UNI 1.0 / 2.0
    - Supports both RSVP-TE and CR-LDP based signaling protocol options
    - Enhancements in O-UNI 2.0 (e.g. bandwidth modification, support for Ethernet)
- **Network-to-Network Interface (NNI)**: Multi-control domain operation for a single service provider as well as multi-control domain operation among different service providers
  - ⇨ **OIF E-NNI:**
    - Work is starting for the specification of an implementation agreement for E-NNI signaling specifications (close linkage between ITU-T G.7713.X series expected)
  - ⇨ **I-NNI**: Intra-control domain operation
- **Network-to-Management Interface (NMI)**: Operations between management systems and service provider administrative domains

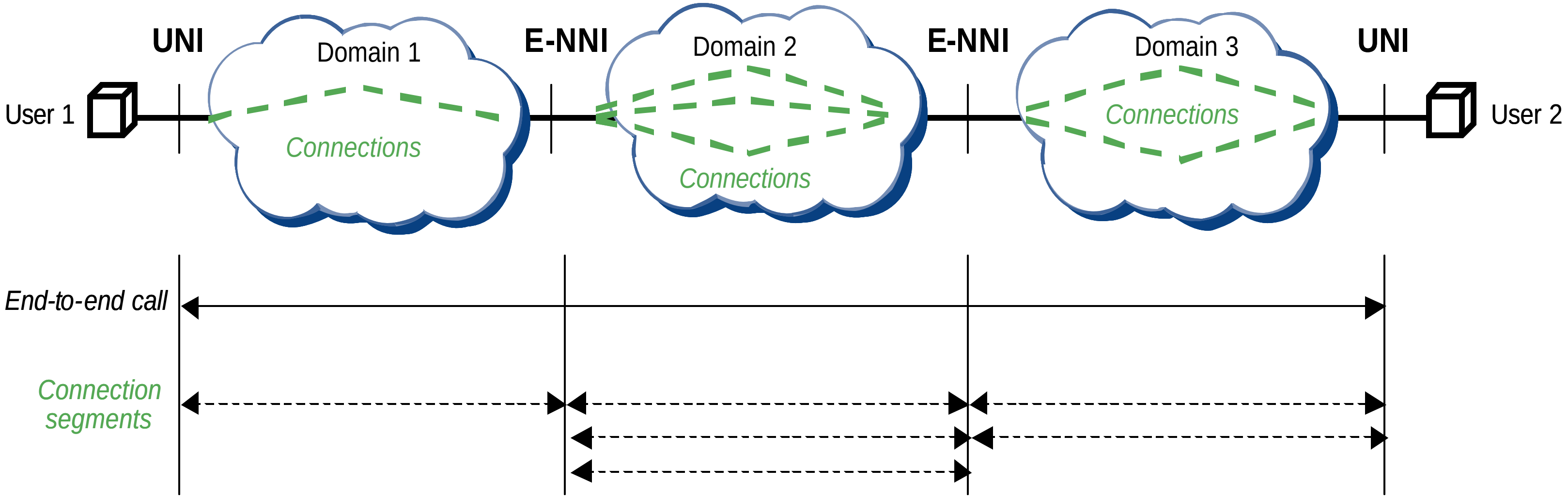
Introduction – The GMPLS/ASON Networking Models



The ASON Model

Architecture enabling *boundaries for policy and information sharing*

- Separation of call and connection control
- Inherent support for multiple address spaces
- Inherent support for multiple domains, cross-domain call & connection mgmt.



Example of call with multiple connection segments

Both the UNI and E-NNI are service demarcation points; i.e., call control is provided

Call properties must accompany the connection

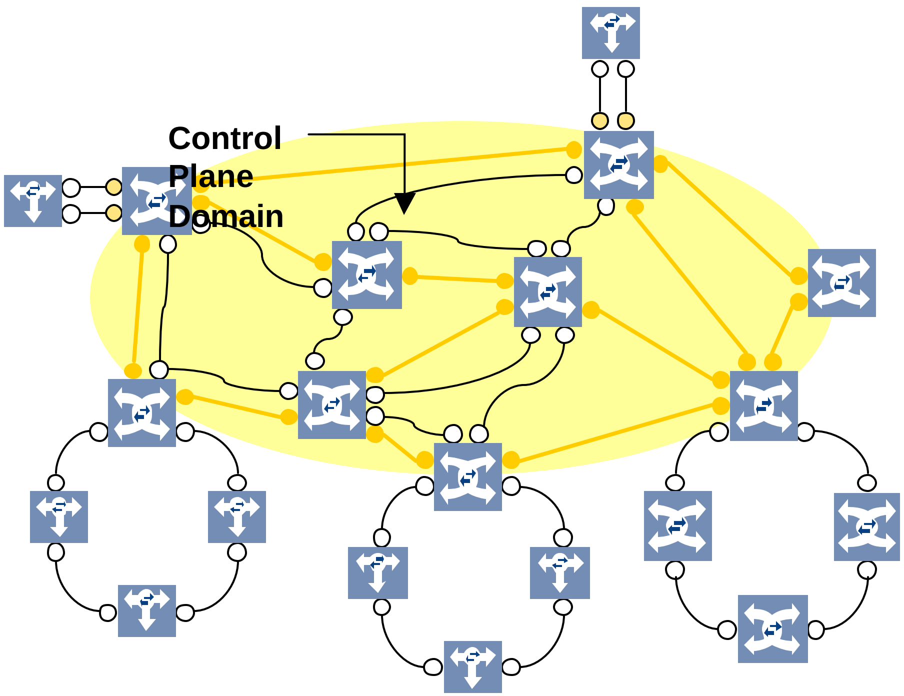
E-NNI applications examples include:

Difference in service realization
Separate address spaces
Independence of survivability (protection/restoration) for each domain
Trust boundaries

Hybrid Network Elements: Enabling Co-Existence With Traditional Networks

Gateway Elements in a Hybrid Ring/Mesh

Rings at the edges and a hybrid mesh/ring core



We see a network architecture with rings at the edges and a hybrid ring/mesh core

- Rings are used at edges and mesh or rings are used in a core
- Rings are optionally used in the core for traffic that must be restorable in 50 ms
- Mesh is used in core for
  - Enhancing the availability of service layer protected traffic
  - 1+1 path protection
  - Lower grades of protection

○ Traditional Port

● Edge Port

● ASON/GMPLS Port

Lower cost and improved reliability via hub ring terminations Control Plane Gateway Element

Summary

Faster time to revenues

- Point and click service connection setups
- Added nodes can immediately be used

Maximize revenues from network

- Hybrid Networks – Best of both Mesh and Rings

New revenues from network

- Offer Optical VPNs with fast path rearrangements
- Multiple connection restoration types

A Managed optical network

- Customizable, end-to-end, service-focused Network
- Scalable for sustained growth and QoS improvements