# Evolution towards flexible Transport Network Services

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# Outline

- Data over transport networks (SDH, OTH)
- Enhancements of transport network flexibility by ASON/GMPLS functions
- Seamless inter-domain and inter-layer interworking based on ASON/GMPLS interface functions
- Summary

# Next Generation NG-SDH Functions
## Virtual concatenation (VCAT), G.707

**Concatenation: Increments of bandwidth within SDH, which can be linked together to give effectively variable bandwidth**

**Contiguous concatenation requires adjacent time slots; used for ATM, IP today**

**Virtual concatenation uses any combination of time slots and path**

- **Needs buffers for differential delay compensation, because payload may be spread on multiple path**
- **Most bandwidth efficient; avoids de-fragmentation losses**

# Next Generation NG-SDH Functions

## Link Capacity Adjustment Scheme (LCAS), G.7042

**LCAS is a methodology for dynamically and smoothly changing (i.e., increase and decrease) the capacity of a container that is transported in a generic transport network (e.g., over SDH or OTN network using Virtual Concatenation)**

**LCAS in the virtual concatenation source and sink adaptation functions provides a control mechanism to smoothly increase or decrease the capacity of a VCG (Virtual Concatenation Group ) link to meet the bandwidth needs of the application**

**Main goal: Synchronization of changes of capacity**

# Next Generation NG-SDH Functions
## Generic Framing Procedure (GFP), G.7041

**Simple and robust encapsulation method for packet traffic:**

- **PDU-oriented adaptation mode, referred to as Frame-Mapped GFP (GFP-F)**
  - **Individual client PDU (protocol data units) are mapped into individual GFP frames**
  - **Used for Ethernet mostly**
  - **Most bandwidth efficient**
- **Block-code oriented adaptation mode, referred to as Transparent GFP (GFP-T)**
  - **Mapping is based on characters, not PDU**
  - **Used for SAN signals mostly**
  - **Minimizes latency**

| | | |
|---|---|---|
| Ethernet | IP/PPP | Other client signals |
| GFP – Client specific aspects (Payload dependent) | | |
| GFP – Common aspects ( Payload independent) | | |
| SDH VC-n path | Other octet-synchronous paths | OTN ODUk path |

# Next Generation NG-SDH Functions

## Gain of virtual concatenation (VCAT) and Generic Framing Procedure (GFP-F)

**Increasing the efficiency of data over SDH transport:**

**VC-12-Xv (X * 2.240 Mbit/s )**

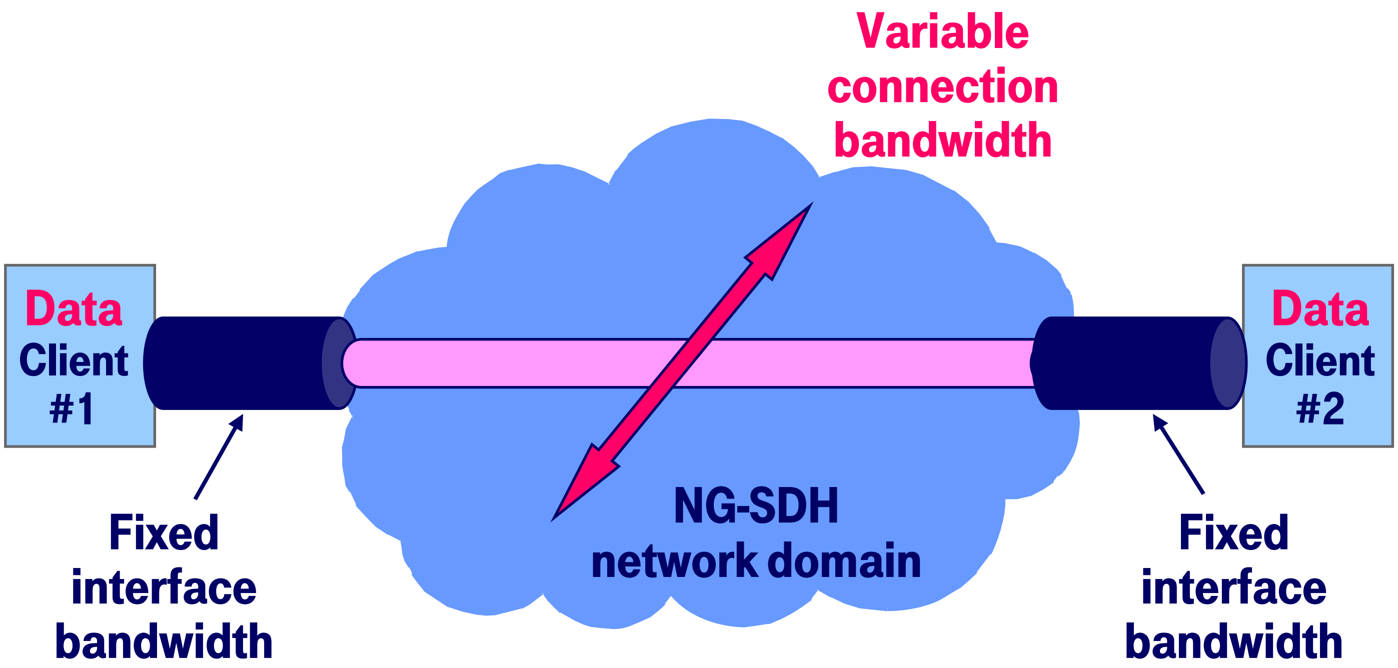
**VC-3-Xv (X * 48.960 Mbit/s )**

**VC-4-Xv (X * 150.336 Mbit/s )**

| Client Signal | Bit Rate | No. SDH VCs | SDH Efficiency |
|---|---|---|---|
| Ethernet | 10 Mbit/s | VC-12-5v | 89% |
| Fast Ethernet | 100 Mbit/s | VC-3-2v | 100% |
| Gigabit Ethernet | 1,000 Mbit/s | VC-4-7v | 96% |
| 10 Gigabit Ethernet | 10,000 Mbit/s | VC-4-64c | 100% |
| FC/FICON | 850 Mbit/s | VC-4-6v | 95% |
| Digital Video | 270 Mbit/s | VC-4-2v | 90% |
| Serial Digital HDTV | 1,485 Mbit/s | VC-4-10v | 100% |

# Next Generation NG-SDH Functions

**Virtual concatenation (VCAT), LCAS and GFP-F → Data over transport capabilities**

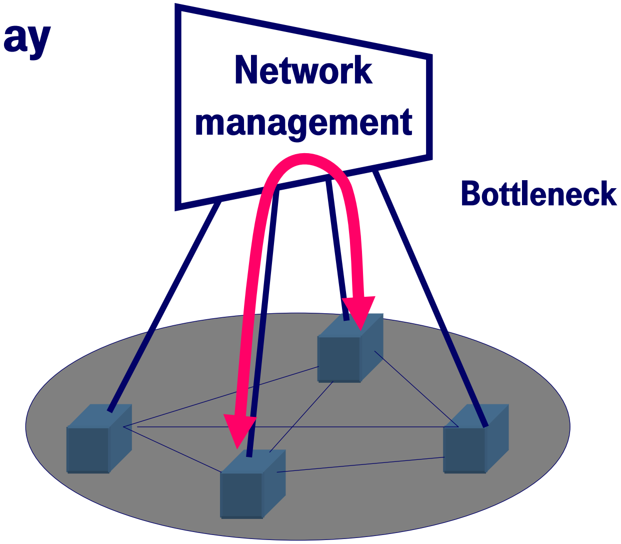



**Interface bandwidth is decoupled from the bandwidth of the connection in the transport network!!!**

# ASON/GMPLS Control Plane enabled Networks

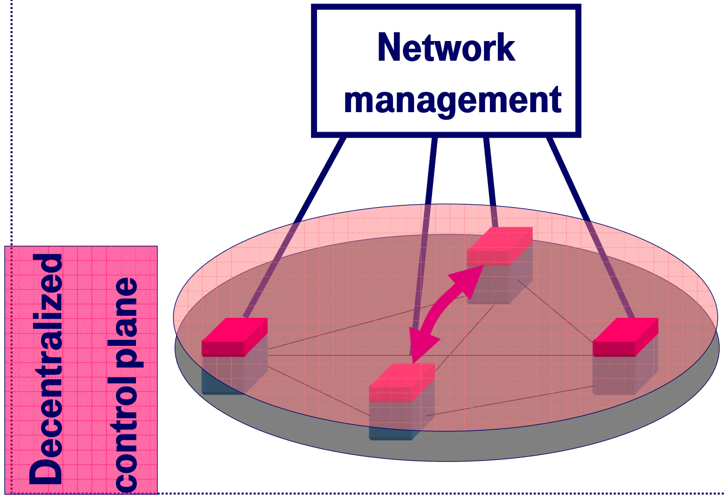
## Reduced complexity of network management and control

### Today




- **Every control communication** between nodes has to be handled **via the network management**
- A node has **no information about the network**
- Only **central** decisions
- **High complexity** of network management

### Control plane solution




- **Direct control communication** between nodes
- A node **has information about the network**
- **Local (and fast) decisions** are possible
- **Reduced complexity** of network management

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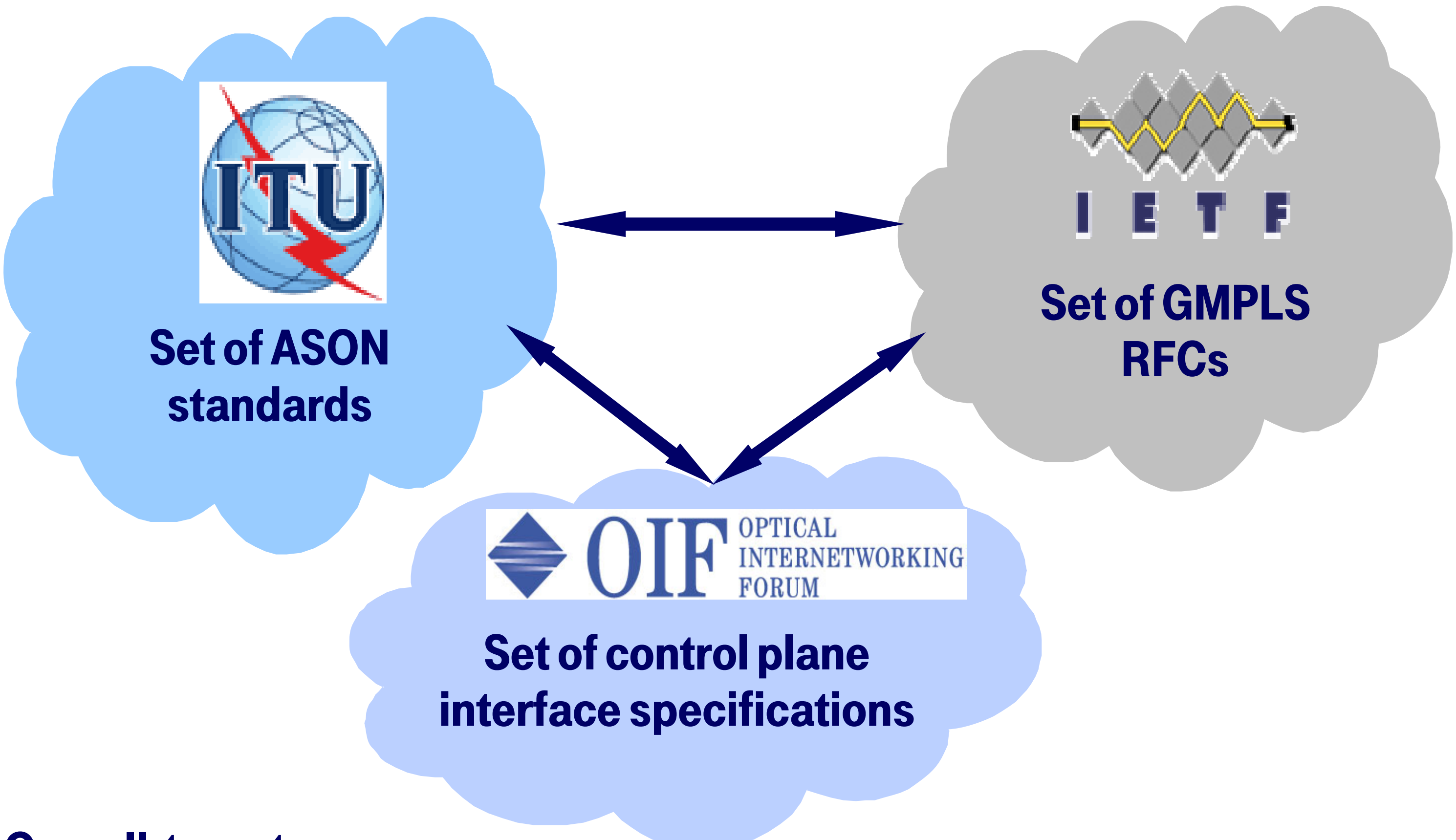
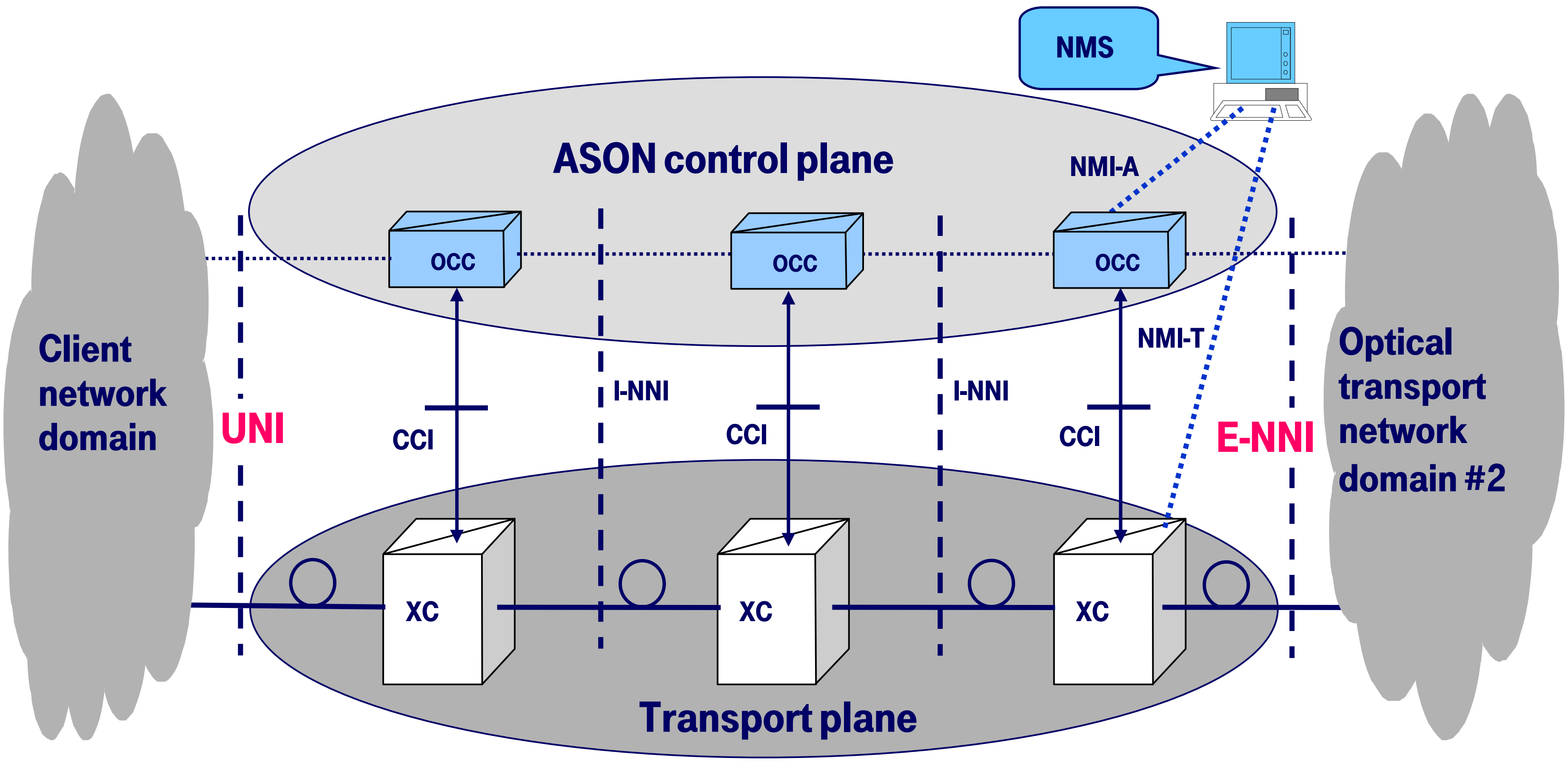
# ASON/GMPLS Standardization Bodies & Forums




**Overall target:**
**Complete <u>one</u> interoperable set of ASON/GMPLS standards and specification to foster the deployment of control plane enabled networks**

# ASON Network Architecture




OCC: Optical Connection Controller
CCI: Connection Control Interface
NMS: Network Management System Interfaces

NNI: Network Network Interface
UNI: User Network Interface
NMI-A/T: Network Management

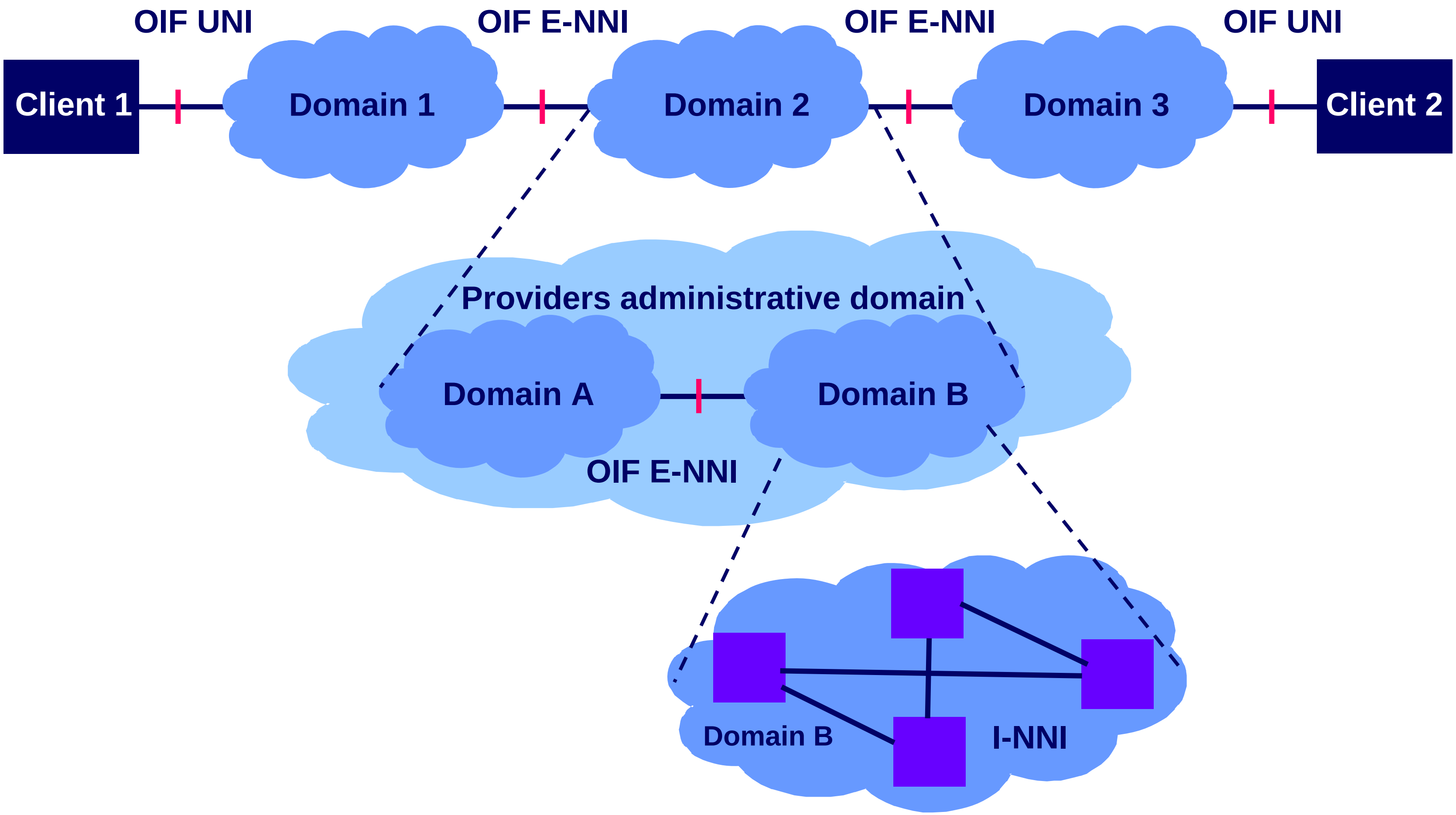
# Intra-Domain ASON/GMPLS Functions (I-NNI)

- **Auto discovery and self inventory**
- **Traffic engineering based on a table of parameters**
- **Flexible protection and restoration schemes**
- **Fast provisioning of Soft Permanent Connections (SPC) initiated by NMS/EMS**
  - **SPCs could be used for dynamic service provisioning for all not control plane enabled client networks and for all signal formats for which UNI functions are not defined yet, e.g. SAN signal formats**

**→ ASON/GMPLS functions enhance network configuration flexibility and increases network resource utilization significantly**

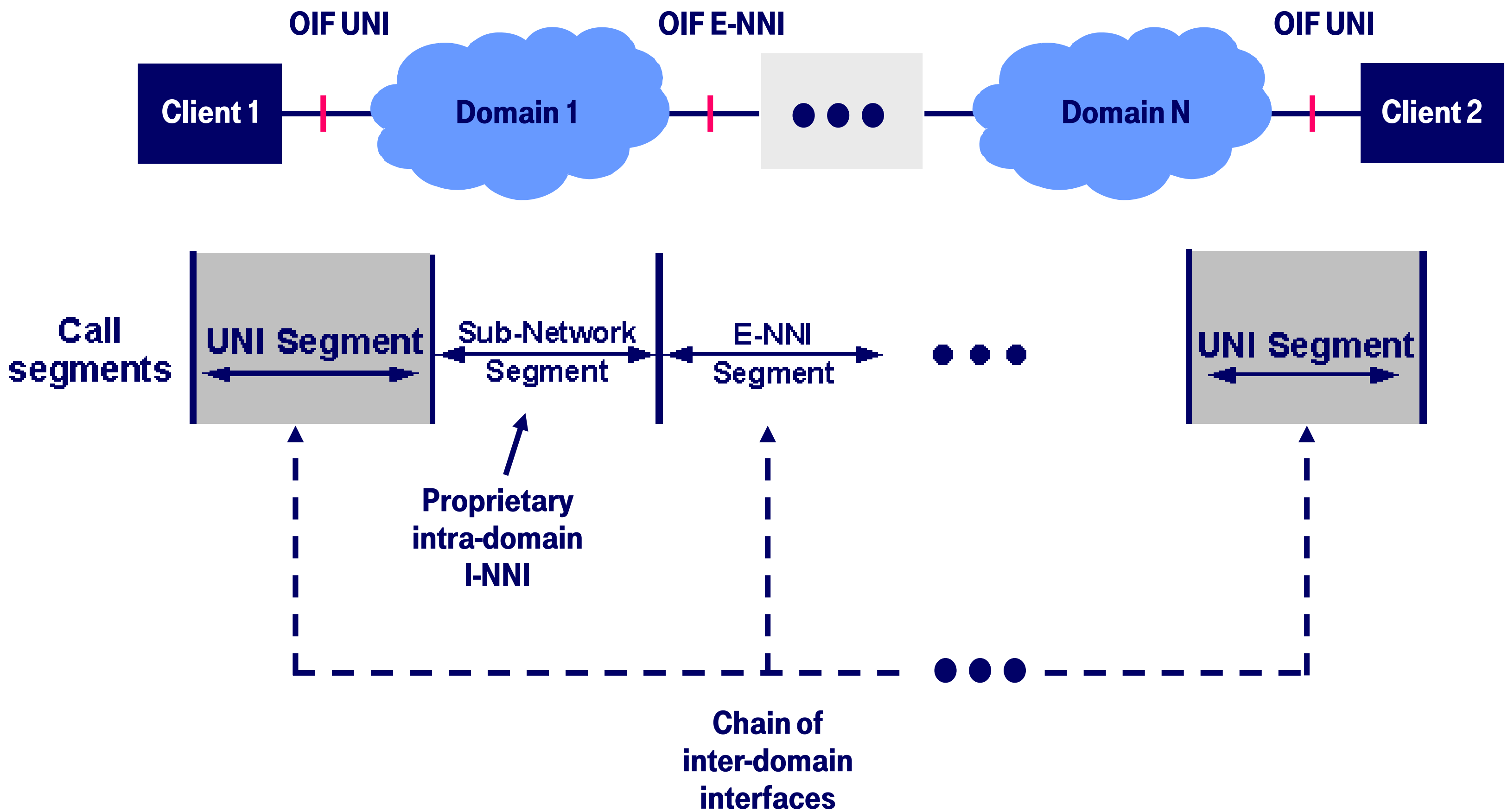
# ASON Multi-Domain Network Scenario

## Partitioning of networks – inter-domain interfaces



# Inter-Domain ASON Interfaces

## Enable multi-domain, on-demand services



# ITU-T and OIF Collaboration

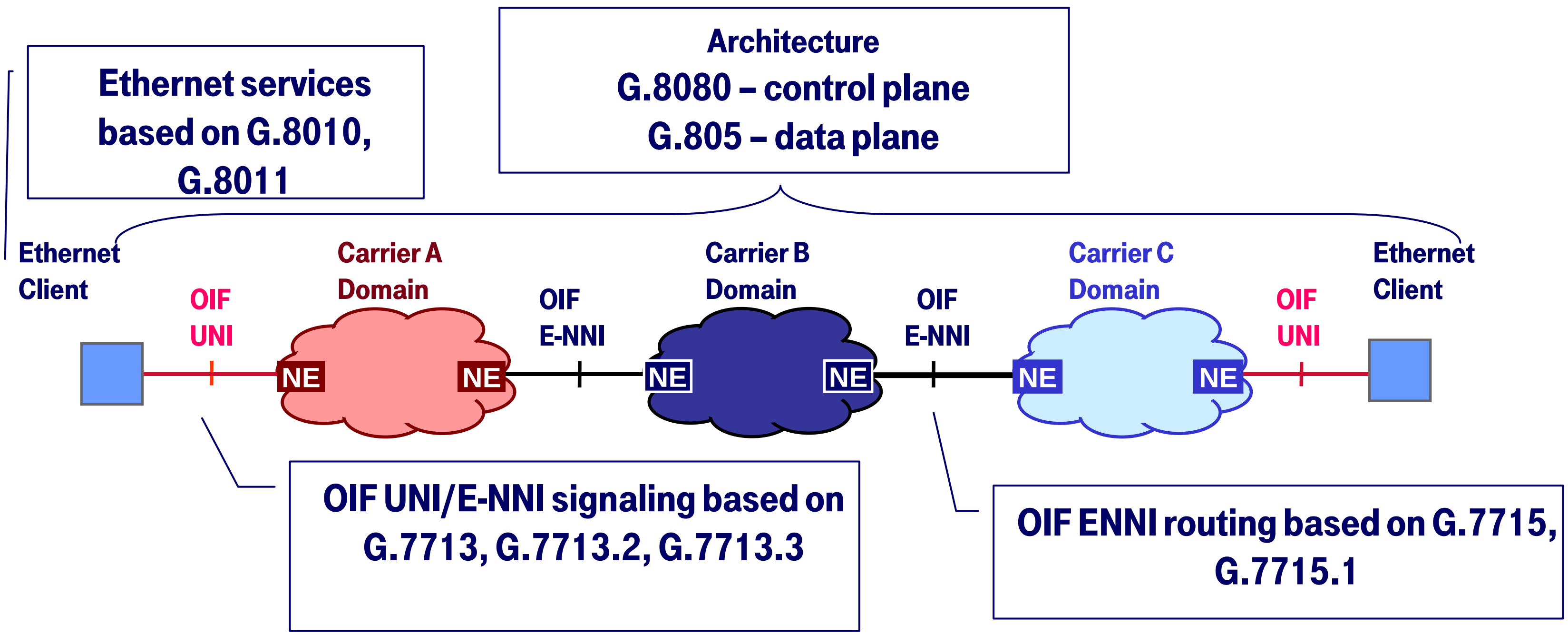
## Correlation of IUT-T and OIF standards/specifications

**OIF**

- Carrier requirements
- Interoperability testing
- Protocol specifications in Implementation Agreement
- Adoption of ITU-T Recs.

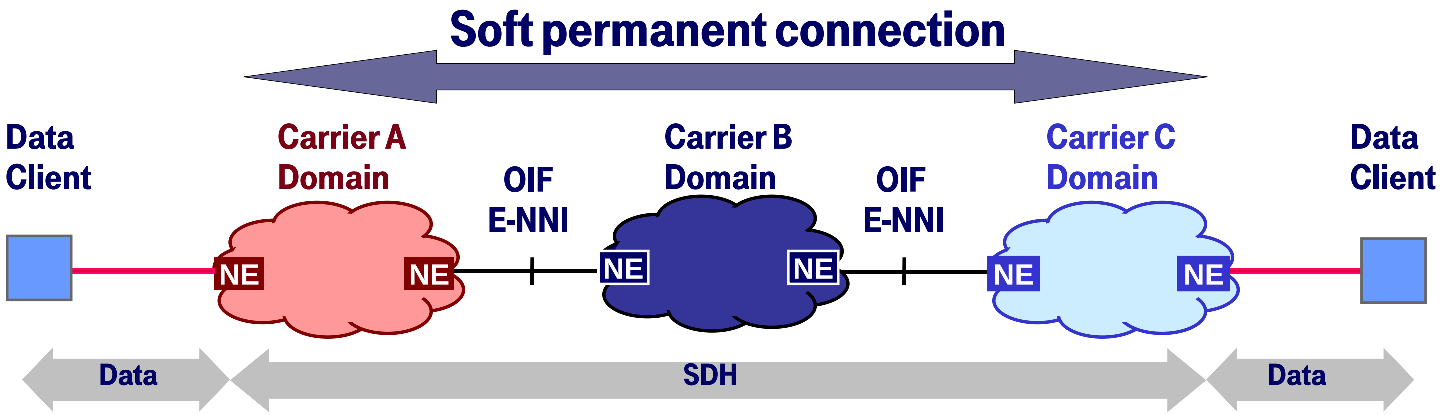
**ITU-T**

- ASON Recommendations for optical signaling and routing
- Transport Recommendations for GFP/G.7041, LCAS/G.4042, VCat/G.707, Ethernet/G.8011



# Inter-Domain E-NNI Function

## Control plane interface between transport network domains



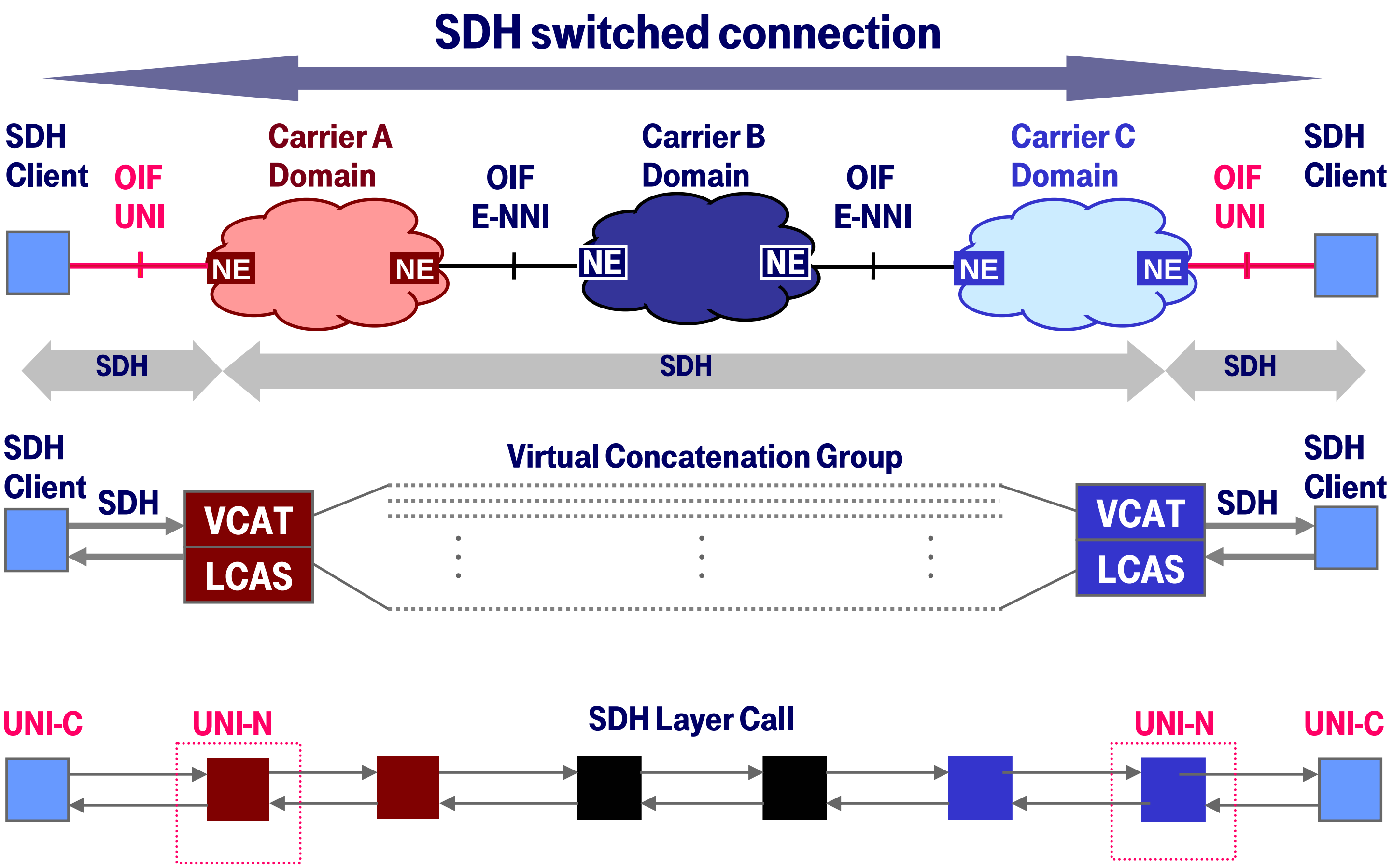

**E-NNI enable seamless interworking of multiple, individual (different in architecture, technology used, management,..) transport network domains**

**Supports soft permanent connections (SPC): EMS/NMS initiated automatic connection provisioning over multiple ASON/GMPLS network domains**

**SPCs could be used for all not control plane enabled client networks (no UNI function available) and for all signal formats for which UNI functions are not defined, e.g. SAN signal formats like FC → see GSN+ Demonstrator section on customer controlled SAN services**

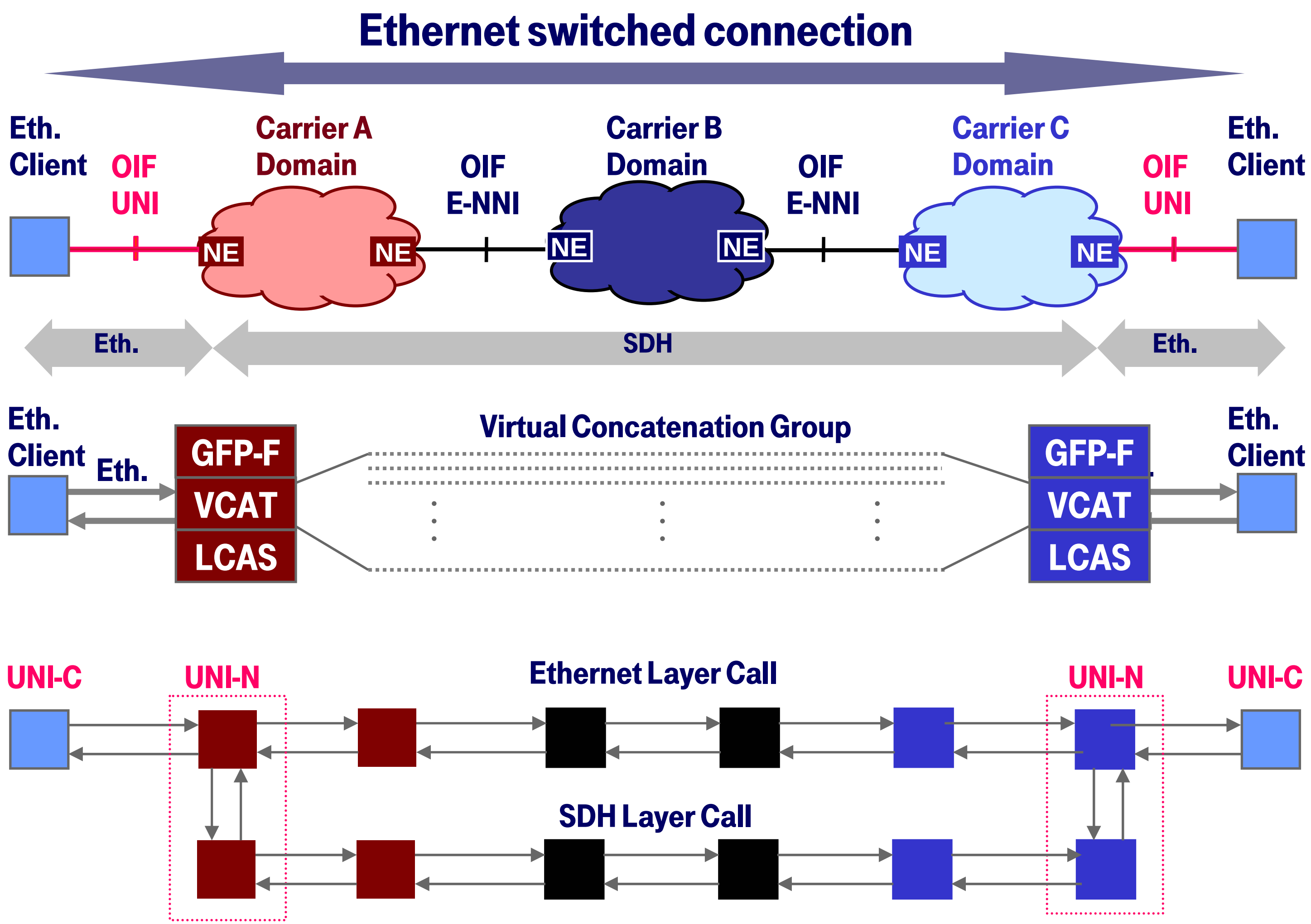
# UNI1.0 Release2: Data and Control Plane

## SDH switched connections (UNI 1.0R2/E-NNI)



# UNI2.0 Ethernet: Data and Control Plane

## Ethernet switched connections (UNI 2.0Ethernet/E-NNI)

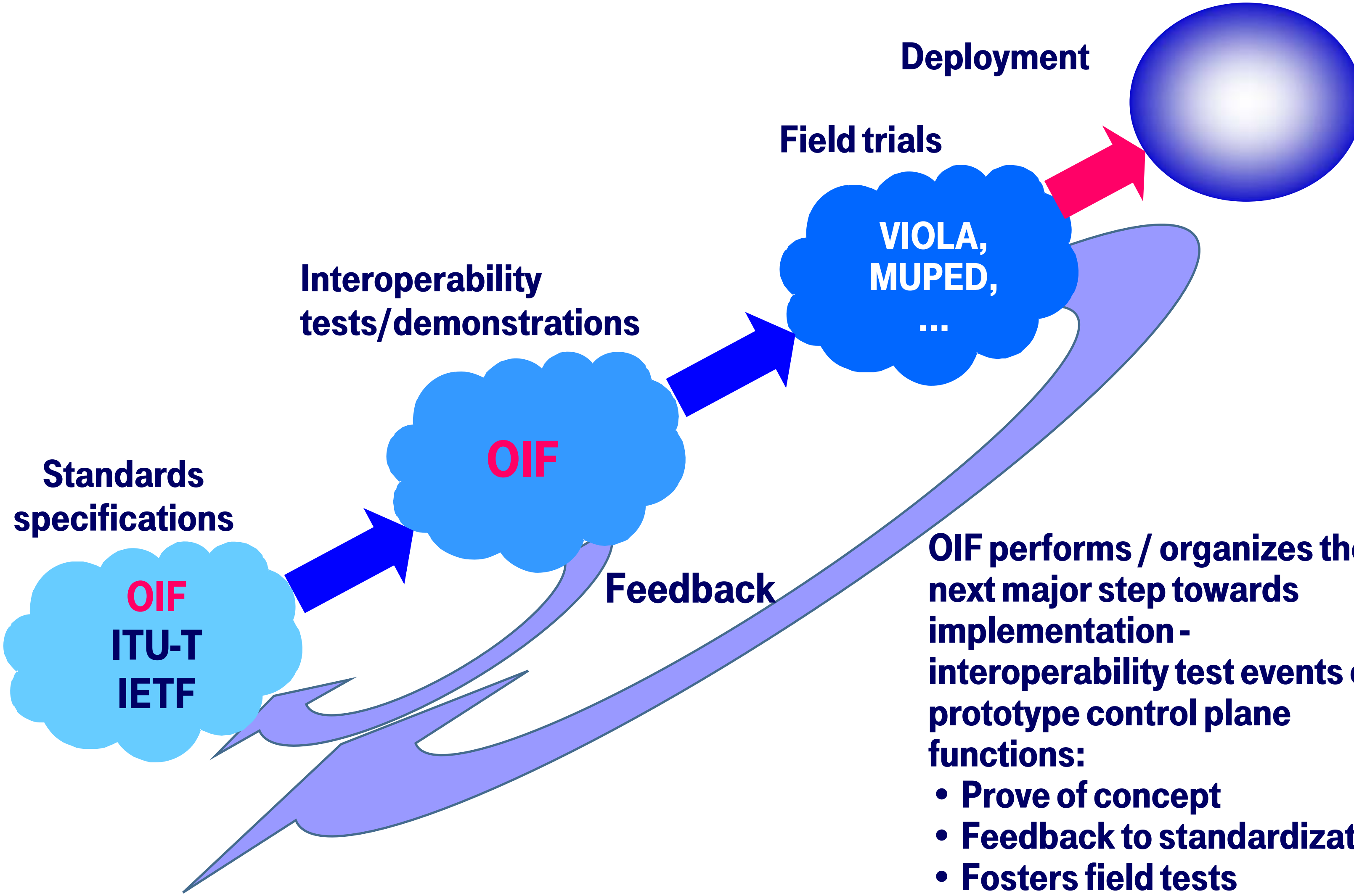


# Inter-Domain ASON/GMPLS Interfaces

- Supports heterogeneous networks environment: Different carriers and vendors may use different approaches and solutions
  - Allows sub-networks to use different methods for the same function (G.805)
  - No external view of sub-network internals (Different addressing, protocols may be used
- Support for clear distinct network boundaries among individual network domains with different technologies, architectures,…
  - UNI: Interface to the client/customer; low trust area; standardization needed
  - E-NNI: Inter-domain interface; medium trust area; standardization needed
  - I-NNI: Intra-domain interface; trusted area; vendor proprietary extensions possible (see description of the GSN+ Demonstrator backbone functions)
- Support of hierarchical multi-area routing
  - Routing area details are opaque to higher level areas (abstracted view only)
  - Allows for different carrier and vendor approaches to coexist
- Support of different control plane and data plane topology
  - Allows for simplification of routing implementations
  - Allows for better support of large networks

# Evolution from Standards to Deployment

## Close relation of standardization and R&D activities

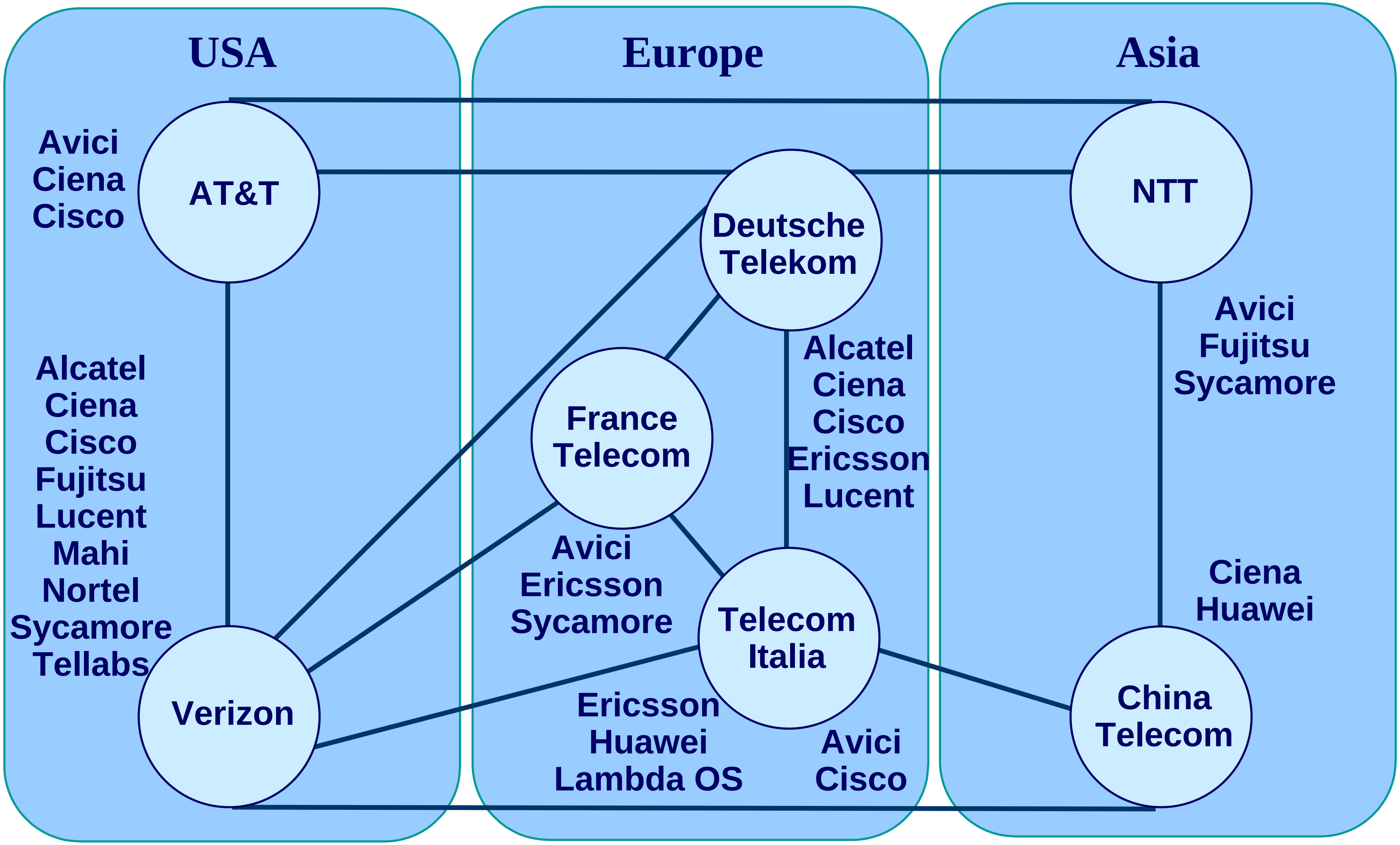



**OIF performs / organizes the next major step towards implementation - interoperability test events of prototype control plane functions:**

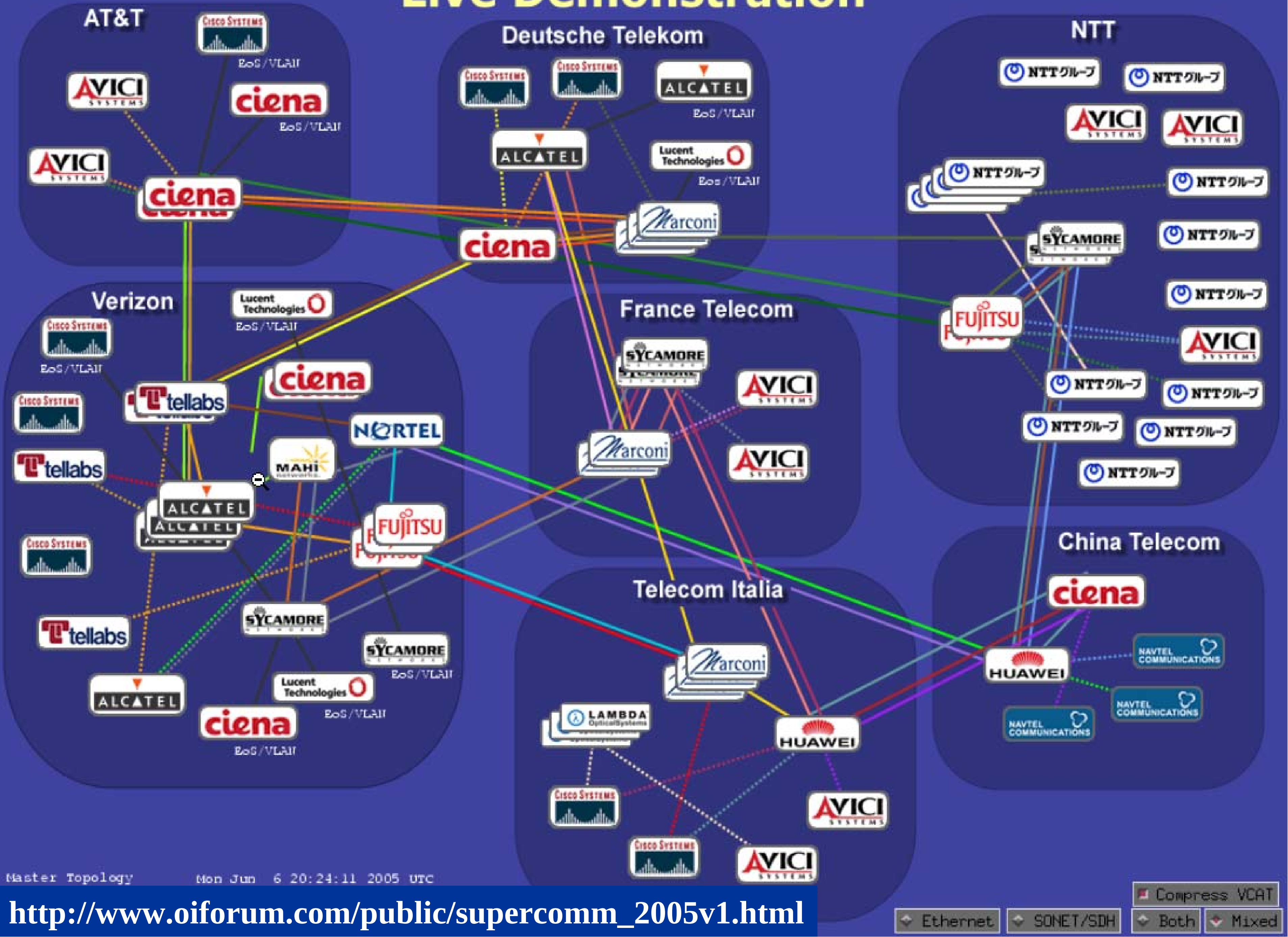
- **Prove of concept**
- **Feedback to standardization**
- **Fosters field tests**

# OIF Interoperability Demonstration 2005

## Global test network topology



# Live Demonstration




http://www.oiforum.com/public/supercomm_2005v1.html

# ASON/GMPLS Implementations

**Implementations based on ASON/GMPLS standards and draft specifications**

**Demonstrators and field tests:**

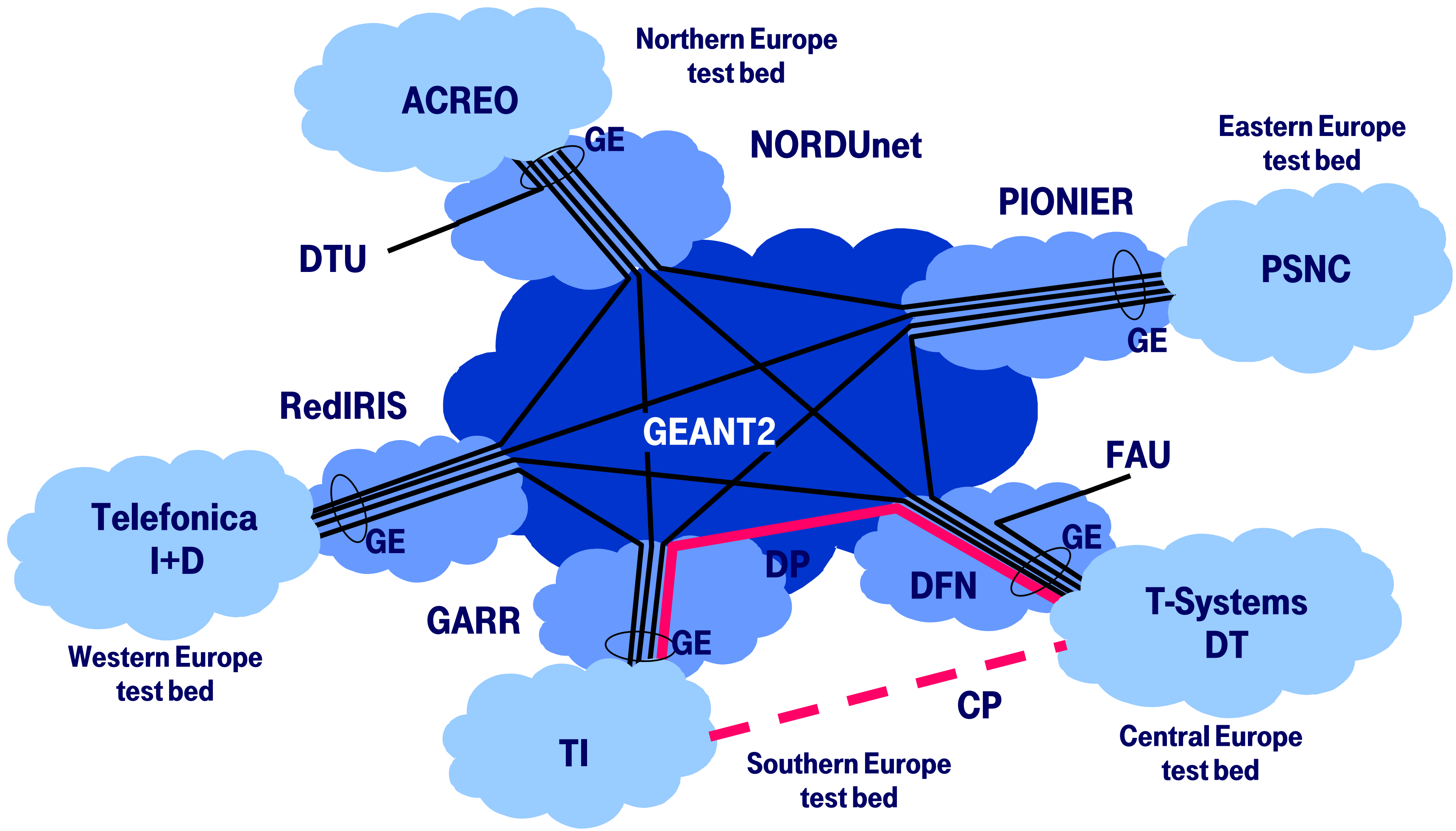
- **Japan, joint carrier, vendor, university activities:**
  - **Several ASON/GMPLS interworking results, e.g. OFC/NFOEC2006, PD47**
- **European projects:**
  - **NOBEL (www.ist-nobel.org)**
  - **MUPBED (www.ist-mupbed.eu)**
- **German project (BMBF):**
  - **VIOLA (www.viola-testbed.de)**

**Carrier networks:**

- **Telecom Italia (ECOC2004)**
- **AT&T (OFC/NFOEC2006, Service Provider Summit)**

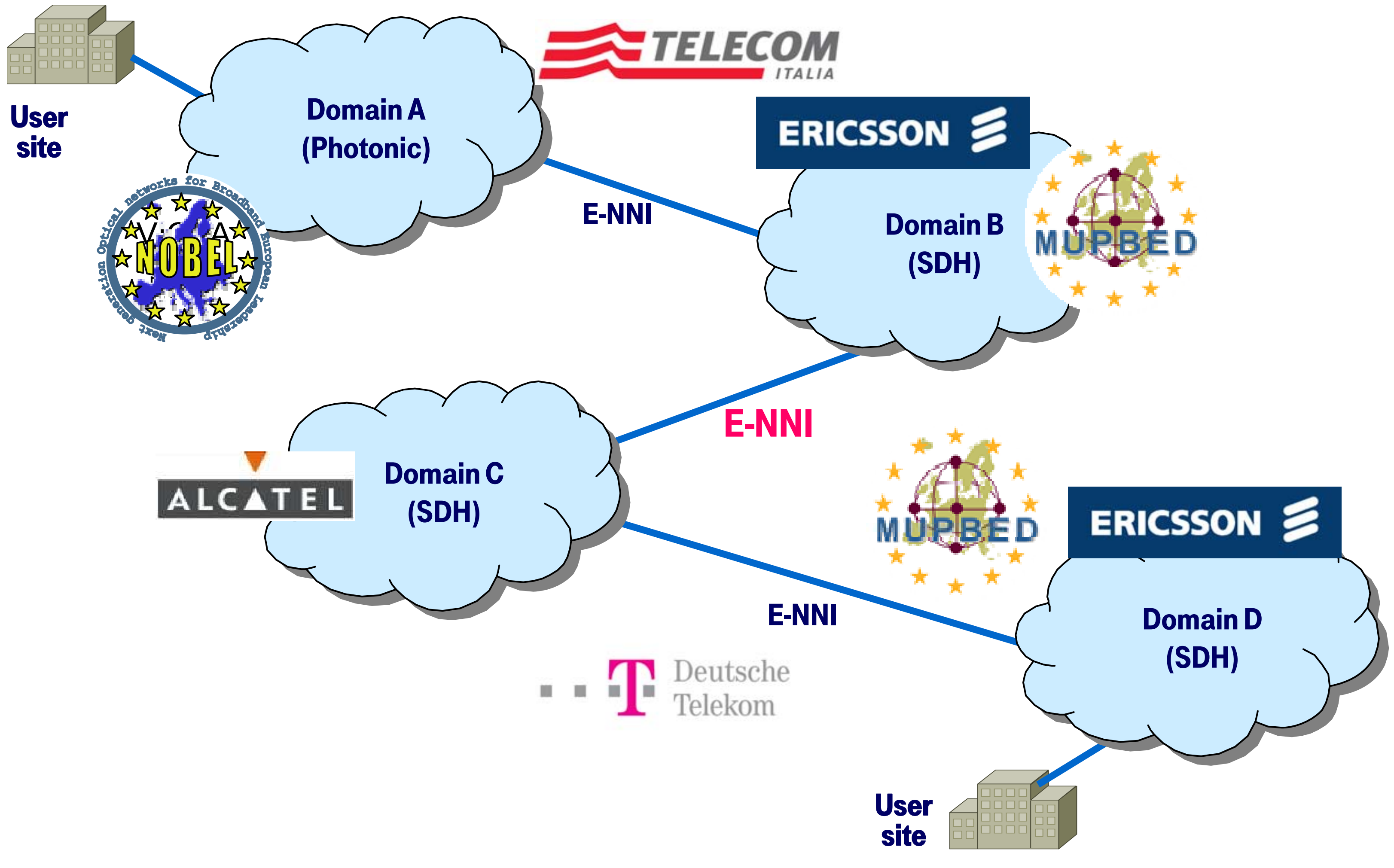
# Multi-domain Eth.-SC based on OIF UNI2.0 Eth. and E-NNI

## Joint MUPBED – NOBEL tests and demonstrations

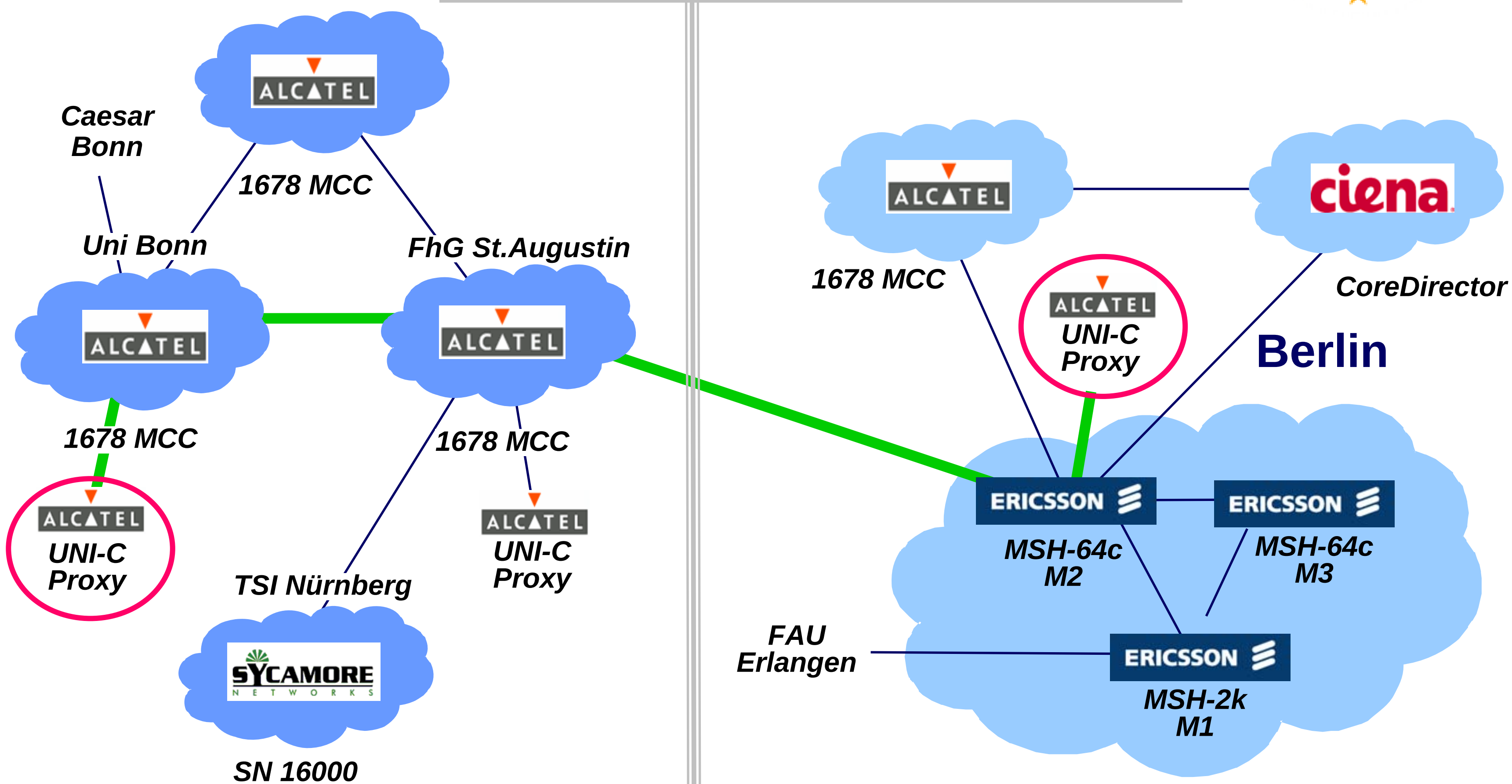


# Implementation of Virtual Inter-Lab E-NNI

## MUPBED – NOBEL: Ethernet Soft Permanent Connection (SPC) TI – DT



# Virtual SDH-SC VIOLA-MUPBED



# Summary

**Integrated data plane and ASON/GMPLS control plane functions build the bases for interoperable solutions and carrier benefits:**

- **Provisioning of end-to-end dynamic connections for flexible data services over multiple, control plane enabled domains**
  - **But maintaining the individual architecture, control, and technology approach in each network domain**
- **Deploy at faster pace innovative network technologies**
- **Select cost effective and leading edge network elements, platforms and multi-vendor solutions**
- **Reduce operations overheads and simplify provisioning of new services**