Dynamic Data Routing and Service Provisioning in Next Generation Optical Networks

DOE Workshop on Ultra High-speed Transport Protocols and Dynamic Provisioning for Large-Scale Science

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Dynamic and Agile Optical Network Architecture

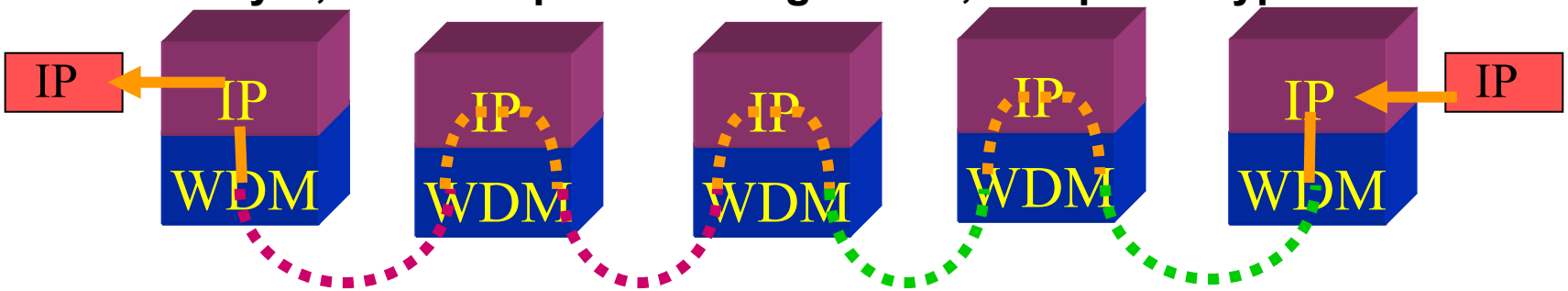
- It has to meet future traffic needs and bandwidth on demand
  - Unpredictable bursty traffic pattern and load distribution
  - Dense WDM over core network, broadband optical access to desktop
- Deliver real time, low latency multi-service by optical layer
  - Establish instant connections with flexible link granularity for short or long sessions
  - Support multi-service data over LSPs by optical switching
  - Speed of configuration determine routing and connection efficiency
- Flexible protection and restoration
  - QoS
- Network Scalability
- Moduality
- Security

Optical Label Switching

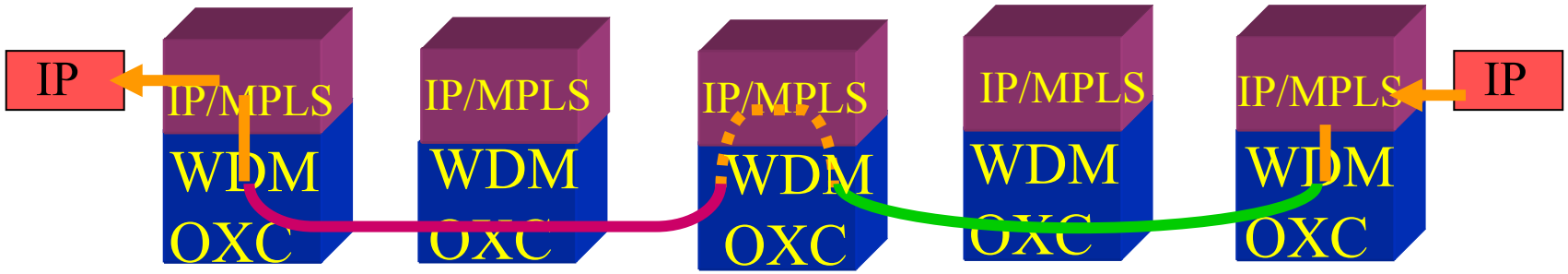
- OLS enables packet switching and multiplexing in the optical domain
- Packet forwarding is based on an optical header
  - For example, header is sub-carrier multiplexed with the optical data
  - “label” field in the optical header determines packet forwarding
  - Data is delayed (in a fiber loop) while the header is examined
  - Data never leaves the optical domain
- Erase and re-insert the label in the optical header
  - using a tunable optical notch filter
  - Operation concerns in terms of hardware construction and network extendability
- Enable optical time slot burst switching and multiplexing in sub-wavelength domain independent of packet protocols without requiring end-to-end network synchronization

Optical Label Switching

a. Client layer, IP based path reconfiguration, no optical bypass

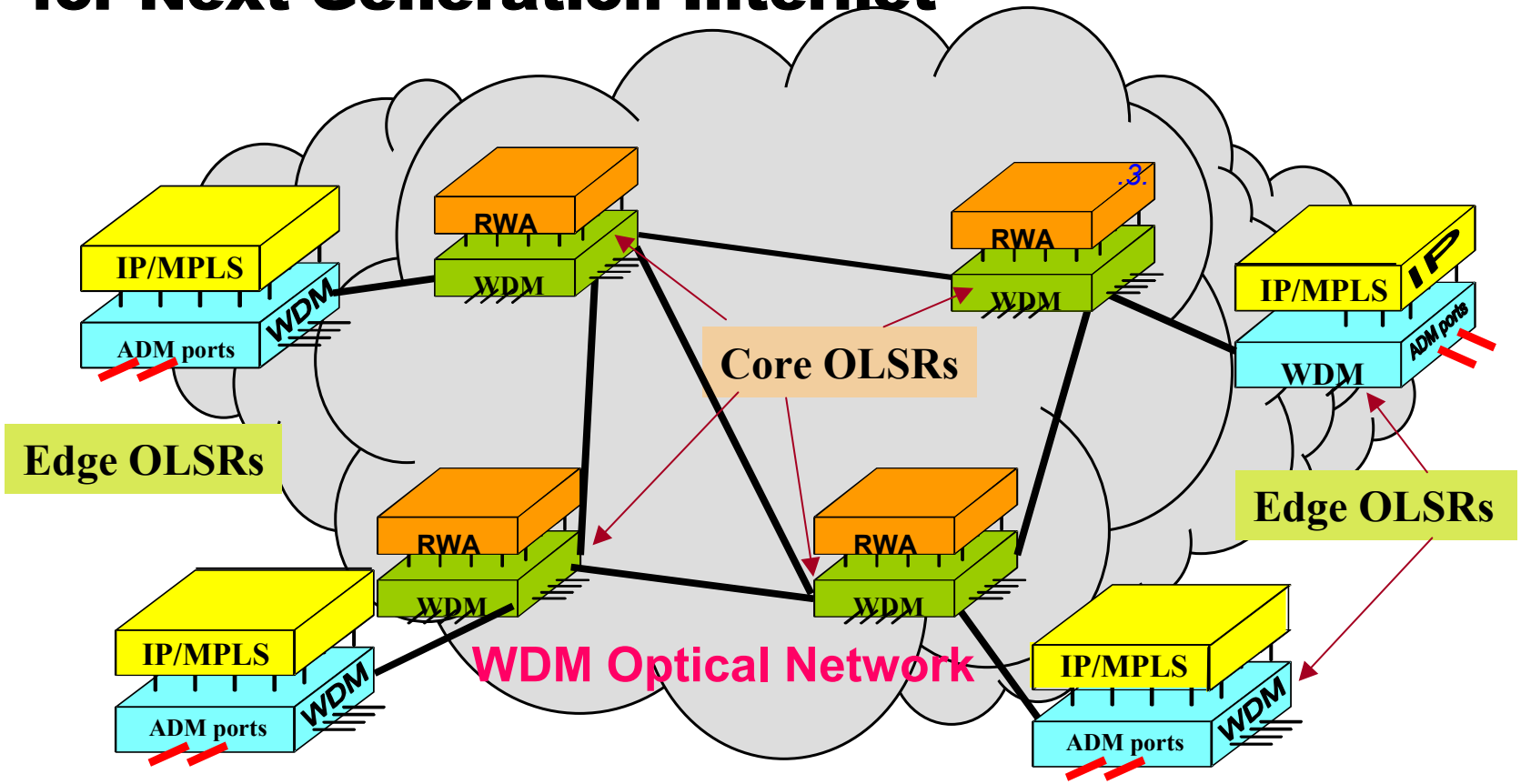


b. Hybrid layer, IP/WDM label-switched path, allow optical bypass



c. Core layer, OLS/WDM reconfiguration, optimize optical bypass

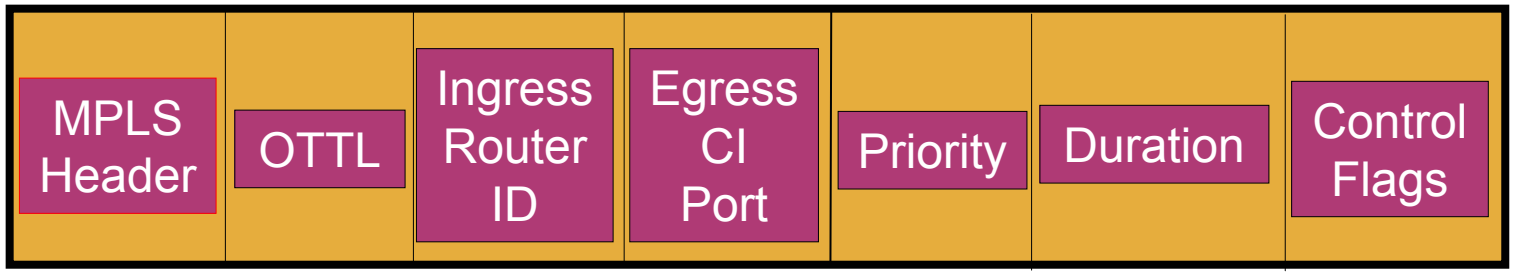
Optical Label Switched Optical Network for Next Generation Internet



OLSRs: Optical Label Switching Routers

RWA: Routing and Wavelength Assignment

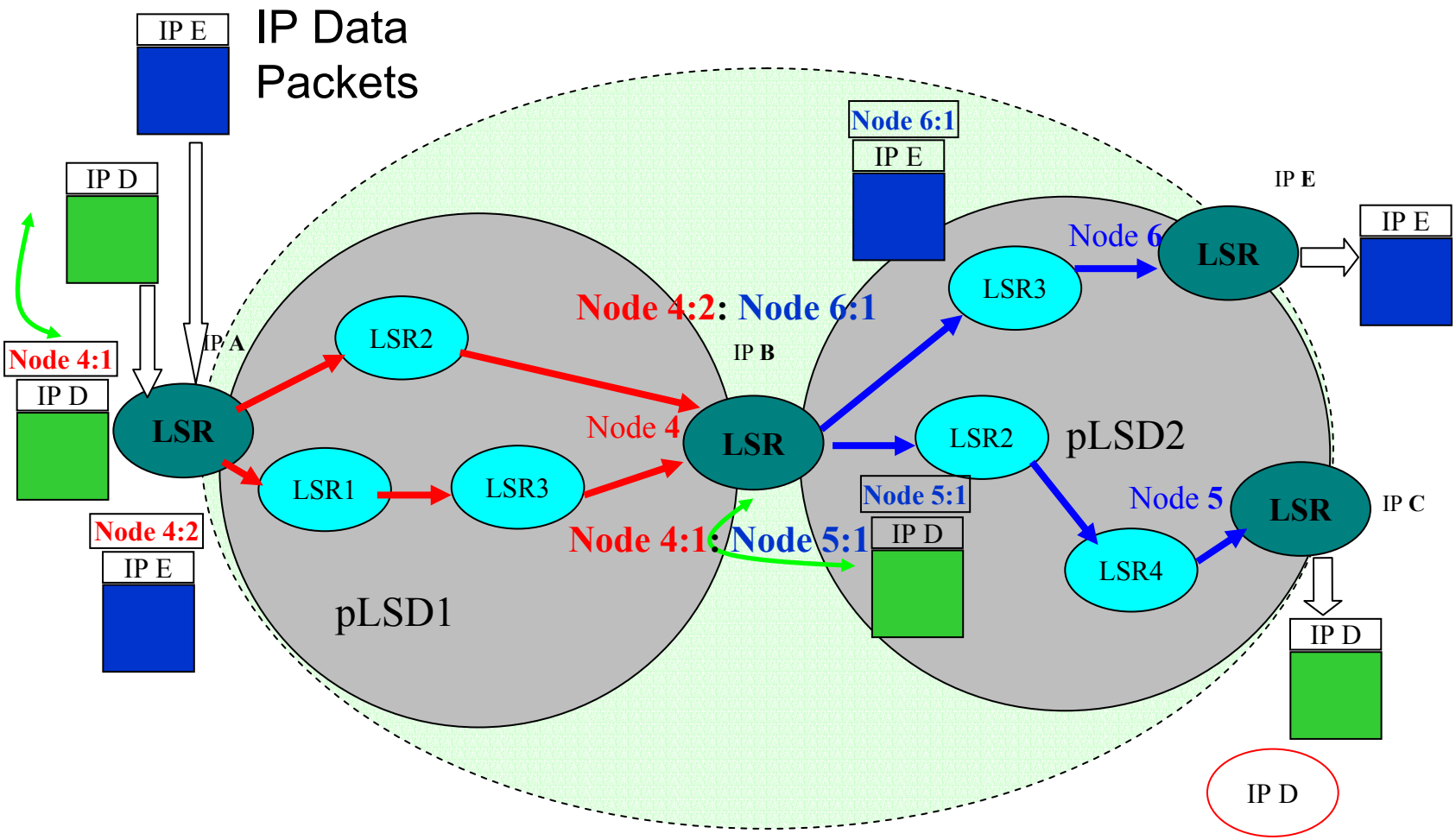
Example of OLS Packet Header Format



MPLS Header 32 bits+ WDM Specific 48 bits

- **Control Flags:** 4 bits, Concatenation of Packets, 1 bit; End of Flow, 1 bit
- **Priority:** 4 bits, 16 levels
- **Duration:** 16 bits, Burst duration
- **Ingress Router-ID:** 8 bits
- **Egress CI Port:** 8 bits
- **OTTL:** 8 bits, optical time to live
- **MPLS Header:** 32 bits, (Label, 20 bits; TTL, 8 bits; Exp, 3 bits; S, 1 bit)

Optical Label Switching with Node IDs and Path IDs



Multiple index values for different destinations 4:1 --> IP D, 4:2 --> IP E etc
Enables packet switching at Swapping OLSRs without IP lookups

OLS NGI Network Demo at OFC 2000 in Baltimore

Dynamic Data Routing and Service Provisioning in the Optical Domain: Optical Label Switching

- OLS proof of principle testbed demonstrated
- Simplified robust management and control
  - Single OLS platform vs separate IP and WDM platforms
  - Eliminates layering overhead and simplifies operations
- Plug and play inter-working module with existing infrastructure
  - Providing appropriate hardware interface, GbE, POS, Fiber channel
  - Adopting standards based control protocols
  - Supporting standards based management interfaces
- Enhanced intelligent new networking services
  - Fast dynamic service creation, provisioning, and protection
  - Flexible real time burst service for various bandwidth granularity

➡ **It's a Natural Next Step in Optical Networking Evolution**

  - OLS unifies wavelength routing and packet switching

Evolution of Optical Networks

Transport, Switching, Routing, and Provisioning Strategies