광인터넷 망관리를 위한 주요 이슈

Jun Kyun Choi

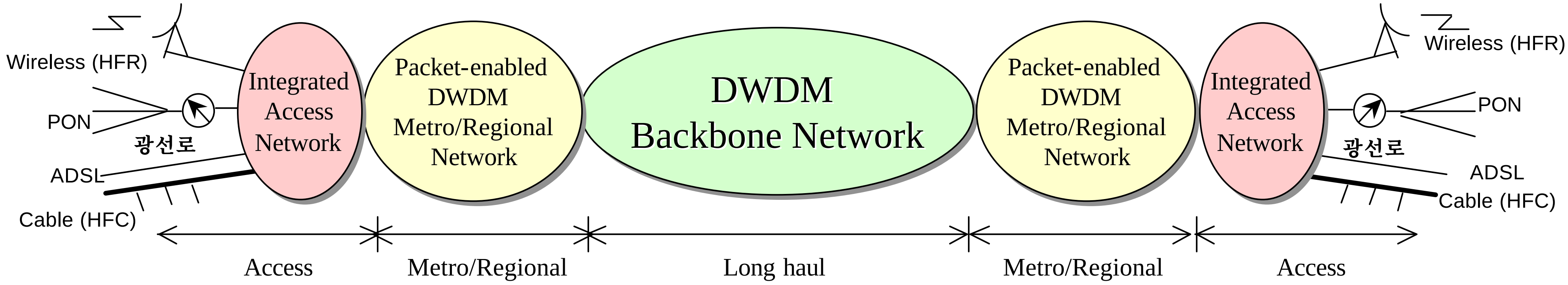
jkchoi@icu.ac.kr

Tel) (042) 866-6122

목차

Vision of Next Generation Infrastructure

- **Future network will be built using DWDM and MPLS**
  - Long-haul network consist of a meshed network of optical cross-connects by DWDM system. The signaling will be based on *MPLambdaS*
  - Terabit Router will be deployed at the gateway or super POPs
  - Core Metro Network will be based on DWDM Optical Ring
  - A specialized router functioning as an IP service switch at each POP
  - Last mile consist of various technologies including ADSL, fixed wireless, PON, FTTC.



Customers Requirements for Multi-Services

- **Security, predictability, and reliability**
- **Cost effectiveness and flexibility**
- **Applications that work all the time – end to end QoS**
- **High reliability for mission critical applications**

Requirements of Next Generation Infrastructure

- **High performance, scalable, efficient network**
- **Always-available network (99.999 %)**
- **Low cost administration nets**
  - Scalable systems (small footprint, low power)
  - Auto provisioning
  - Fast troubleshooting & reaction to problems
  - Fast service activation
  - Up- to- date network knowledge
- **Policy-based management**

Service Provider Objectives

- **Maximize revenue opportunities from optical network investments**
  - Create new revenue opportunities, while avoiding the loss of existing revenue streams
- **Efficiency and reduced capital and operational costs through convergence and consolidation**
  - Multiple networks create unnecessary duplication of effort and expertise in a single organization
- **Ease and automation of service provisioning**
  - Faster and less expensive

Backgrounds for Optical Network

- **Re-evaluation of traditional network platforms and cost structures**
  - Requirements changing on Service delivery and OAM
  - Limitations of existing architecture
    - Existing SONET/SDH ring-based architecture moves to Mesh configuration
    - Optimized for voice, Can't scale enough for data
- **Utilize dynamic allocation for DWDM network capacity**
- **Just-in-time provisioning for Dynamic Re-configurable Optical Network**
- **Innovation and advances in optical components and transport technologies**
  - Increased focus between electrical and optical devices

Dynamic Provisioning ?

- Dynamic just in time provisioning
- Efficient management of network assets
- Migrating service provisioning responsibilities into the network and offloading the network management systems
- A variety of protection and restoration options
- Interoperability across multi-vendor, multi-technology, and multi-domain networks

Motivation for Optical Networking

- **Cost and Efficiencies**
  - Wavelengths cheaper than switching packets
  - Eliminates costly O/E/O conversions and equipments
- **Flexibility and Management**
  - Just-in-time service provisioning ?
  - Traffic engineering at the wave level ?
- **Revenue Opportunities**
  - Fast provisioned wave services
  - Bursty IP services through backbone network

Toward Optical IP Network

- **Guidelines and Direction**
  - Optical bandwidth reduces the cost of IP services
  - Use of Generalized MPLS signaling
  - Desire to have restoration behavior of current SONET network
  - Goal of dynamic optical path service
  - Greater bandwidth efficiency from IP layers

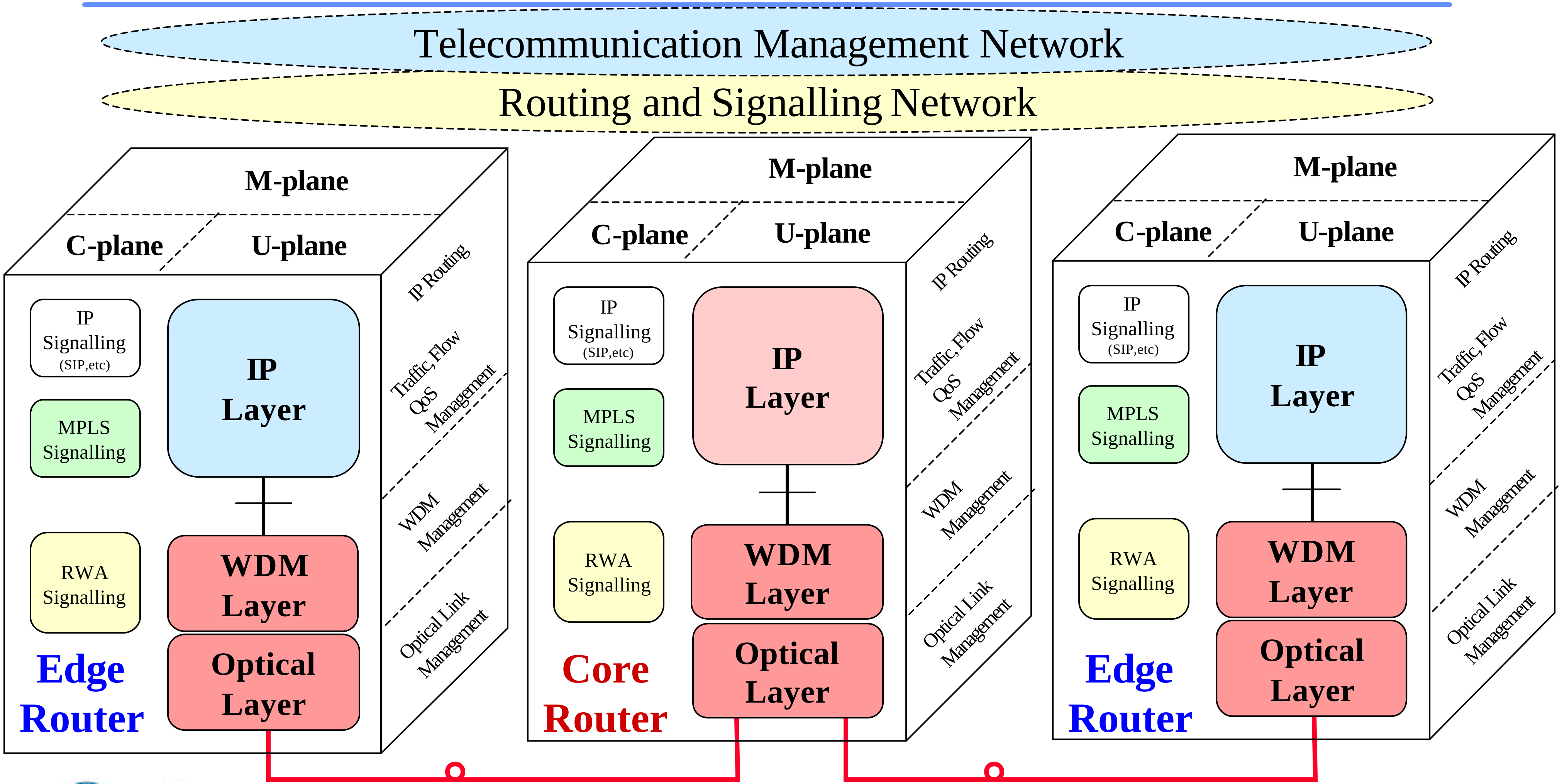
Control Requirements for Optical Networking

- **Dynamic Reconfiguration of Optical Network**
  - Link Protection and restoration, Capacity Planning, performance monitoring, etc.
- **Rapid service provisioning for negotiated bandwidth and QoS**
- **Scalability on bandwidth provisioning**
- **Grooming of sub-rate circuits**
- **Dynamic Optical VPN for multicast according to SLA**
- **Automatic configuration and topology auto-discovery**
- **Integrated control of L1, L2 and L3 Switching/Routing**

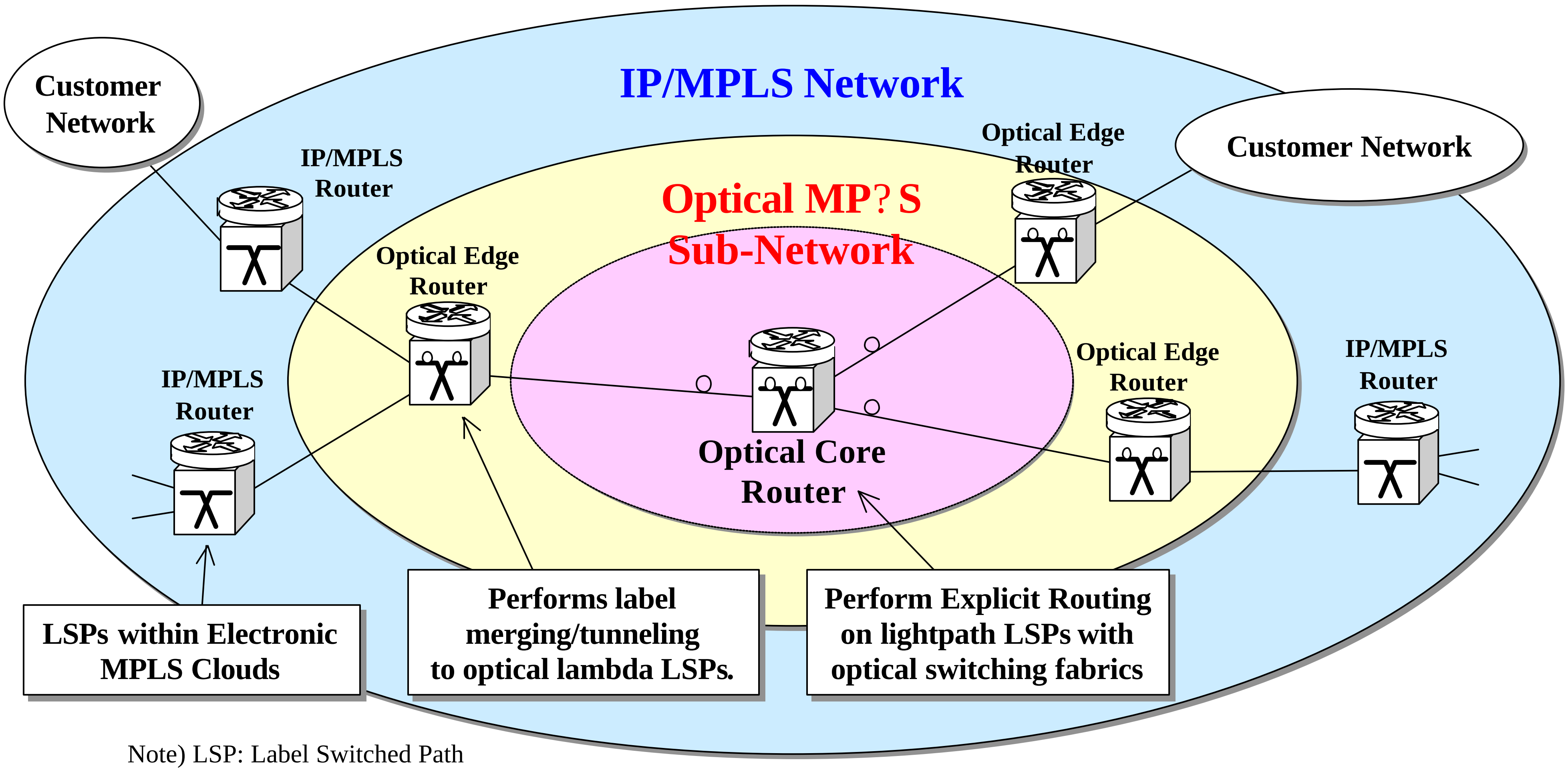
Separation of Control Plane from Data Plane

- **Separate control and data channels**
  - Out of band in fiber, out of band out of fiber
  - Control channel failure might not disrupt data
  - Control plane reboot might not disturb data plane
- **Handling Protection and Repair Conditions**
  - Selection of Protection Domains
  - Requirements for Recovery
  - Failure Detection and Reporting
  - Recovery after Node Failure

Protocol Reference Model for Optical Internet



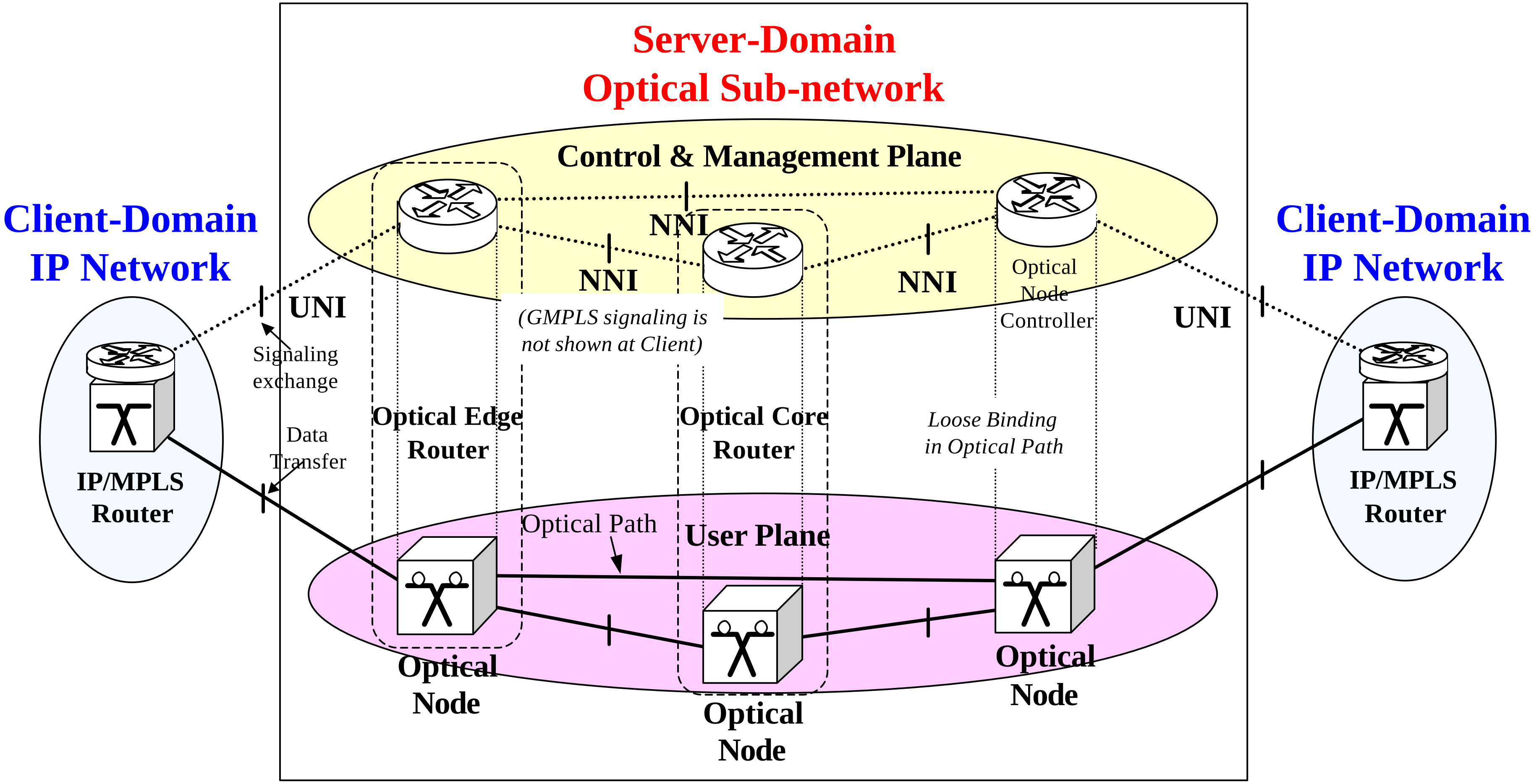
MPLS-Based Optical IP Network Architecture



Note) LSP: Label Switched Path

Service Model for Optical Internet - 1

Domain Service Model



Note) UNI: User to Network Interface NNI: Network to Network Interface
MPLS: Multi-Protocol Label Switching GMPLS: Generalized MPLS

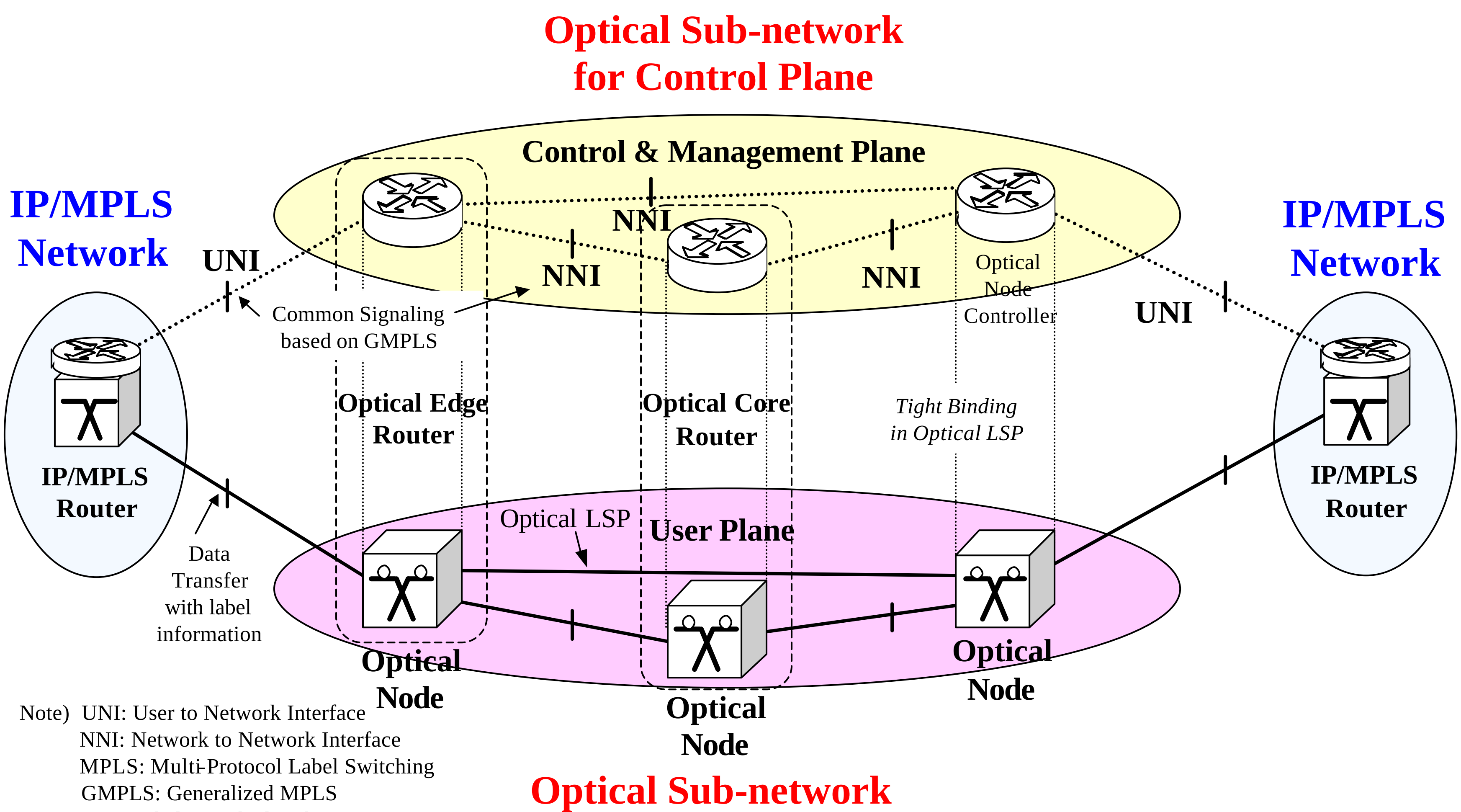
Service Model for Optical Internet - 2

Domain Services Model

- Clients access to optical network using well defined UNI
- Client/Server domain relationship
  - IP is a client of the optical domain
  - Optical layer provides point-to-point channels for clients
- Optical/transport paths requested by clients and setup dynamically within optical network. Path setup method unspecified
- For router network clients, optical paths are used as point-to-point IP links
- For TDM clients, optical paths are large structured, fixed bandwidth paths

Service Model for Optical Internet - 3

Unified Service Model



Note) UNI: User to Network Interface
NNI: Network to Network Interface
MPLS: Multi-Protocol Label Switching
GMPLS: Generalized MPLS
LSP: Label Switched Path

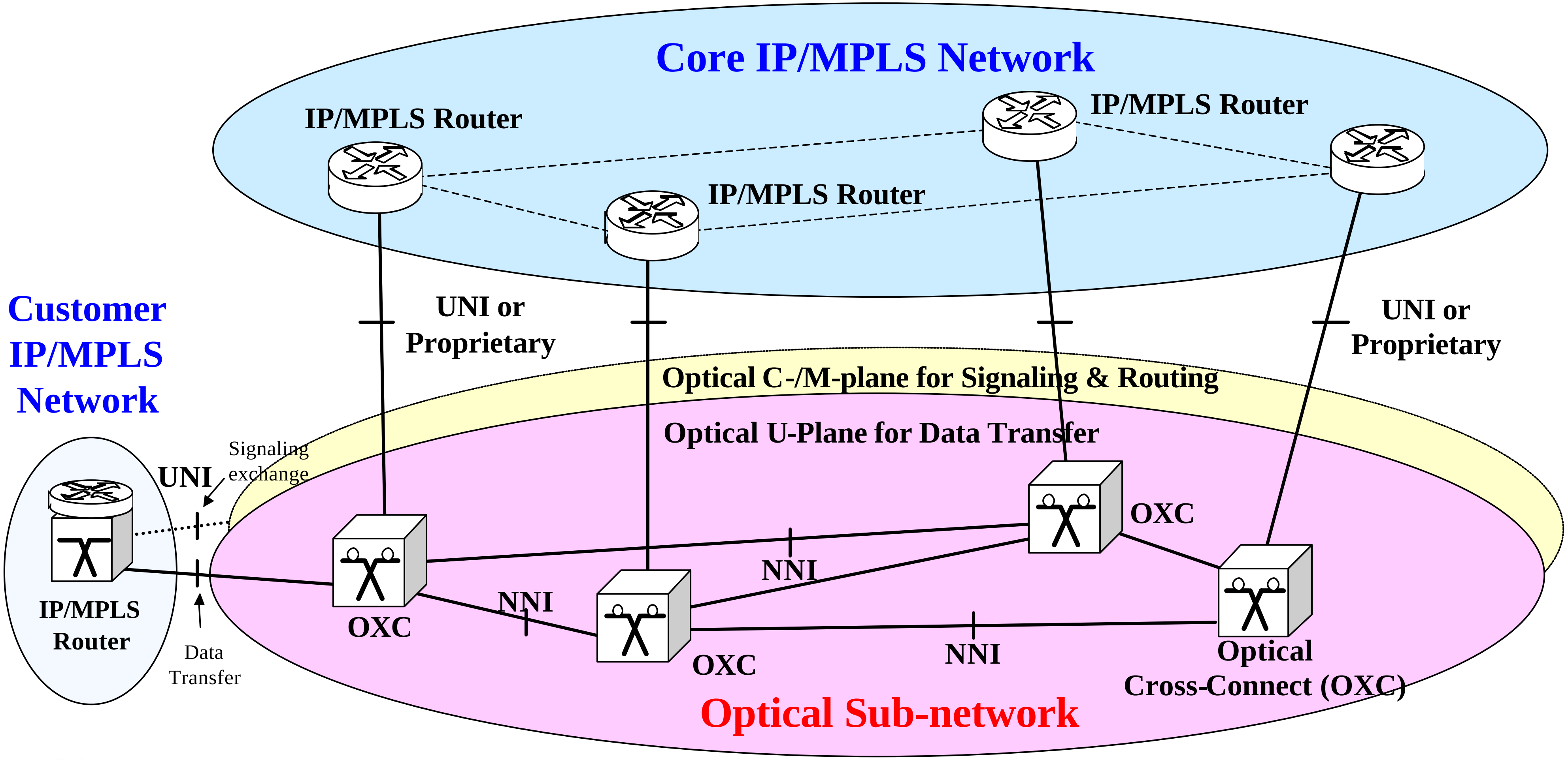
Service Model for Optical Internet - 4

- **Unified Service Model**
  - A single control plane for User and Optical Network Node
    - single signaling and routing protocol
  - MP?S-based optical network using label binding by Clients
    - IP router's FEC is matching to Optical LSP
  - IP signaling and routing protocols need to be modified to support optical characteristics
  - No UNI, Client use NNI directly

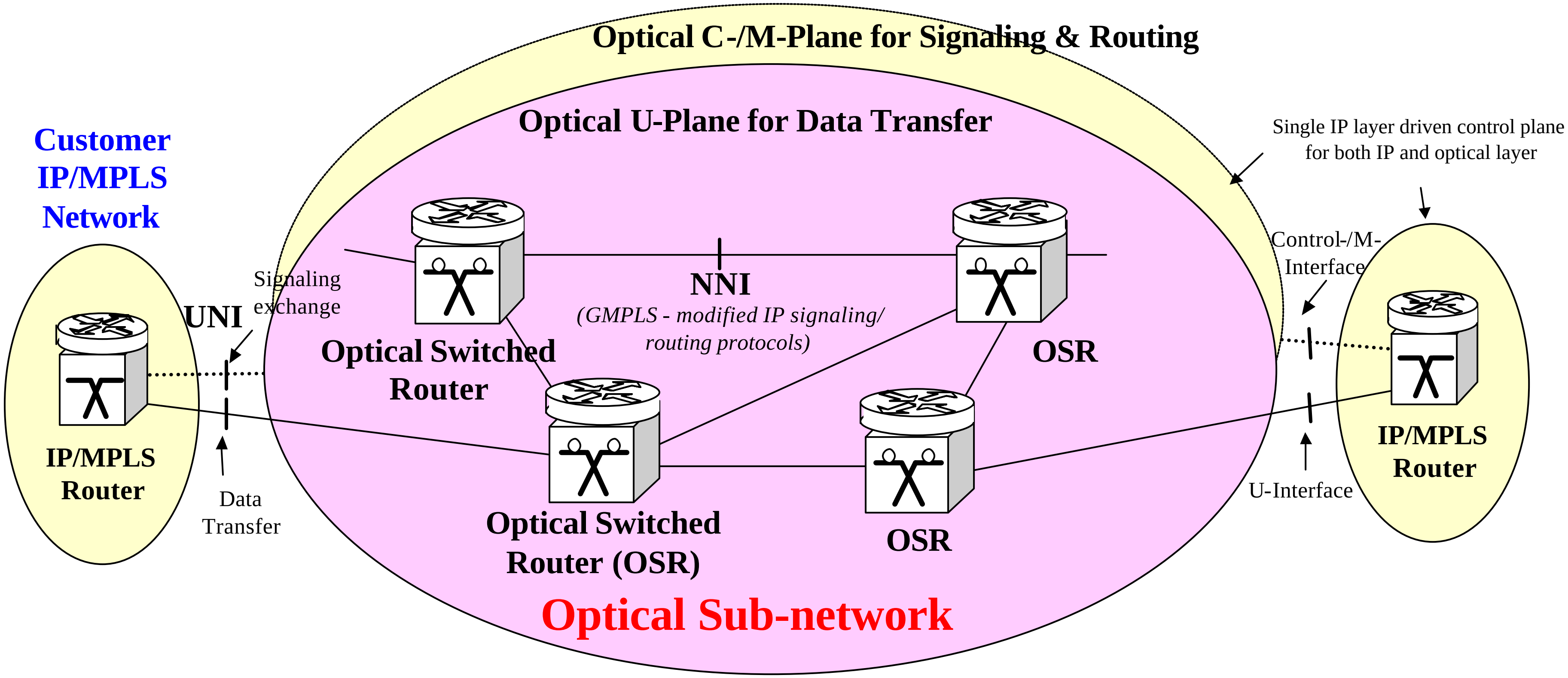
Network Architecture Model

- **Overlay Model**
  - Separate routing of IP and Optical layer
  - Separate the control plane between Optical Transport Network (OTN) domains and IP domains
  - Augmented routing can be applied
- **Peer Model**
  - Integrated signaling and routing of IP layer and Optical layer
  - Same control plane in the OTN and IP domains

Overlay Model



Peer/Integrated Model



OXC : Optical Cross Connect

Management Infrastructure

- **MPLS MIBs already exist for**
  - Modeling the cross-connects in an LSR
  - Requesting and controlling TE-LSPs
- **Enhancements are being made to**
  - Support wider definition of “label”
  - Allow control of new GMPLS features
- **Other new MIBs for**
  - LMP
  - Link bundling

Reliability Requirements

- **Problems**
  - Layer 3 rerouting may be too slow
  - Granularity of lower layers may be able to protect traffic may be too coarse for traffic that is switched
  - Lower layers may provide link protection
  - But is unable to provide protection against node failures or compute disjoint paths
- **Need for GMPLS- based recovery**
  - Establishing interoperability of protection mechanisms between GMPLS enabled devices (Routers, SONET ADMs, Optical Cross- connects, etc)
  - Enables IP traffic to be put directly over WDM optical channels and provide a recovery option without an intervening SONET layer.

Restoration Requirements

- **Restoration Time under 50 ms**
- **Required Steps**
  - Fault detection, Fault isolation, Error reporting, Re-provisioning, Switch-over
- **Controlling Management Status**
  - Management status carried on Signaling requests and responses, Notify messages
  - Alarm-free setup and teardown
  - Status control during protection switchover

Traffic Engineering Requirements

- Require to compute paths to deliver QoS
- Need to know basic topology of the network
- Need to know available resources on links
- Must also know link properties in network
- User/application requests services

Managing Optical Link Resources

- **Need to address a common set of issues**
  - Isolation of faults transparent networks
  - Scale the number of links without increasing configuration
  - Scale the parallel ("bundled") links without increasing the amount of information
- **Requires a new protocol to resolve these issues**

Link Management Protocol

- **Control Channel Management**
  - Maintain an IP control channel between LMP peers
- **Link Verification**
  - Map interface IDs and verify data connectivity
- **Link Property Correlation**
  - Discover and agree data link properties
- **Fault Management**
  - Detect and isolate faults
- **! Authentication**

MPLS Benefits for Optical Internet

- **MPLS was initially designed to optimize and scale IP core networks, via traffic engineering**
  - Core for aggregation and scalability
  - Edge traffic classification
- **Take advantage of these existing MPLS capabilities**
  - Use label stacking for hierarchical aggregation
  - Provides scalable edge services

MPLS-based Control for Optical Internet – 1

- **IP-based approaches for rapid provisioning**
  - Re-use existing signaling framework
  - Less standardization, faster vendor interoperability
  - No addressing concerns arise (use IP addresses)
- **Key MPLS features exploited**
  - Hierarchical LSP tunneling (label stacking/swapping)
  - Explicit routing capabilities
  - LSP survivability capabilities
  - Constraint-based routing

MPLS-based Control for Optical Internet – 2

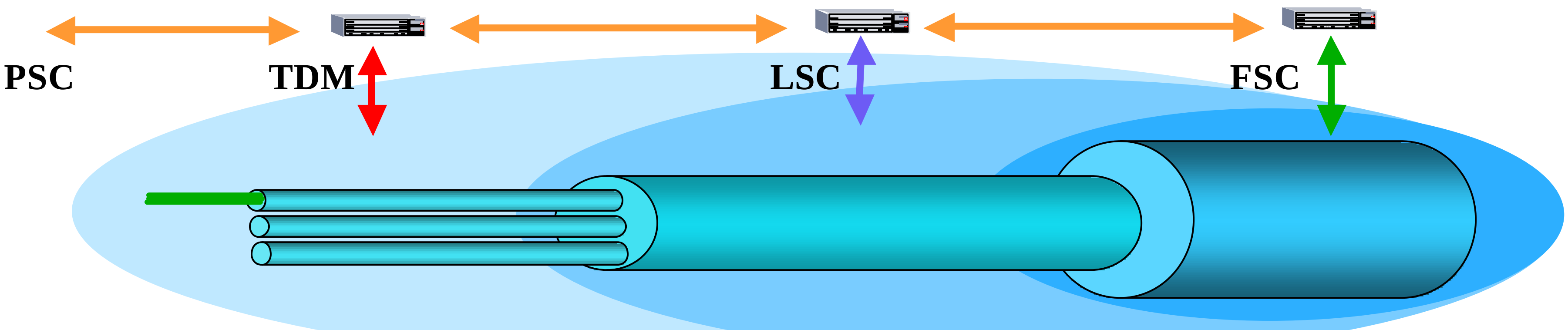
- **Traffic Engineering in Optical Network**
  - Optical network load balancing
  - Performance optimization
  - Resource utilization optimization
- **Extensions to MPLS signaling**
  - Encompass time-division (e.g. SONET ADMs), wavelength (optical lambdas) and spatial switching (e.g. incoming port or fiber to outgoing port or fiber)
  - Label is encoded as a time slot, wavelength, or a position in the physical space
  - Bandwidth allocation performed in discrete units.

MPLS-based Control for Optical Internet – 3

- **Supports Multiple Types of Switching**
  - Support for TDM, lambda, and fiber (port) switching
  - OXC (Optical Cross-Connect) can switch an optical data stream on an input port to a output port
  - A control-plane processor that implements signaling and routing protocol
- **Optical Mesh Sub-Network**
  - A net. of OXCs that supports end-to-end networking
  - Provide functionality like routing, monitoring, grooming and protection and restoration of optical channels

Forwarding Interface of GMPLS

- **Packet-Switch Capable (PSC)**
  - Recognize packet/cell boundaries and forward data based on header.
- **Time-Division Multiplex Capable (TDM)**
  - Forward data based on the data's time slot in a repeating cycle.
- **Lambda Switch Capable (LSC)**
  - Forward data based on the wavelength
- **Fiber-Switch Capable (FSC)**
  - Forward data based on a position of the data in the real physical spaces.



Allow the system to scale by building a forwarding Hierarchy

Technical Challenges

- **Scalability**
- **Quality of Service**
  - Needed for existing user applications to work as expected
- **Service Transparency**
  - For user applications to work
- **Manageability**
  - Provisioning

Conclusions

- **Architectural Evolution for Optical Network**
  - Boundary between Control Plane and Management Plane is obscure
  - Single Control/Management Plane both for IP domain and Optical Domain
  - IP-centric control mechanisms has cost competitiveness
- **Extends MPLS to Optical World**
  - Extends Generalized MPLS technologies to encompass time-division, wavelength and spatial switching network
  - Adapt IP Traffics to Optical Bandwidth Granularity
  - Generalized MPLS is used for network evolution scenario