MPLS and GMPLS

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CS294 presentation

Outline

- Part I: MPLS
- Part II: GMPLS
- Part III: The reality check

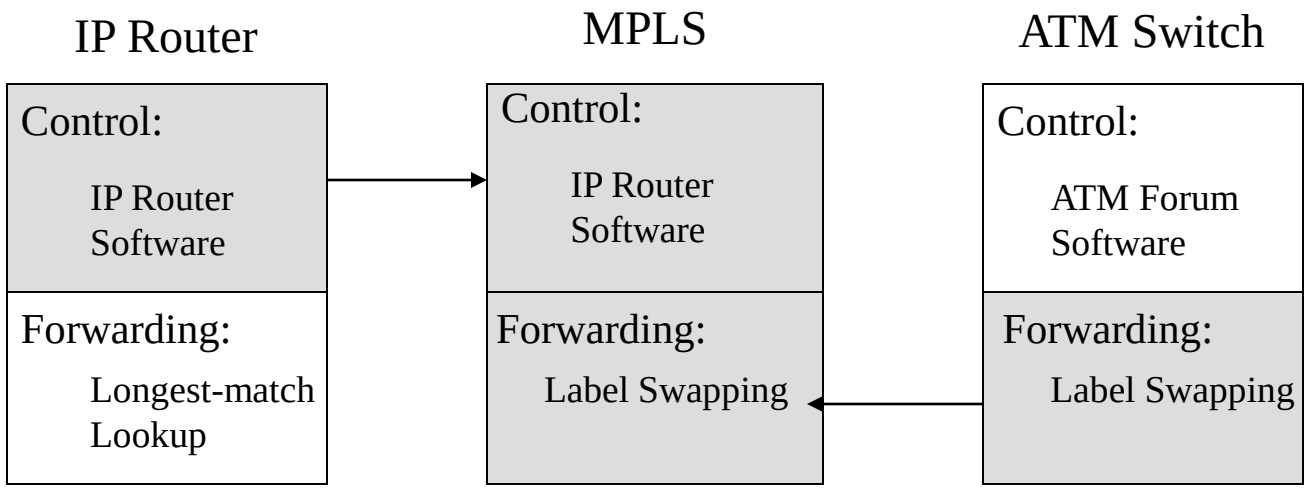
Part I: MPLS

Why MPLS?

- MPLS stands for: “Multi-Protocol Label Switching”
- Goals:
  - Bring the speed of layer 2 switching to layer 3
    - May no longer perceived as the main benefit: Layer 3 switches
  - Resolve the problems of IP over ATM, in particular:
    - Complexity of control and management
    - Scalability issues
  - Support multiple layer 2 technologies

Basic Idea

- MPLS is a hybrid model adopted by IETF to incorporate best properties in both packet routing & circuit switching



Basic Idea (Cont.)

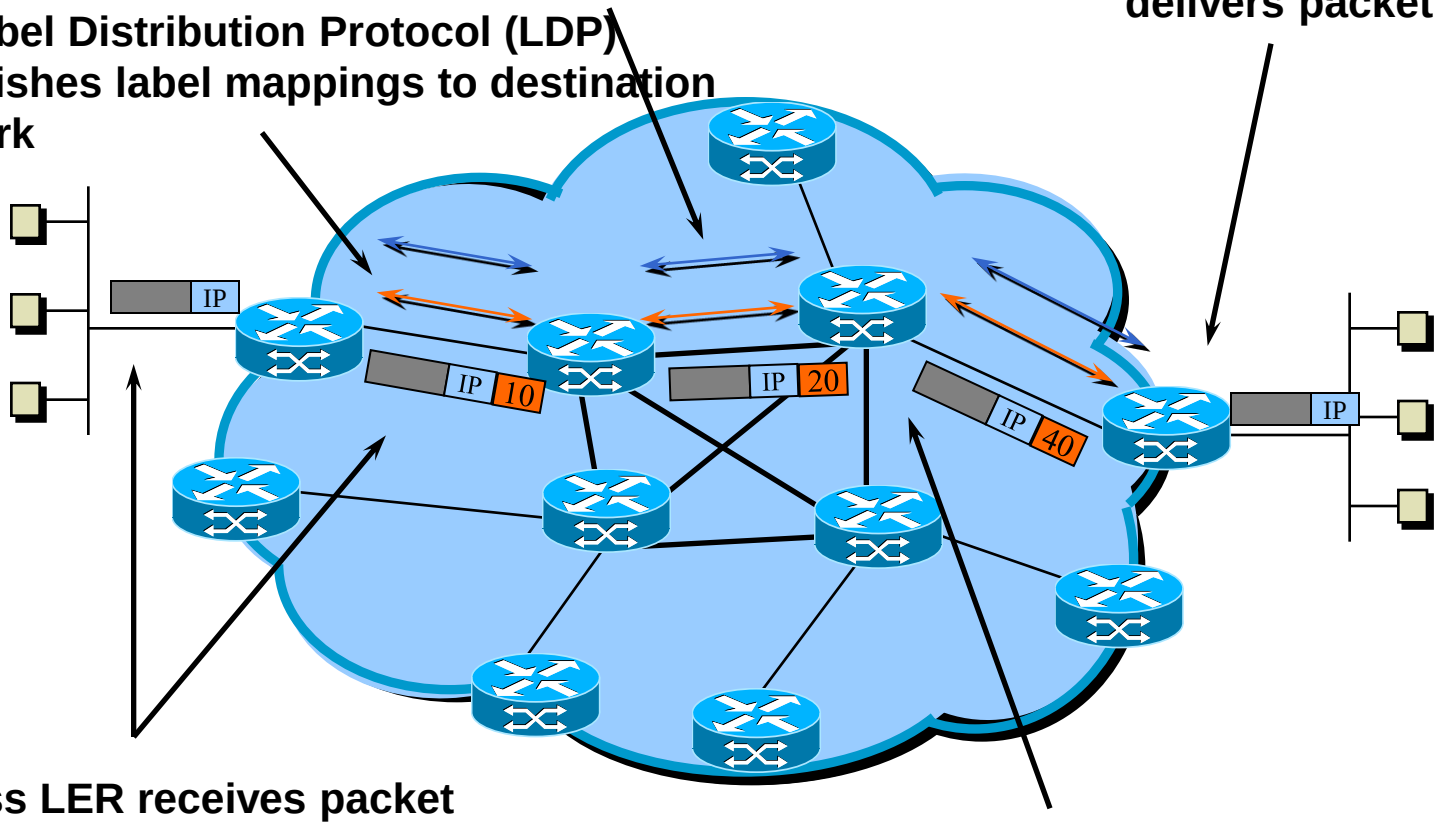
- Packets are switched, not routed, based on labels
- Labels are filled in the packet header
- Basic operation:
  - Ingress LER (Label Edge Router) pushes a label in front of the IP header
  - LSR (Label Switch Router) does label swapping
  - Egress LER removes the label
- The key : establish the forwarding table
  - Link state routing protocols
    - Exchange network topology information for path selection
    - OSPF-TE, IS-IS-TE
  - Signaling/Label distribution protocols:
    - Set up LSPs (Label Switched Path)
    - LDP, RSVP-TE, CR-LDP

MPLS Operation

1a. Routing protocols (e.g. OSPF-TE, IS-IS-TE) exchange reachability to destination networks

1b. Label Distribution Protocol (LDP) establishes label mappings to destination network

4. LER at egress removes label and delivers packet



2. Ingress LER receives packet and “label”s packets

3. LSR forwards packets using label swapping

Main features

- Label swapping:
  - Bring the speed of layer 2 switching to layer 3
- Separation of forwarding plane and control plane
- Forwarding hierarchy via Label stacking
  - Increase the scalability
- Constraint-based routing
  - Traffic Engineering
  - Fast reroute
- Facilitate the virtual private networks (VPNs)
- Provide class of service
  - Provides an opportunity for mapping DiffServ fields onto an MPLS label
- Facilitate the elimination of multiple layers

Part II: GMPLS

Outline

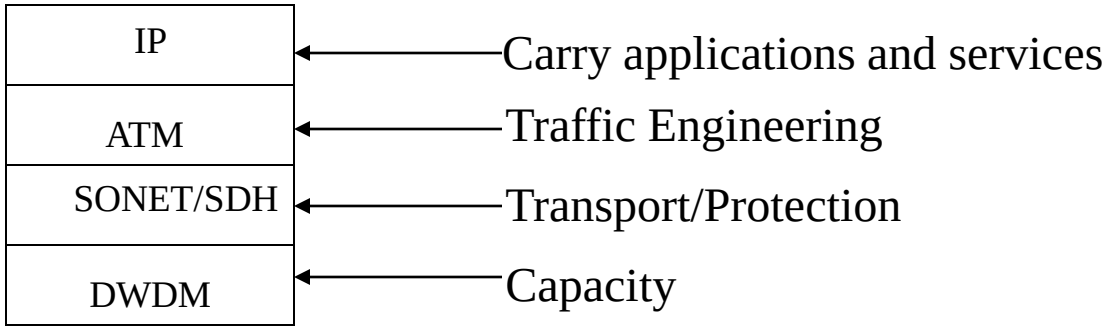
- Why GMPLS?
- GMPLS and MPLS
- Control interfaces
- Challenges of GMPLS
- Several proposed techniques
  - Suggested label
  - Bi-direction LSP setup
  - LMP
- Summary

GMPLS

- GMPLS stands for “Generalized Multi-Protocol Label Switching”
- A previous version is “Multi-Protocol Lambda Switching”
- Developed from MPLS
- A suite of protocols that provides common control to packet, TDM, and wavelength services.
- Currently, in development by the IETF

Why GMPLS?

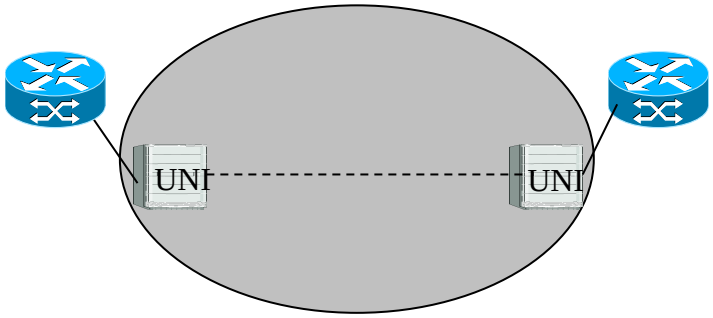
- GMPLS is proposed as the signaling protocol for optical networks
- What service providers want?
  - Carry a large volume of traffic in a cost-effective way
  - Turns out to be a challenge within current data network architecture



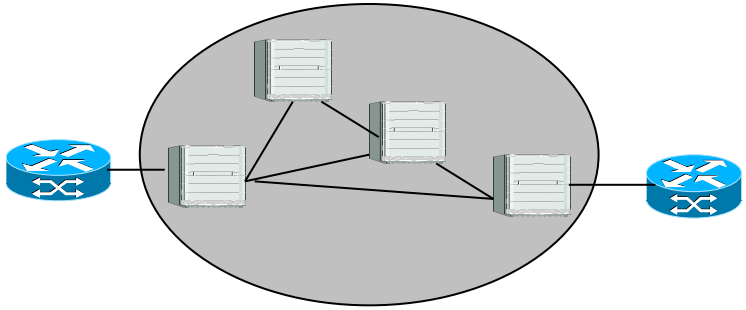
  - Problems:
    - Complexity in management of multiple layers
    - Inefficient bandwidth usage
    - Not scalable
  - Solutions: eliminate middle layers→ IP/WDM
- Need a protocol to perform functions of middle layers

Why GMPLS? (Cont.)

- Optical Architectures



Overlay Model



Peer Model

- A control protocol support both overlay model and peer model will bring big flexibility
  - The selection of architecture can be based on business decision

Why GMPLS? (Cont.)

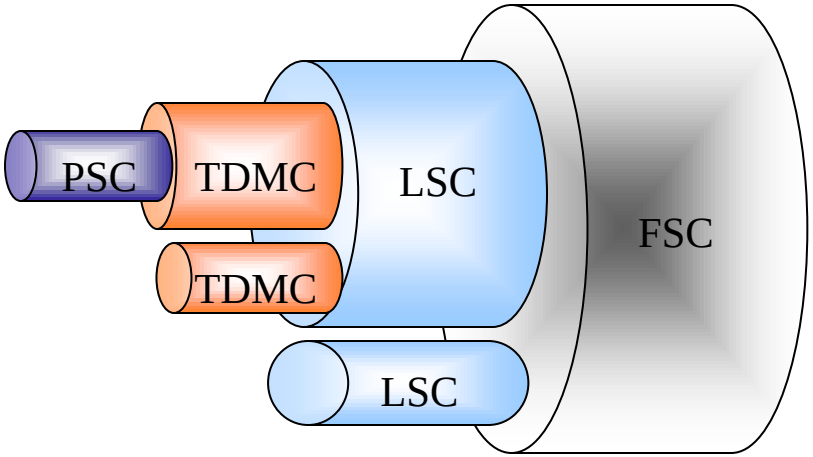
- What we need? A common control plane
  - Support multiple types of traffic (ATM, IP, SONET and *etc.)*
  - Support both peer and overlay models
  - Support multi-vendors
  - Perform fast provisioning
- Why MPLS is selected?
  - Provisioning and traffic engineering capability

GMPLS and MPLS

- GMPLS is deployed from MPLS
  - Apply MPLS control plane techniques to optical switches and IP routing algorithms to manage lightpaths in an optical network
- GMPLS made some modifications on MPLS
  - Separation of signaling and data channel
  - Support more types of control interface
  - Other enhancement

Control interfaces

- Extend the MPLS to support more interfaces other than packet switch
  - Packet Switch Capable (PSC)
    - Router/ATM Switch/Frame Reply Switch
  - Time Division Multiplexing Capable (TDMC)
    - SONET/SDH ADM/Digital Crossconnects
  - Lambda Switch Capable (LSC)
    - All Optical ADM or Optical Crossconnects (OXC)
  - Fiber-Switch Capable (FSC)
- LSPs of different interfaces can be nested inside another

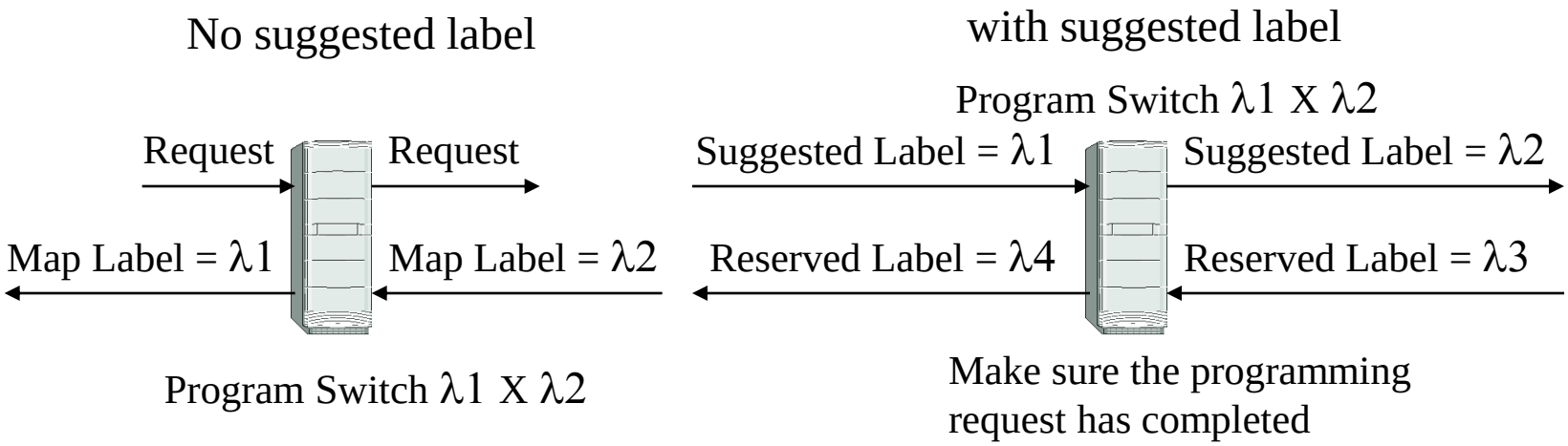


Challenges

- Routing challenges
  - Limited number of labels
  - Very large number of links
    - Link identification will be a big problem
    - Scalability of the Link state protocol
    - Port connection detection
- Signaling challenges
  - Long label setup time
  - Bi-directional LSPs setup
- Management challenges
  - Failure detection
  - Failure protection and restoration

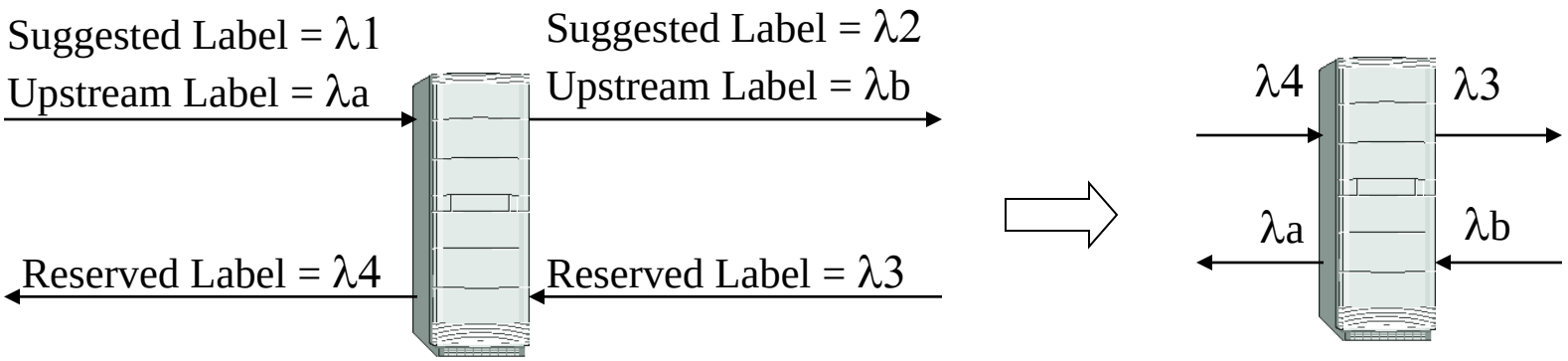
Suggested label

- Problem: it takes time for the optical switch to program switch
  - Long setup time
- Solution:
  - Each LSR selects a label (Suggested Label) and signals this label to downstream LSR, and start program its switch.
- reduce LSP setup overhead



Bi-Directional LSP setup

- Problem: How to set up bi-directional LSP?
- Solution:
  - Set up 2 uni-directional LSP
    - Signaling overhead
    - End points coordination
  - One single message exchange for one bi-directional LSP
    - Upstream Label.



Link Management Protocol

- Problem:
  - How to localize the precise location of a fault?
  - How to validate the connectivity between adjacent nodes?
- Solution: link management protocol
  - Control Channel Management
  - Link Connectivity Verification
  - Link Property Correlation
  - Fault Management
  - Authentication

GMPLS Summary

- Provides a new way of managing network resources and provisioning
- Provide a common control plane for multiple layers and multi-vendors
- Fast and automatic service provisioning
- Greater service intelligence and efficiency

Part III: The Reality Check

Question:

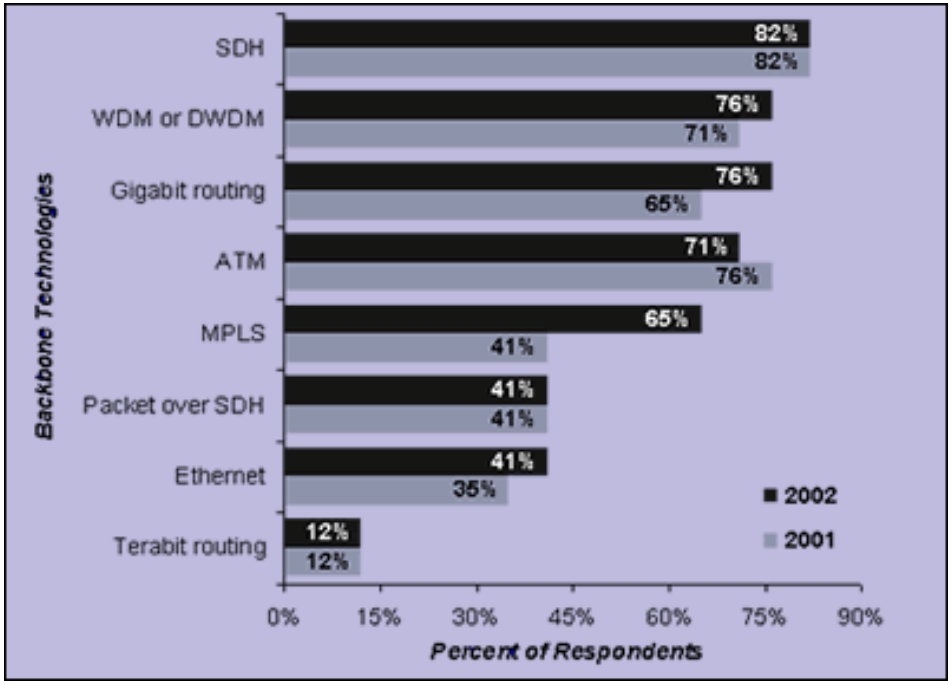
Will MPLS replace ATM?

Opinion 1:

- MPLS might replace ATM eventually however, the migration may be slow.
- Why MPLS will replace ATM eventually?
  - Future network is data-centric
    - IP instead of ATM
  - MPLS can act ATM's functionalities
    - Traffic engineering using MPLS
    - VPNs based on MPLS
  - From service provider's view, MPLS reduces the cost and provides operational efficiencies
  - Scalable

Opinion 1 (Cont.)

- MPLS deployment status



- ISPs deploy/plan to deploy MPLS for traffic engineering and VPNs
  - UUNET, AT&T, Equant, Global Crossing, Cable & Wireless and *etc*..
- Equipment vendors are pushing MPLS to the market
- Lucent killed its next-generation ATM core switch and switch to MPLS-based switch

Opinion 1 (Cont.)

- Why the migration may be slow?
  - ATM is still the biggest revenue generator
    - The networks are installed already
    - Customers care about the price and the services only
      - MPLS is more expensive
      - ATM can provide most service MPLS can provide
    - ISPs care more about revenue than new technologies
      - ISPs have to grow their existing business. At this point, they are more concerned about leveraging existing services rather than migrating to new technologies for technology's sake.
  - The cost of migration
  - MPLS still has problems to be solved
    - Interoperability
  - It takes time for a protocol to be mature. (usually 5 years)

Opinion 2

- MPLS cannot COMPLETELY replace ATM
- Why?
  - Some customers may still choose ATM instead of MPLS
    - Traffic engineering of ATM
      - ATM provides better QoS than MPLS
      - For those customers care about delay and jitter, they may want to stick to ATM instead of trying a new technology
    - ATM based VPN
      - Customers maintain the routing table
      - MPLS based VPN: entail ISP handling all the routing on behalf of customers
      - Will customer trust ISP?
      - The size of the routing table.

GMPLS Questions

- Does the success of GMPLS depend on the success of MPLS?
  - No.
  - MPLS and GMPLS are proposed for different purposes.
  - GMPLS is proposed to support IP over WDM. After all, a signaling protocol is needed to perform provisioning.
- The future of GMPLS is unclear
  - GMPLS certainly will offer operational benefits to carriers
    - However, it is not necessarily provide immediate return on investment.
    - Need to prove the efficacy
  - GMPLS proposes an entirely new way of managing network resources and provisioning
    - More difficult to be adopted
- It may take some time to prove GMPLS.

Summary

- MPLS and GMPLS are promising technologies
- ISPs are interested in MPLS and GMPLS
- Whether the MPLS will replace ATM or not has no final answer
- The efficacy of GMPLS may take years to prove