

# **LAN Emulation, IP Switching and Label Switching**

Raj Jain

Professor of Computer and Information Sciences  
The Ohio State University

<http://www.cis.ohio-state.edu/~jain/>

Raj Jain

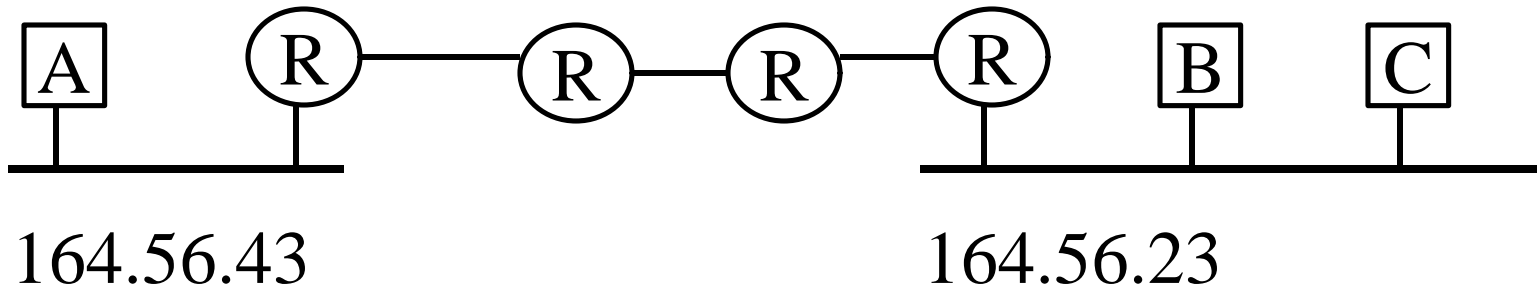


- ❑ LAN Emulation
- ❑ Classical IP over ATM
- ❑ Next Hop Resolution Protocol (NHRP)
- ❑ Multiprotocol over ATM (MPOA)
- ❑ IP Switching (Ipsilon)
- ❑ Tag Switching (CISCO)
- ❑ Multi-protocol label switching (MPLS)

# IP Forwarding: Fundamentals

To: 164.56.23.34

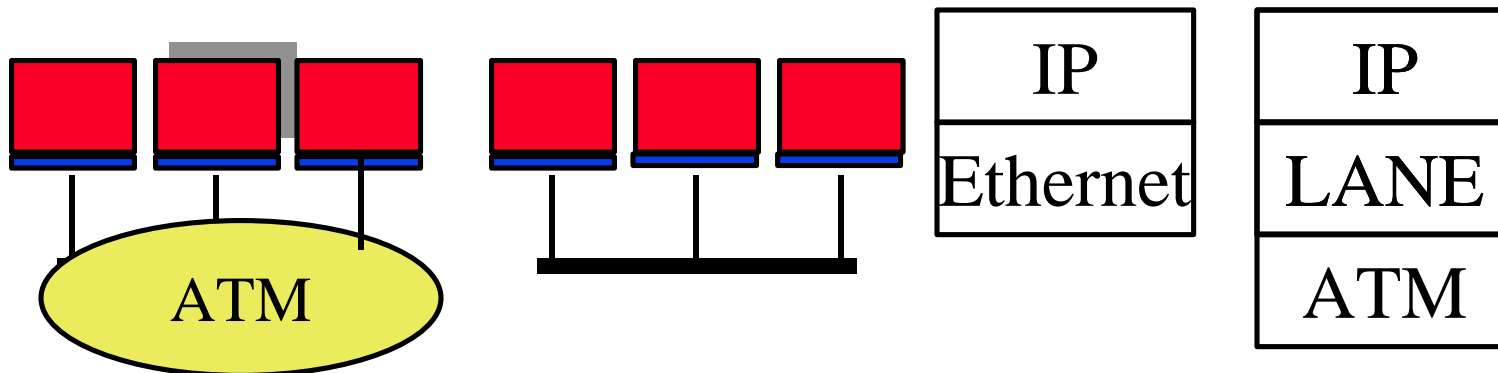
From: 164.56.43.96



- ❑ IP routers forward the packets towards the destination subnet
- ❑ On the same subnet, routers are not required.
- ❑ IP Addresses: 164.56.23.34  
Ethernet Addresses: AA-23-56-34-C4-56  
ATM : 47.0000 1 614 999 2345.00.00.AA....

Raj Jain

# LAN Emulation

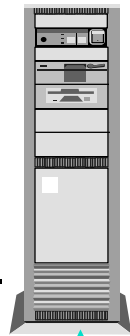


- ❑ LAN Emulation driver replaces Ethernet driver and passes the networking layer packets to ATM driver.
- ❑ Each ATM host is assigned an Ethernet address.
- ❑ LAN Emulation Server translates Ethernet addresses to ATM addresses
- ❑ Hosts set up a VC and exchange packets
- ❑ All software that runs of Ethernet can run on LANE

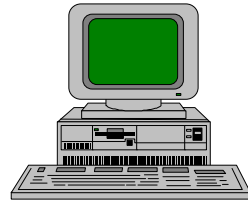
Raj Jain

# LAN Emulation

1. Client gets recipient's address from LES and sets-up a VC.

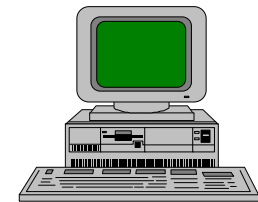
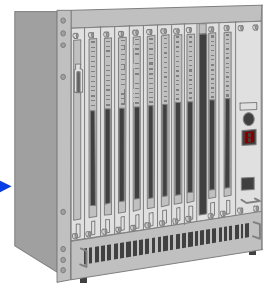
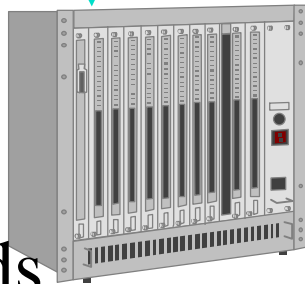
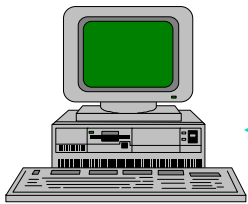


LAN Emulation Server



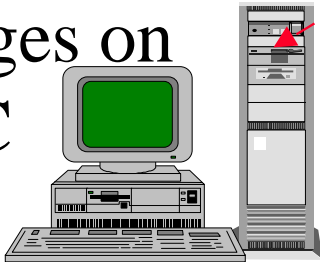
3. Messages for ATM clients are delivered directly.

Switches



ATM client B  
Bridge

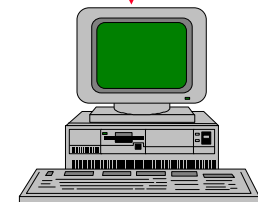
2. Client sends messages on the VC



4. Messages for non-ATM clients are forwarded through bridges

Broadcast/Unknown Server (BUS)

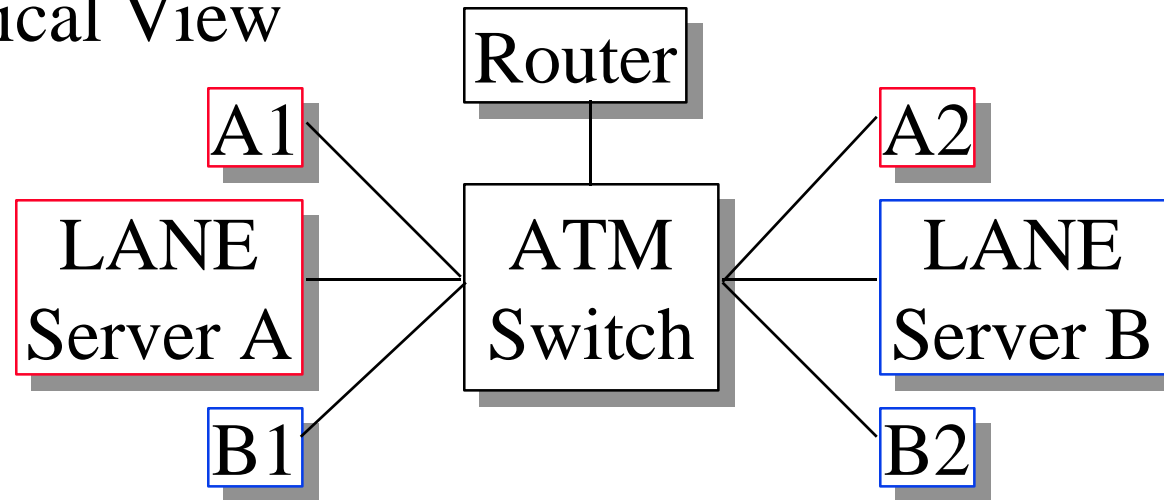
Non-ATM client



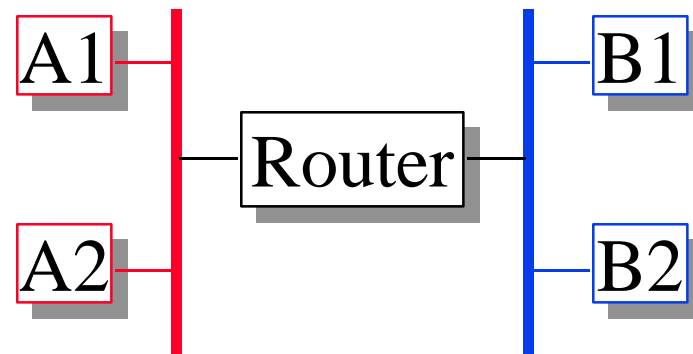
Raj Jain

# ATM Virtual LANs

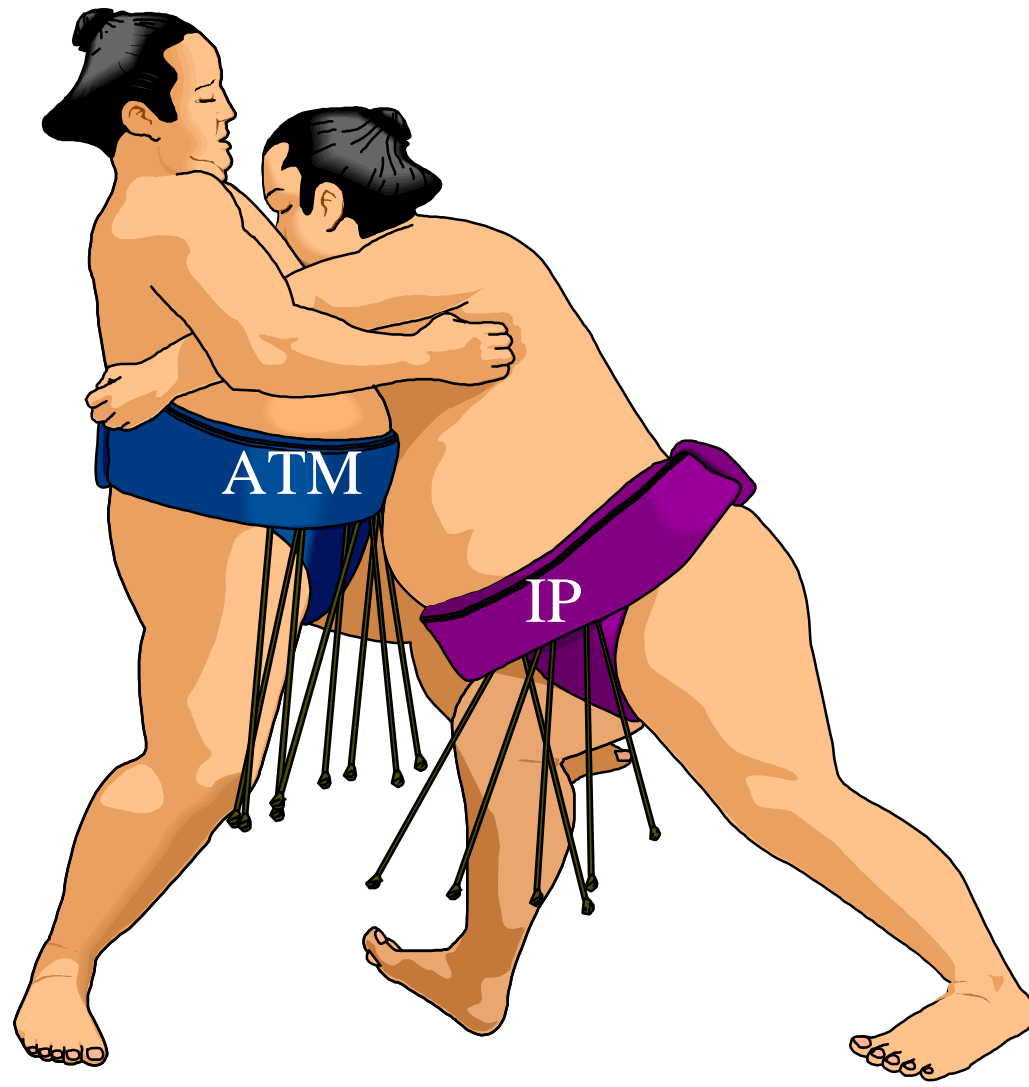
## Physical View



## Logical View

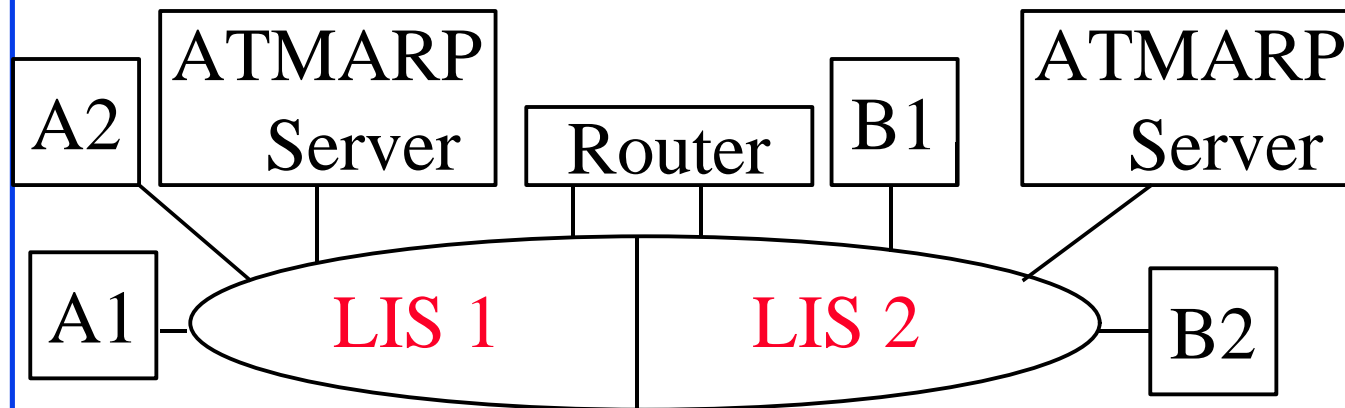


# IP Over ATM



Raj Jain

# Classical IP Over ATM



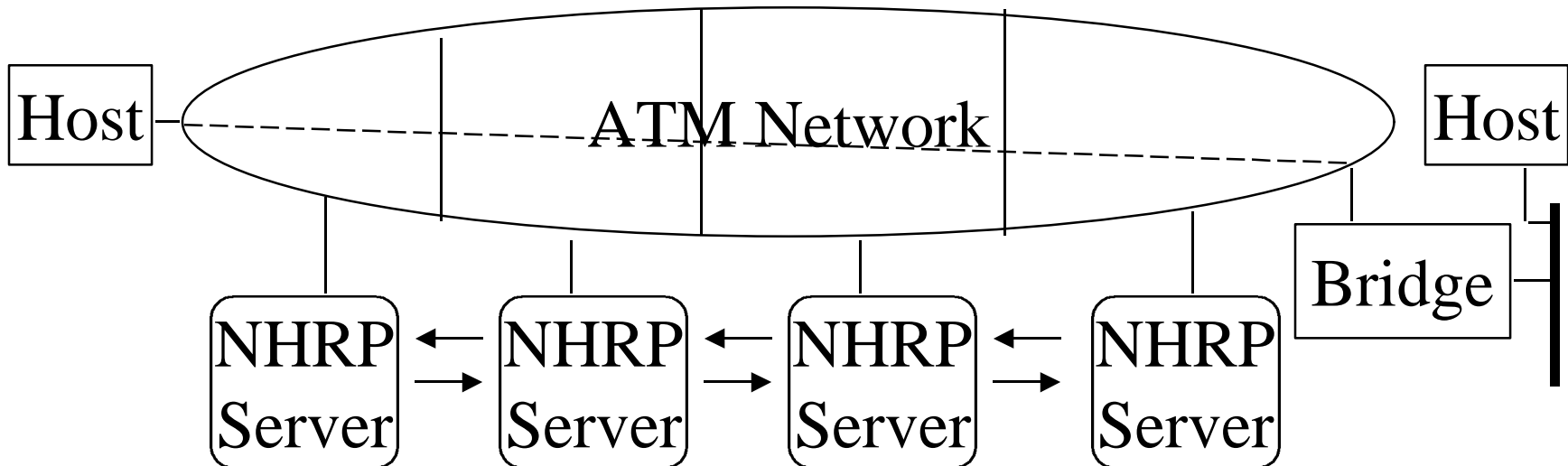
- ❑ ATM stations are divided into Logical IP Subnets (LIS)
- ❑ ATMARP server translates IP addresses to ATM addresses.
- ❑ Each LIS has an ATMARP server for resolution
- ❑ IP stations set up a direct VC with the destination or the router and exchange packets.

# IP Multicast over ATM

- ❑ Multicast Address Resolution Servers (MARS)
- ❑ Internet Group Multicast Protocol (IGMP)
- ❑ Multicast group members send IGMP join/leave messages to MARS
- ❑ Hosts wishing to send a multicast send a resolution request to MARS
- ❑ MARS returns the list of addresses
- ❑ MARS distributes membership update information to all cluster members

# Next Hop Resolution Protocol

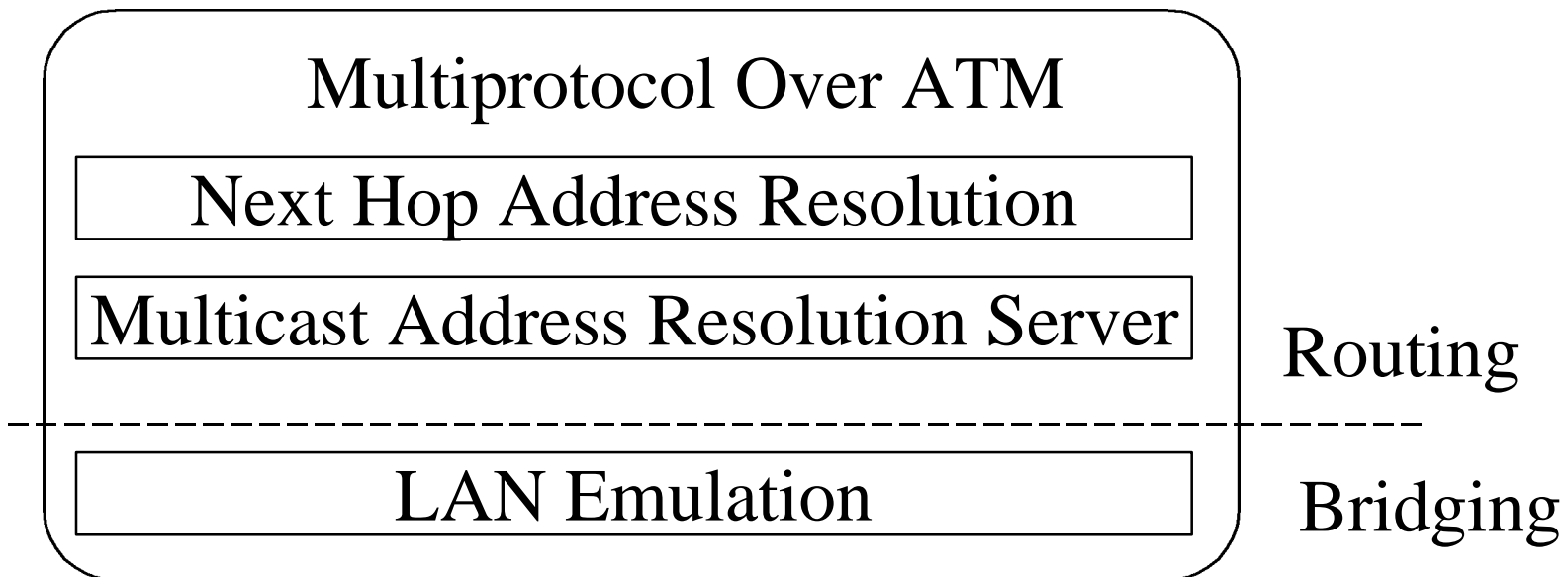
- ❑ Routers assemble packets  $\Rightarrow$  Slow
- ❑ NHRP servers can provide ATM address for the edge device to any IP host
- ❑ Can avoid routers if both source and destination are on the same ATM network.



Raj Jain

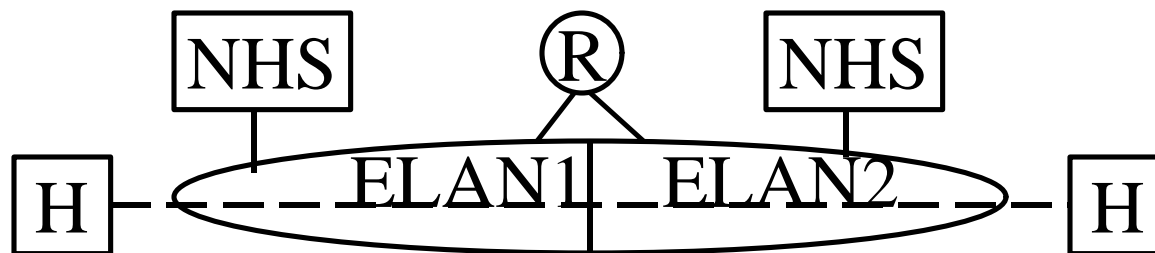
# Multiprotocol Over ATM

- ❑ MPOA= LANE + “NHRP+”
- ❑ Extension of LANE
- ❑ Uses NHRP to find the shortcut to the next hop
- ❑ No routing (reassembly) in the ATM network



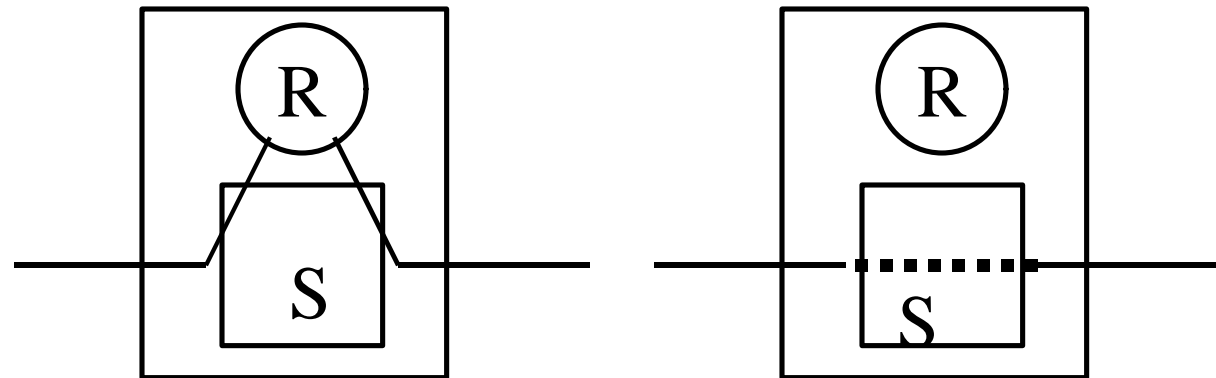
# MPOA (Cont)

- ❑ LANE operates at layer 2
- ❑ RFC 1577 operates at layer 3
- ❑ MPOA operates at both layer 2 and layer 3
  - ⇒ MPOA can handle non-routable as well as routable protocols
- ❑ Layer 3 protocol runs directly over ATM
  - ⇒ Can use ATM QoS
- ❑ MPOA uses LANE for its layer 2 forwarding



# IP Switching

- ❑ Developed by Ipsilon
- ❑ Routing software in every ATM switch in the network
- ❑ Initially, packets are reassembled by the routing software and forwarded to the next hop
- ❑ Long term flows are transferred to separate VCs. Mapping of VCIs in the switch  $\Rightarrow$  No reassembly



Raj Jain

# IP Switching (Cont)

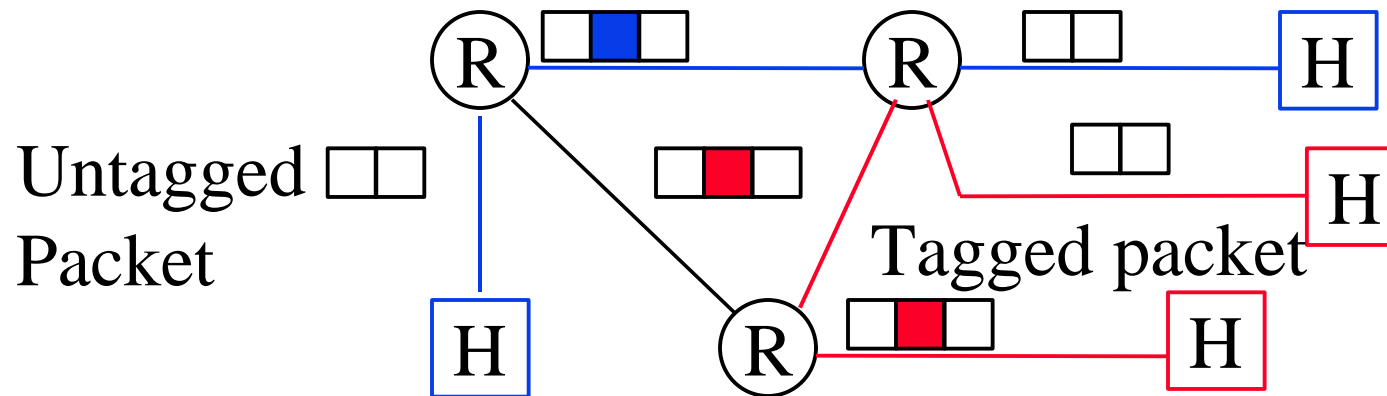
- ❑ Flow-oriented traffic: FTP, Telnet, HTTP, Multimedia
- ❑ Short-lived Traffic: DNS query, SMTP, NTP, SNMP, request-response  
Ipsilon claims that 80% of packets and 90% of bytes are flow-oriented.
- ❑ IP switching implemented as a s/w layer over an ATM switch
- ❑ Ipsilon claims their Generic Switch Management Protocol (GSMP) to be 2000 lines, and Ipsilon Flow Management Protocol (IFMP) to be only 10,000 lines of code

# Tag Switching

- ❑ Proposed by CISCO
- ❑ Similar to VLAN tags
- ❑ Tags can be explicit or implicit L2 header



- ❑ Ingress router/host puts a tag. Exit router strips it off.

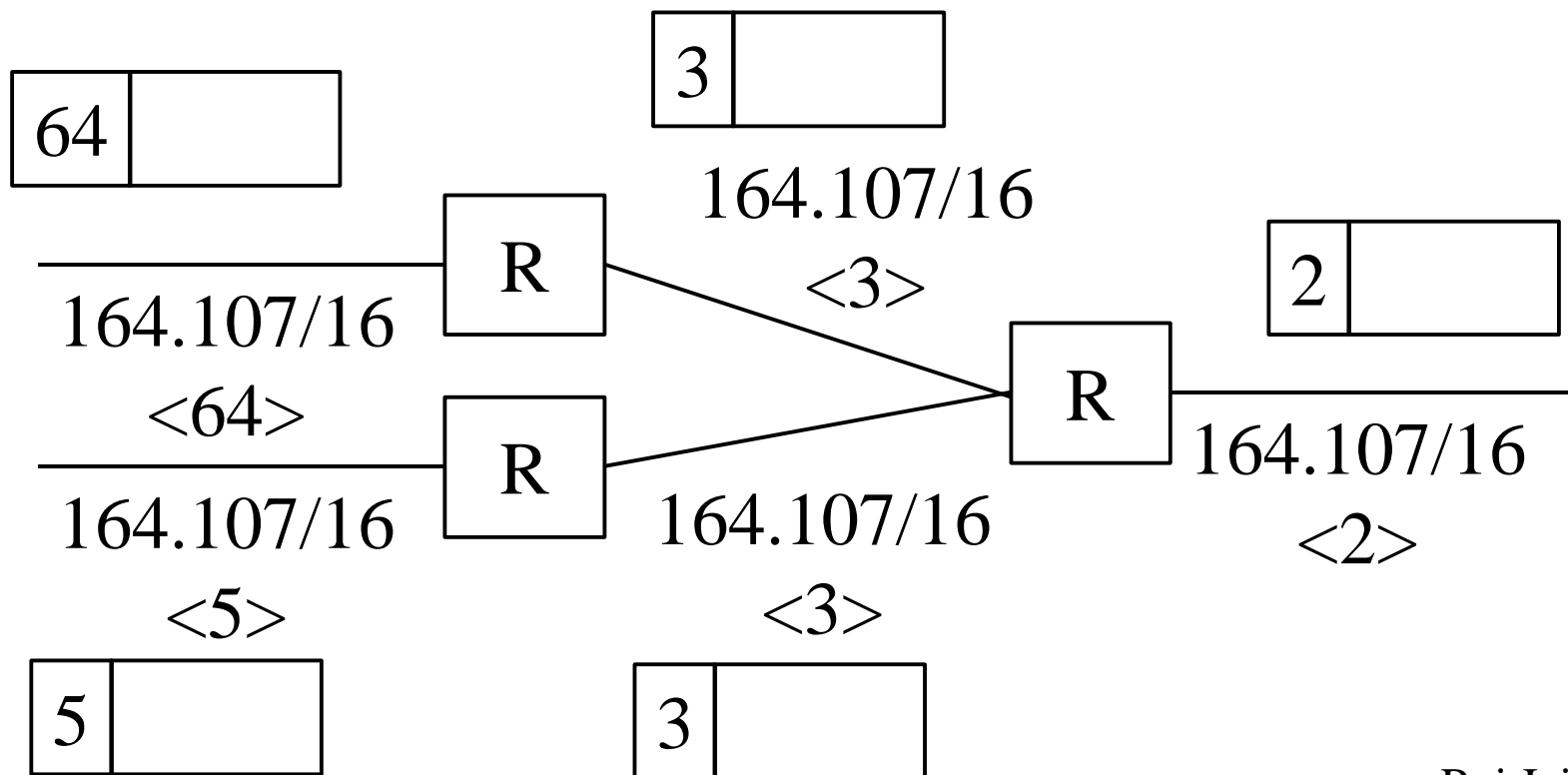


# Tag Switching (Cont)

- ❑ Switches switch packets based on labels.  
Do not need to look inside  $\Rightarrow$  Fast.
- ❑ One memory reference compared to 4-16  
in router
- ❑ Tags have local significance  
 $\Rightarrow$  Different tag at each hop (similar to VC #)

# Tag Switching (Cont)

- One VC per routing table entry



Raj Jain

# Alphabet Soup

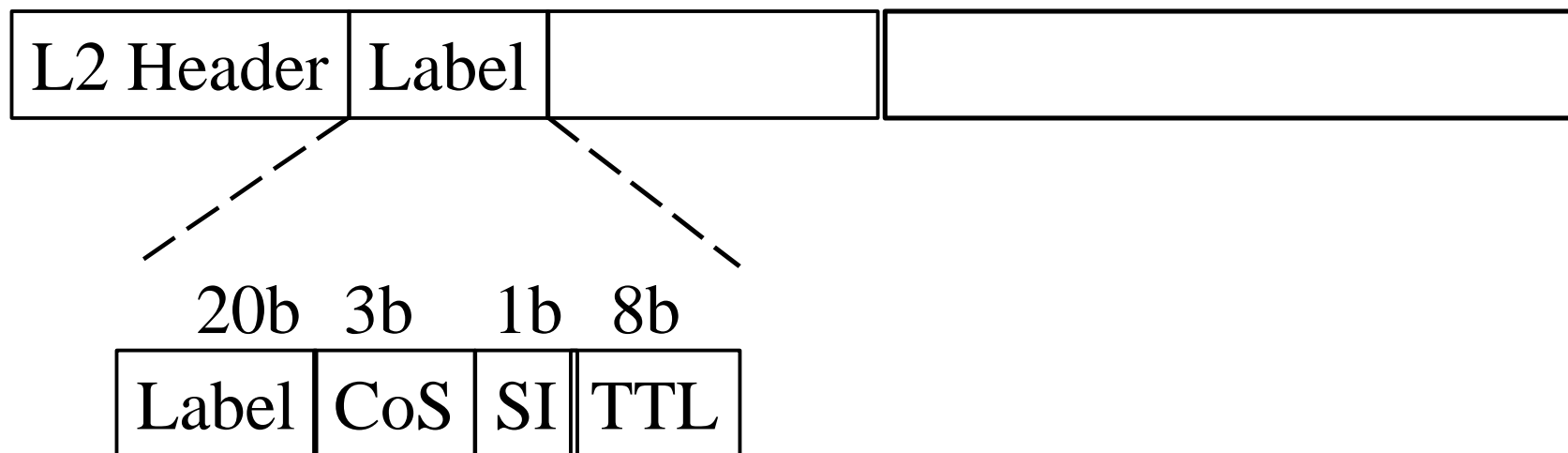
- ❑ CSR Cell Switched Router
- ❑ ISR Integrated Switch and Router
- ❑ LSR Label Switching Router
- ❑ TSR Tag Switching Router
- ❑ Multi layer switches, Swoters
- ❑ DirectIP
- ❑ FastIP
- ❑ PowerIP

# MPLS

- ❑ Multiprotocol Label Switching
- ❑ IETF working group to develop switched IP forwarding
- ❑ Initially focused on IPv4 and IPv6.  
Technology extendible to other L3 protocols.
- ❑ Not specific to ATM. ATM or LAN.
- ❑ Not specific to a routing protocol (OSPF, RIP, ...)
- ❑ Optimization only. Labels do not affect the path.  
Only speed. Networks continue to work w/o labels

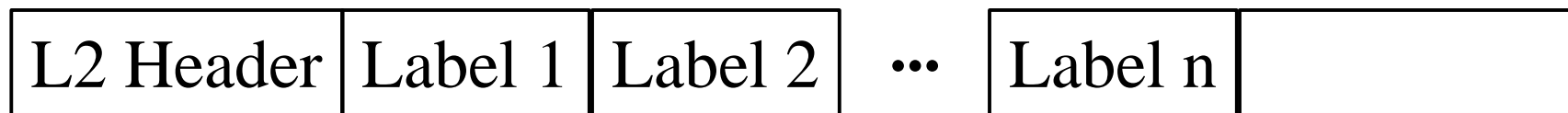
# Label Format

- ❑ Labels = Explicit or implicit L2 header
- ❑ TTL = Time to live
- ❑ CoS = Class of service
- ❑ SI = Stack indicator



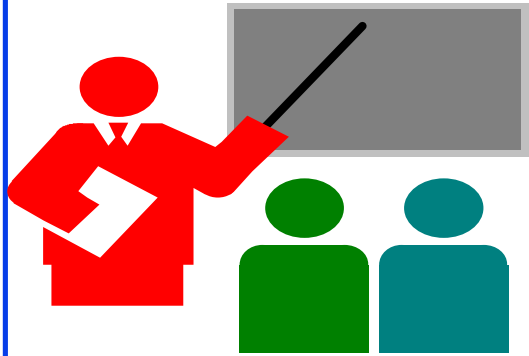
# Label Stacks

- ❑ Labels are pushed/popped as they enter/leave MPLS domain
- ❑ Routers in the interior will use Interior Gateway Protocol (IGP) labels. Border gateway protocol (BGP) labels outside.



# MPLS: Issues

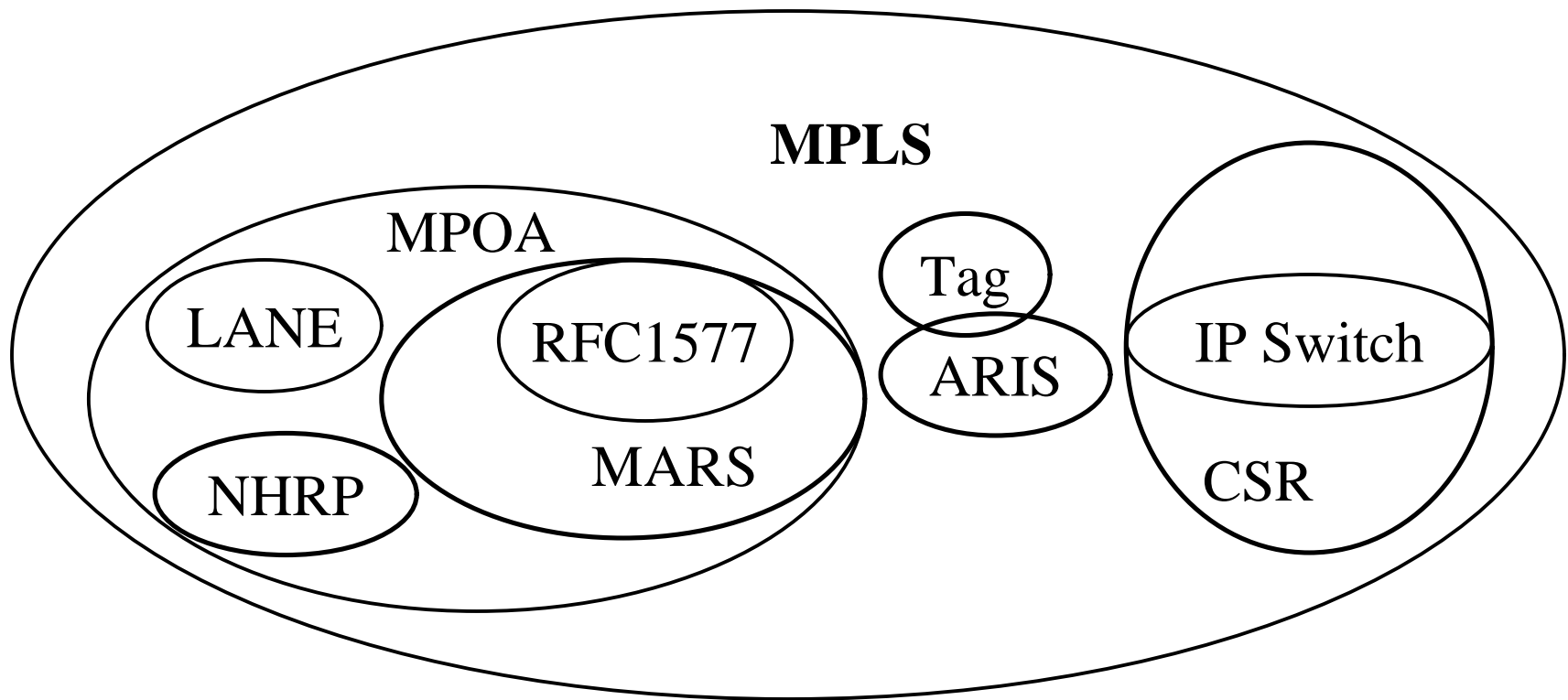
- ❑ Loop prevention, detection, survival
- ❑ Multicast:  
Multiple entries in label information base
- ❑ Multipath: Streams going to the same destination but different sources/port # may be assigned separate labels.
- ❑ Host involvement: Label-enabled hosts will avoid first hop reassembly
- ❑ Security: Label swapping may be terminated before firewall



## Summary

- ❑ LANE allows current applications to run on ATM
- ❑ Classical IP allows ARP using ATMARP servers
- ❑ NHRP removes the need for routing in an ATM net
- ❑ MPOA combines LANE and NHRP
- ❑ IP Switching: Traffic-based, per-hop VCs, downstream originated
- ❑ Tag switching: Topology based, one VC per route
- ❑ MPLS combines various features of IP switching, CSR, Tag switching, ARIS

# Summary (Cont)



# Key References

- ❑ See [http://www.cis.ohio-state.edu/~jain/refs/ipoa\\_ref.htm](http://www.cis.ohio-state.edu/~jain/refs/ipoa_ref.htm) and [http://www.cis.ohio-state.edu/~jain/refs/ipsw\\_ref.htm](http://www.cis.ohio-state.edu/~jain/refs/ipsw_ref.htm)
- ❑ "A Framework for Multiprotocol Label Switching", 11/26/1997, <http://www.internic.net/internet-drafts/draft-ietf-mpls-framework-02.txt>
- ❑ Multiprotocol Label Switching (mpls) working group at IETF. Email: [mpls-request@cisco.com](mailto:mpls-request@cisco.com)

## References (Cont)

- ❑ ATM Forum, "MPOA V1.0," July 1997, <ftp://ftp.atmforum.com/pub/approved-specs/af-mpoa-0087.000.doc>
- ❑ RFC 2332, "NBMA Next Hop Resolution Protocol (NHRP)", <ftp://ftp.isi.edu/in-notes/rfc2322.txt> , 2/6/98.
- ❑ RFC 2225, "Classical IP and ARP over ATM," 1/20/94, <ftp://ftp.isi.edu/in-notes/rfc2225.txt>
- ❑ LAN Emulation over ATM v1.0 Specification (Jan 1995), <ftp://ftp.atmforum.com/pub/approved-specs/af-lane-0021.000.ps>