DiffServ & MLPS

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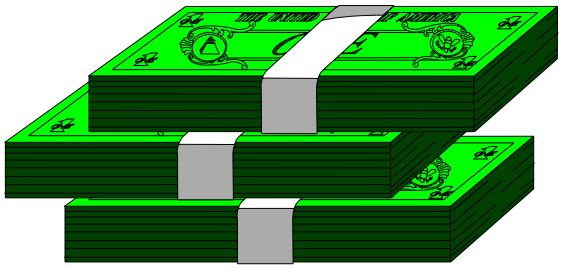
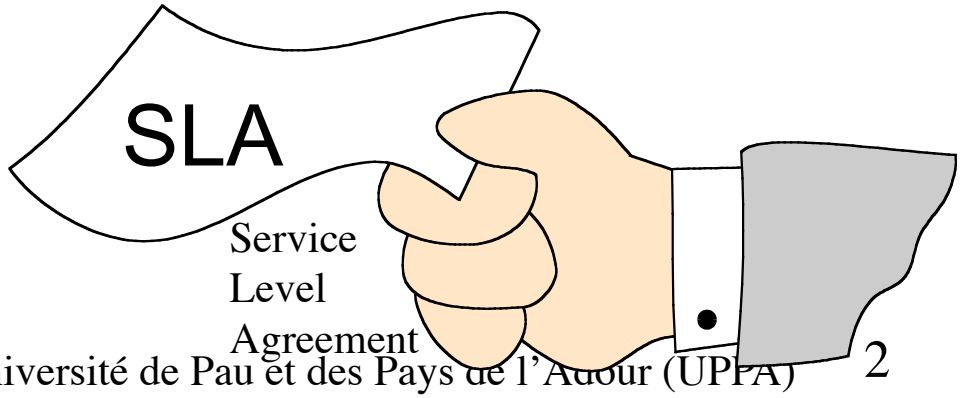
NEW CHAPTER

Service Differentiation

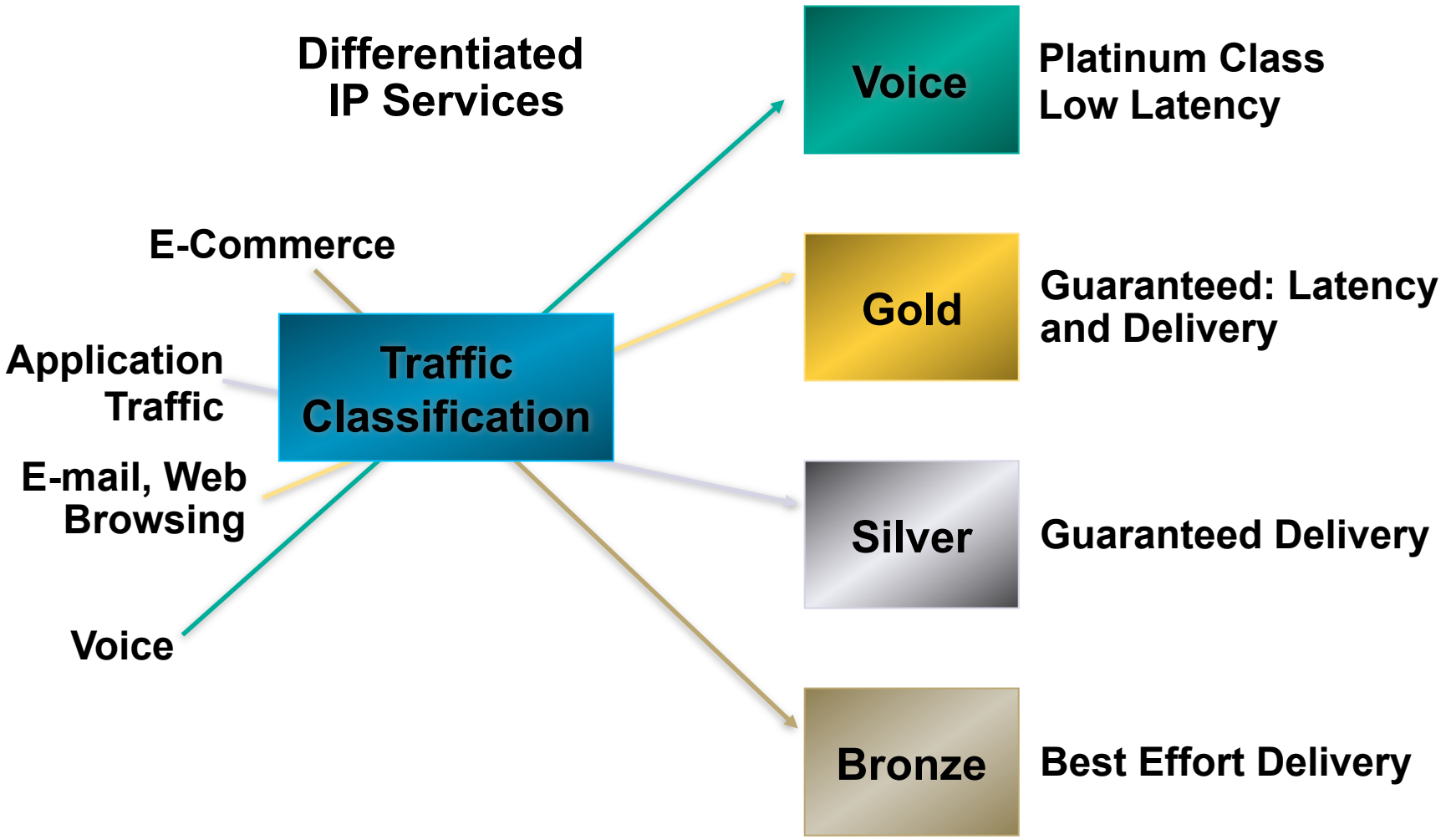
The real question is to choose which packets shall be dropped. The first definition of differential service is something like "not mine."
-- Christian Huitema

- Differentiated services provide a way to specify the relative priority of packets
- Some data is more important than other
- People who pay for better service get it!

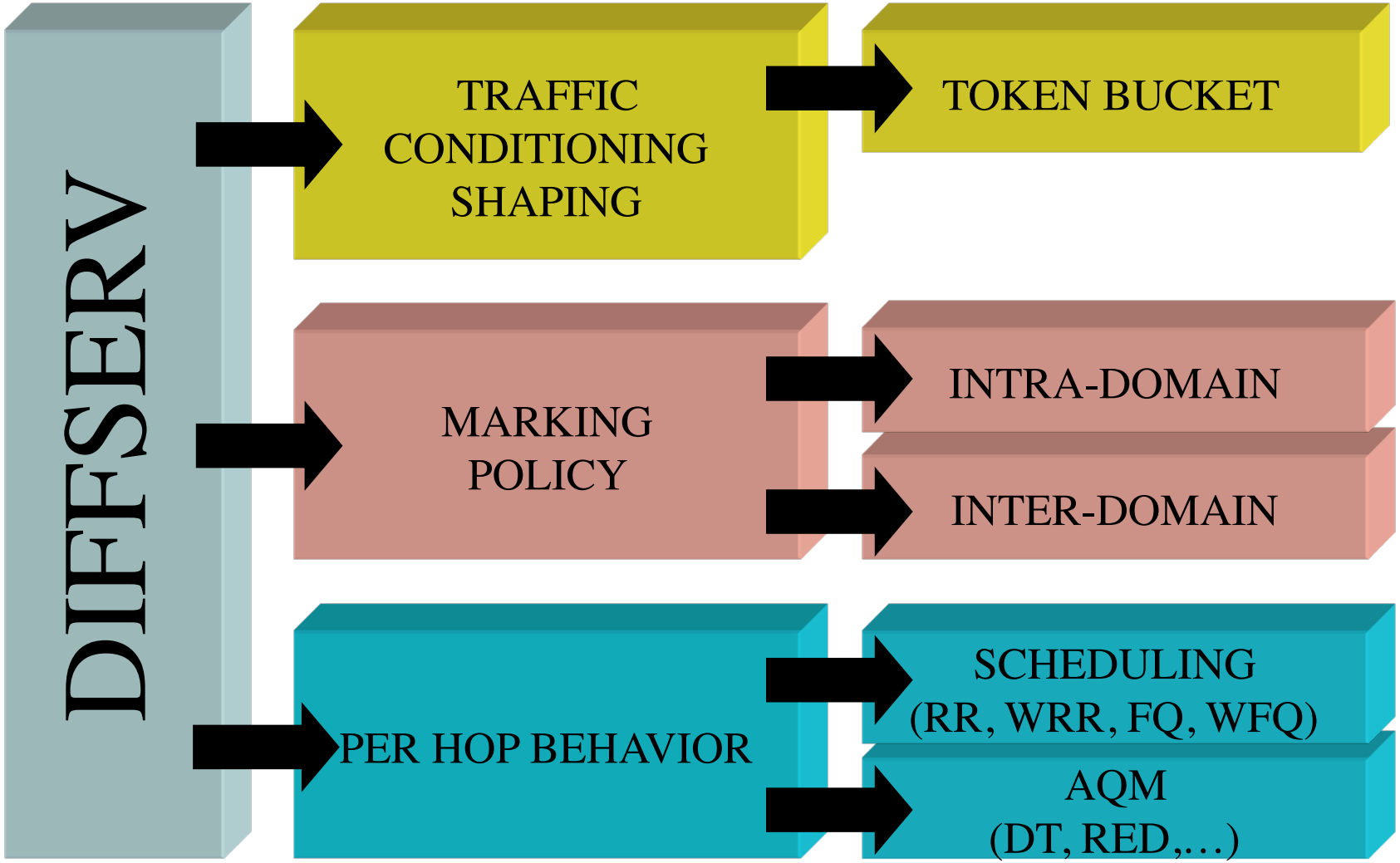




Divide traffic into classes

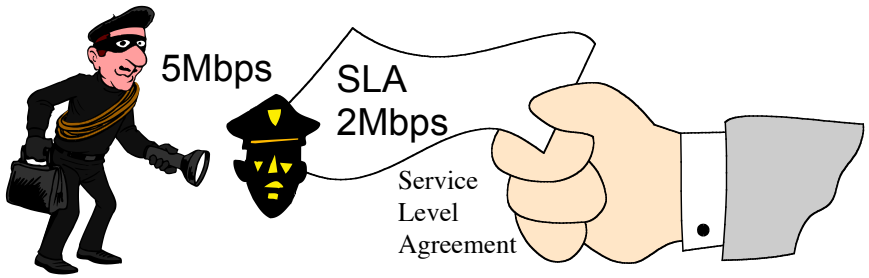


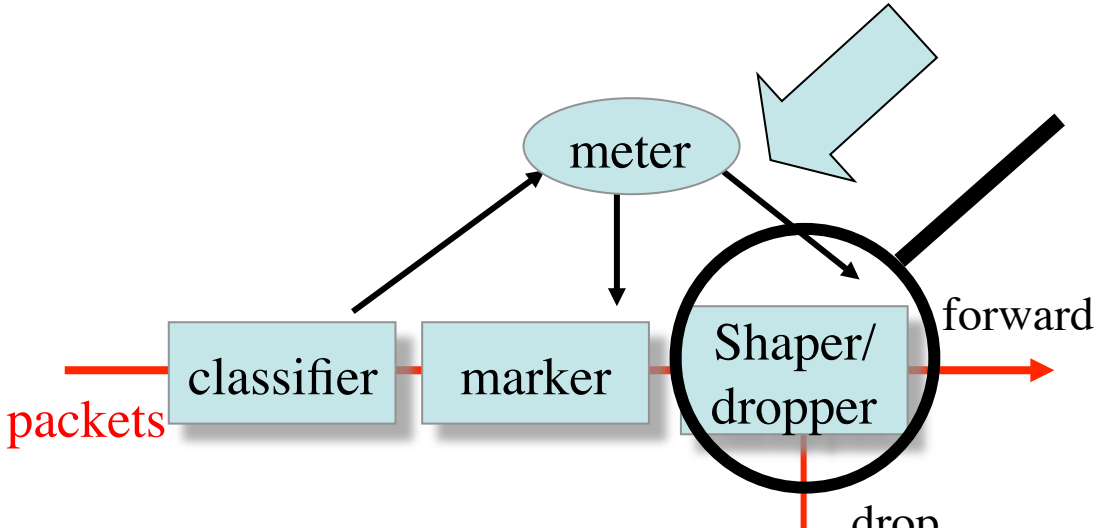
DiffServ building blocks

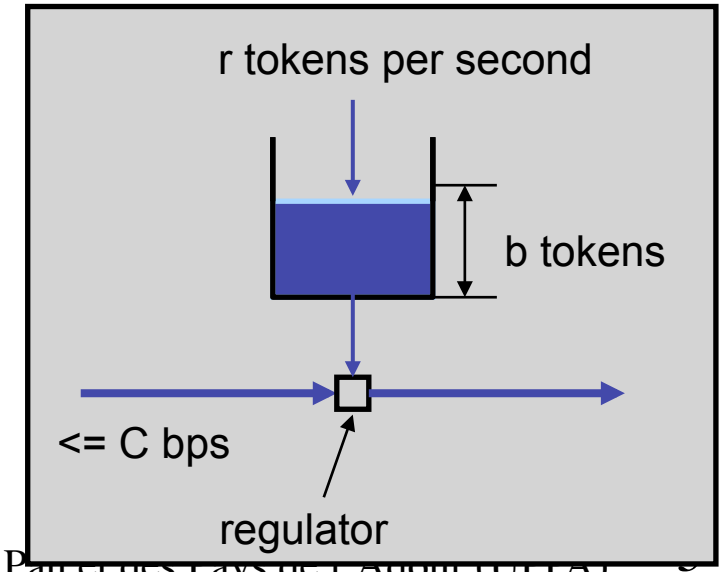


Traffic Conditioning

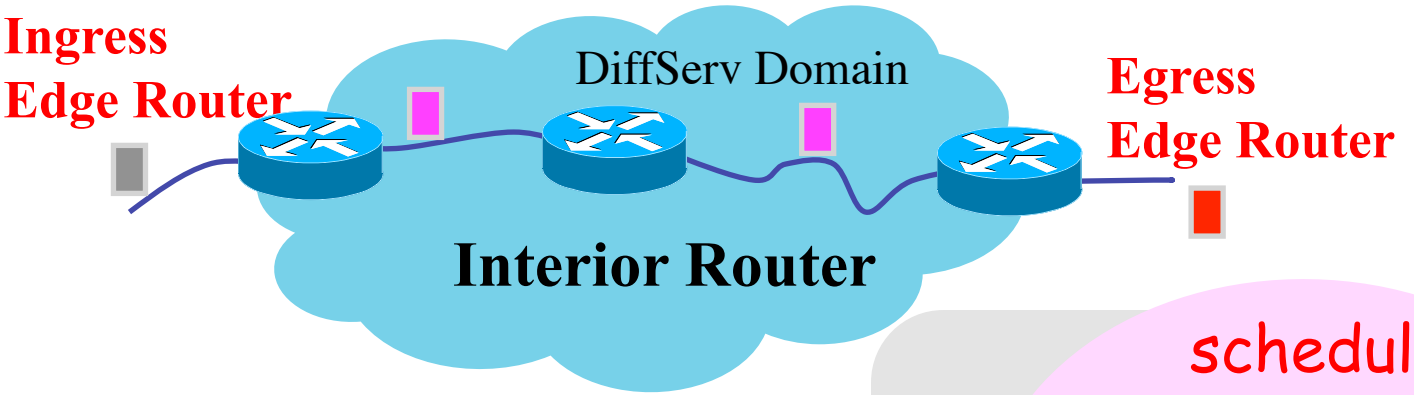
- User declares traffic profile (eg, rate and burst size); traffic is metered and shaped if non-conforming







Differentiated Architecture



Marking:

per-flow traffic management

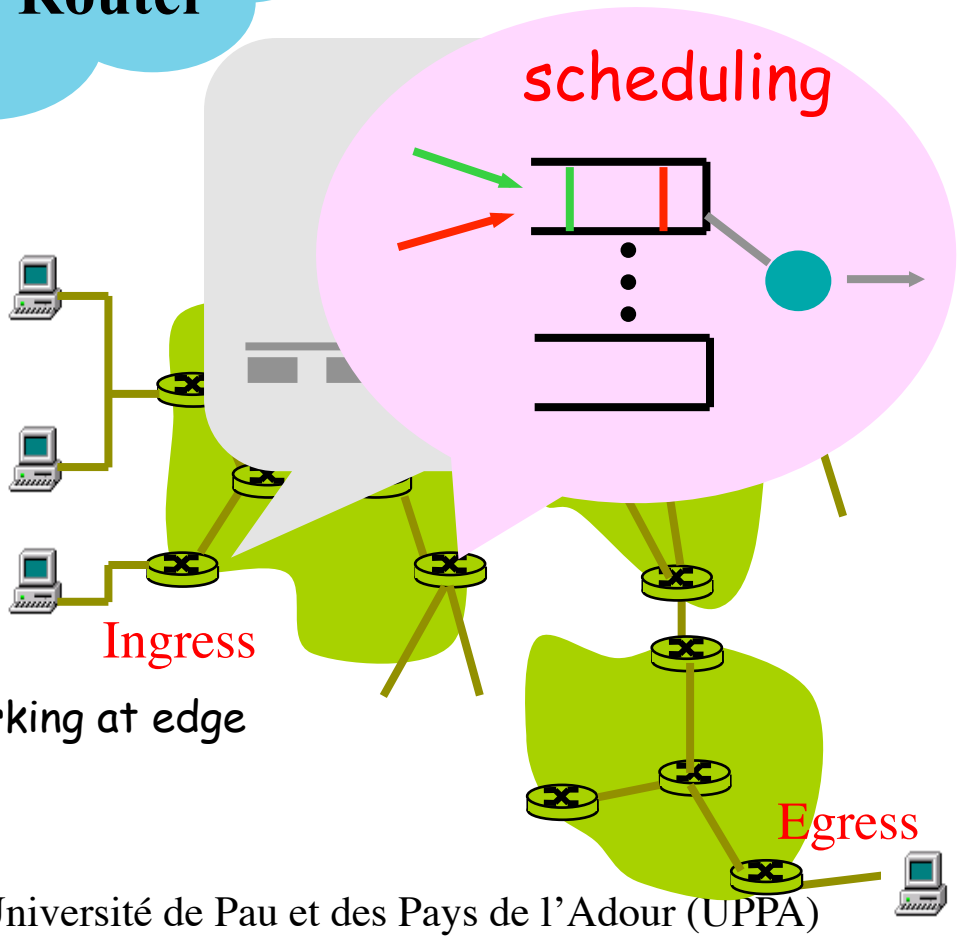
marks packets as in-profile and out-profile

Per-Hop-Behavior (PHB):

per class traffic management

buffering and scheduling based on marking at edge

preference given to in-profile packets



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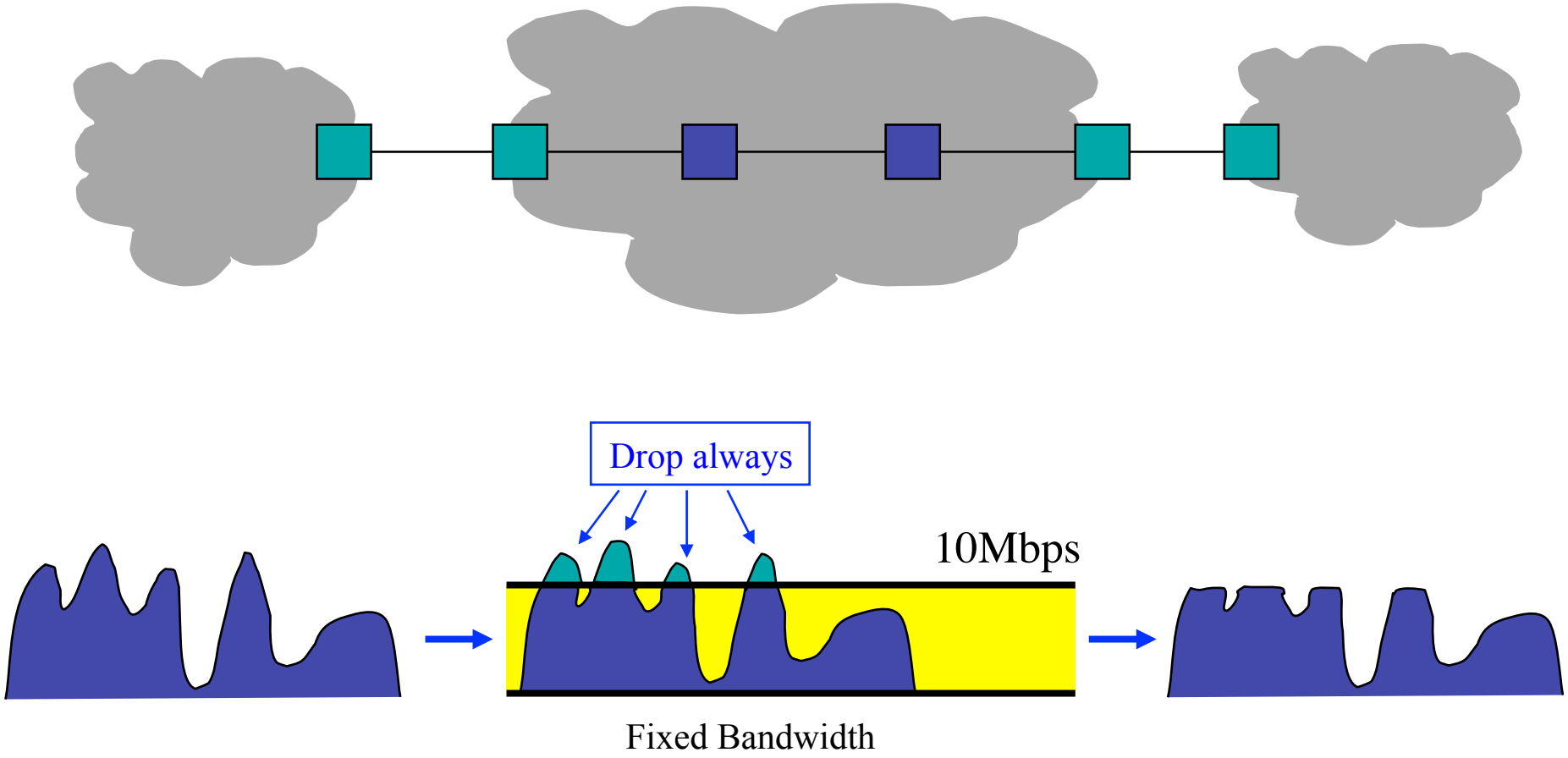
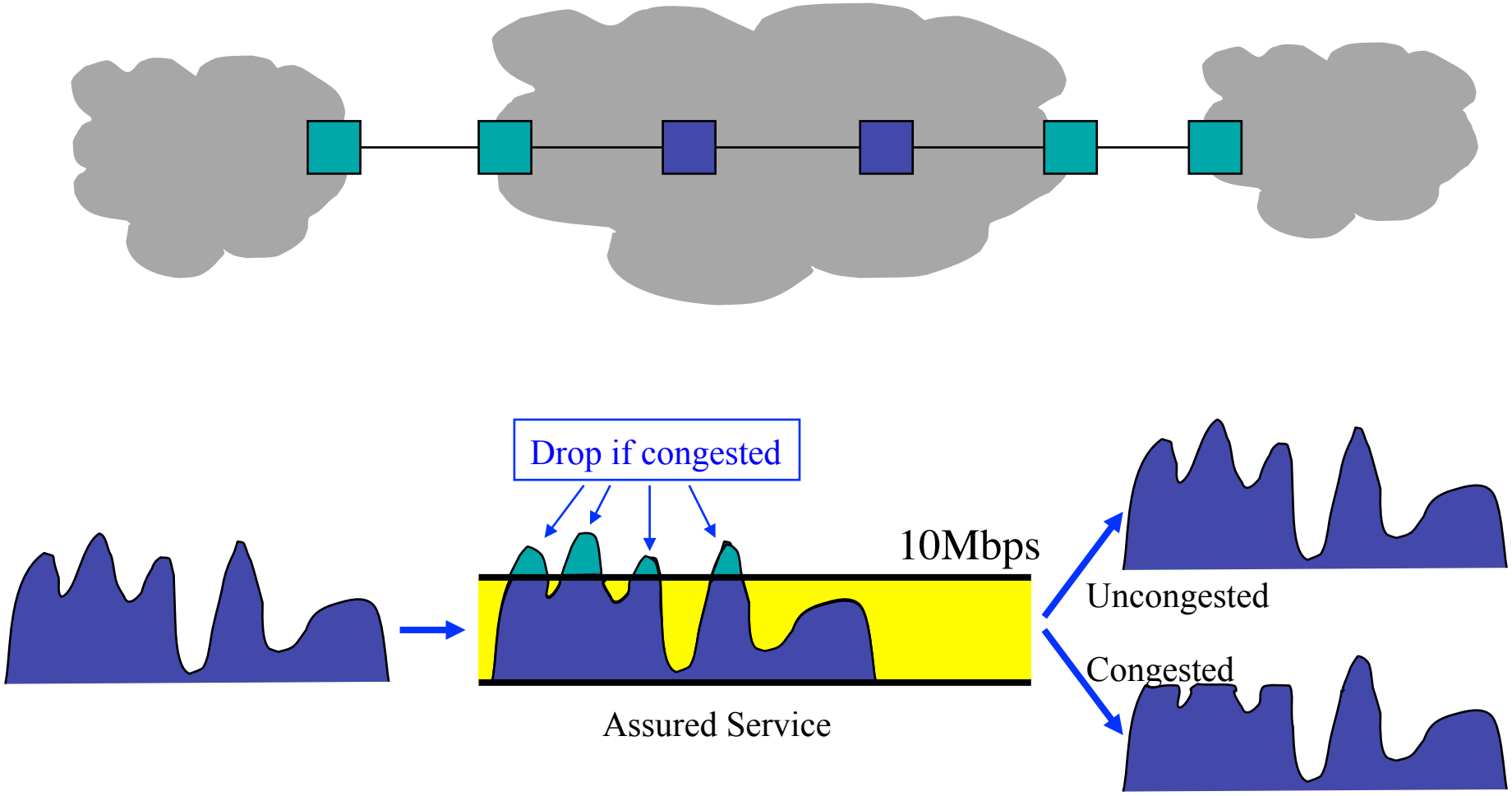
Pre-defined PHB

- Expedited Forwarding (EF, premium):
  - departure rate of packets from a class equals or exceeds a specified rate (logical link with a minimum guaranteed rate)
  - Emulates leased-line behavior
- Assured Forwarding (AF):
  - 4 classes, each guaranteed a minimum amount of bandwidth and buffering; each with three drop preference partitions
  - Emulates frame-relay behavior

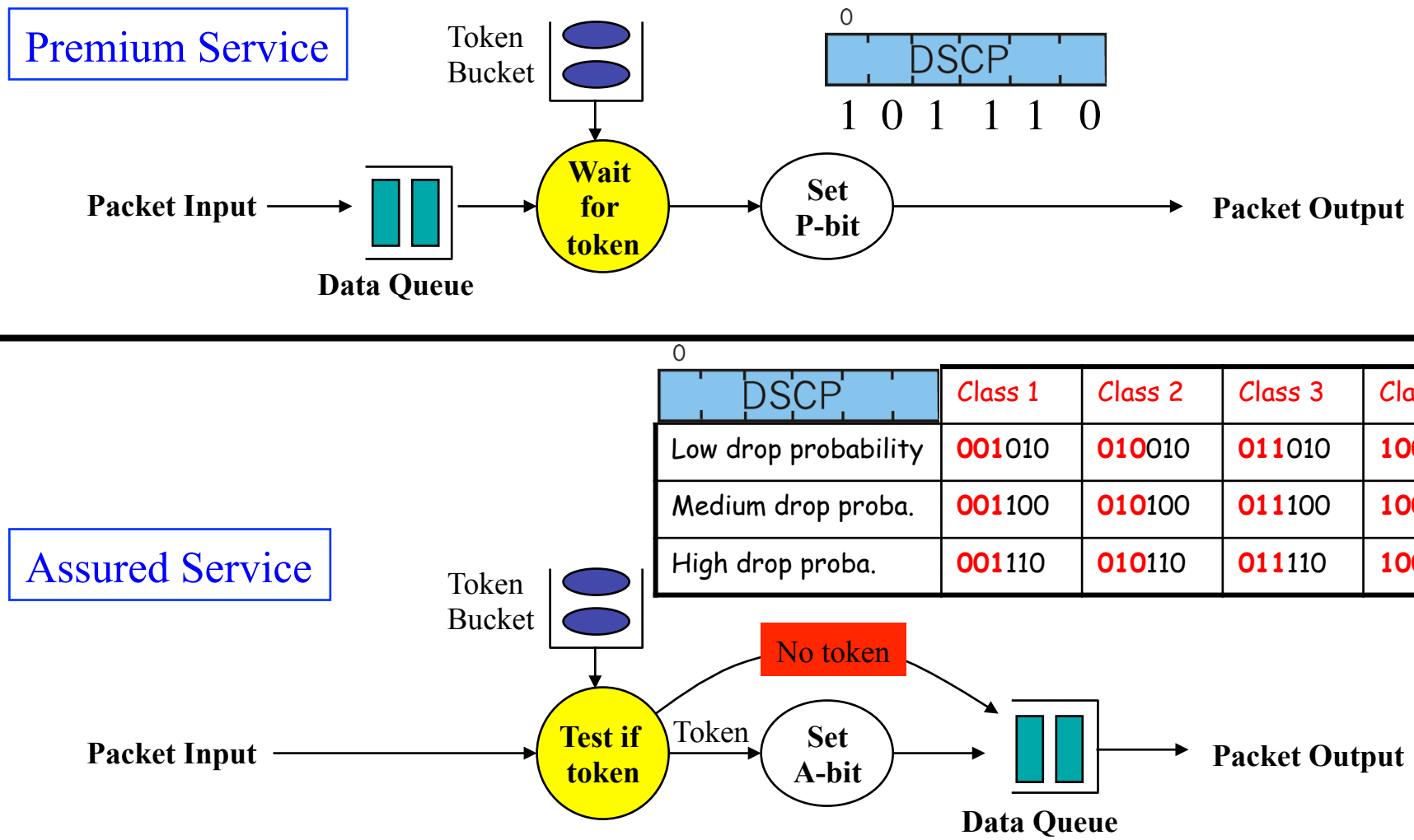
Premium Service Example



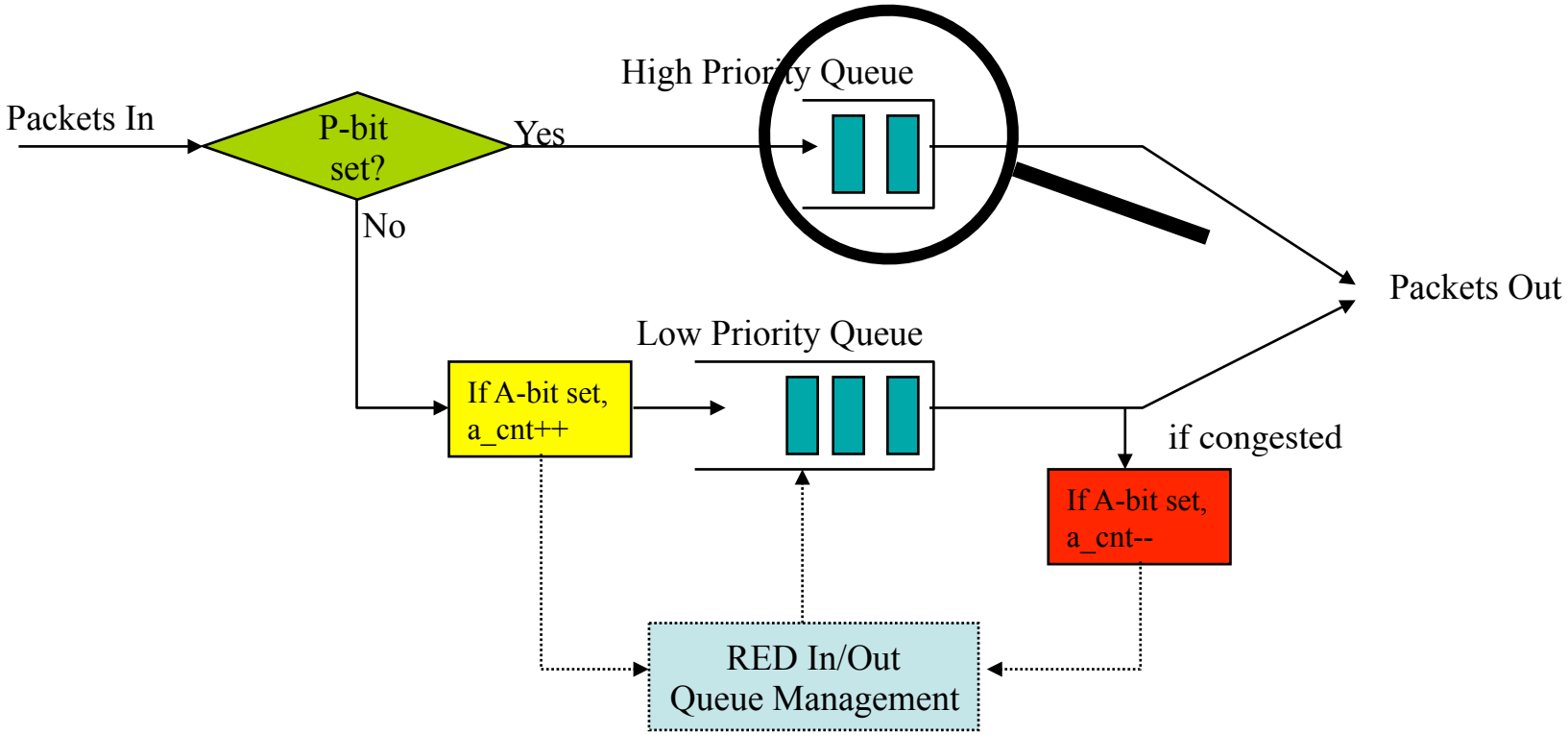
Assured Service Example



Border Router Functionality



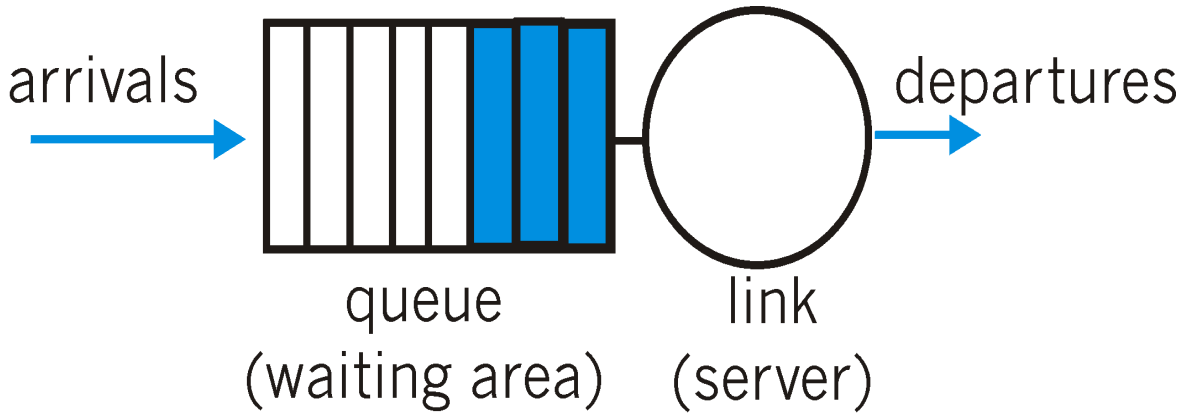
Internal Router Functionality



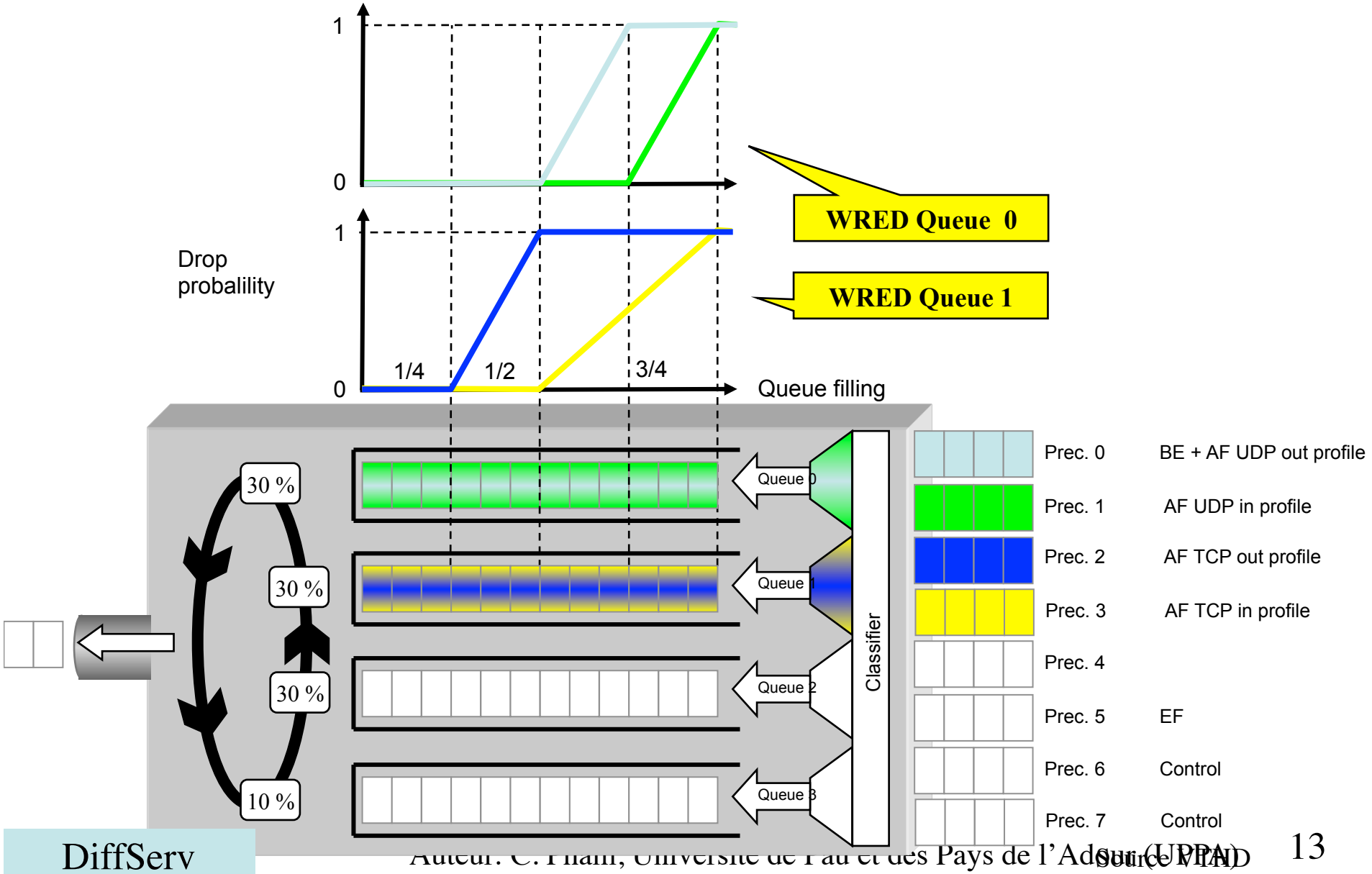
A DSCP codes aggregates, not individual flows
No state in the core
Should scale to millions of flows

Scheduling

- DiffServ PHB relies mainly on scheduling
  - choose the next packet for transmission
  - FIFO: in order of arrival to the queue; packets that arrive to a full buffer are either discarded, or a discard policy is defined.
  - More complex policies: FCFS, PRIORITY, EDD, RR, WRR, FQ, WFQ, …



Putting it together!

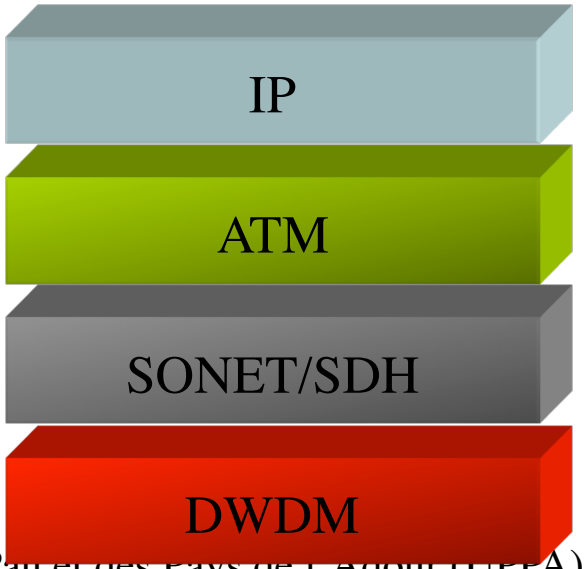


Auteur: C. Pham, Université de Pau et des Pays de l'Adour (UPPA) Source : ITU-D

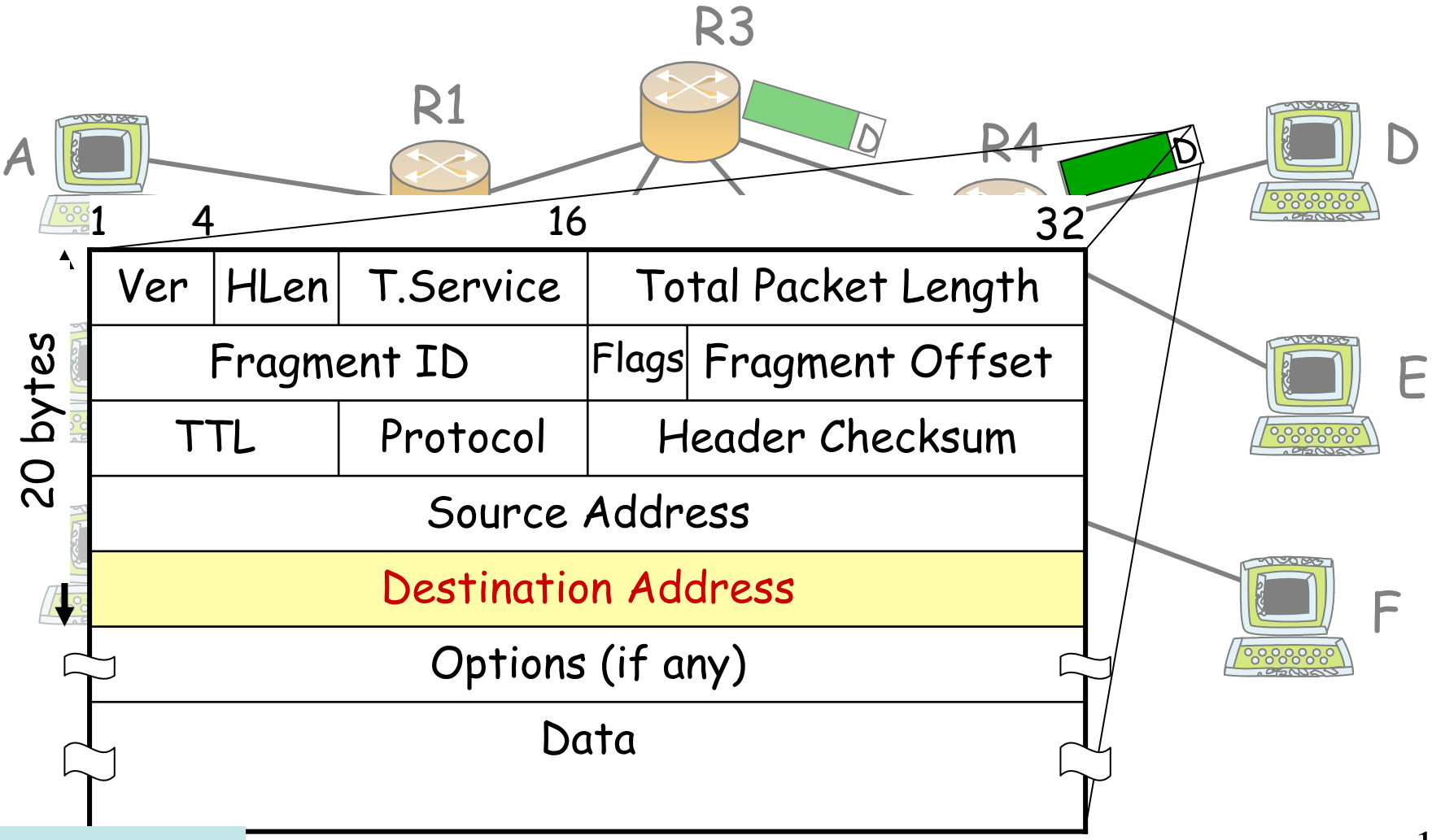
NEW CHAPTER

Bandwidth provisioning

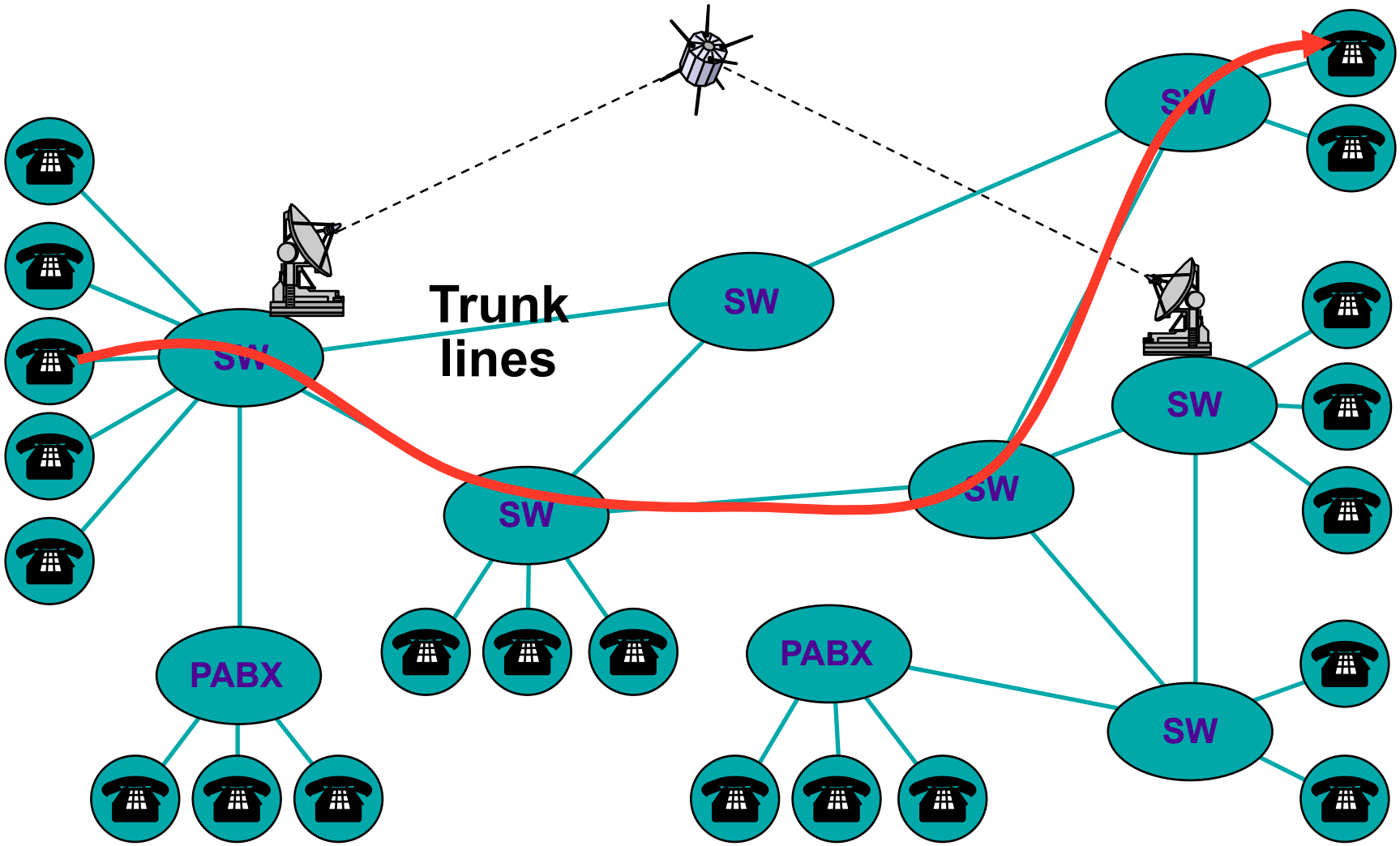
- DWDM-based optical fibers have made bandwidth very cheap in the backbone
- On the other hand, dynamic provisioning is difficult because of the complexity of the network control plane:
  - Distinct technologies
  - Many protocols layers
  - Many control software



Review of IP routing



The telephone circuit view



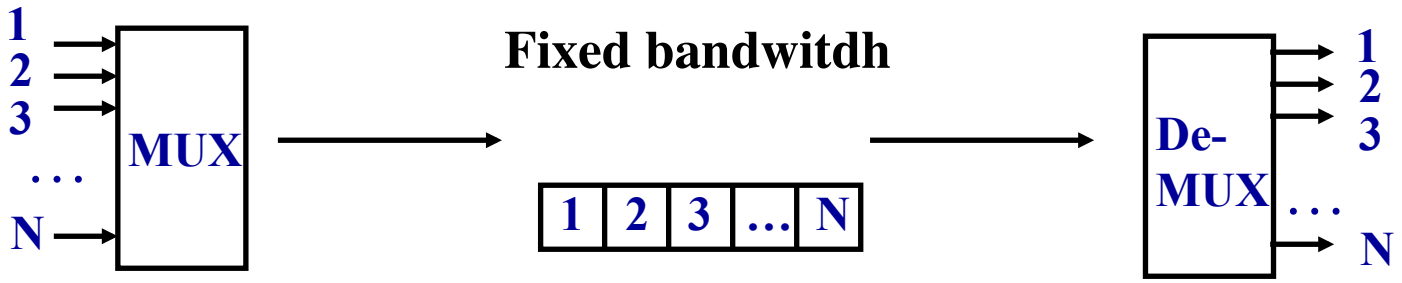
Advantages of circuits

- Provides the same path for information of the same connection: less out-of-order delivery
- Easier provisioning/reservation of network's resources: planning and management features

Time Division Circuits

- Most trunks time division multiplex voice samples
- At a central office, trunk is demultiplexed and distributed to active circuits
- Synchronous multiplexor
  - N input lines
  - Output runs N times as fast as input

Simple, efficient, but low flexibility and wastes resources

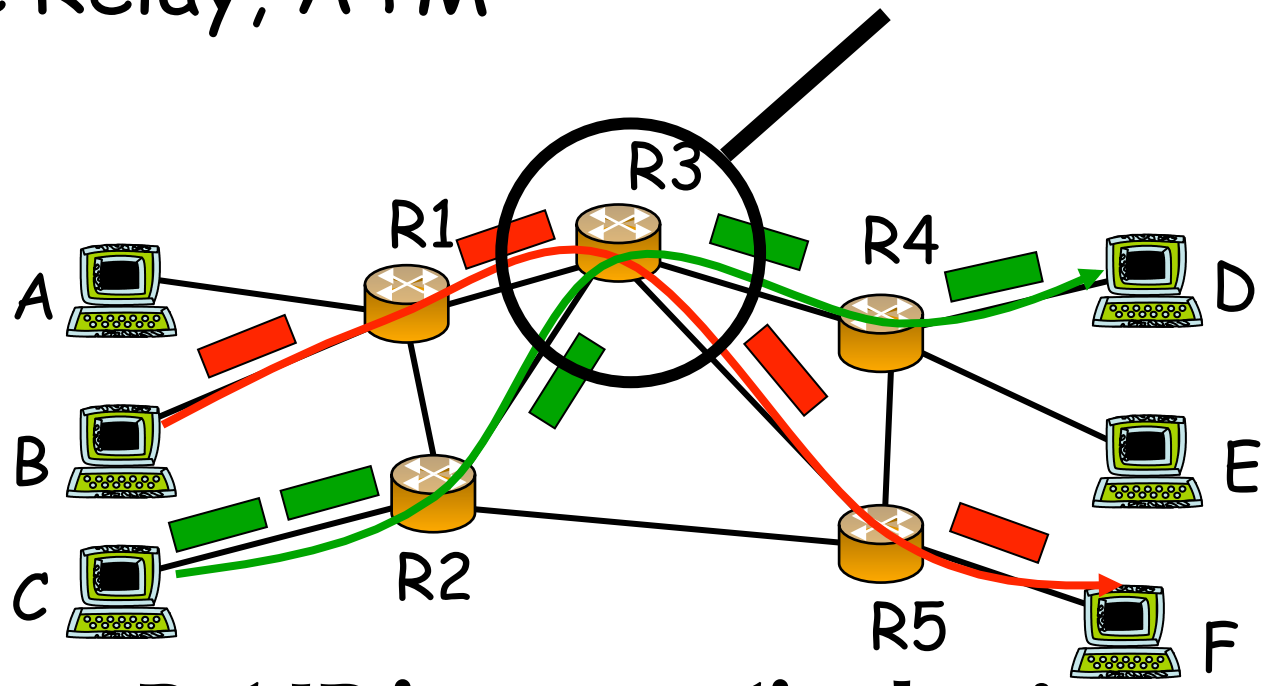


1 sample every 125us gives a 64Kbits/s channel

Back to virtual circuits

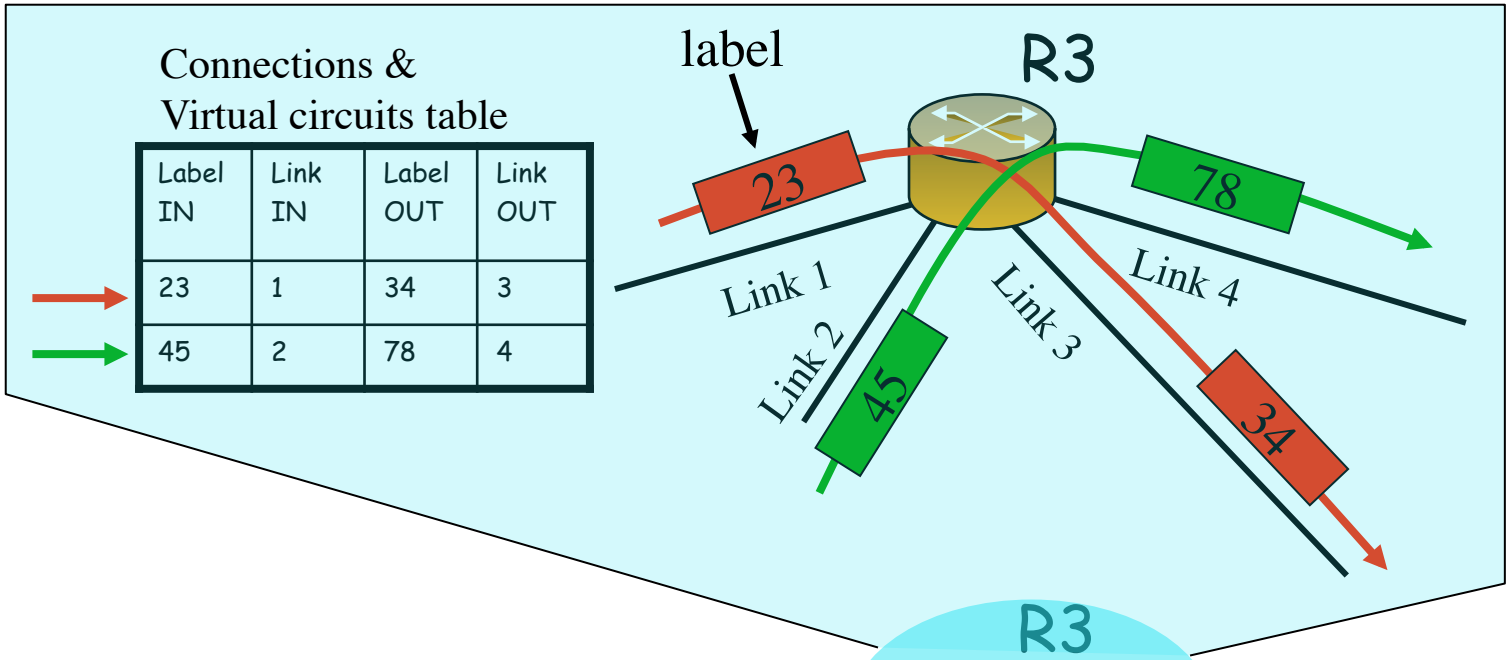
- Virtual circuit refers to a connection oriented network/link layer: e.g. X.25, Frame Relay, ATM

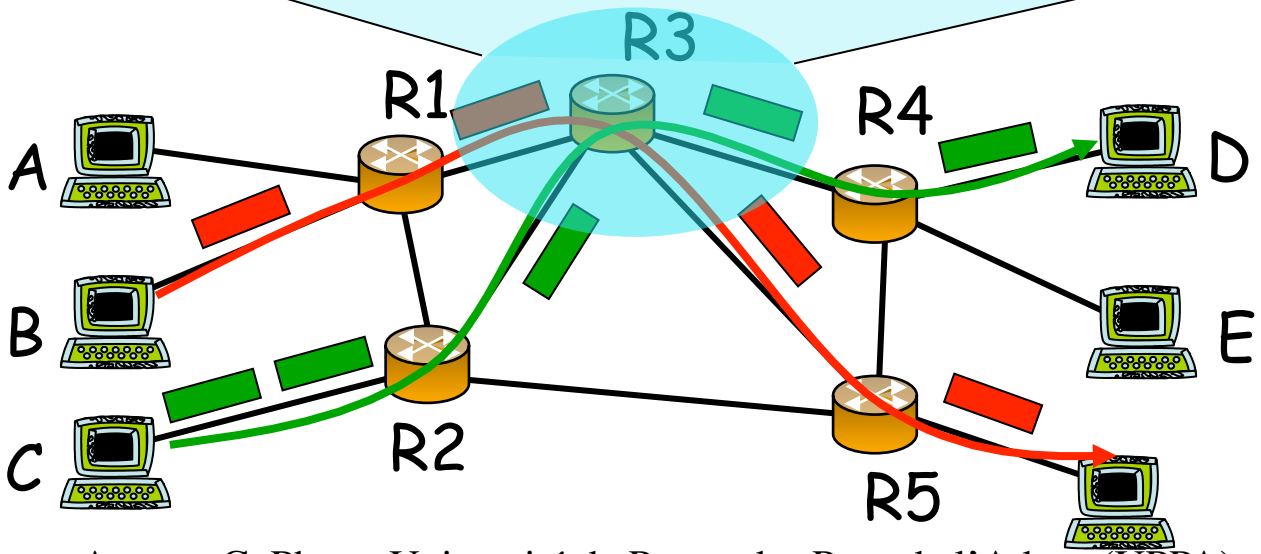
Virtual Circuit Switching: a path is defined for each connection



But IP is connectionless!

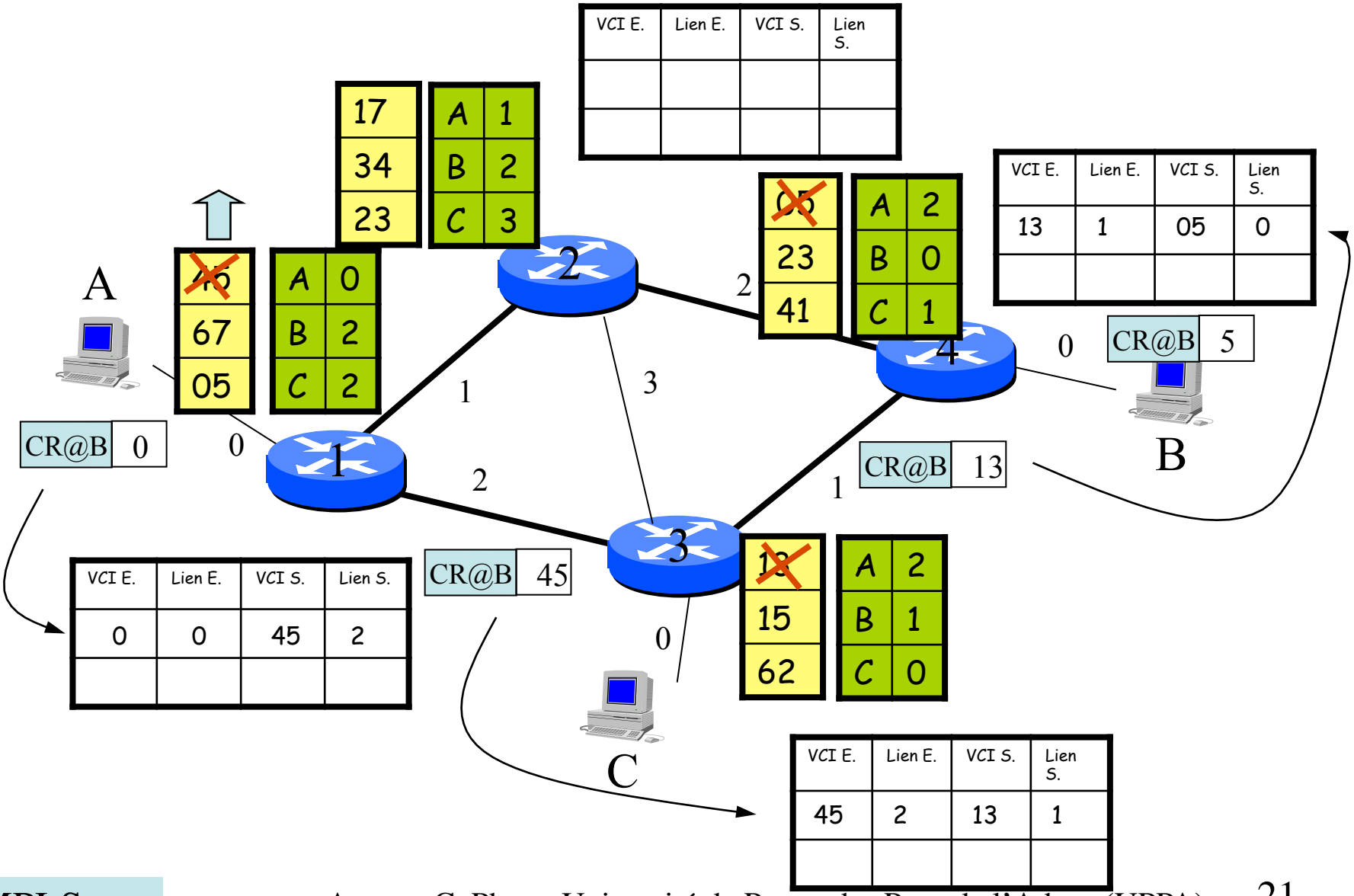
Virtual circuit principles



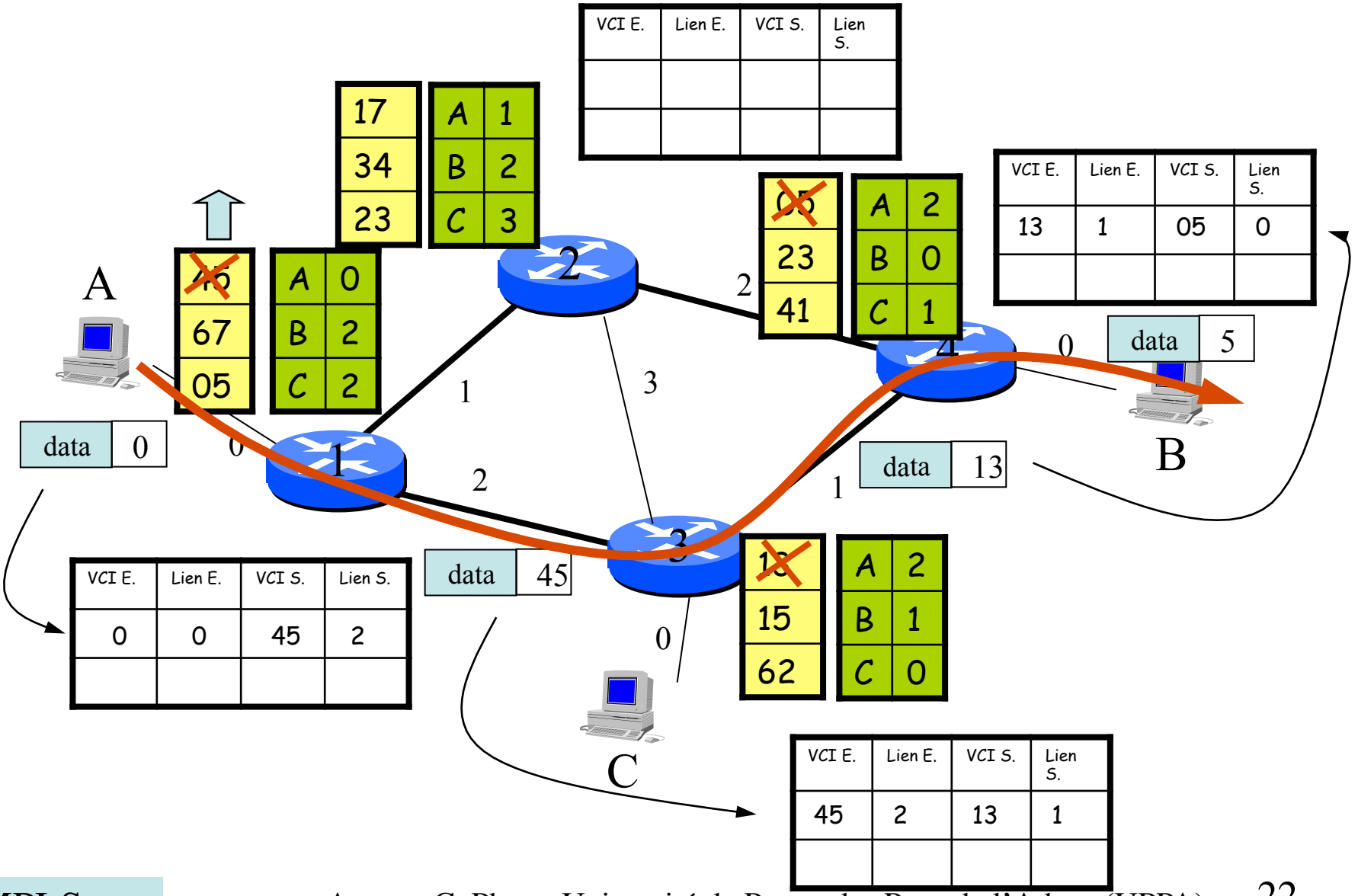


Virtual Circuit Switching

End-to-end operation (1)



End-to-end operation (2)



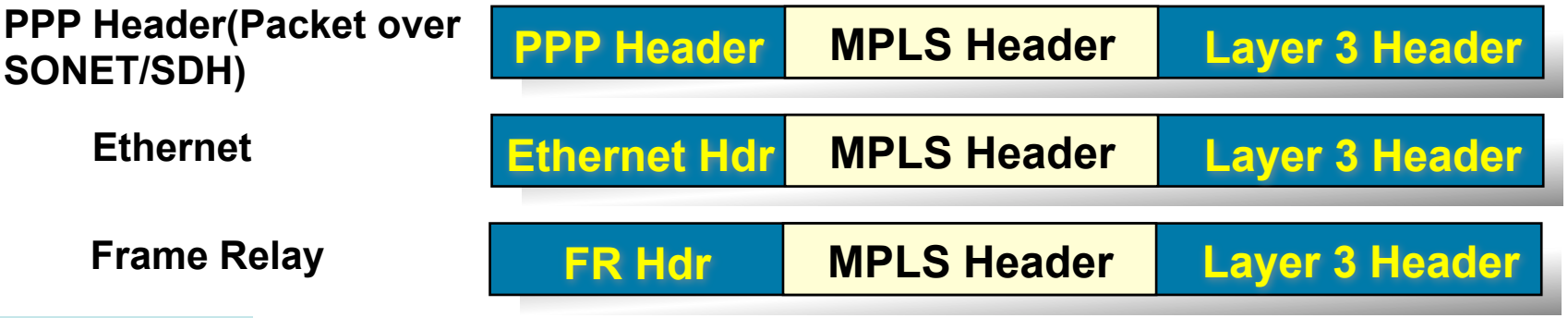
Why virtual circuit?

- Initially to speed up router's forwarding tasks: X.25, Frame Relay, ATM.

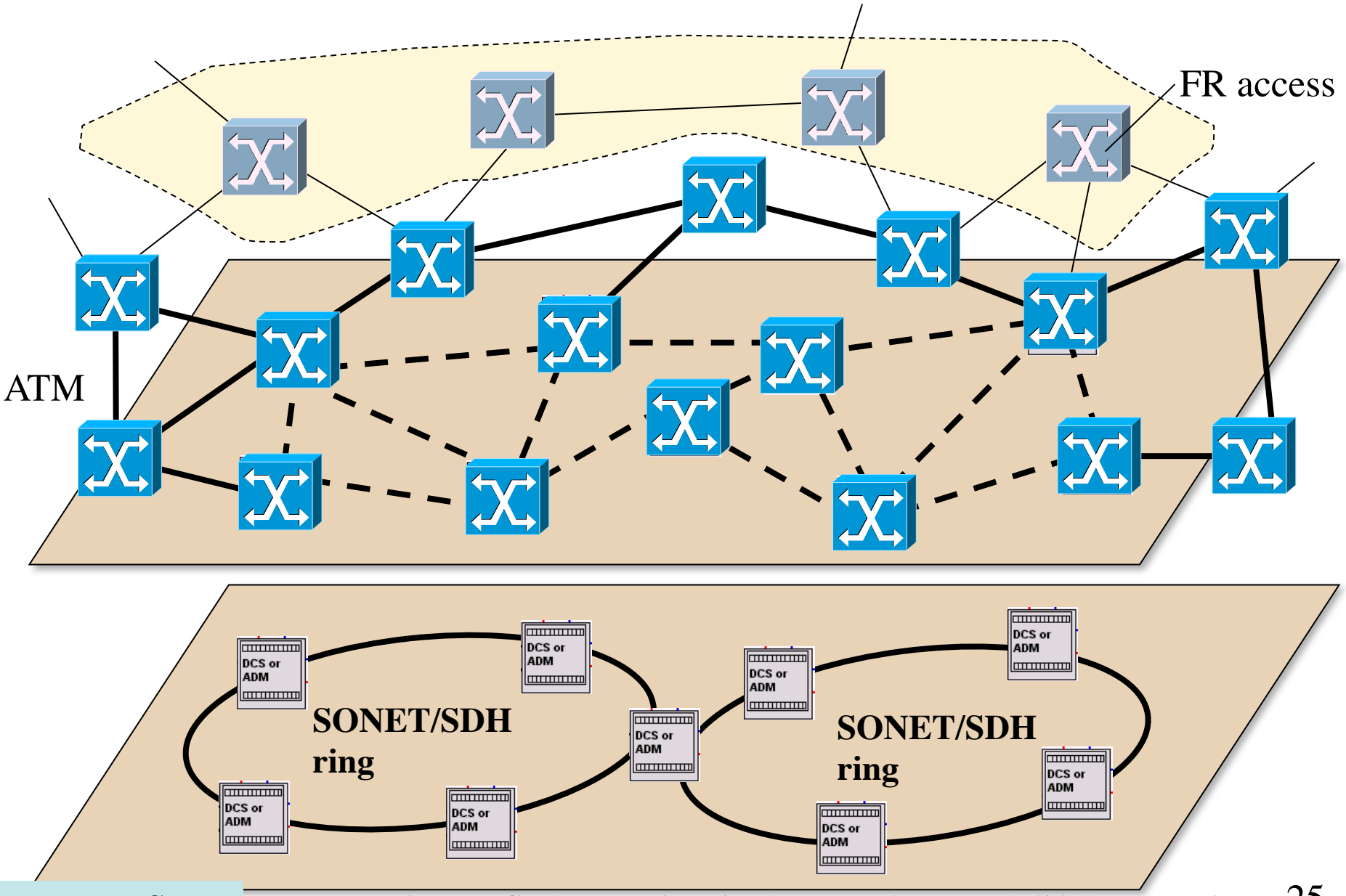
Now: Virtual circuits for traffic engineering!

Virtual circuits in IP networks

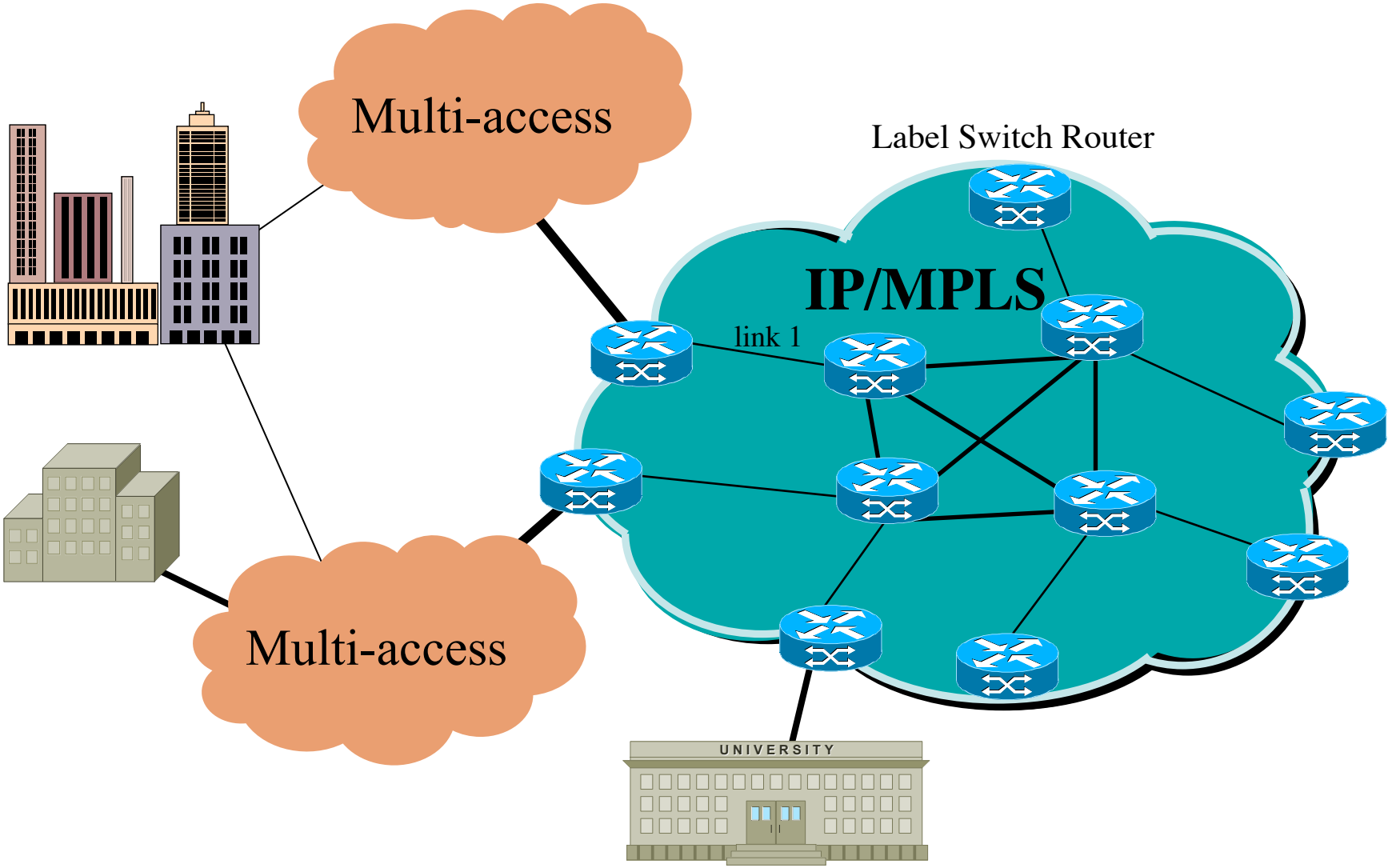
- Multi-Protocol Label Switching
  - Fast: use label switching➔ LSR
  - Multi-Protocol: above link layer, below network layer
  - Facilitate traffic engineering



From multilayer networks…



…to IP/MPLS networks

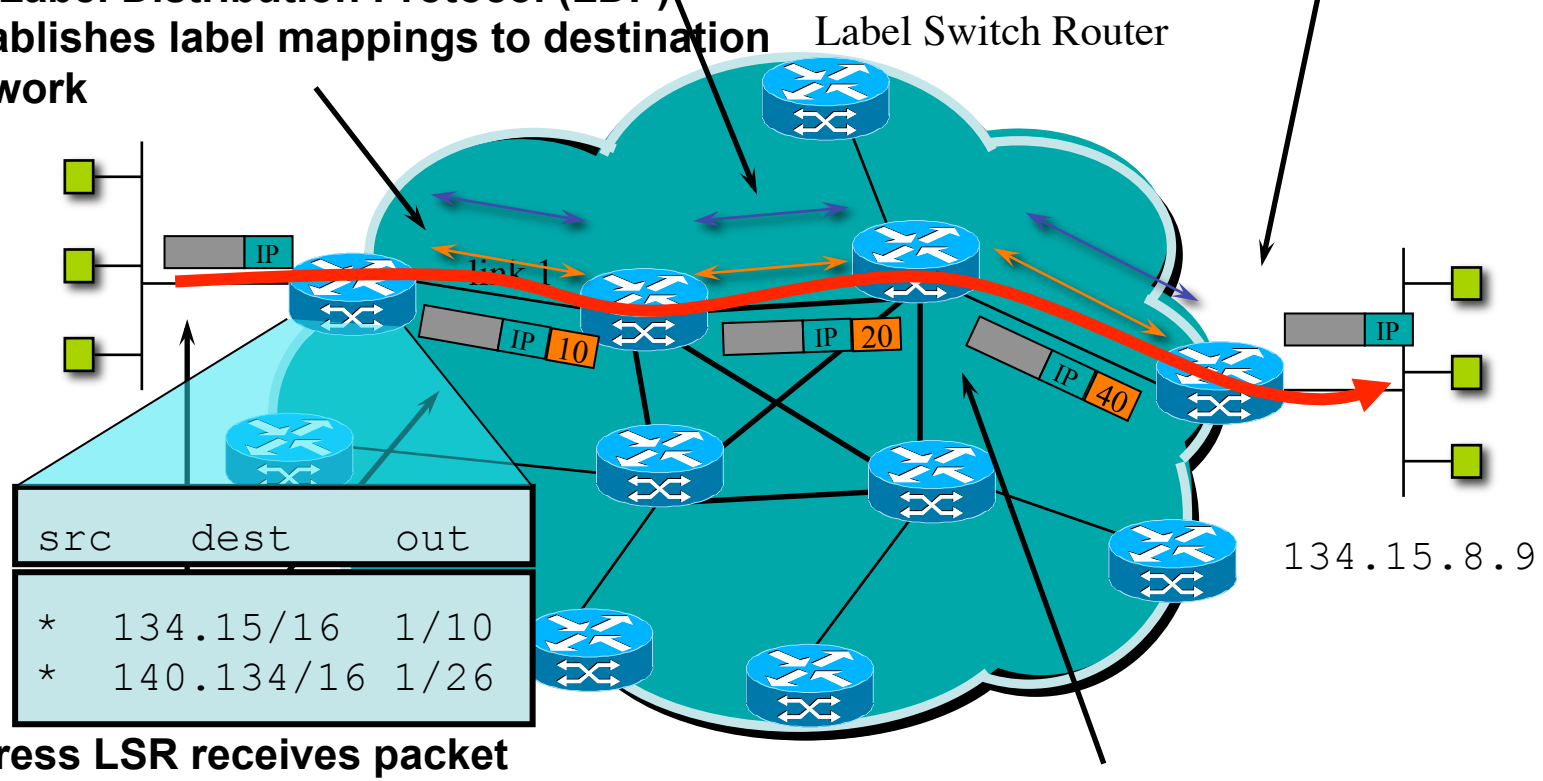


MPLS operation

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

4. LSR at egress removes label and delivers packet

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

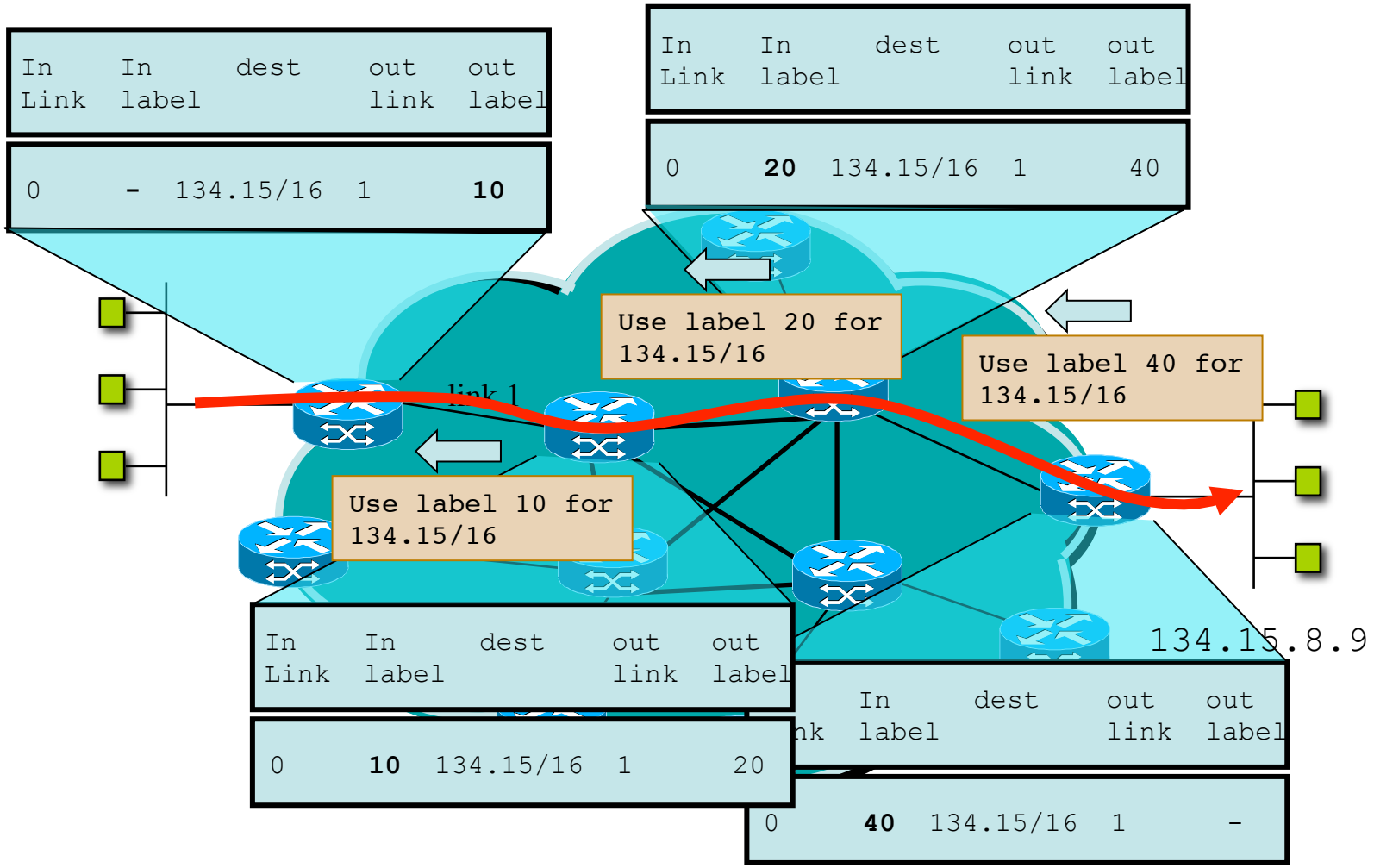


2. Ingress LSR receives packet and "label"s packets

3. LSR forwards packets using label switching

Source Yi Lin, modified C. Pham

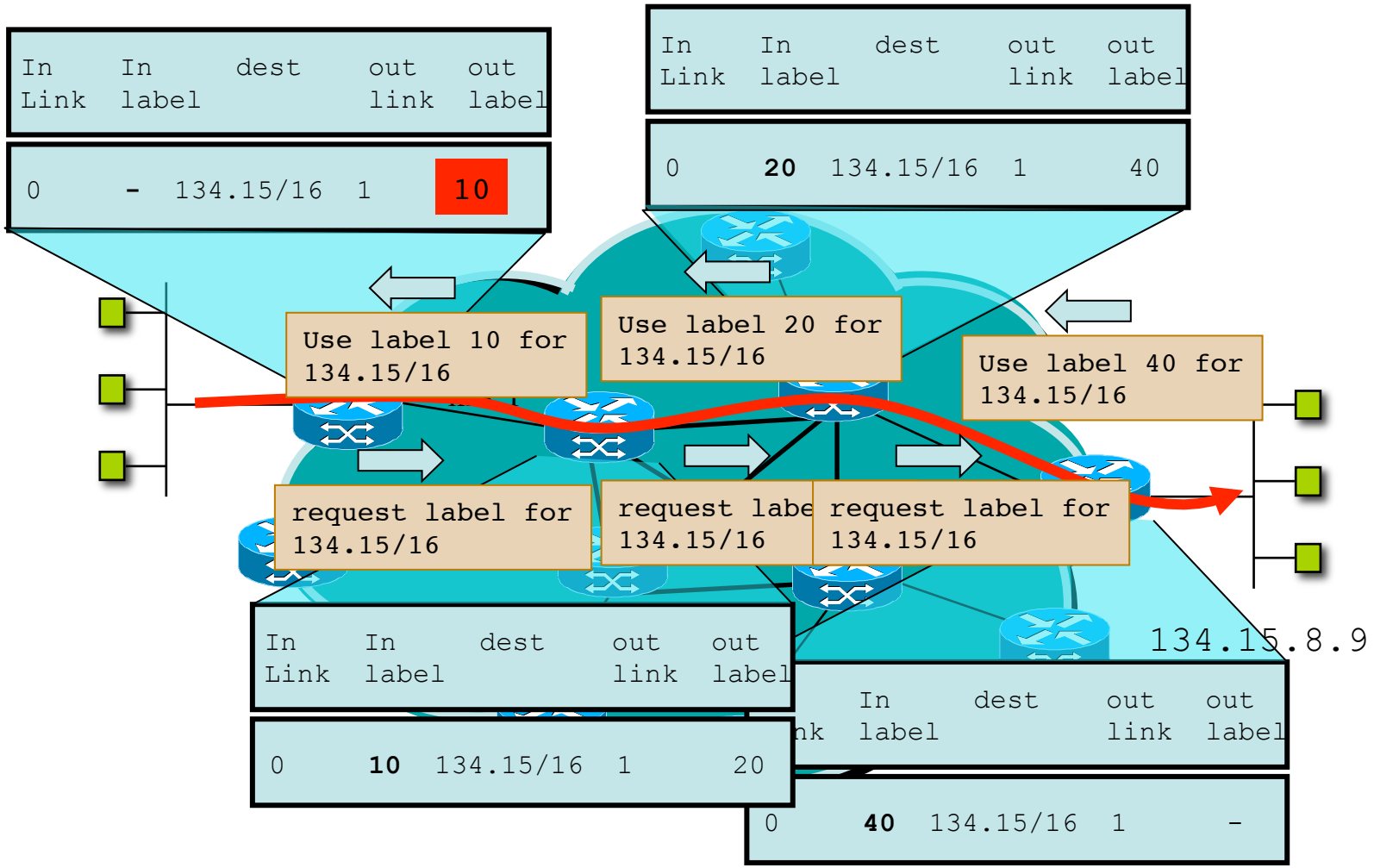
Label Distribution



Unsolicited downstream label distribution

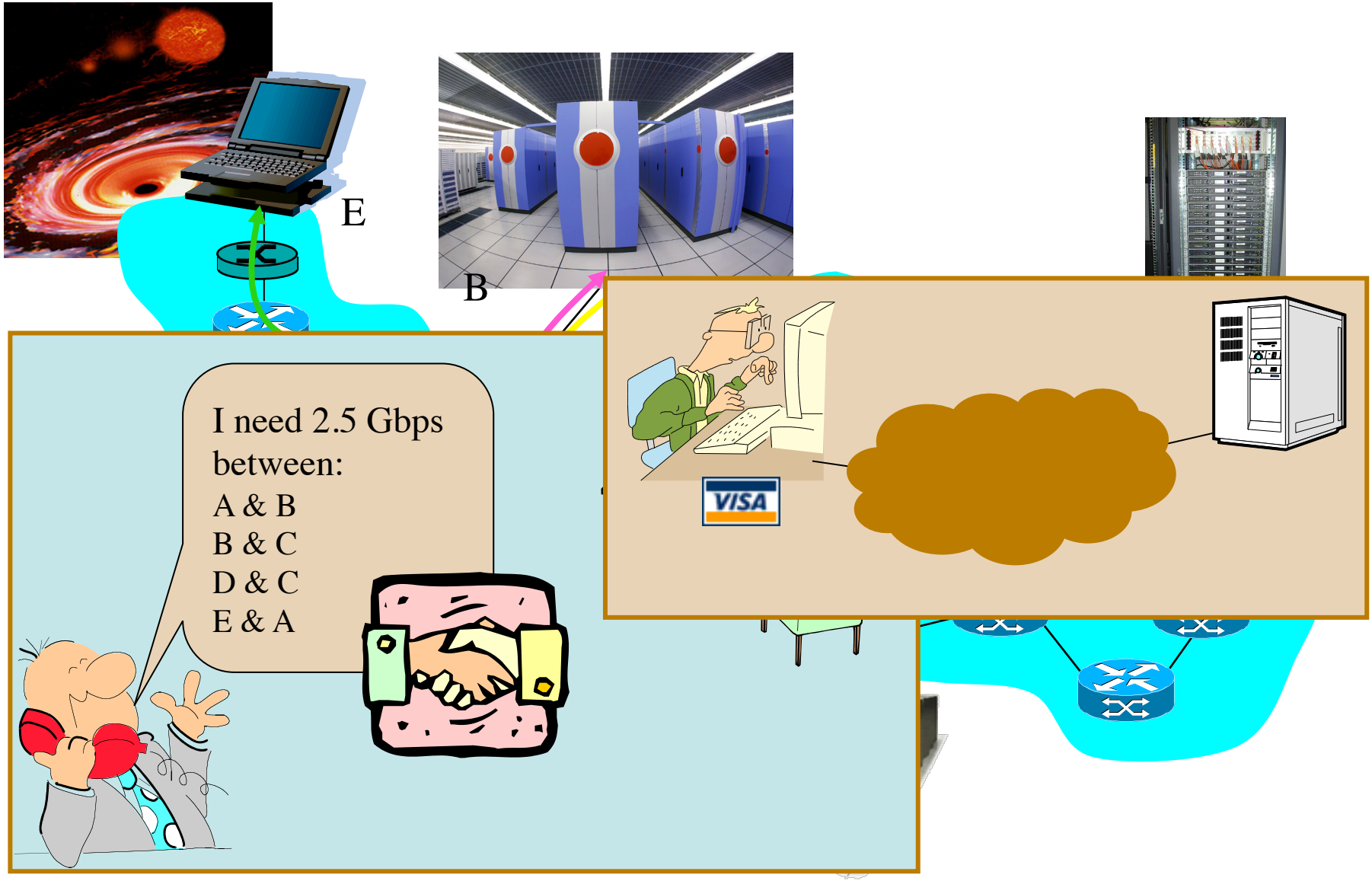
Auteur: C. Pham, Université de Pau et des Pays de l'Adour (UPPA)

Label Distribution (con't)



On-demand downstream label distribution

Dynamic circuits for grids

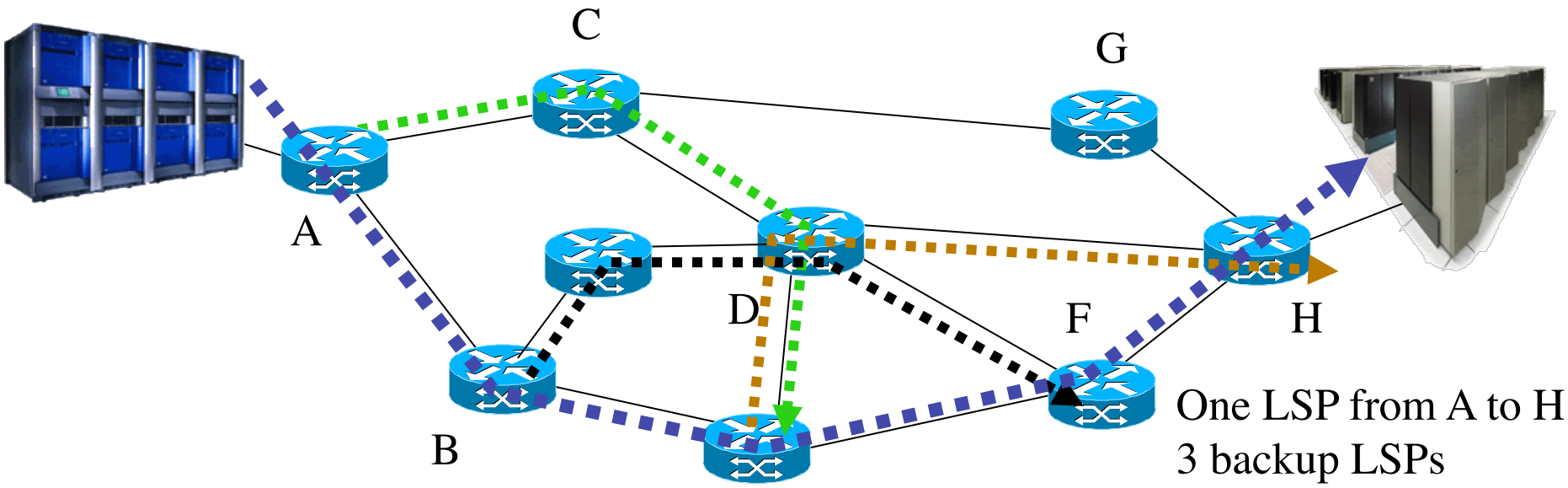


MPLS for resiliency
MPLS FastReroute

- Intended to provide SONET/SDH-like healing capabilities
- Selects an alternate route in tenth of ms, provides path protection
- Traditional routing protocols need minutes to converge!
- FastReroute is performed by maintaining backup LSPs

MPLS for resiliency, con't
Backup LSPs

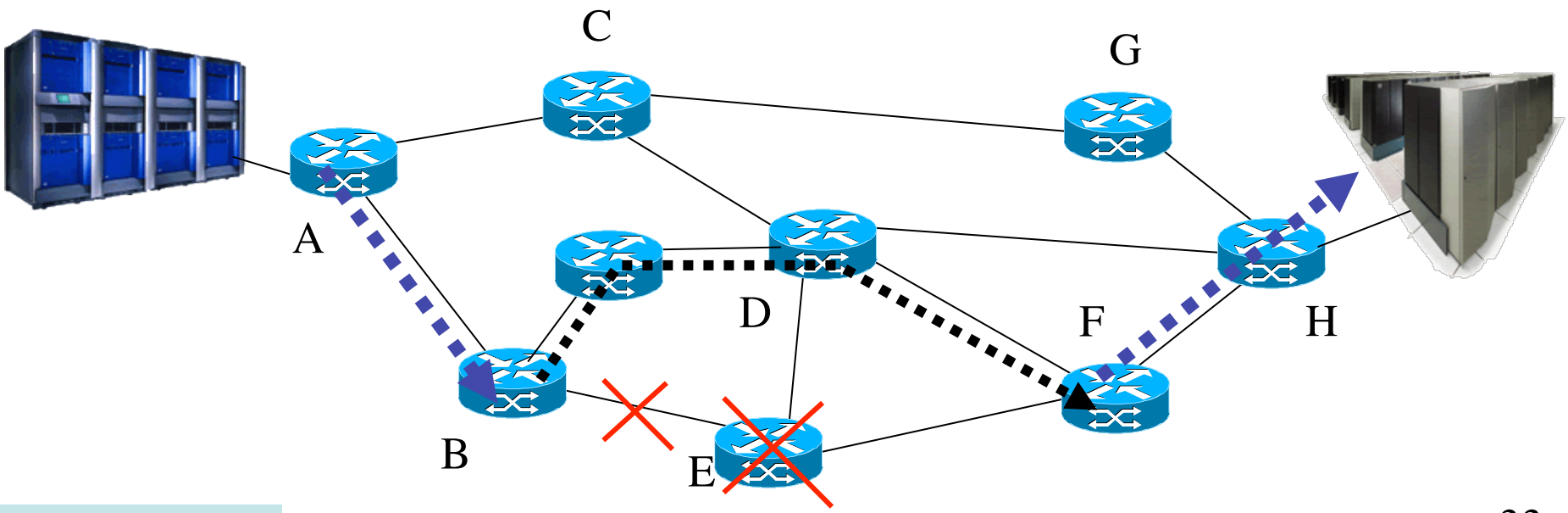
- One-to-one
- Many-to-one: more efficient but needs more configurations



MPLS for resiliency, con't

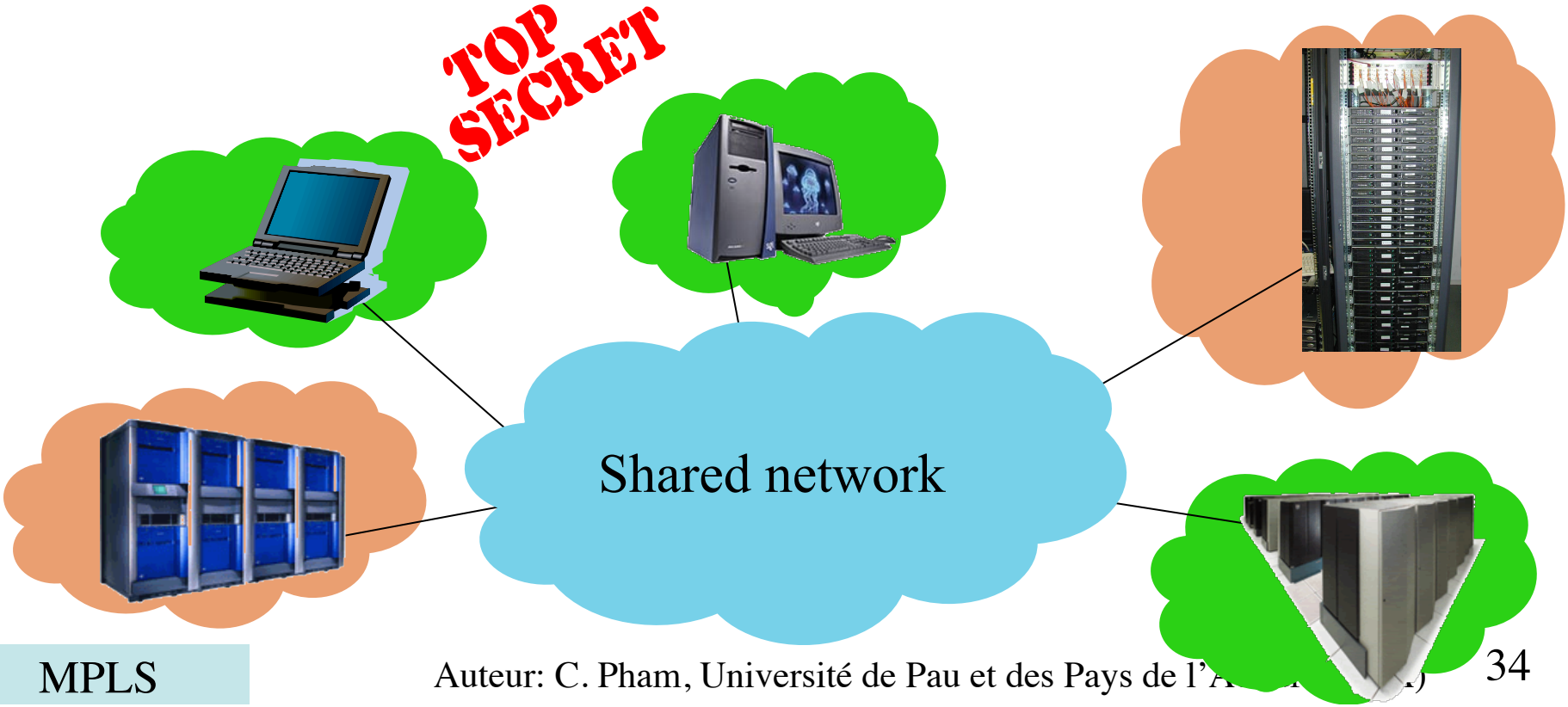
Recovery on failures

- Suppose E or link B-E is down…
- B uses detour around E with backup LSP



MPLS for VPN
(Virtual Private Networks)

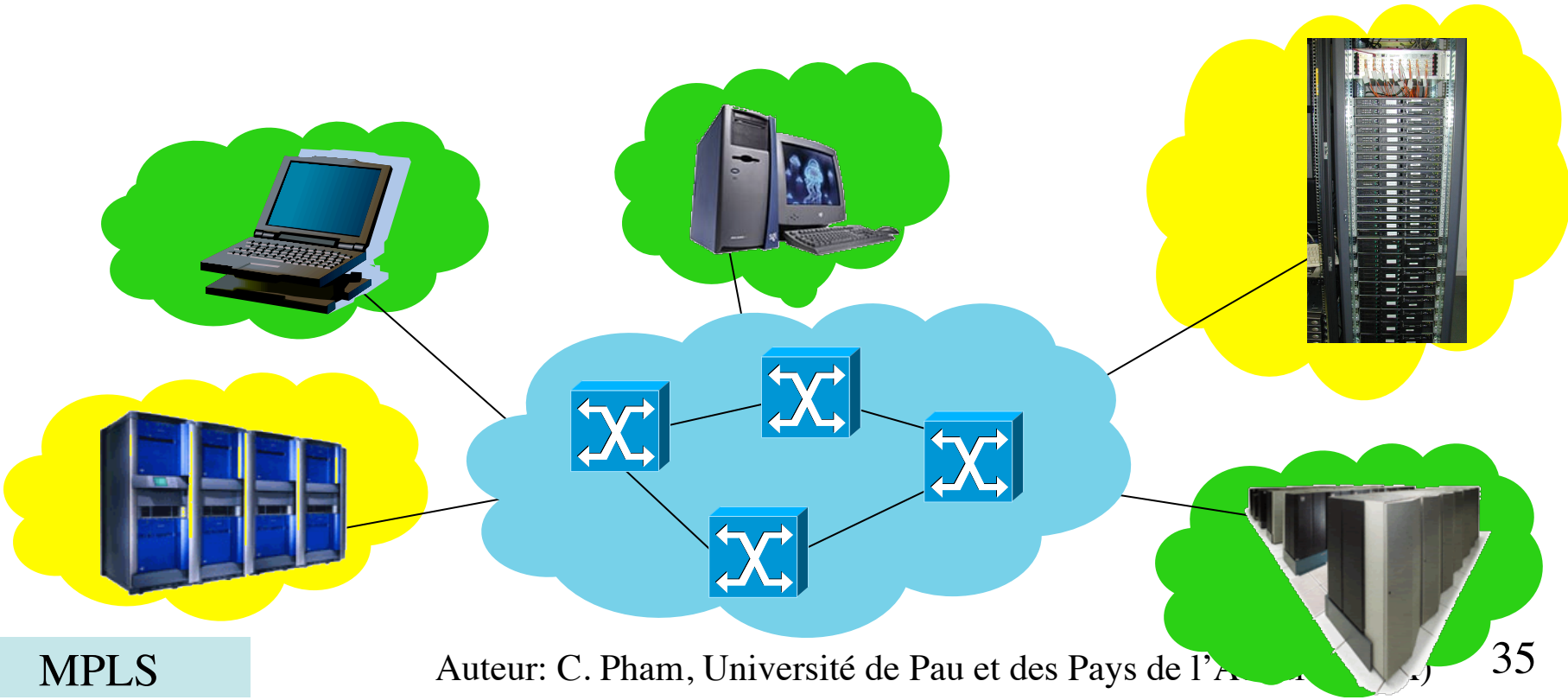
- Virtual Private Networks: build a secure, confidential communication on a public network infrastructure using routing, encryption technologies and controlled accesses



MPLS for VPN, con't

The traditional way of VPN

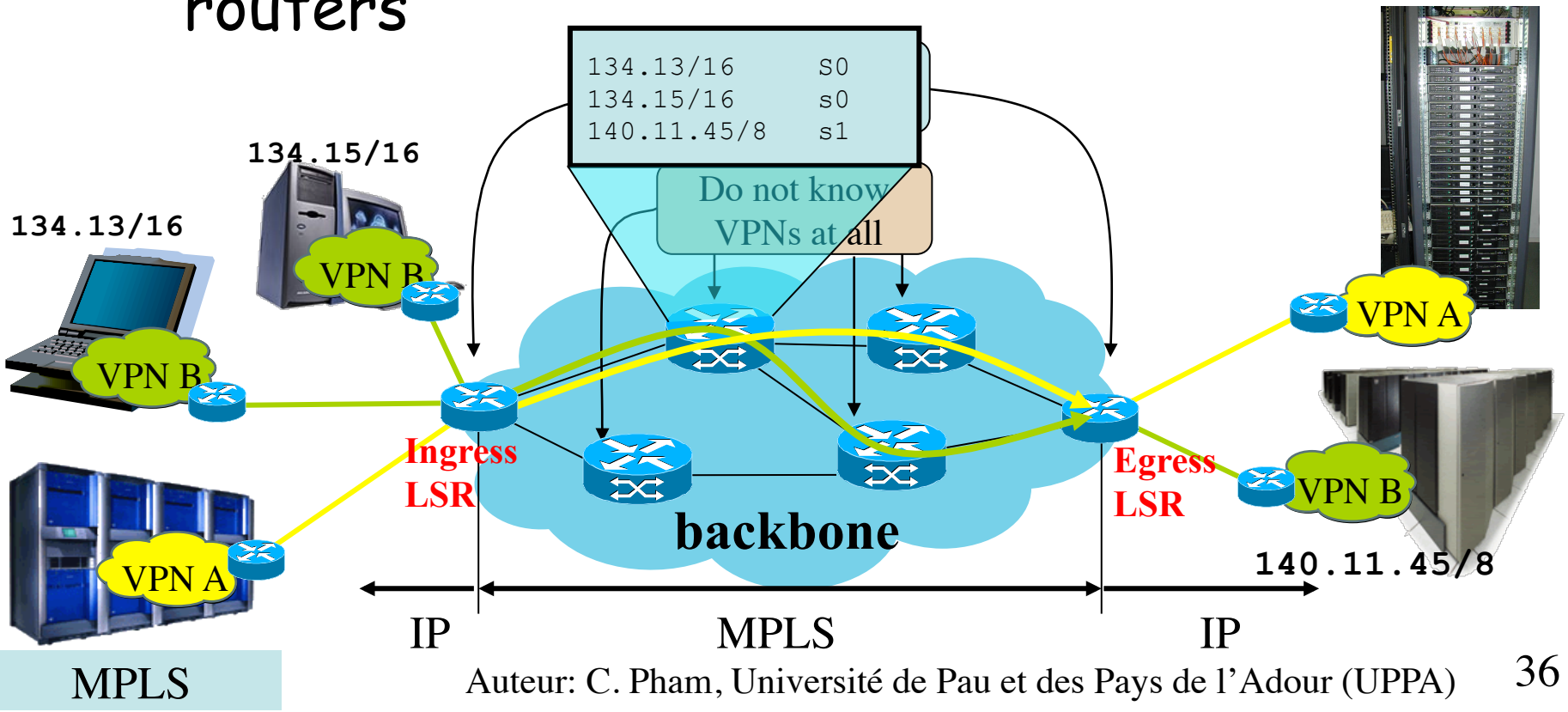
- Uses leases lines, Frame Relay/ATM infrastructures…



MPLS for VPN, con't

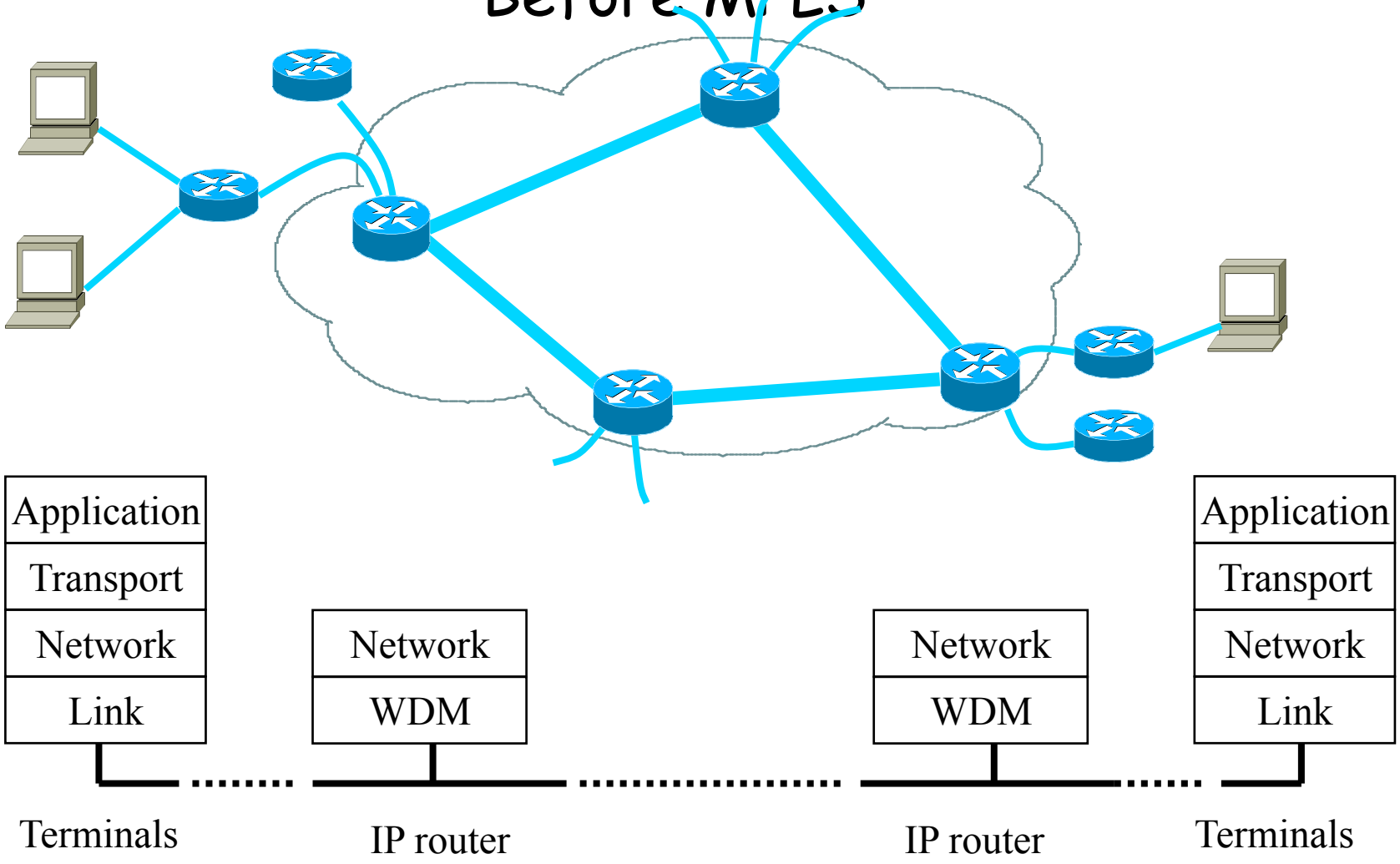
VPN over IP/MPLS

- IP/MPLS replace dedicated networks
- MPLS reduces VPN complexity by reducing routing information needed at provider's routers



MPLS for optical networks

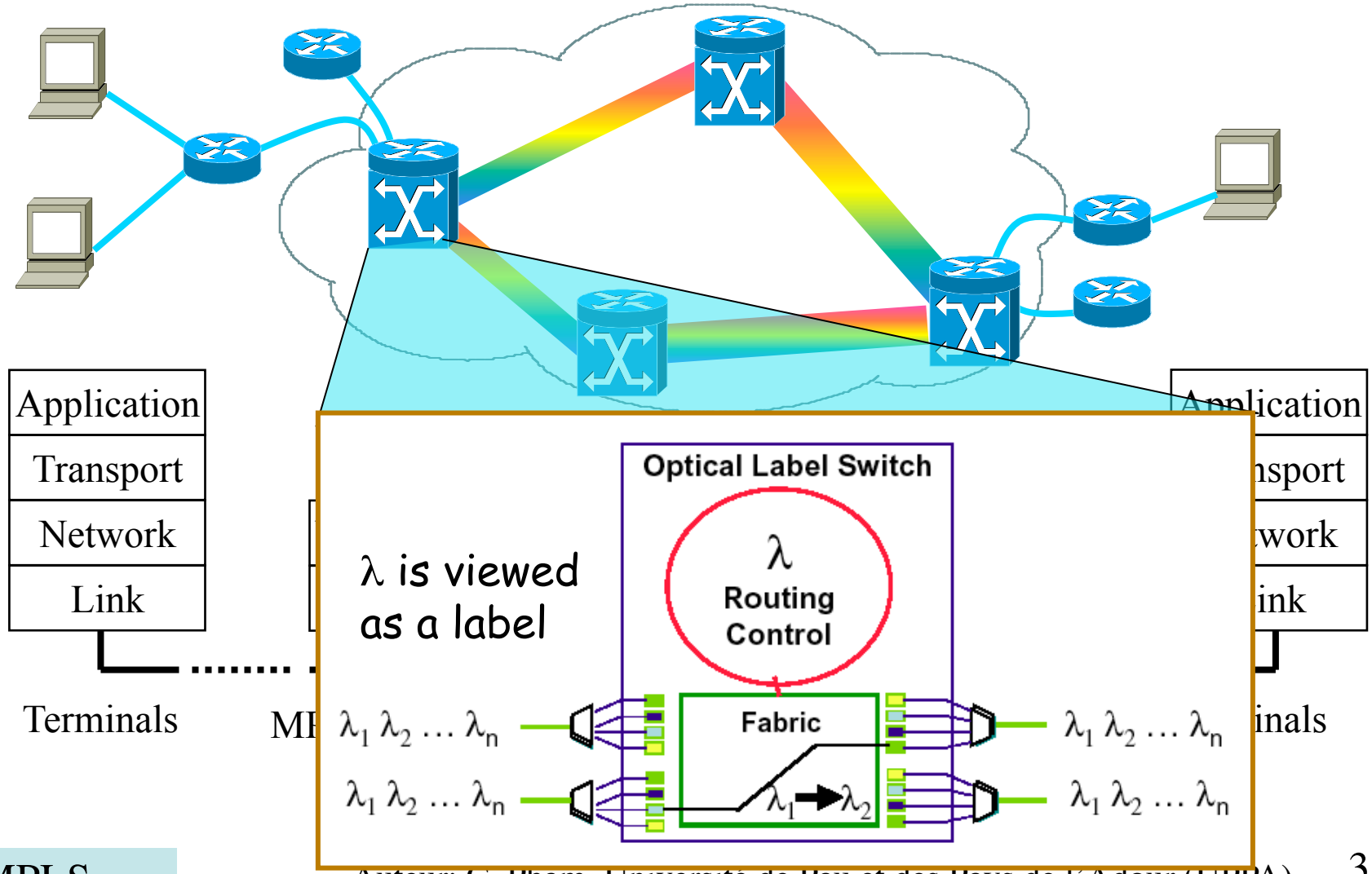
Before MPLS



Source J. Wang, B. Mukherjee, B. Yoo

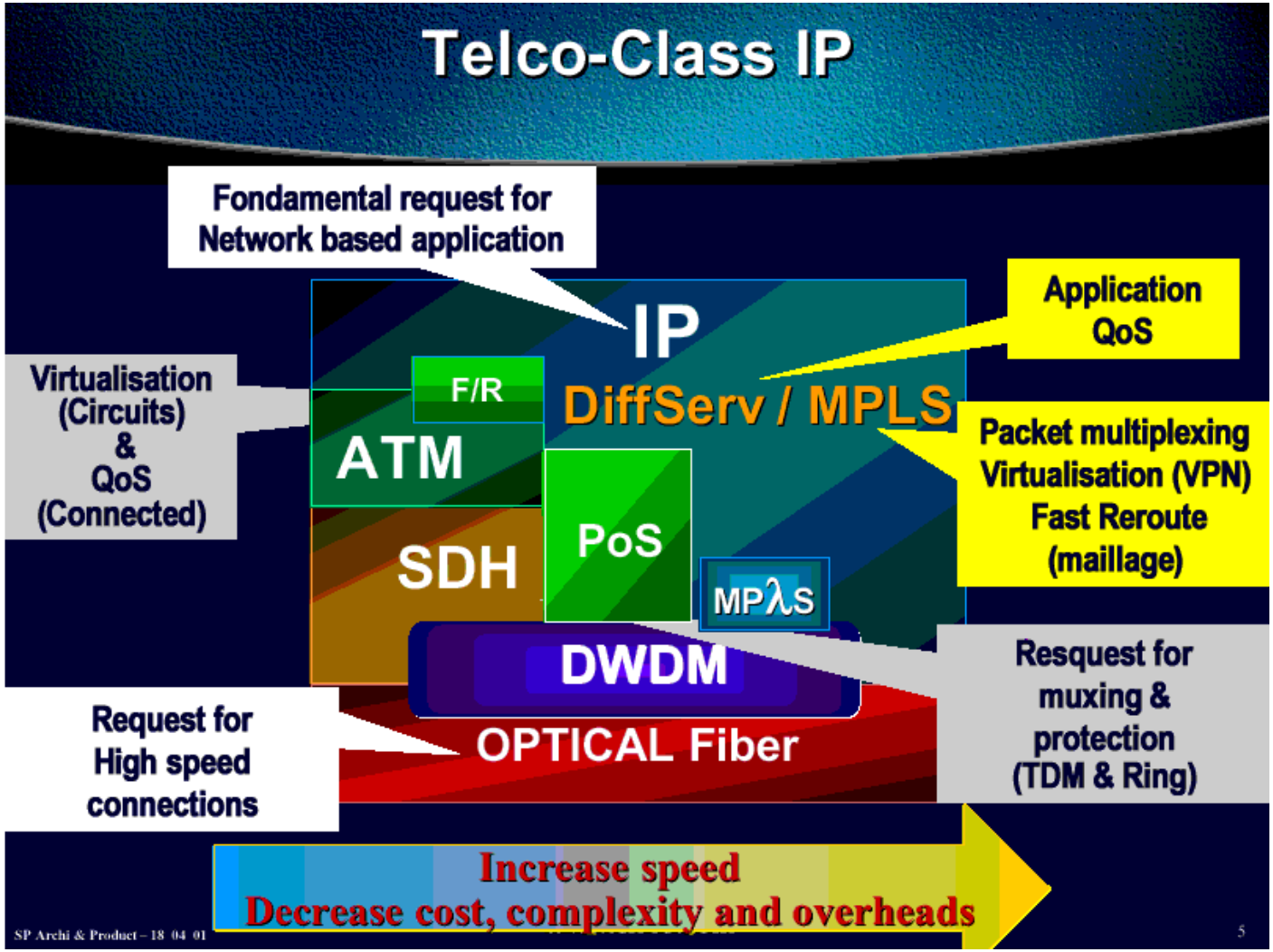
MPLS for ON, con't

MPλS=MPLS+λ lightpath



Summary
Towards IP/(G)MPLS/DWDM

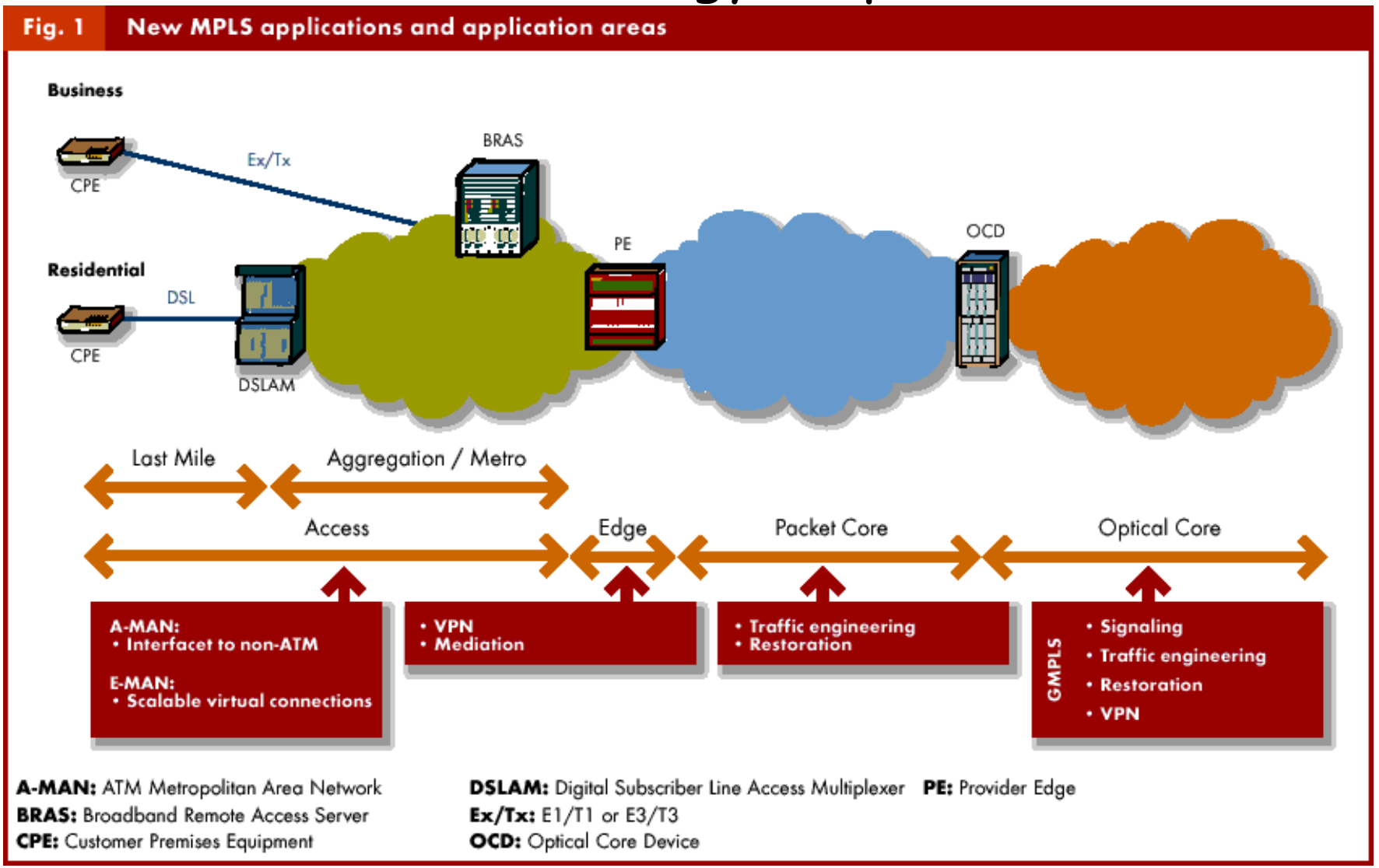
From cisco



Summary

Technology scope

Source Alcatel



Want to know more?

- GMPLS: IEEE Comm. Mag., Vol. 43(7), July 2005
- Optical Control Plane for the Grid Community: IEEE Comm. Mag., Vol. 44(3), March 2006.
- "Optical Transport Systems/Networks" by S. Kinoshita & R. Rabbat, APNOMS 2005. http://www.apnoms.org/2005/tutorial/Tutorial%202.pdf
- « Inter-domain Traffic Engineering for QoS-guaranteed DiffServ Provisioning », Young-Tak Kim, APNOMS 2005. http://www.apnoms.org/2005/tutorial/Tutorial%203.pdf
- See Tutorial IV of HOTI 2006: Dynamic Optimal Networks for Grid Computing