

Control Plane capabilities and challenges for NGN and Grids

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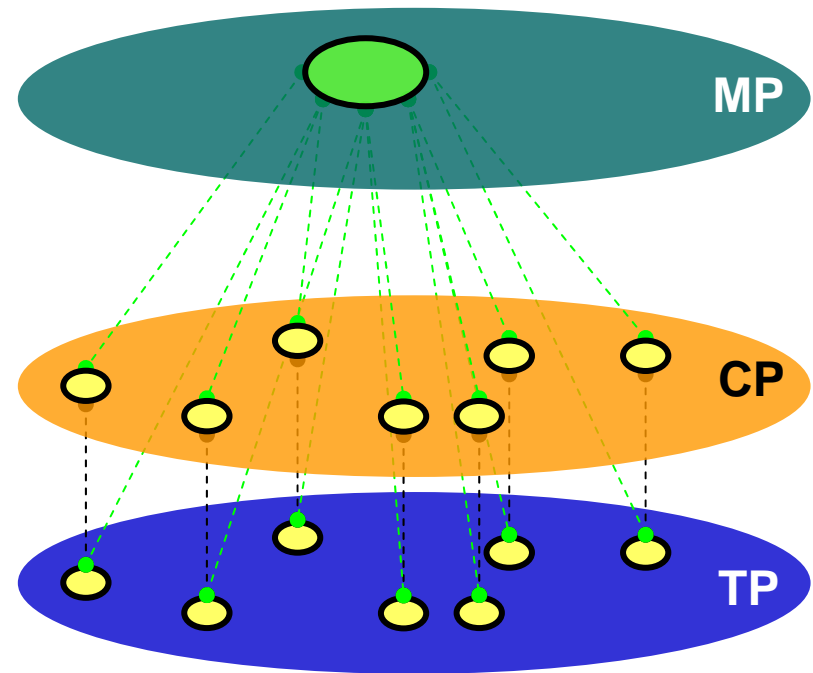
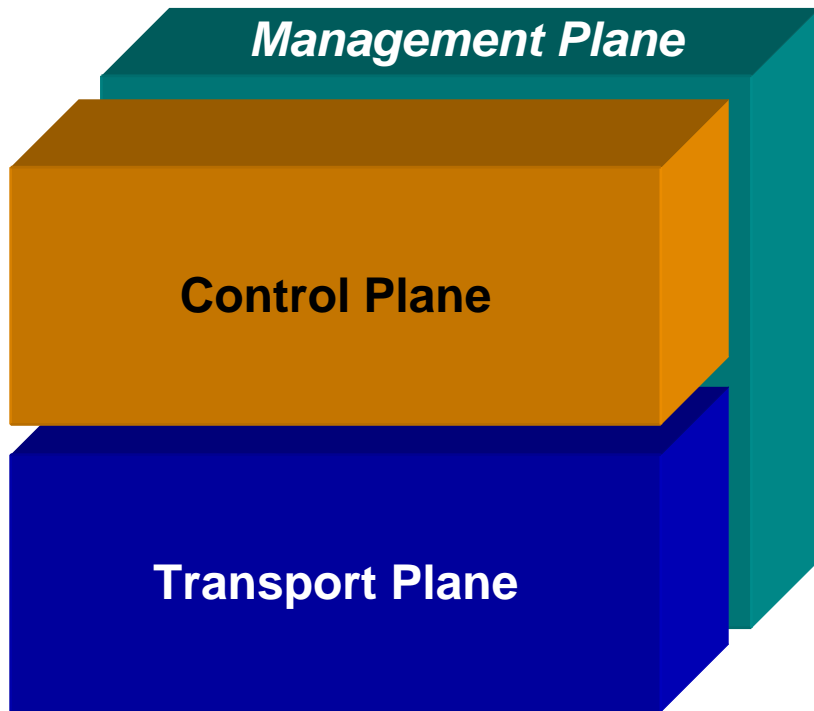


- Introduction to CP and ASON/GMPLS
- ASON/GMPLS quick overview
 - ASON architecture
 - OIF network interfaces
 - GMPLS architecture & protocols
- Control Plane future challenges
 - General overview
 - Insight on GMPLS control of Ethernet switched networks
 - Insight on GMPLS control of wavelength switched optical networks
- The G²MPLS in the Phosphorus project



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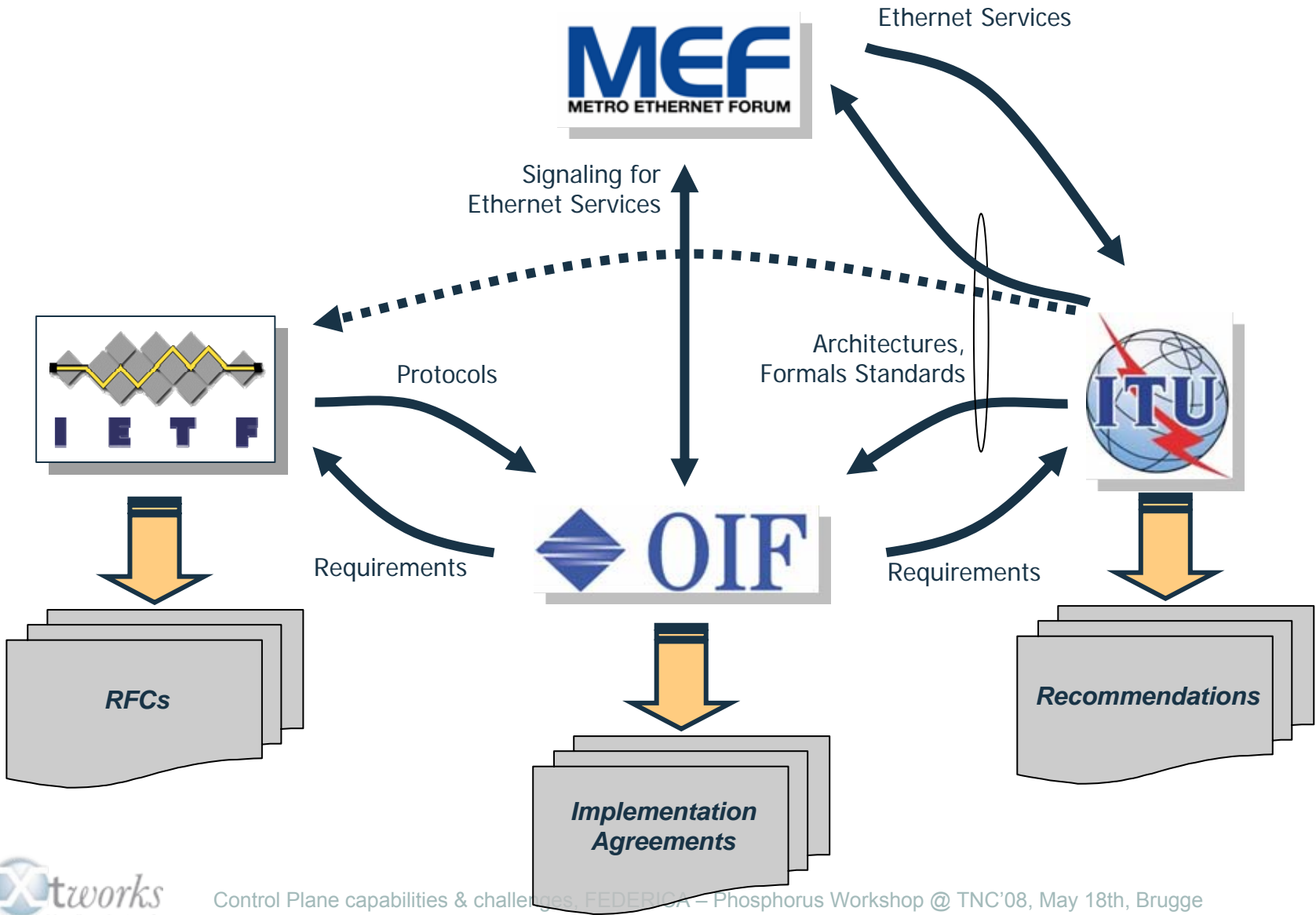
The Control Plane in the overall picture



Control Plane scope & advantages

- Distributed and reactive traffic engineering, allowing network resources to be dynamically allocated to connections
- Use of specialised control plane protocols rather than generalised network management protocols with small primitive sets
- Extendable capability sets for signalling
- Connection control in a multi-vendor environment
- Distributed and reactive restoration, taking into account the current state of the transport network
- Fast service provisioning
- Reusability of control plane protocols to handle different transport technologies under a common control framework

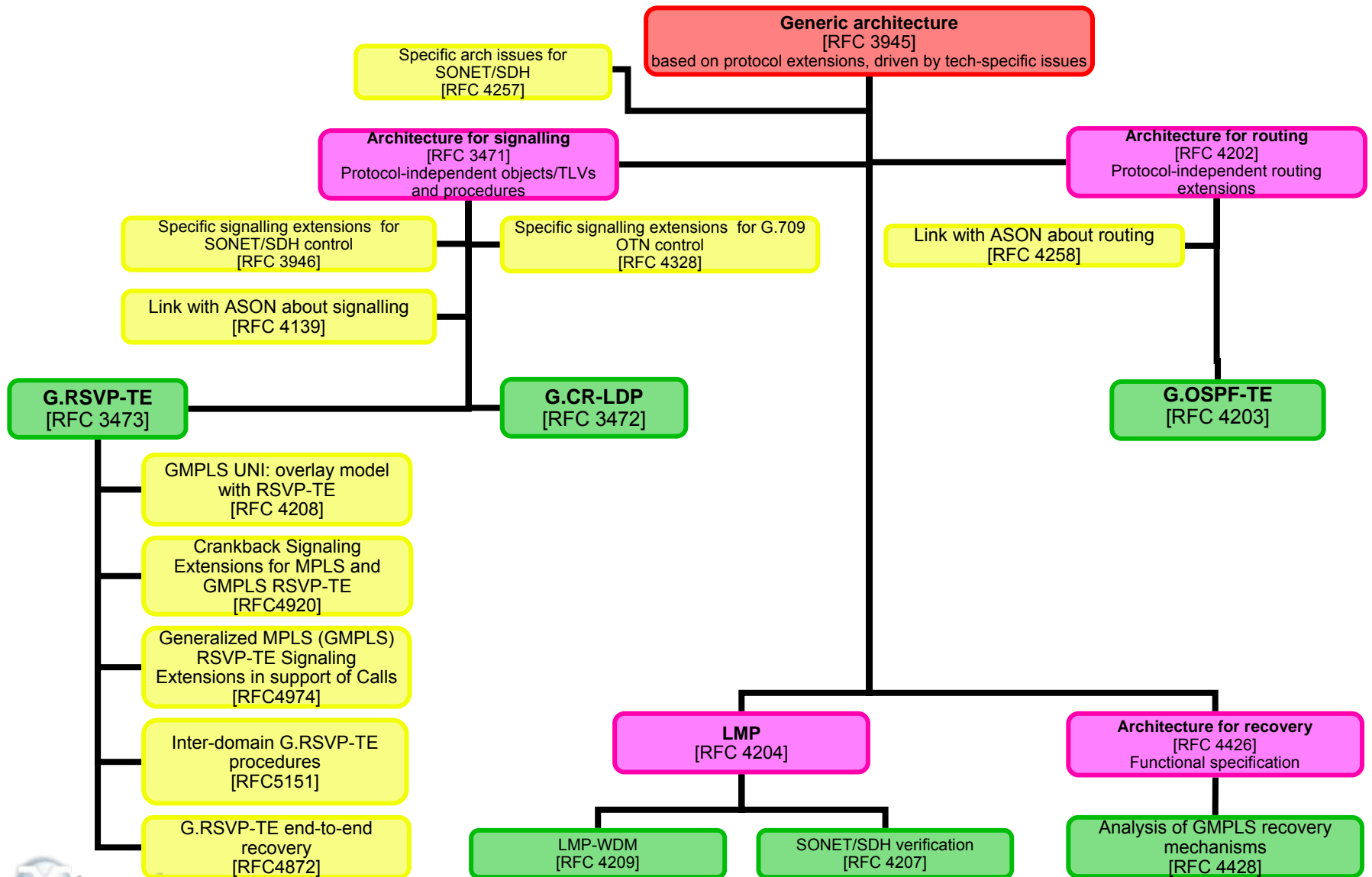
SDOs focusing on ASON/GMPLS



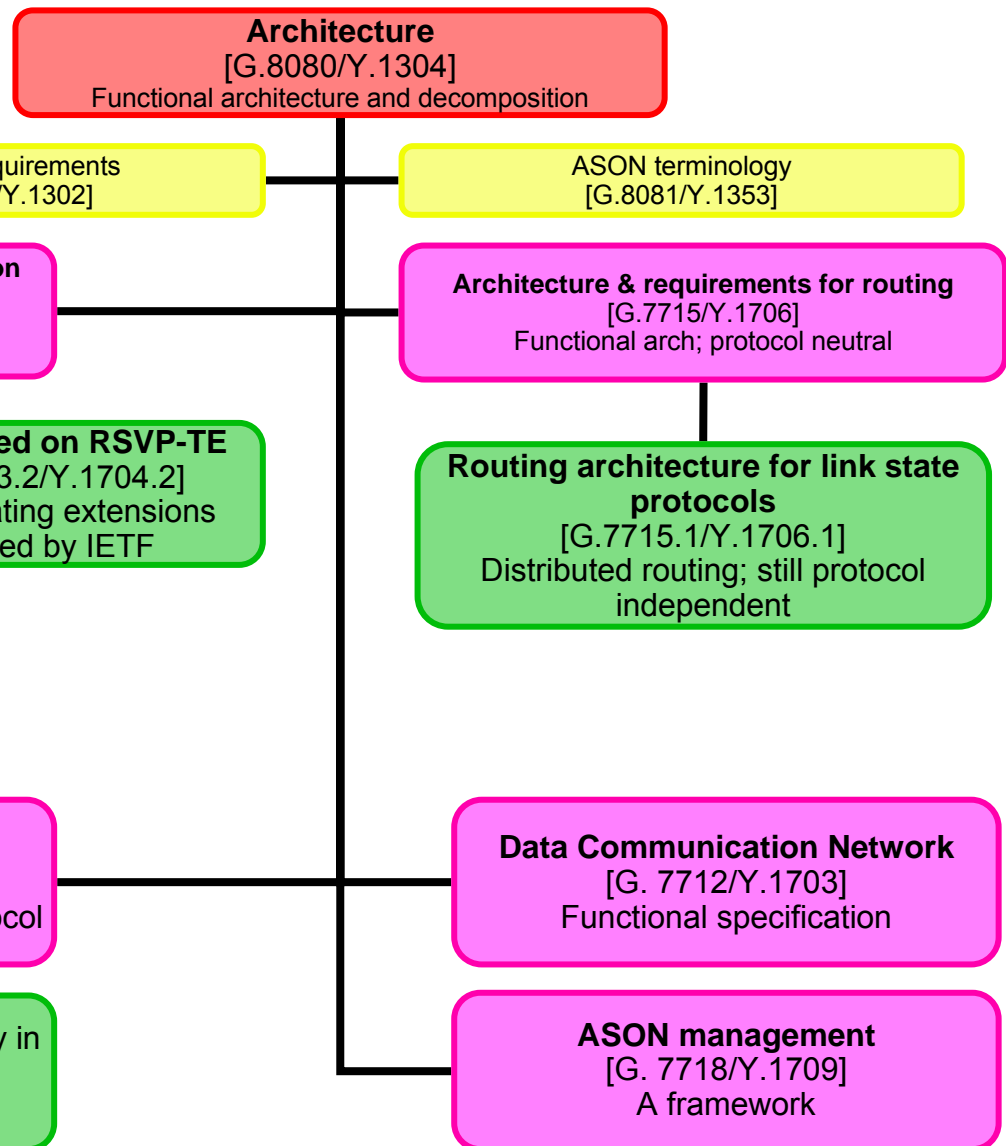
ITU-T ASON vs. IETF GMPLS

- Both aim to equip a generic Transport Network with a Control Plane
- ITU's approach
 - ...defines the requirements for a Control Plane over the (Optical) Transport Network reference model
 - ...specify an overall architecture and functional decomposition for that
 - \Rightarrow an **abstract (protocol independent) Control Plane architecture** on an optical Transport Plane architecture
 - It's a **top-down approach**:
 - ◆ then goes down to the protocols, where it “meets” IETF
 - ◆ OIF work on Network Interfaces is aligned with this approach
- IETF's approach
 - starts from the MPLS architecture and protocols and
 - tries to “generalize” and extend the MPLS approach to a wider set of switching devices
 - ◆ e.g. TDM, lambda-switching and fiber-switching
 - it's a **bottom-up approach**:
 - ◆ extensions to “popular” protocols
 - ◆ fit this work into an architecture (not as generic and abstract as the ITU's one)

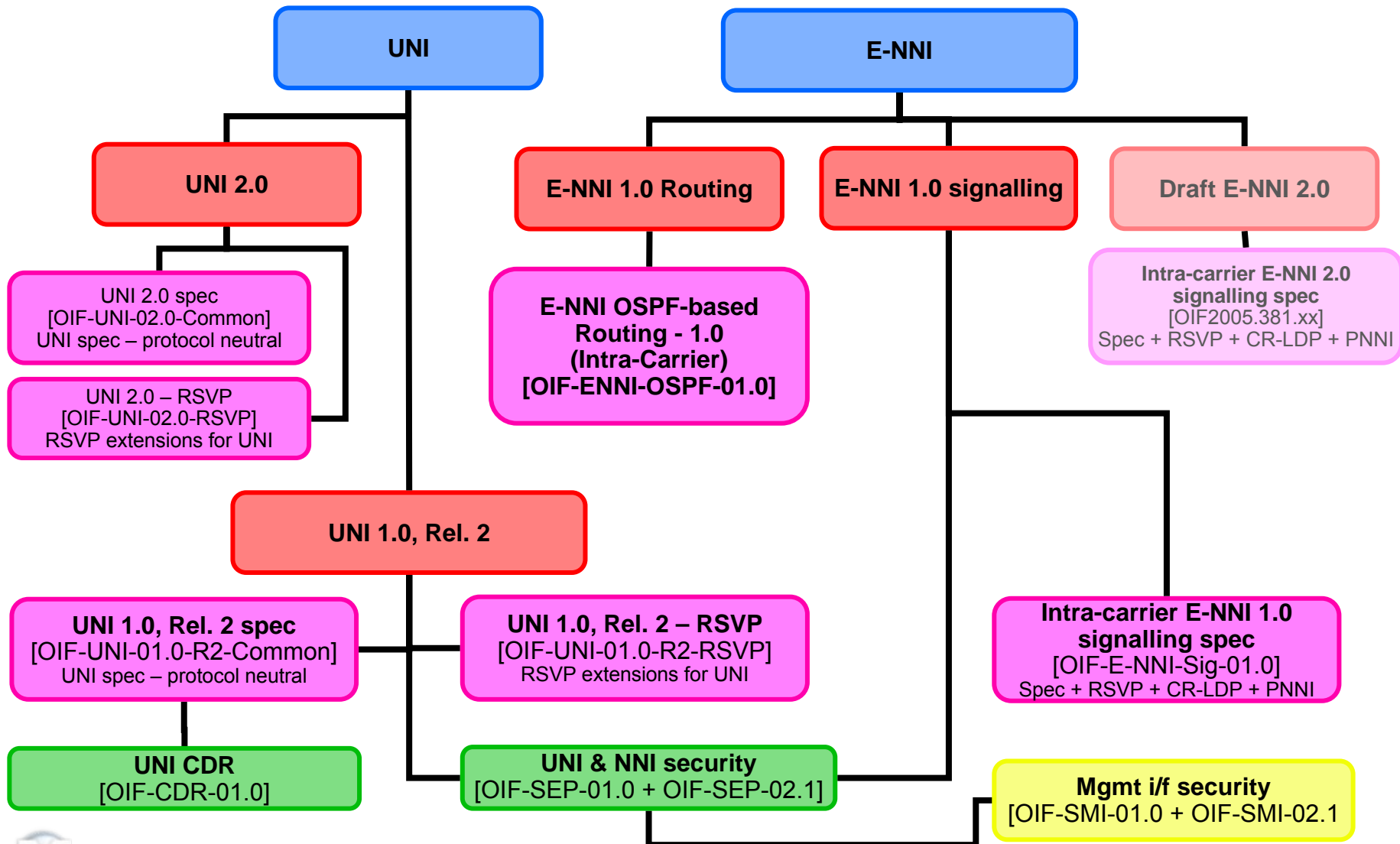
IETF's way to GMPLS



ITU's way to ASON



OIF's Network Interfaces



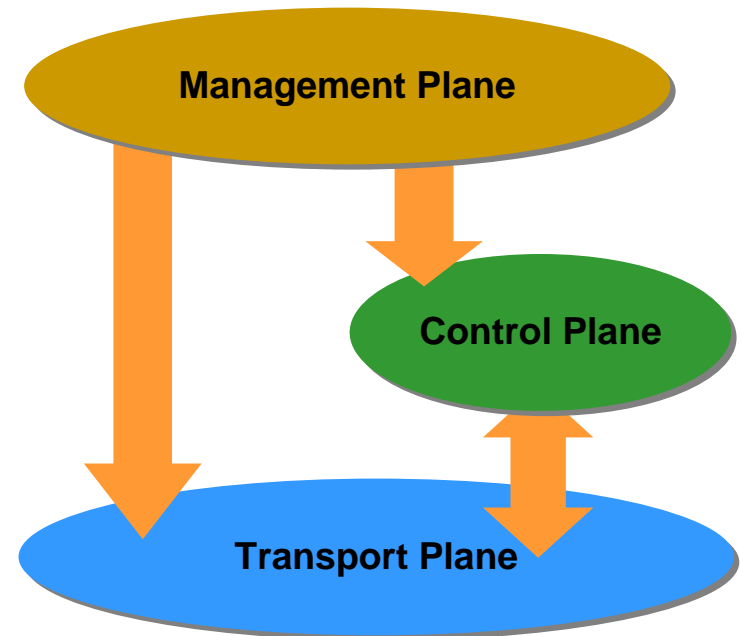


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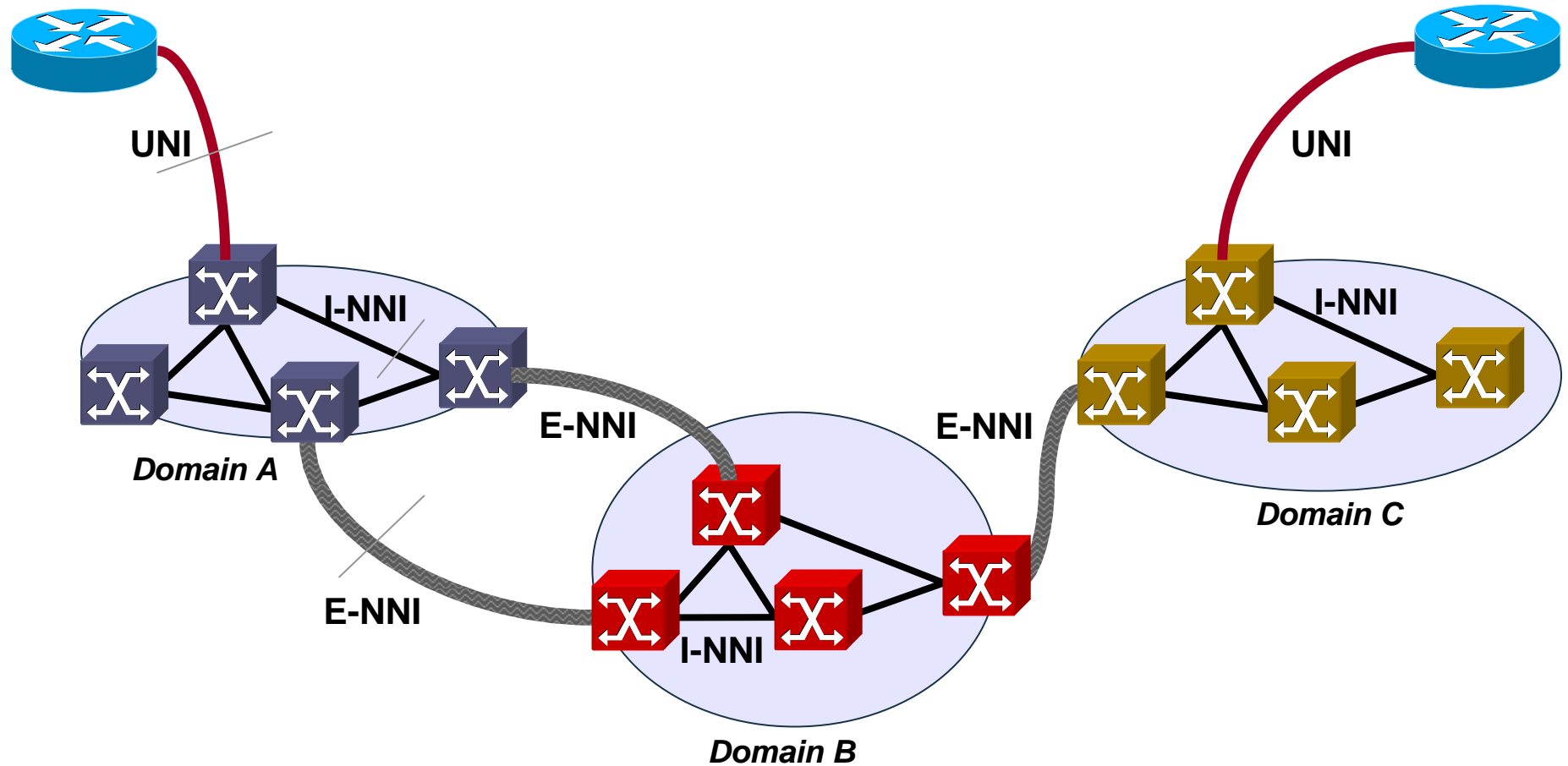
ITU's ASON scope

- General requirements
- Architecture
- Control Plane Data Communication Network
- Distributed Call & Connection Management
 - Instantiated via PNNI Q.2931, GMPLS RSVP-TE and GMPLS CR-LDP
- Requirements and architecture for routing
- Automatic resource discovery mechanisms
 - Instantiated for SDH and OTN networks

- G.8080/Y.1304 specifies the requirements and architectures of ASTN for these transport networks
 - SDH (G.803)
 - OTN (G.872)
- G.8080 deals with the interaction between the control, management and transport planes



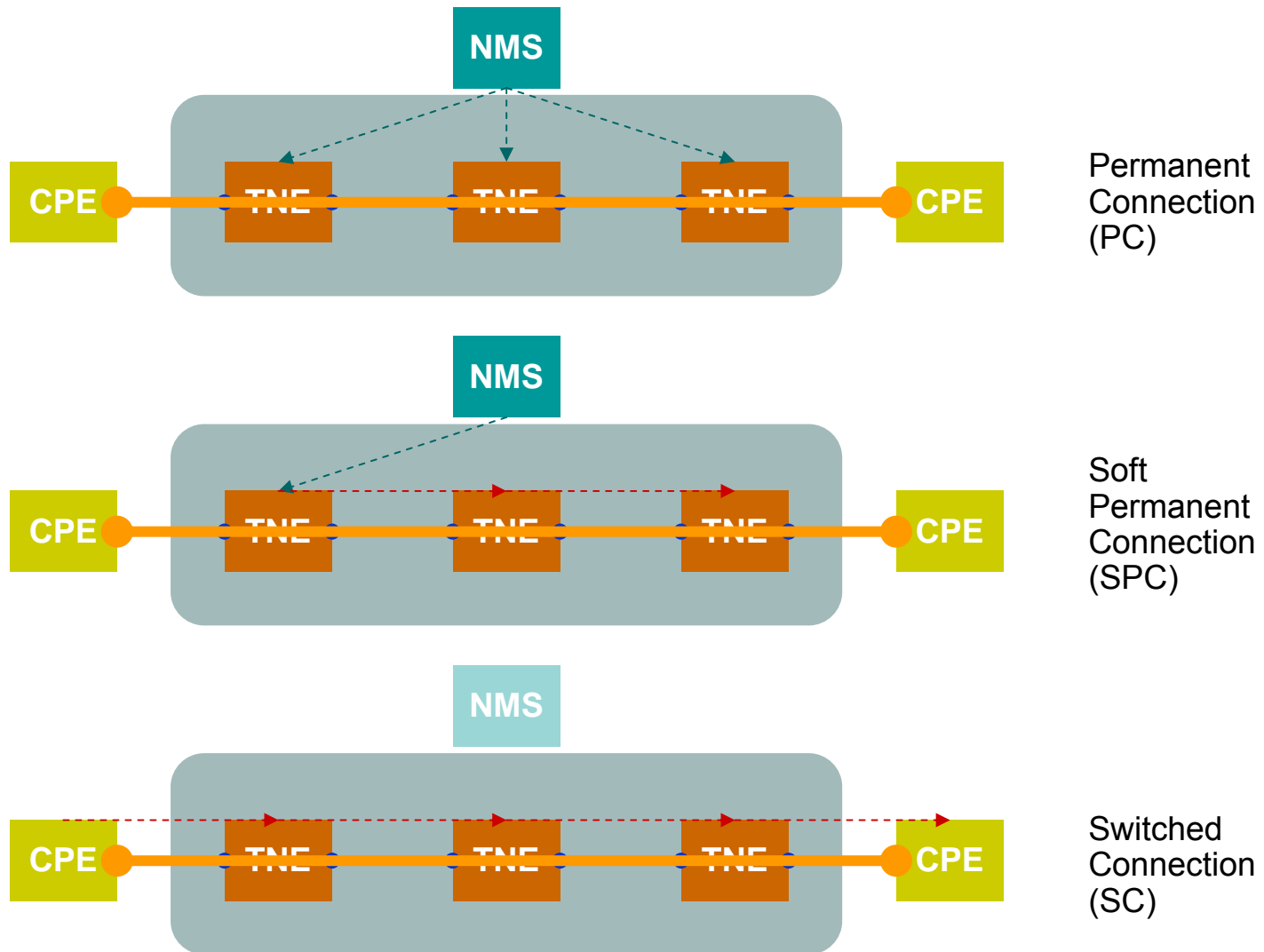
ASON reference points



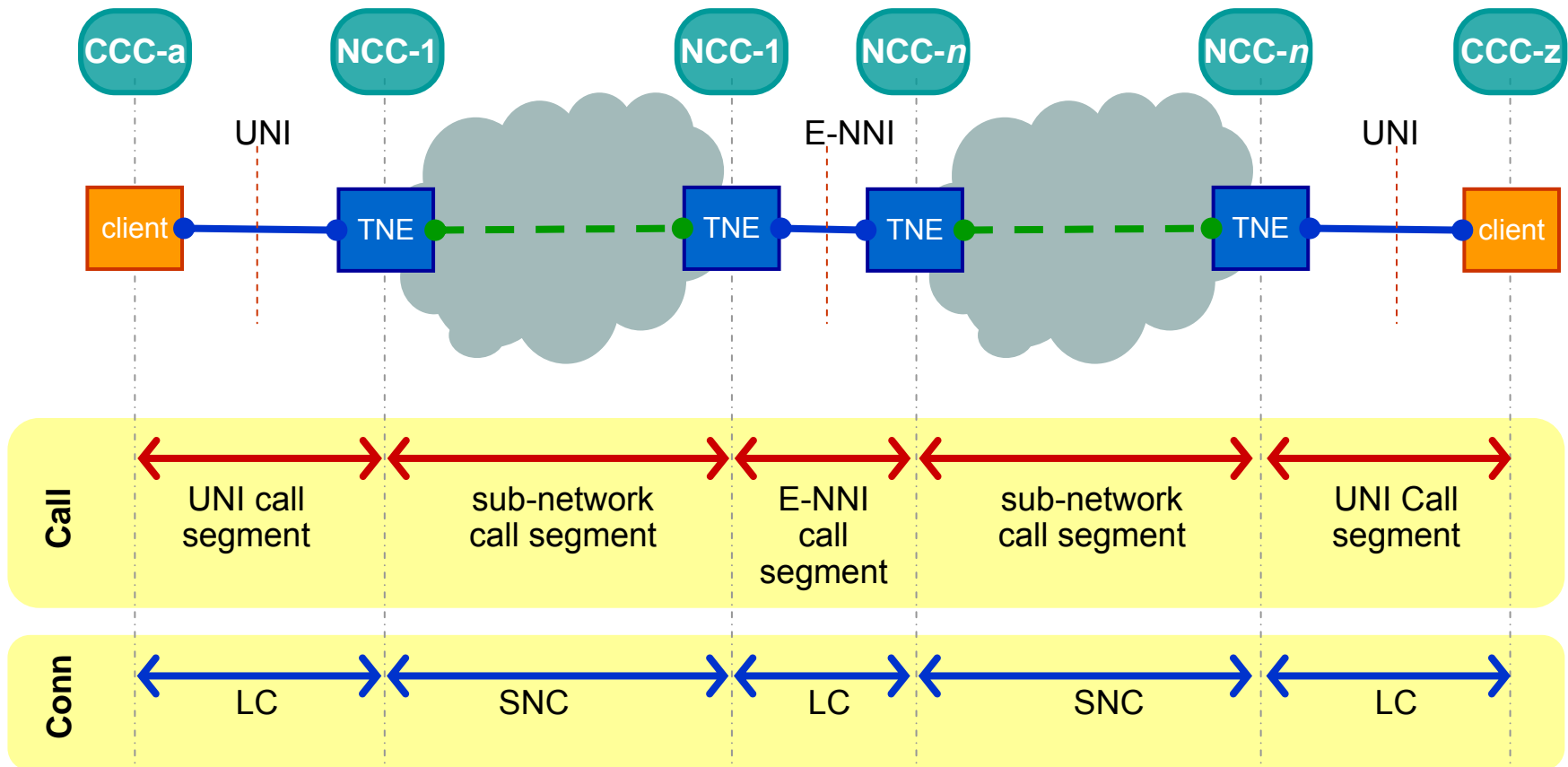
Connection establishment types



scope and purpose of ASTN CP



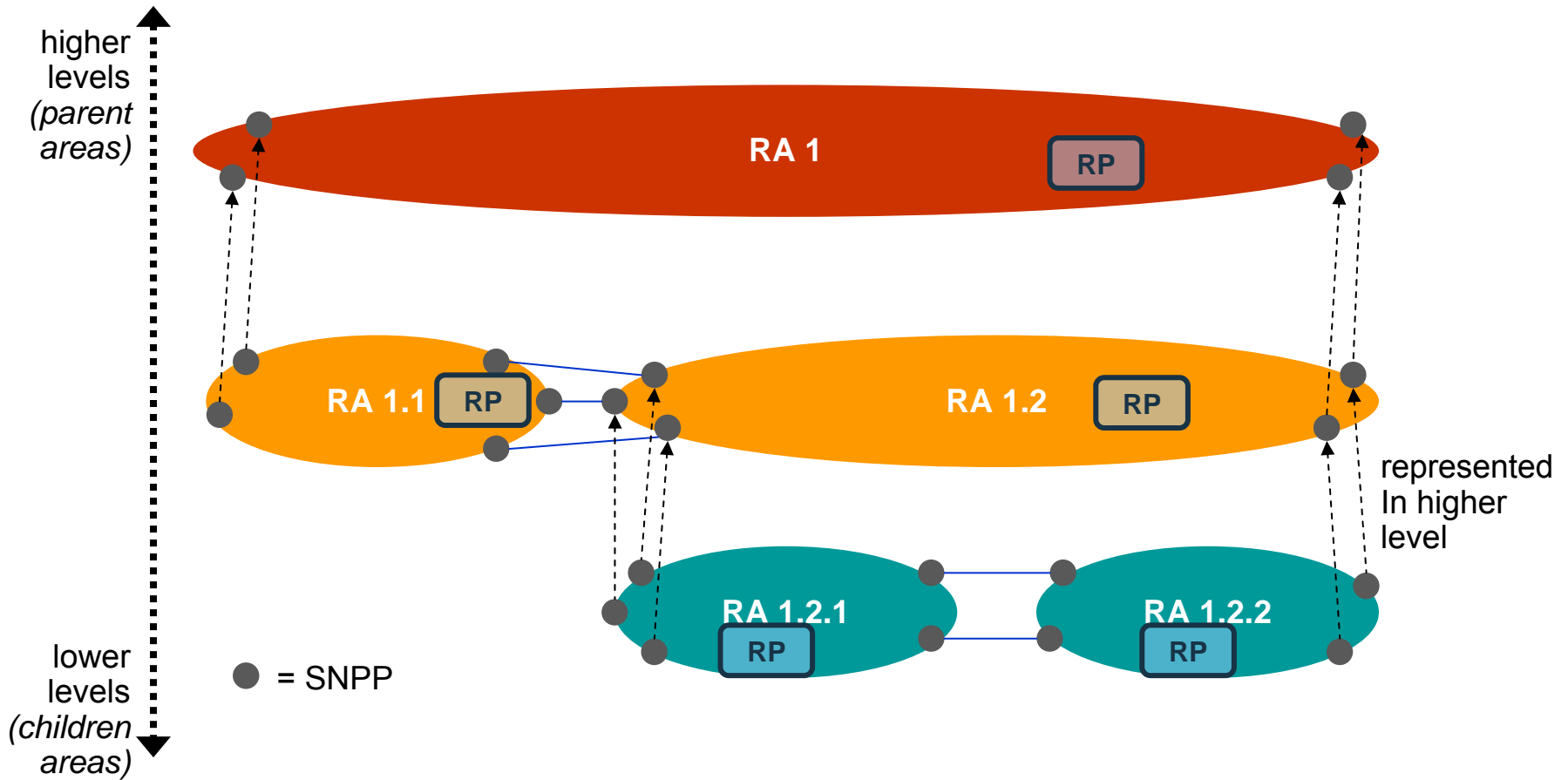
Call and connections



ASON routing principles

- ASON might be subdivided into **Routing Areas (RAs)**, *hierarchically*
- RA = “a set of subnetworks, the SNPP links that interconnect them, and the SNPPs representing the ends of the SNPP links exiting that routing area” [G.8080]
- Partitioning into RAs might be based on several criteria: geography, administration, technology, etc...
- The services of a routing area are implemented by a **Routing Performer (RP)** – e.g. path selection
 - RP is a federation of RCs; it serves a single area
- The **Routing Controller (RC)** implements the coordination and distribution of routing information within a routing area, and across its borders
- RC functions may be implemented by distributed entities
 - the **Routing Control Domain (RCD)** abstraction hides the details of this distribution

RAs hierarchy: an example



Data Communication Network

- Specified by G.7712
- Covers layers L1, L2 and L3
- Supports specific networks:
 - MCN (Management Communication Network) used by the TMN to deliver management messages
 - SCN (Signalling Communication Network) used by the ASTN Control Plane to deliver signalling and routing traffic
- IP [+MPLS], OSI or mixed
- Connection-less or connection-oriented network services are supported
- Built on WAN, LAN and ECC (Embedded Control Channel) i/fs



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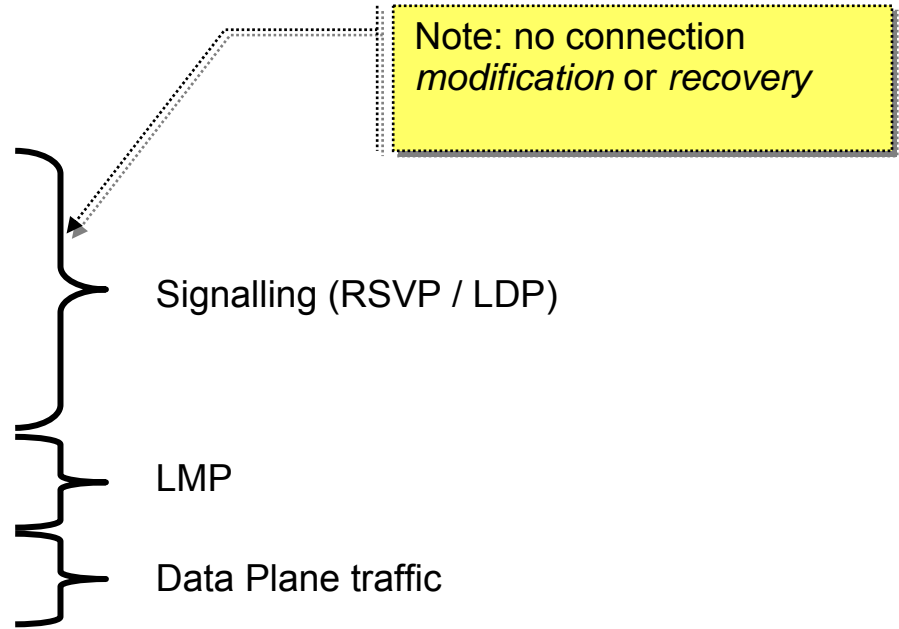
OIF Control Plane IAs scope

- Specified network reference points
 - User-Network Interface
 - Network-to-Network Interface
- Limited to inter-vendor interfaces, *not* inter-carrier
- Compliant with the ASON reference points
- Using the ASON hierarchical routing model
- Compliant with ASON (and now GMPLS) Call and Connection separation
- Using (and extending) IETF GMPLS protocols for both signalling and routing

Operations across the UNI

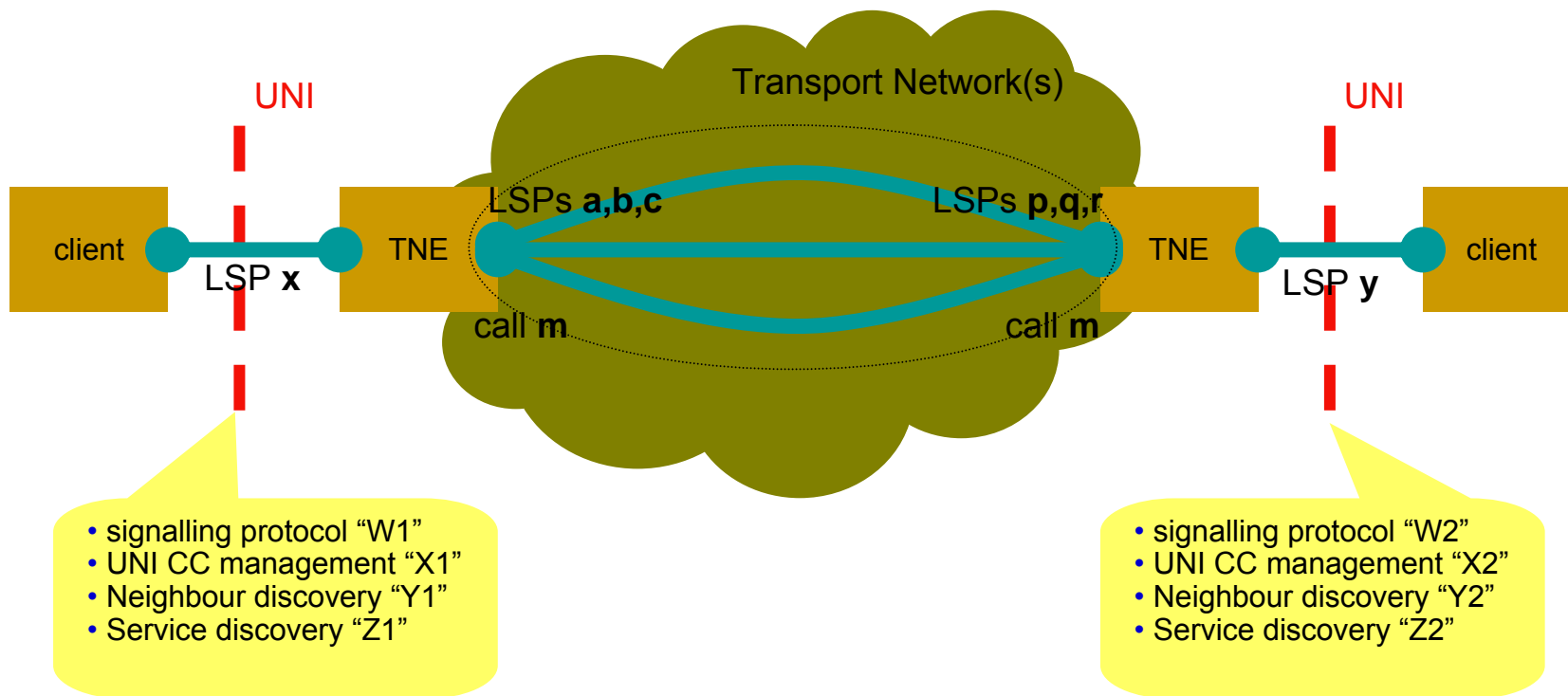


- Connection establishment
- Connection deletion
- Status exchange
- Auto-discovery
- Use



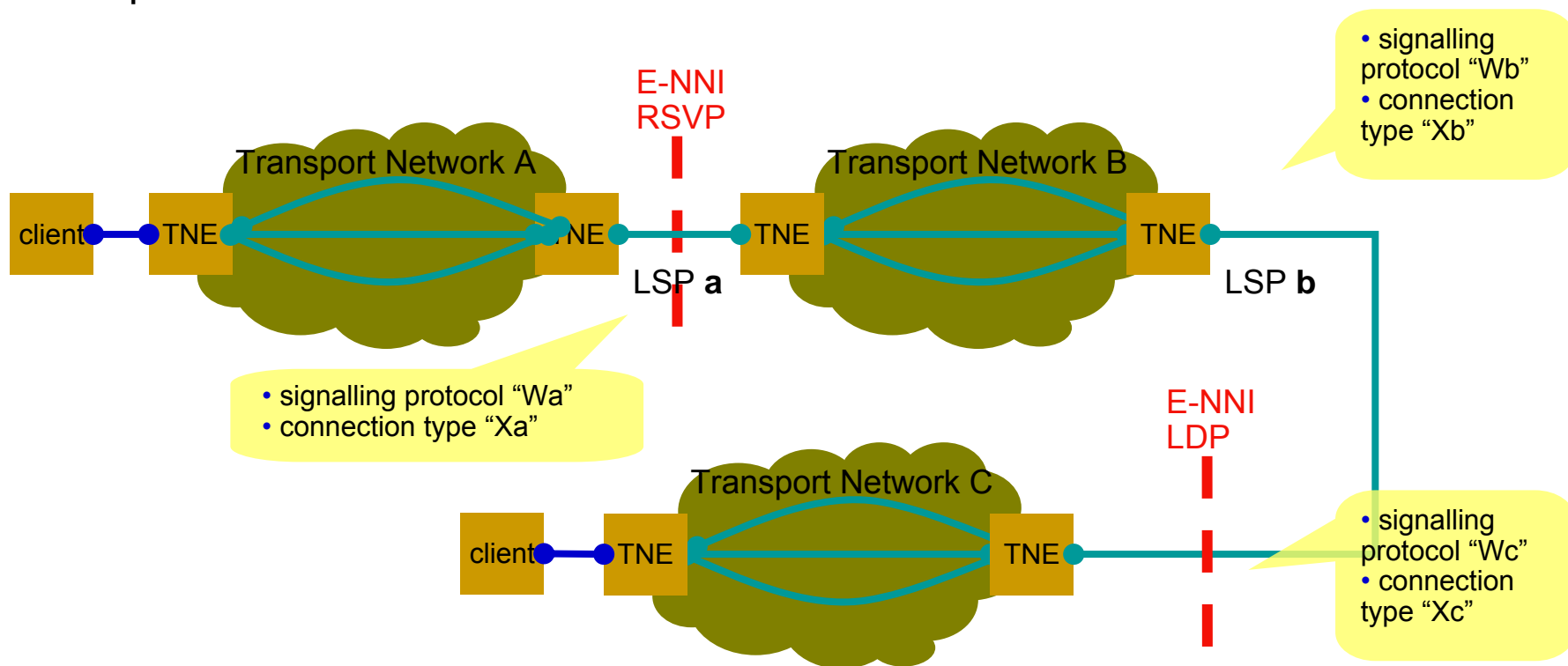
OIF UNI reference model

- For each end-to-end connection
 - each UNI will apply its own “rules” (i.e. protocols, procedures), independently
 - the Transport Network has different “rules”, as well
- The UNI LSPs are not LSPs for the set-up of network connections, but just 2-points transactions



OIF E-NNI reference model

- For each end-to-end connection
 - each E-NNI will apply its own “rules” (i.e. protocols, procedures), independently
 - the Transport Network has different “rules”, as well
- The E-NNI LSPs are not LSPs for the set-up of network connections, but just 2-points transactions



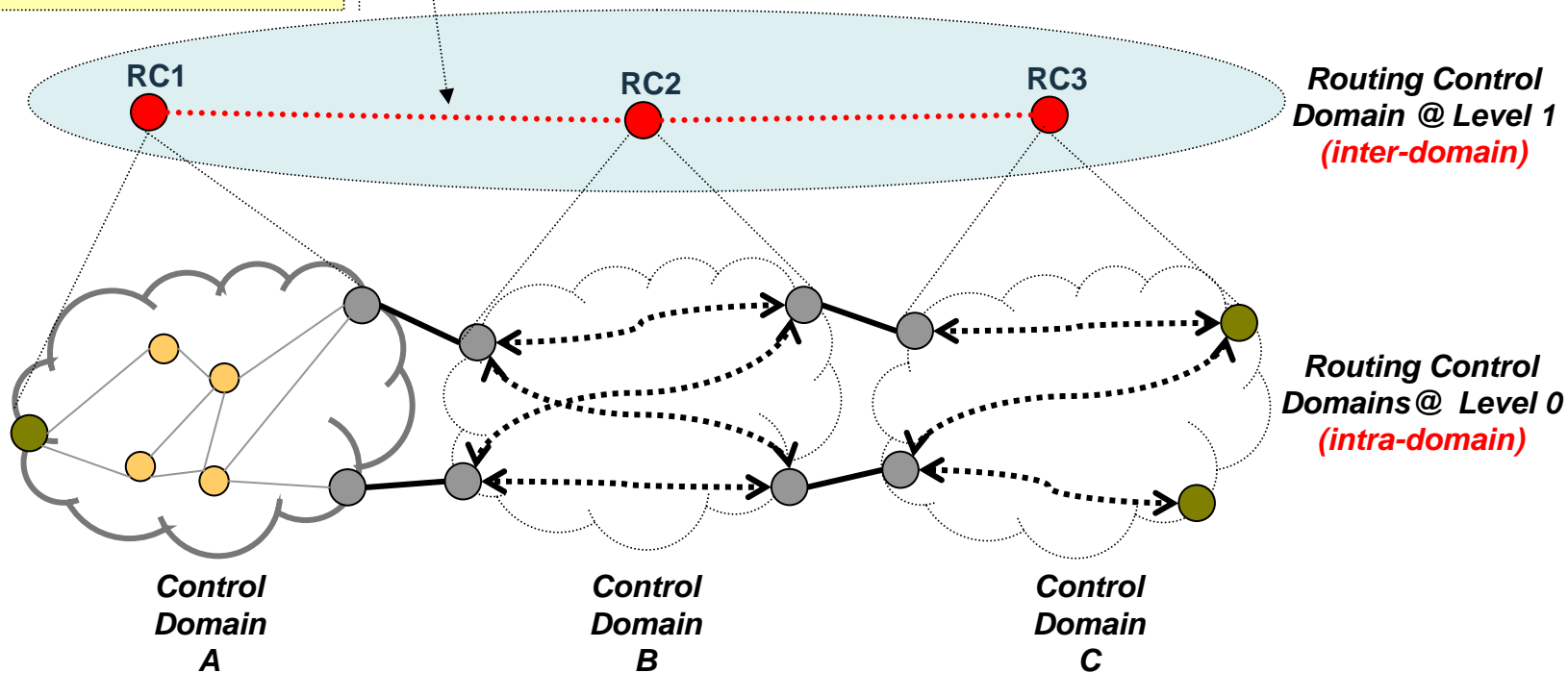
OIF E-NNI routing: basic requirements

- At each hierarchical level, 1 OSPF area per Routing Area (as per G.7715)
- No OSPF multi-area operations are used
- Tunneling of OSPF packets is needed, since the nodes forming a routing adjacency across the E-NNI are not adjacent on the SCN
- The routing info exchanged over the E-NNI routing adjacency between RCs should only concern the (O)TN topology
 - ⇒ No IP-specific LSAs (Router LSAs, Summary Network LSAs)

OIF E-NNI routing: 2-level hierarchy

Speaking of:

- Real inter-domain links at L0, represented without changes at L1
- “summarized” intra-domain links at L1 based on intra-domain info at L0
- TNAs



■ Fully compliant with G.8080 + G.7715



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GMPLS architecture

- Specified by RFC3945 (GMPLS Architecture), as a *generalization* of RFC3031 (MPLS Architecture)
- It “*covers the main building blocks needed to build a consistent control plane for multiple switching layers*”
- MPLS deals with 1 type of switching: packet / cell
- GMPLS supports multiple types of switching:
 - TDM (e.g. SONET/SDH)
 - Lambda (e.g. WDM, but not completely – see WSON extensions)
 - Fiber

Classification of interface switching capabilities

MPLS [-TE]

- Packet Switch Capable (PSC)
 - i/f detects packet boundaries
 - i/f forward or switches data based on the content of the packet header
- Layer-2 Switch Capable (L2SC)
 - i/f detects frame/cell boundaries
 - i/f forward or switches data based on the content of the frame/cell header
- **Time-Division Multiplex Capable (TDM) interfaces**
 - **Switching is based on rx time slot**
- **Lambda Switch Capable (LSC) interfaces**
 - **Switching is based on rx wavelenght**
- **Fiber-Switch Capable (FSC) interfaces**
 - **Switching is based on the physical position of the fiber/port**

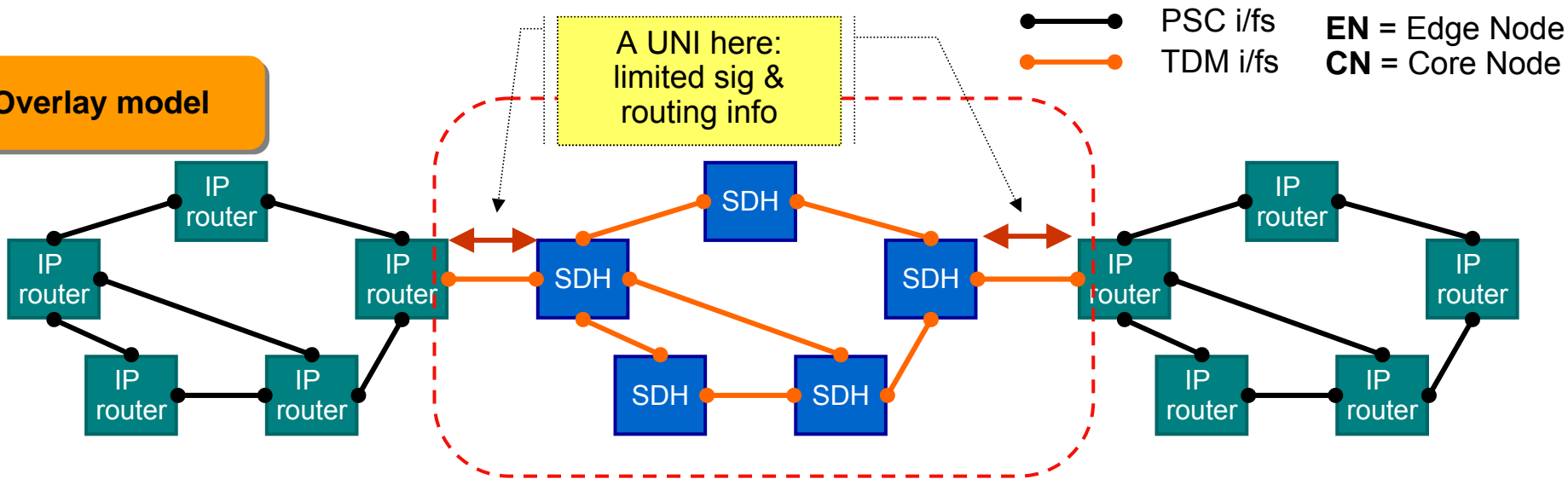
Key extensions to MPLS-TE

- Control Plane and Data Plane decoupling
- Label encoding: labels on IP or ATM links + labels representing time slots, wavelengths or physical space positions
- LSPs should be terminated by homogeneous interfaces (in terms of switching capability); MPLS: IP LSPs should be terminated by routers
- Payload extensions: SONET/SDH, G.709, 1/10+ Gb Ethernet
- Forwarding Adjacencies
- Label suggestion by upstream node
- Restriction of downstream label selection by the upstream node is extended to the whole LSP path; MPLS: single hop
- Bi-directional LSPs (not asymmetric LSPs!)
- Selection of the terminating egress port
- RSVP-TE mechanisms for rapid failure notification

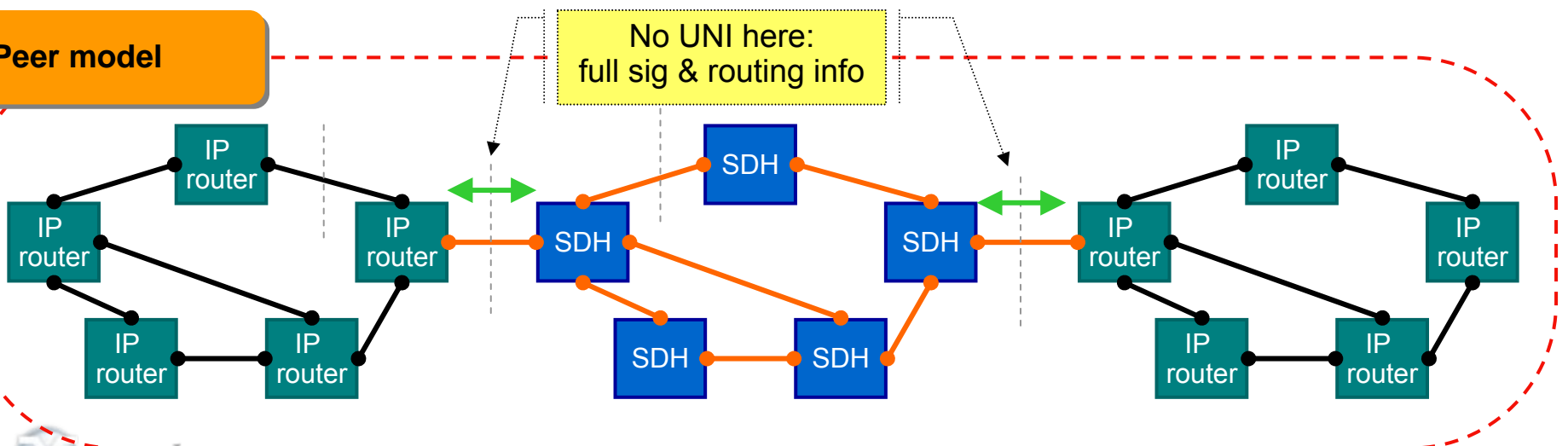
GMPLS architectural models: overlay & peer



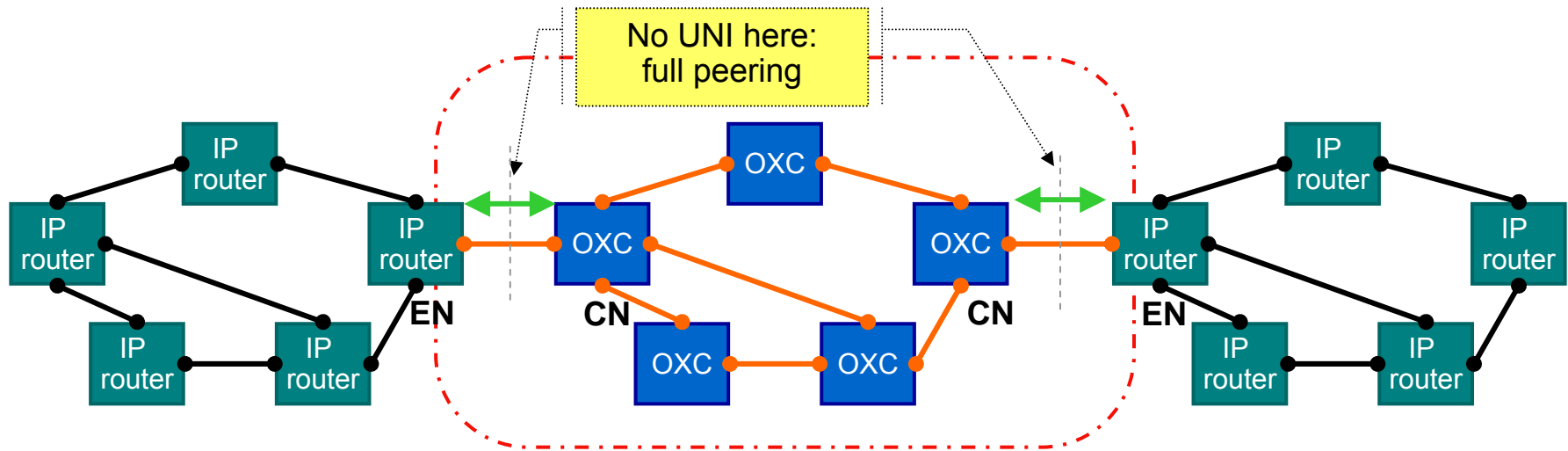
Overlay model



Peer model



GMPLS architectural models: border peer model



- S-GMPLS: the boundary runs across the “i/f-SC-hybrid” LSR (Edge Node), not across the EN-CN link
 - ⇒ full signalling & routing peering between the EN and the CN; no UNI
- But the EN keeps the routing info partitioned
 - One Topology DB for the info learnt from the optical core
 - One Topology DB for the info learnt from its the IP edge
 - No flowing of routing info from one side to the other
- Is this a kind of “augmented” model?

Overlay vs peer model

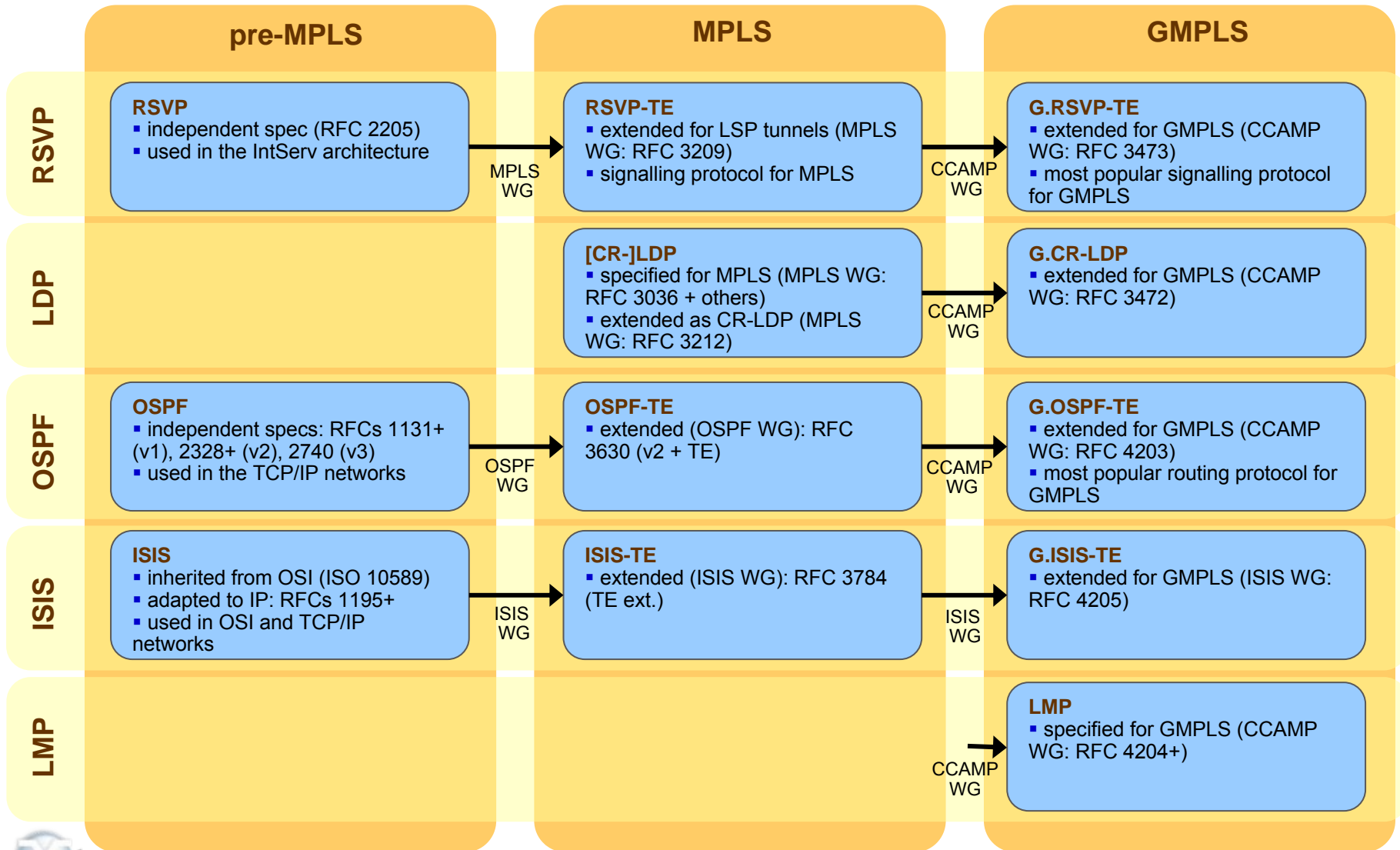
- The overlay model can be applied to both an administrative or technology boundary
 - But it's strictly needed only for admin boundaries
- The peer model can only be applied to a technology boundary
 - the I-NNI is not adequate to support admin discontinuities
- When a operator has to manage different tech domains (\Rightarrow MLN/MRN) in a single admin domain, the overlay model might be an overkill
 - 2+ instances of Control Plane to be managed
 - Limited/no "transpiration" of routing information through the domains \Rightarrow limited capability for sources to compute optimal paths
 - Partitioning of signalling (setup/teardown, crankback, restoration)
- The peer model is a more lightweight solution, in this case
 - (But the signalling has to be extended in order to support multiple I/f Switching Capabilities on the same LSP)
- MLN/MRN extensions help in this case

Overlay vs peer model



	admin boundary	tech boundary
Overlay model	Perfectly fits	<ul style="list-style-type: none">• much more complex than needed, in some cases• limited routing info around, sub-optimal paths• partitioning of set-up / tear-down, crankback and restoration signalling
Peer model	Not applicable	<ul style="list-style-type: none">• lightweight (but some increased complexity in signalling to support multiple sw caps)• source path computation of optimal routes

Brief genesis of GMPLS protocols



- Some GMPLS specific features (enhanced/added w.r.t. MPLS) make LMP useful and needed
 - Control Plane and Data Plane decoupling
 - ◆ the control channels between two adjacent nodes do not necessarily use the same physical medium as the data links between those nodes
 - ◆ ⇒ need for procedures to manage control plane and data plane communication *separately*
 - Link bundling
 - ◆ need to automate the bundling operations on the two sides of a node adjacency, to make it easier and coherent



- Control Channel Management (*mandatory*)
 - Implicit address resolution service
 - SCN auto-discovery
 - Graceful restart
 - LMP-WDM negotiation (*optional*, RFC 4209)
- Link Property Correlation (LPC) (*mandatory*)
- Link Verification (*optional*)
 - Transport network auto-discovery
 - TE link discovery (on one end, if LV has TE link scope)
 - Trace monitoring procedures (*optional*, RFC 4207)
- Fault Management (*optional*)

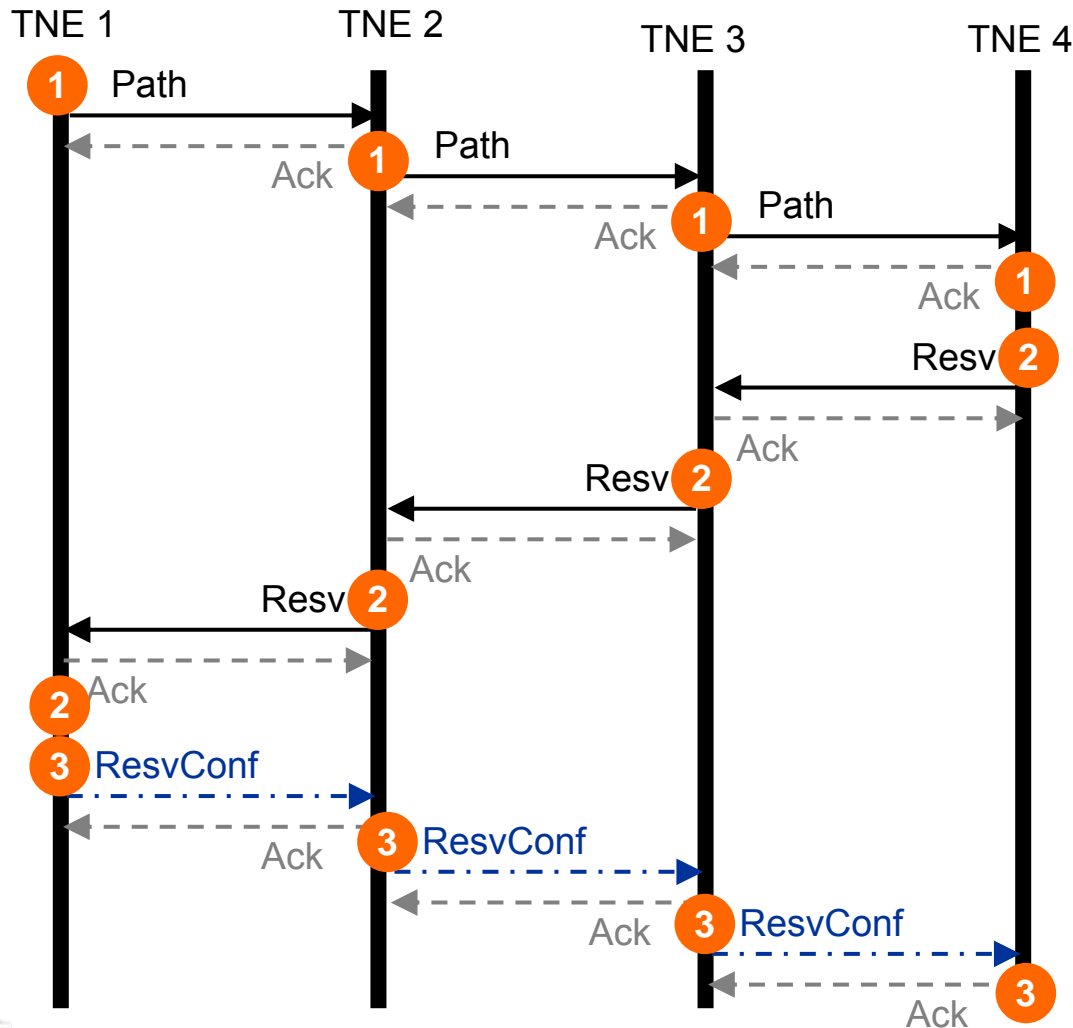
GMPLS signalling extensions per technology

	SONET/SDH	Lambda switching	Fiber switching
New generic label request format	SONET/SDH label	generic format	generic format
Waveband switching support		In some cases	
Label suggestion by the upstream	Suggested	Yes	
Label restriction by the upstream		Yes	
Bi-directional LSP establishment with contention resolution	Yes	Yes	Yes
Rapid failure notification extensions	Optional	Yes	Yes
Protection information	Optional	Yes	
Explicit routing with explicit label control	Yes	Yes	Yes
Specific traffic parameters per technology	SONET/SDH parms		
Handling of LSP administrative status	Yes	Yes	Yes
Control channel separation	Typical	Typical	

New/extended objects/TLVs in signalling

- Generalized Label Request
- SONET/SDH Traffic Parameters
- G.709 Traffic Parameters
- Generalized Label
- Waveband Switching
- Suggested Label
- Upstream Label
- Label Set
- Acceptable Label Set
- Notify message
- Protection Information object/TLV
- Explicit Route Object (ERO) / Explicit Route (ER) TLV
- Admin Status object/TLV
- RSVP_HOP sub-object / Interface TLV

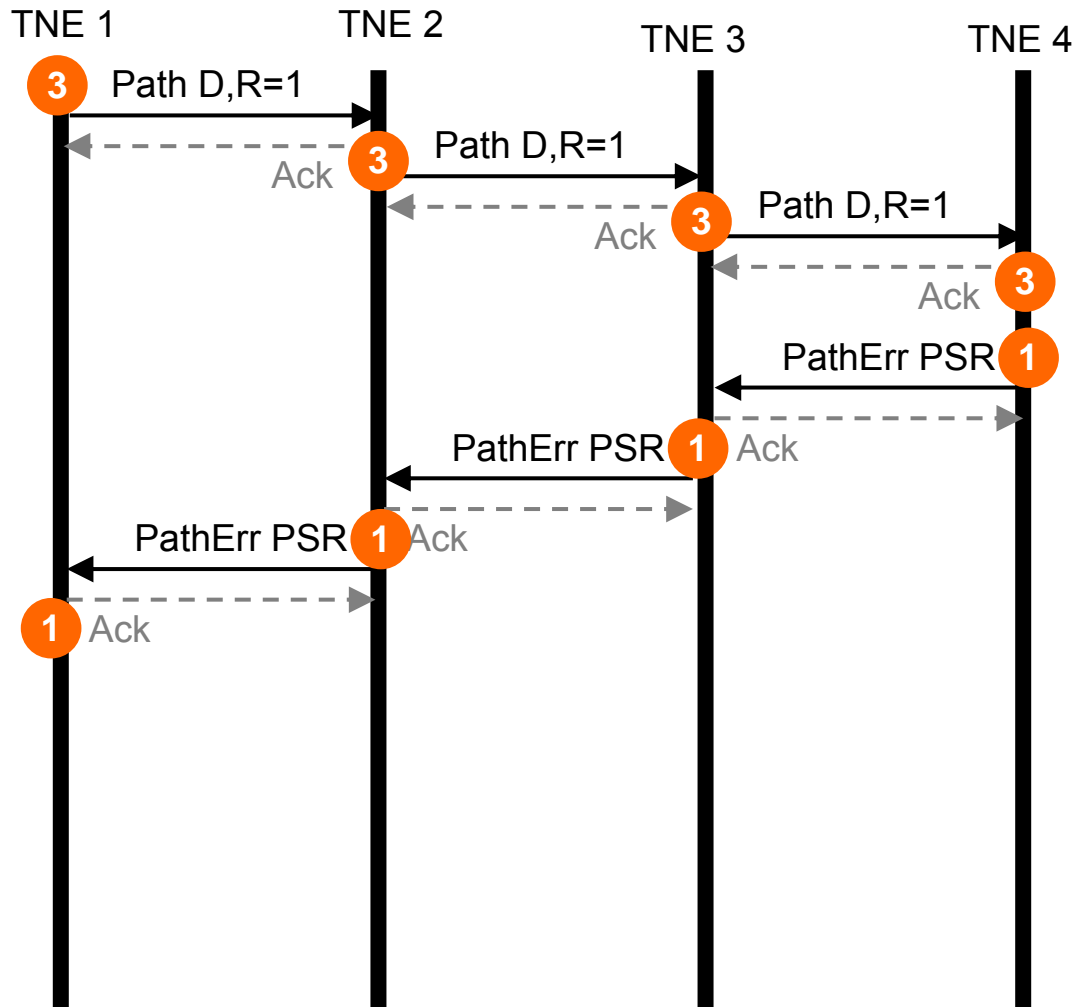
G.RSVP-TE LSP set-up



- 1 = XC setup request
- 2 = wait for XC to be ready
- 3 = alarms enabling

- .-> = optional tier
- .-> = optional ack proc

G.RSVP-TE LSP tear-down from the ingress



- 3 = alarms disabling
- 1 = XC removal

- .-> = optional tier
- -> = optional ack proc

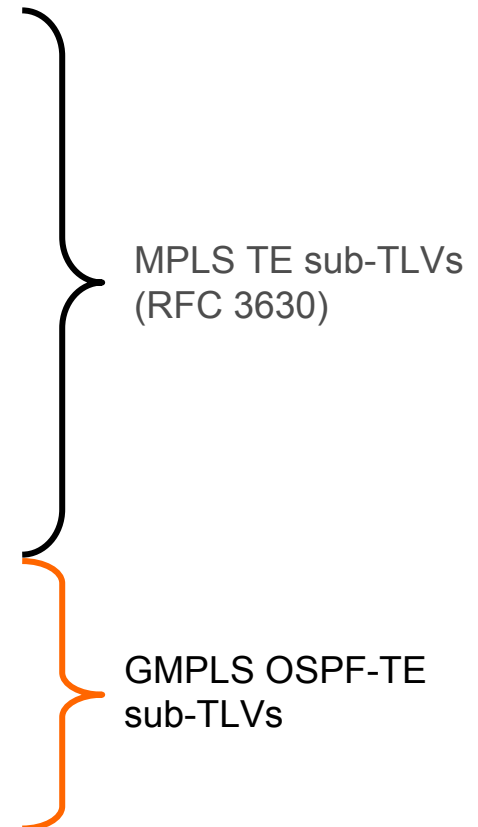
G.RSVP-TE additional procedures

- Crankback
- Graceful Restart
- Exclude routes
- Support for calls
- GMPLS UNI: G.RSVP-TE in the Overlay model
- Extensions for inter-domain TE

GMPLS OSPF-TE extensions

New sub-TLVs for the Link TLV

sub-TLV in Link TLV	status	type	length
Link type			
Link ID			
Local interface IP address			
Remote interface IP address			
Traffic engineering metric			
Maximum bandwidth			
Maximum reservable bandwidth			
Unreserved bandwidth			
Administrative group			
Link Local/Remote Identifiers	new	11	8 B
Link Protection Type	new	14	4 B
Interface Switching Capability Descriptor	new	15	var
Shared Risk Link Group	new	16	var





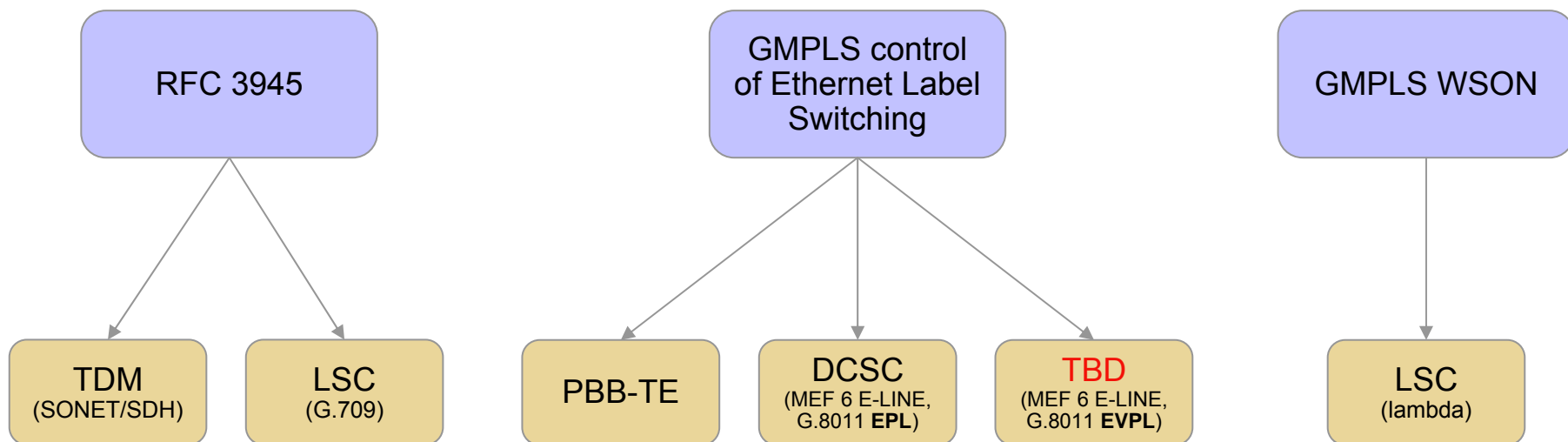
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Some Control Plane challenges and open issues for the (near) future

- GMPLS to control ISCs related Ethernet switching services
- GMPLS to control Wavelength Switched Optical Networks
- Heterogeneous ISCs in one domain: multi-region (MRN), multi-layer (MLN) issues
- Inter-carrier ASON/GMPLS
- Integration between ASON/GMPLS and the Service Plane
 - AuthN/AuthZ at the UNI and E-NNI
- Support of advance reservations (with a distributed approach)
 - OSPF extensions for calendars + signalling crankback
- Interworking of MPLS metro networks with GMPLS cores
- Service-awareness: bridging between network and application resources; e.g. grid-like (storage, computing) – G²MPLS

- Standard ASON/GMPLS is ok for “ideal” switches (i.e. switches performing label swapping with non- or low- blocking matrixes)
 - ASON is generic enough to be ok for any ISC
 - Today’s GMPLS is complete for SONET/SDH and G.709
 - ◆ with some limitations in routing info granularity (e.g. per-timeslot availability) and signalling tricks for non-TSI regions (e.g. crankback)
- Some transport planes (i.e. ISCs) are not so ideal:
 - Wavelength-switched Optical Networks, e.g. λ constraints/continuity
 - PBB-TE (IEEE 802.1Qay), i.e. long label continuity
 - MEF 6,10 and G.8011 Ethernet Transport Services, i.e. short label uniqueness
- The T-MPLS model of switches is more suitable for a GMPLS adoption as a control plane

Ongoing extensions to IETF GMPLS for more ISCs



GMPLS control of Ethernet Label Switching

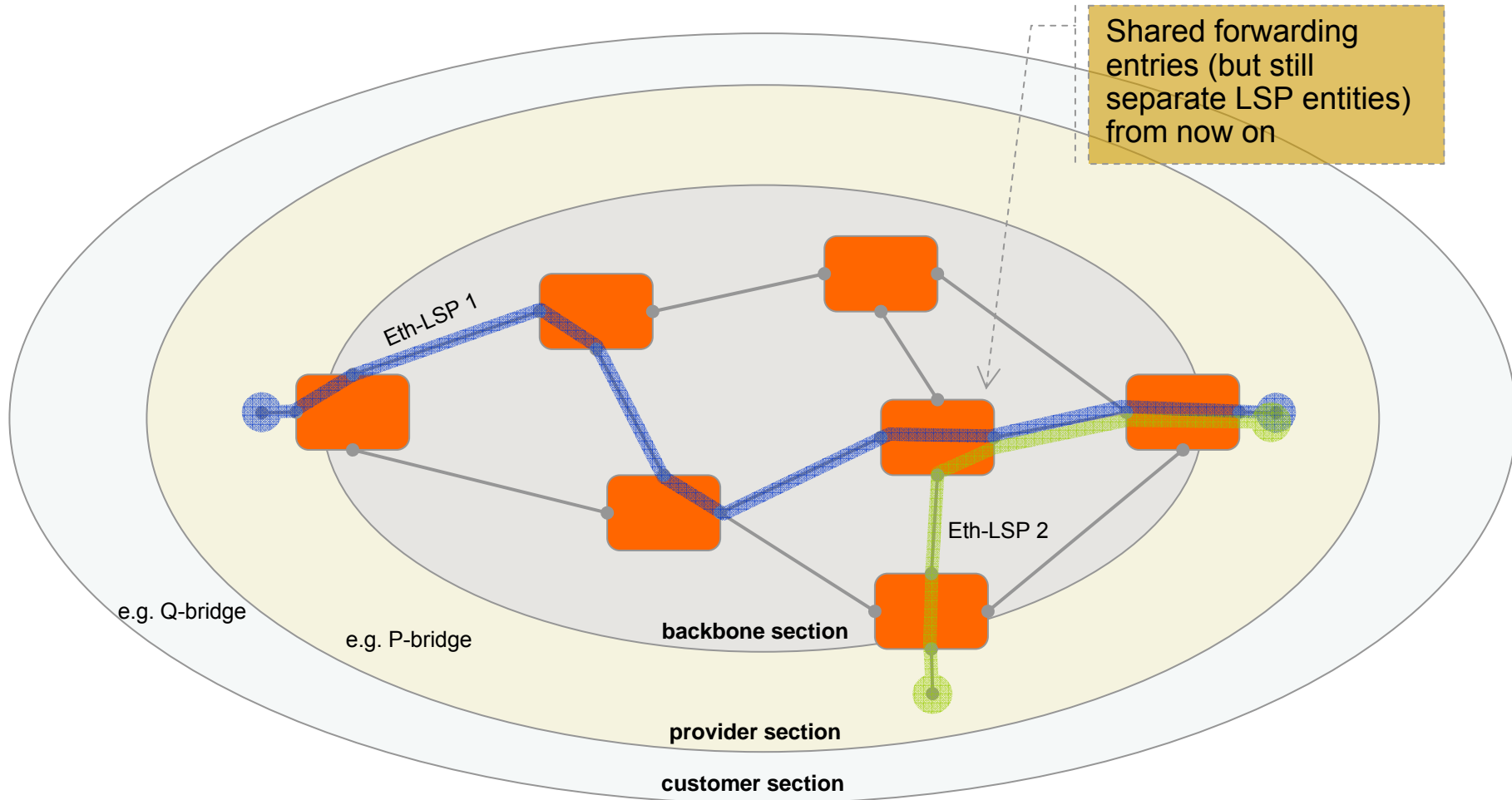
- The GMPLS Ethernet Label Switching architecture (by CCAMP) is not bound to any specific Ethernet service framework
 - E.g. similar approach to RFC 3945 for TDM and LSC ISCs
- New ISCs, one per supported Ethernet switching paradigm
 - L2SC could already have been used (e.g. in ATM), and means little for Ethernet services
- Naming, addressing and routing: same as in RFC 3945 GMPLS
 - Data Link \equiv switch port, with IPv4, IPv6 or Unnum names
 - TE Link \leftrightarrow bundle of switch ports, with IPv4, IPv6 or Unnum names
- Signalling: same as in RFC 3945 GMPLS, but
 - Needed support of RFC 4875 for P2MP LSPs (Eth-LSPs can be P2MP)
 - No more “quick setups” (i.e. XC on Path); it has to be on Resv
- Link Management: LMP still welcome; not conflicting with IEEE 802.1AB
- Ongoing specs:
 - GMPLS for PBB-TE (i.e. PBB-TE ISC)
 - GMPLS for MEF 6,10 / G.8011 EPL and EVPL



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Eth-LSP

e.g. in a PBB-TE scenario



The basic issues in Eth GMPLS

- What is a label and which is its scope?
 - Short label (VLAN-ID) or long label (VLAN-ID + DA-MAC)?
 - No more label swapping: the label is a domain wide identifier, no more local to a link
- Bi-directional LSPs
 - Common paths are a status-quo for TDM GMPLS (ref. Upstream label)
 - Asymmetric LSPs could be desirable in many deployment scenarios for Transport Ethernet
 - ◆ Is there a need to preserve the same path? If yes,
 - ◆ Full 108-bit label SA/VID/DA inferred from upstream label (which will be mandatory)
 - ◆ Different FLOWSPEC, TSPEC for the downstream and upstream direction (draft-ietf-ccamp-asymm-bw-bidir-lsps-00.txt)
- Support for OAM configuration and procedures

Ongoing specs in Eth GMPLS [1]

- An architectural framework complementing GMPLS arch (RFC3945)
 - “*GMPLS Ethernet Label Switching Architecture and Framework*”, draft-ietf-ccamp-gmpls-ethernet-arch-01.txt,
- A GMPLS for PBB-TE ISC
 - Provider Backbone Bridges Traffic Engineering (PBB-TE) amendment to 802.1Q [IEEE 802.1Qay]
 - “*GMPLS control of Ethernet*”, draft-ietf-ccamp-gmpls-ethernet-pbb-te-00.txt
 - Connections \equiv ESP (Ethernet Switched Path): unidirectional, <ESP-MAC DA, ESP-MAC SA, ESP-VID>
 - ◆ Ethernet point to point (P2P) and P2MP MAC switched paths
 - ◆ P2P/P2MP VID based trees
 - Eth-LSP: the CP view of the ESP in the Data Plane
 - Support and no modification of IEEE standards
 - Long label (60 bit): ESP VID + ESP DA MAC
 - Signalling and routing extensions
 - ◆ TBD (e.g. new TSPEC, FLOWSPEC, ecc.)

Ongoing specs in Eth GMPLS [2]

- A GMPLS for MEF and G.8011 Ethernet Service Switching
 - “*GMPLS Support For Metro Ethernet Forum and G.8011 Ethernet Service Switching*”, draft-ietf-ccamp-gmpls-ether-svcs-00.txt
 - GMPLS extensions to support MEF 6,10 E-LINE / ITU G.8011 EPL (Ethernet Private Line) + EVPL (Ethernet Virtual Private Line)
 - Short label (12 bit): VLAN label
 - ◆ Fits the current GMPLS generalized label format
 - ◆ Limited label space (4096)
 - Signalling extensions to GMPLS RSVP-TE
 - ◆ “*Ethernet Traffic Parameters*”, draft-ietf-ccamp-ethernet-traffic-parameters-04.txt
 - ◆ TSPEC and FLOWSPEC including Ethernet traffic parameters (CIR, CBS, EIR, EBS) for EPL/EVPL



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The need for WSON extensions

- WSONs with optical constraints (e.g. with global wavelength continuity requirement) ⇒
 - need for a wavelength label with global significance
 - ◆ *draft-otani-ccamp-gmpls-lambda-labels* (on polling)
- Drawing paths in WSONs is based on Routing Wavelength Assignments computations
- Current GMPLS does not support RWA algorithms with
 - Connectivity Matrix
 - Port Wavelength Restrictions
 - WDM Link Characterization (i.e. Wavelength Ranges)
 - Laser Transmitter Range
 - Wavelength Converter Characterization
 - Wavelength Availability
 - All-optical impairments (chromatic dispersions, OSNR, amplifiers spontaneous emissions, etc.)
- 1-step RWA ⇒ almost standard routing info, but enhanced signalling procedures
- 2-step RWA ⇒ enhanced routing info, but almost standard signalling procedures
- ⇒ Need for WSON-specific routing, signalling and PCE extensions

■ WSON signalling extensions

- New SENDER_TSPEC and FLOWSPEC
- If 2-steps RWA, use of LABEL_SET (wavelength sets, ranges and bitmaps) \Rightarrow no more XCs on Path! (\Rightarrow slower setup time)
- ... and others (e.g. wl assignment method, metric, etc.)

■ WSON routing extensions

- Potential Wavelength Connectivity Information
 - ◆ This is a link capability \rightarrow updated at very slow pace
 - ◆ Expressed in the form of a matrix $M[R,C]$ of wavelength bitmaps (connectivity of lambda X between link R and link C is a bit X set in the bitmap)
- Wavelength status
 - ◆ This is a link availability \rightarrow possibly updated very frequently (ongoing discussion on thresholds)
 - ◆ Expressed in the form of a per-link bitmap (availability of lambda X on link Y is a bit X set in the bitmap)

■ PCE extensions

- New computation options (just RA, just WA, RWA)
- Lightpath Route Parameter TLV
 - ◆ for bidirectional assignment of wavelengths and use of the same wavelength to primary and backup paths
- Wavelength Selection Preferences TLV
 - ◆ Random, First Fit, Most Used, Least Loaded, Don't Care
- Wavelength Suggestion/Restriction TLV (TBD in next version of the ID)



- Introduction to CP and ASON/GMPLS
- ASON/GMPLS quick overview
 - ASON architecture
 - OIF network interfaces
 - GMPLS architecture & protocols
- Control Plane future challenges
 - General overview
 - Insight on GMPLS control of Ethernet switched networks
 - Insight on GMPLS control of wavelength switched optical networks
- The G²MPLS in the Phosphorus project

The Phosphorus CP: what is G²MPLS ?

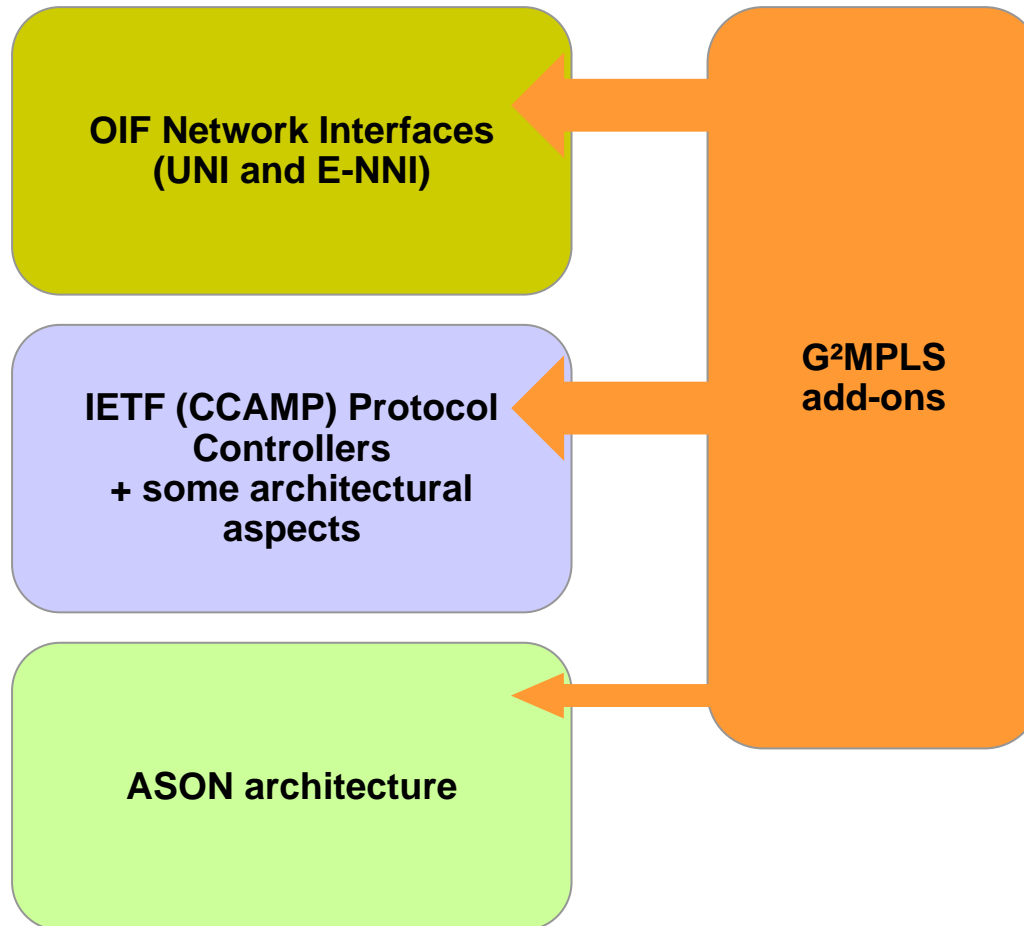
■ G2MPLS is ...

- a Network Control Plane architecture that implements the concept of **Grid Network Services**
 - ◆ *GNS is a service that allows the provisioning of network and Grid resources in a single-step, through a set of seamlessly integrated procedures.*
- expected to expose **interfaces specific for Grid services**
- made of a set of **extensions to the standard GMPLS**
 - ◆ provide enhanced network and Grid services for “power” users / apps (the Grids)
- Basically, a **superset** of ASON/GMPLS \Rightarrow G²MPLS can behave like a normal GMPLS, or a GMPLS with some nice add-ons

■ G2MPLS is not ...

- an application-specific architecture; it aims to
 - ◆ support **any kind of end-user applications** by providing network transport services and procedures that can fall back to the standard GMPLS ones
 - ◆ provide automatic setup and resiliency of network connections for “standard” users

G²MPLS positioning w.r.t. standards

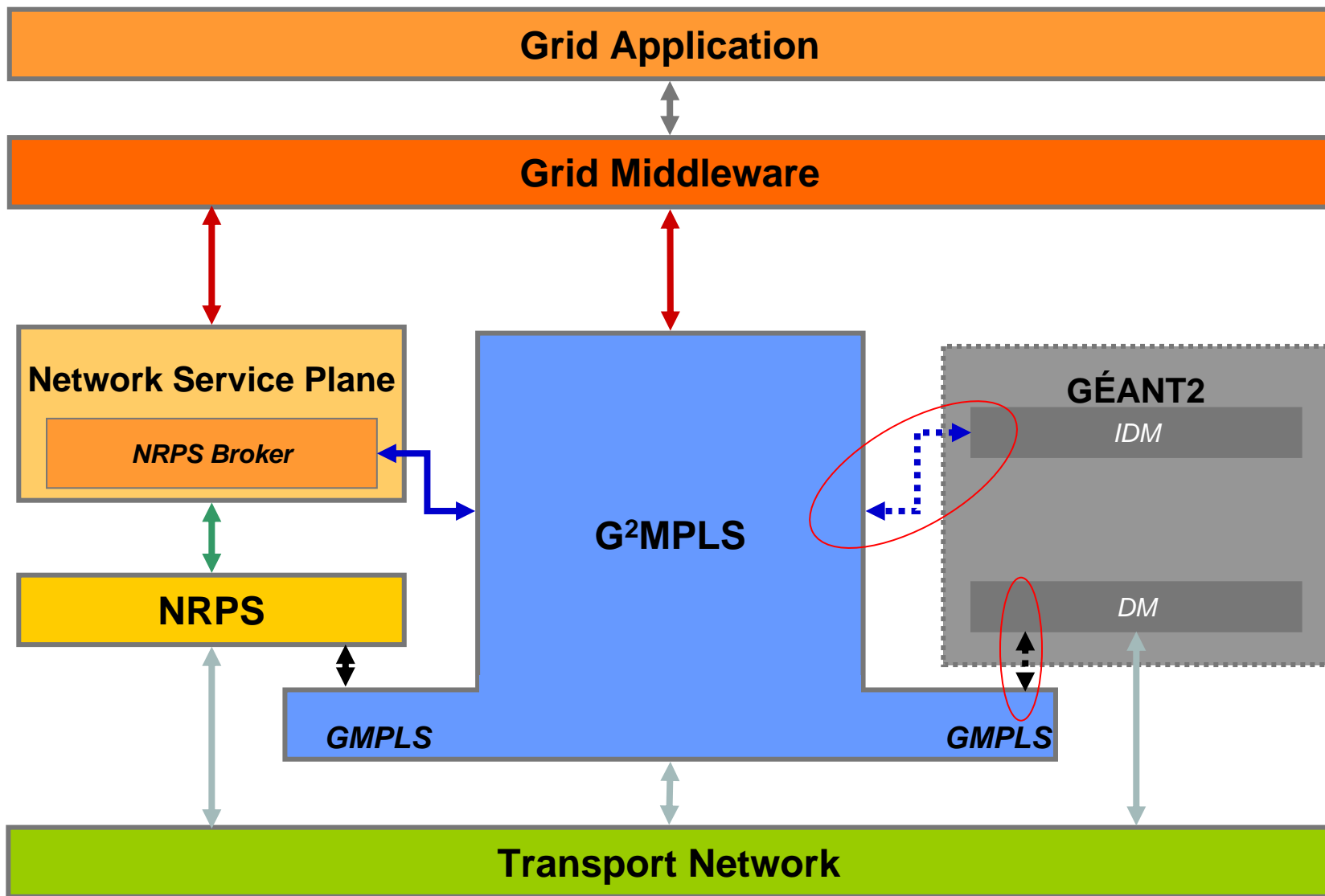


G²MPLS goals and functional scope

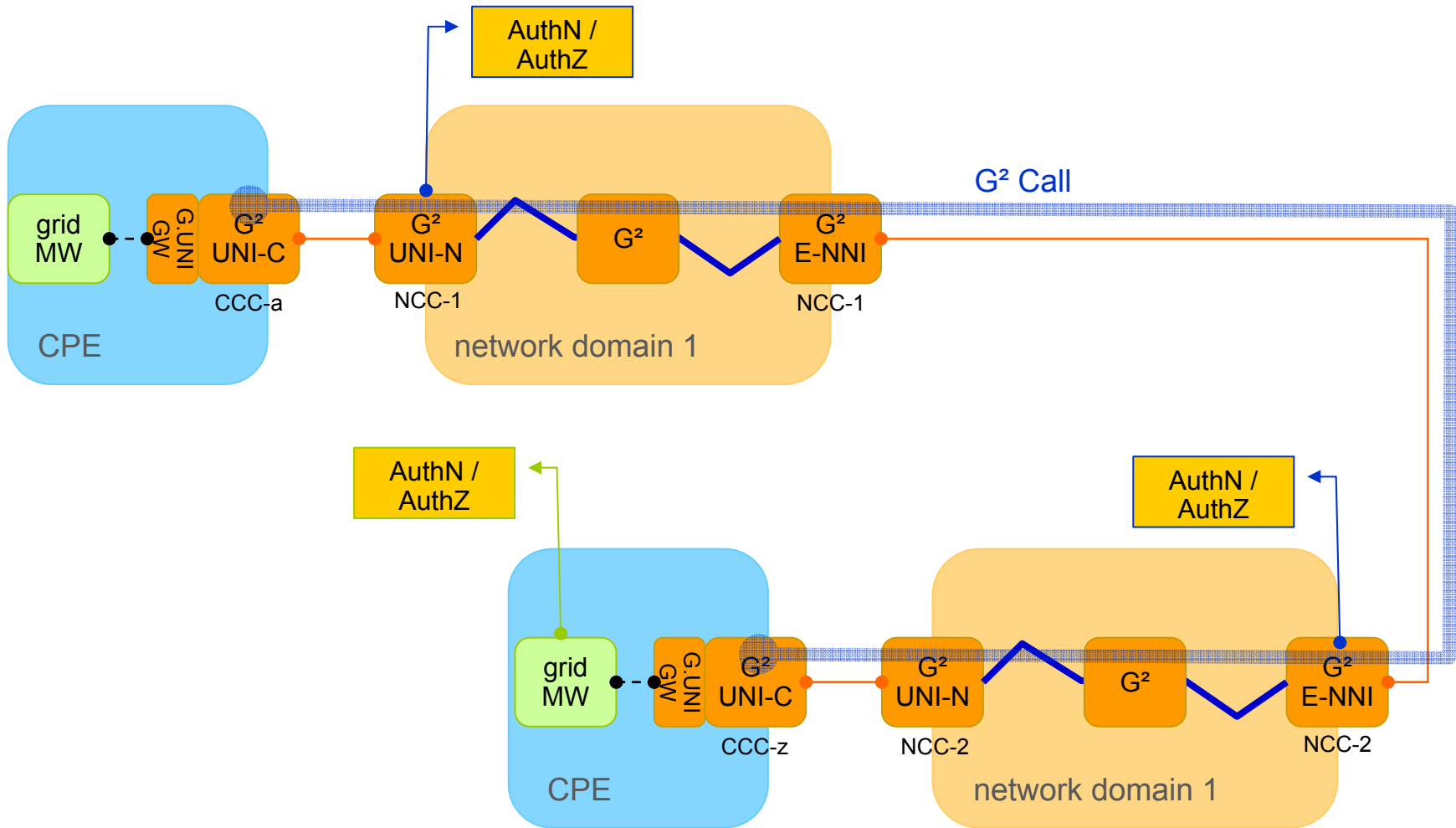
- G²MPLS will provide part of the functionalities related to the **selection and co-allocation** of both Grid and network resources
- Co-allocation functionalities
 - **Discovery and Advertisement** of Grid + network capabilities and resources of the participating virtual sites (Vsites)
 - **Service setup / teardown**
 - ◆ **coordination** with local job scheduler in middleware
 - ◆ **configuration** of the involved network connections among the participating Vsites
 - (The network end-point – TNA – might not be specified, if Grid resources are specified)*
 - ◆ **resiliency** mgmt for the installed network connections and possible recovery escalation to the Grid MW for job recovery
 - ◆ **advance reservations** of Grid and network resources
 - **Service monitoring**
 - ◆ retrieving the status of a job (*Grid transaction*) and of the related network connections

- I-NNI, E-NNI and UNI routing extensions to distribute grid node resources
- I-NNI, E-NNI and UNI signalling extensions
 - for both Call and LSP signalling
- Support for advance reservations (in a distributed way)
- Integration with the Service Plane (AAI)
 - [G.]E-NNI is an inter-carrier i/f
- Stitching of heterogeneous Switching Capabilities at the I-NNI
 - Pre-MRN/MLN drafts
- ⇒ support for Grid Network Services (GNS) at the G.UNI
 - UNI-Cs accept grid job submissions from the local MW through gateways
 - Extended TNAs (e.g. grid sites instead of links)
 - Anycasting
 - ◆ “connect this local TNA with this amount of grid resources (anywhere)”
 - Indirect calls
 - ◆ “connect this TNA / amount of grid resources (maybe elsewhere) to this TNA / amount of grid resources (anywhere)”

G²MPLS in the Phosphorus architecture



G² network scenario





Thank you!

Questions?



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