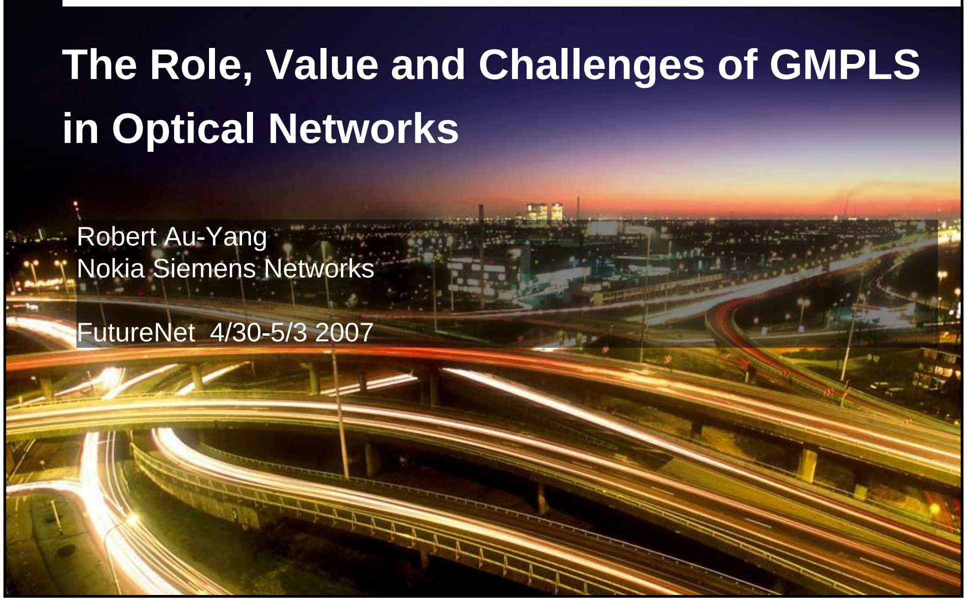
# The Role, Value and Challenges of GMPLS in Optical Networks

Robert Au-Yang
Nokia Siemens Networks

FutureNet 4/30-5/3 2007



## Outline

- GMPLS Introduction
  - Recap of origin of GMPLS
  - GMPLS and ASON
  - Role of GMPLS
- GMPLS in Optical Networks
  - Value of GMPLS
  - Classes of Optical Networks
  - Challenges for GMPLS in transparent optical network
- Summary & Conclusions

## GMPLS Evolution

- Introduced in late nineties (MPLS/MPLS-TE -> MP$\lambda$S -> GMPLS)
- Evolved from MPLS to accommodate TDM switching capable (TSC), Lambda switching capable (LSC) and Fiber switching capable (FSC) elements
- One of the key drivers was to simplify the provisioning of connections in a multi-layer, multi-technology based network to realize CapEx and OpEx savings
- Extension of MPLS-TE protocols (e.g. OSPF-TE, IS-IS-TE, RSVP-TE, CR-LDP)
- Other technical innovations (e.g. LMP, LSP hierarchies, link bundling)

## GMPLS and ASON

- GMPLS (Generalized Multi-Protocol Label Switching)
  - defines a suite of protocols utilized by the control plane to support switched connections
  - extends MPLS signaling and routing protocols for use in non-packet based transport networks like SDH, DWDM, etc.
    - additional label types for TDM, lambda and fiber switch capable LSRs
    - additional features like: bidirectional label types, label suggestion and label restriction
  - GMPLS documents are developed at the CCAMP working group within the IETF

- ASON/ASTN (Automatically Switched Optical/Transport Network)
  - Architecture for transport networks enabling distributed connection control
  - ASTN and ASON are often used as synonyms (Automatically Switched Transport/Optical Network)
  - Requirement documents have been approved by ITU-T (G.807, G.8080 suite)




## Deployment of GMPLS

- MPLS-TE widely deployed in Layer-3 and Layer-2 networks
- GMPLS gaining popularity in SONET/SDH networks
- Common characteristics among these networks are:
  - high operation complexity for connection provisioning warrants **automated** provisioning (e.g. multi-layer service provisioning, or multi-domain provisioning)
  - where electrical switch fabrics are available
  - equipment availability for on-demand turn-up

How about Transparent Optical Networks?
What are the GMPLS/ASON benefits in Transparent Optical Networks?

## Outline

GMPLS Introduction
- Recap of origin of GMPLS
- GMPLS and ASON
- Role of GMPLS

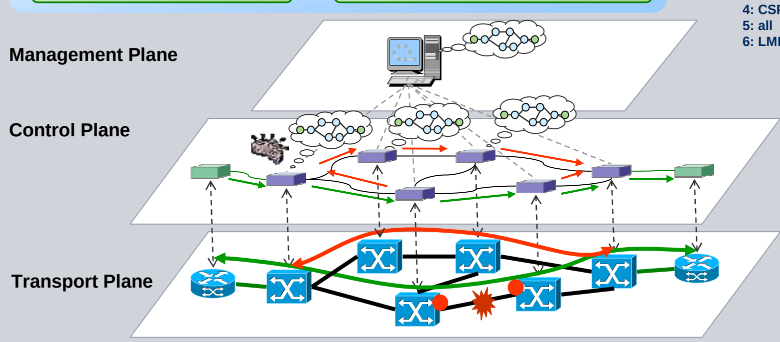
**GMPLS in Optical Networks**
- Value of GMPLS
- Classes of Optical Networks
- Challenges for GMPLS in transparent optical network

Summary & Conclusions

## GMPLS Control Plane functions

**Inventory and Resource Management**
- 1. Neighbor Discovery
- 2. Global Topology Dissemination

Protocols:
1: LMP
2: OSPF-TE / LSA
3: RSVP-TE / CR-LDP
4: CSPF
5: all
6: LMP




**Dynamic Provisioning**
- 3. Signaling for Connection Provisioning
- 4. Routing (Path Calculation)

**Network Resilience**
- 5. Distributed Recovery
- 6. Fault Localization

## GMPLS in Optical Networks – What is Optical Network?

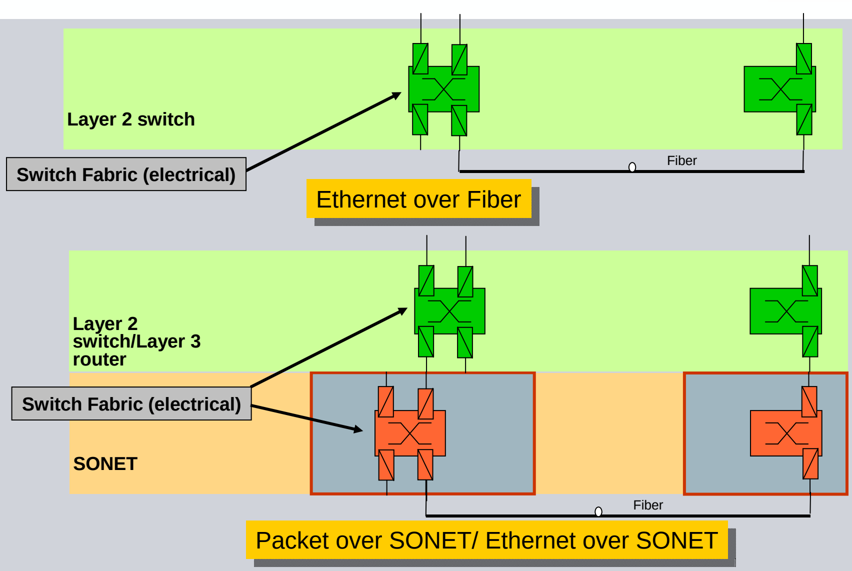
Nokia Siemens Networks

- Classes of the optical network:
  - Optical Network based on electrical switch fabrics
    - Ethernet over Fiber
    - Packet over SONET/ Ethernet over SONET
    - SONET networking
  - Optical Network based on optical switch fabrics
    - Transparent Optical Network based on ROADM and Photonic Cross Connect
    - EO/OE at the connection terminating sites
    - OEO at regenerator sites are not switchable

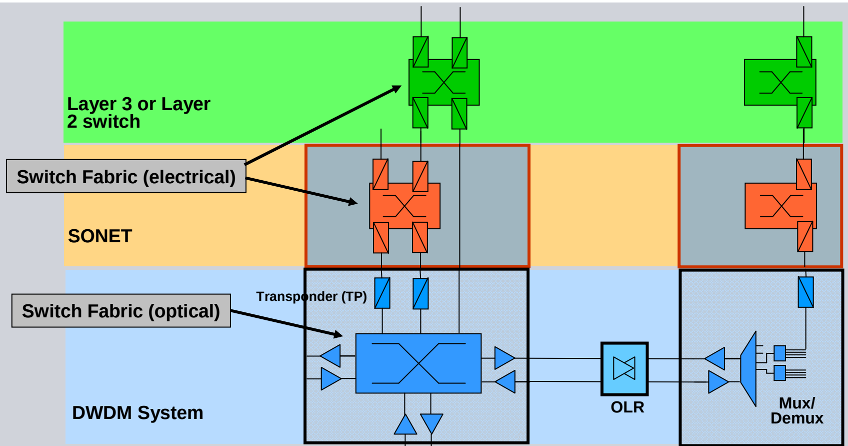



## Examples of Optical Network with Electrical Switch Fabric

Nokia Siemens Networks



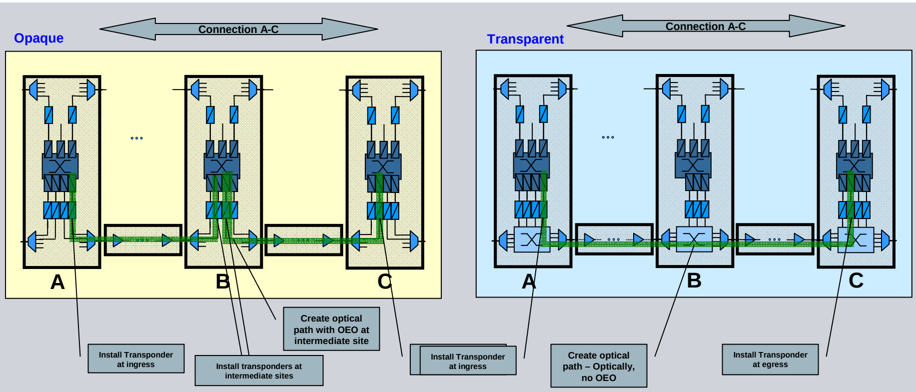
## Example of Transparent Optical Network at Lambda Layer




Optical switch is one of the key element to reduce CapEx to enable transparent optical networks by eliminating unnecessary electrical switch fabrics and OEO conversions

## Connection with optical transparency

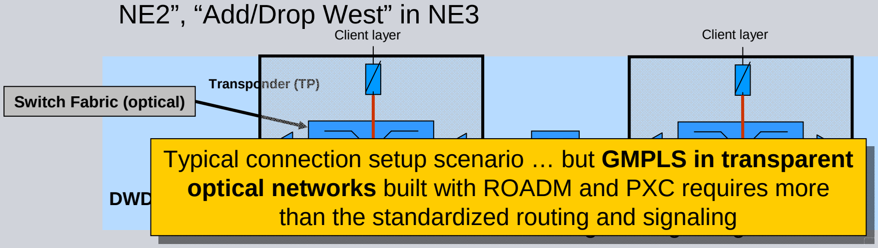



Optical transparency reduces CapEx:
- eliminates unnecessary OEO conversions
- reduces electrical switch fabric capacity requirements

## Example: Provisioning Of Optical Connection

- Transponders at ingress and egress connected to the “optical switch”
- Route computed by routing software for path (NE1-NE2-NE3) and wavelength (channel #42)
- Connection setup via GMPLS signaling (explicit route)
- Results:
  - Transponder tuned to the wavelength
  - Cross connection setup as “Add/Drop East” in NE1, “Express in NE2”, “Add/Drop West” in NE3

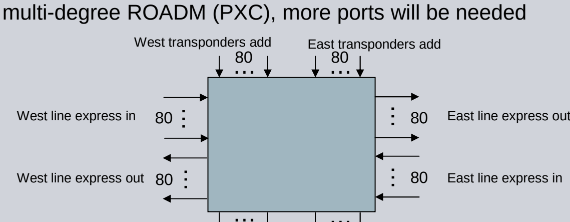



Typical connection setup scenario … but **GMPLS in transparent optical networks** built with ROADM and PXC requires more than the standardized routing and signaling

## Nodal Architecture and Scalability for Lambda switching

- DWDM system (the LSC) supports typically 32 to 80 wavelengths
- A ROADM supporting 2 DWDM line directions (east/west):
  - Assume 80 channels per DWDM line and 2 uni-directional ports per transponder
    - => 2 x 80 x 2 = 320 ports for add/drop traffic
    - => need to optimize and limit the add/drop ports REALLY needed to reduce port count requirement!
  - 2 DWDM lines with 80 channels per line => 2 x 80 x 2 = 320 ports for express traffic
  - An optical switch size of 320x320 is required to support any-to-any port connection with full capacity
  - For multi-degree ROADM (PXC), more ports will be needed




The port counts and switch size is a problem for optical switches
=> Cost and size impacts are significant

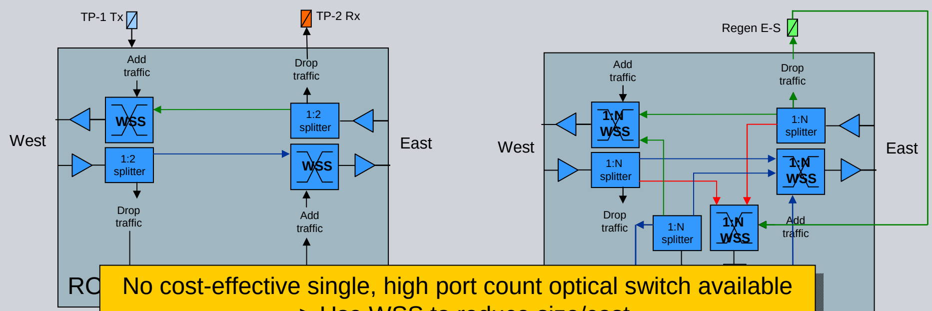
 

## Typical ROADM and Photonic Cross Connect (PXC) Node

▪Technology: Wavelength Selective Switch (WSS) used to build ROADM or PXC

▪Optical Transparency: Signal switched optically, no conversion to electrical domain

▪PXC offers multi-directional, any line direction to any line direction switching per lambda




No cost-effective single, high port count optical switch available
=> Use WSS to reduce size/cost
=> But … Add/Drop/Regen connection is directional

## Route Planning required

- Signal bit rate, modulation format affects regenerator placements
- Tunable laser is a must for wavelength assignment flexibility
- Link related optical impairments:
  - Optical penalty due to optical switch (insertion loss, extinction ratio)
  - Dispersion management
  - PMD
  - Non-linearity
- Nodal architecture and components related optical impairments:
  - Optical penalty due to optical switch (insertion loss, extinction ratio) may limit the number of switches an optical signal can traverse
  - Crosstalks penalty

Route computation with currently standard protocol is not sufficient …
⇒Vendor specific implementation
⇒Shared restoration implications … how sharable are the paths?

## Connection Setup and Restoration Considerations

- Connection setup must take into account of number of channels added to the routes (for either new connection or restoration), to ensure proper power control is maintained to avoid impacting existing channels in those routes.
- Some kind of connection setup sequence is required to avoid sudden optical power surge (RAMAN effect) which may risk impacting existing channels.
- Complex optical engineering calculations may impact “real-time” path computation response time. May use pre-planned restoration route => background pre-plan restoration calculation when new connections are setup

Proper power control essential to ensure orderly ramp-up of optical power in the fiber to avoid any traffic impact
⇒Setup time impact
⇒Restoration time impact




## What does this all mean?

- Pre-provisioning considerations
  - Provisioning granularity is a wavelength thus requires pre-provisioning of transponders and/or regenerators
- Cost optimization of nodal architecture with optical switch implementation to best fit the application of the network
  - Directional assignment of transponders needs to be planned
  - requires careful pre-planning of pre-provisioned transponders and possible routes
- Optical engineering in routing engine that correlate choices of optical path to optical impairments incurred with the link and optical components.
- Implementation for connection setup must control optical power changes to avoid traffic impact

Transparent optical networking requires more than routing and signaling defined in GMPLS. It also requires sophisticated optical engineering know-how and cost-effective optical technology

## Outline



## GMPLS deployment in Transparent Optical Network

| | Benefits from GMPLS? | Additional Remarks |
|---|---|---|
| Automatic Connection Setup | Yes. Configuration of optical switch for lambda switching | Signaling can be used for provisioning the cross connections |
| Topology discovery | Yes. Use of standardized routing protocol. | Optical Supervisory channel (OSC) to support in fiber-out of band DCN |
| Rapid Circuit provisioning | Yes, but … | **New circuit implies new wavelength. Requires pre-provisioning of equipments (e.g. transponders, regenerators) to turn on the needed wavelength** |
| Mesh Restoration | Yes, but … | **Computation of new optical path may takes long time.**<br>**Pre-provisioning of equipments required.**<br>**Massive restoration of optical connections need additional precautions to avoid sudden optical power surge.** |
| Traffic Engineering | Limited applicability using standard routing protocol (e.g. OSPF-TE) | **Optical engineering dominated routing.**<br>**More sophisticated path routing computation engine required to handle calculations of photonic effects.** |
| Bandwidth on Demand | Limited support using rapid | **Wavelength is the discrete unit. Scaling of … ut** |

Major benefit of GMPLS for transparent optical network is the simplification of provisioning

## Conclusions

- GMPLS/ASON is a maturing protocol and architecture suite with successful deployments in the PSC, L2SC and TSC layers
- **GMPLS in transparent optical networks additionally requires sophisticated optical engineering**
  - Unique attributes in optical networks such as route choices, regenerator placements, power control
  - Synchronization of routing engine between NE and planning tool
- **Cost-effective deployment of GMPLS in transparent optical networks requires cost-effective optical switches and elimination of transponder directionality to make it viable for transponder/regenerator pre-provisioning.**