

# QoS over Data Networks

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# Integrated Services

- ❑ Best Effort Service: Like UBR.
- ❑ Controlled-Load Service: Performance as good as in an unloaded datagram network. No quantitative assurances. Like nrt-VBR or UBR w MCR
- ❑ Guaranteed Service: rt-VBR
  - ❑ Firm bound on data throughput and delay.
  - ❑ Delay jitter or average delay not guaranteed or minimized.
  - ❑ Every element along the path must provide delay bound.
  - ❑ Is not always implementable, e.g., Shared Ethernet.
  - ❑ Like CBR or rt-VBR

# Problems with RSVP and Integrated Services

- ❑ Complexity in routers: packet classification, scheduling
- ❑ Scalable in number of receivers per flow but  
Per-Flow State:  $O(n)$   $\Rightarrow$  Not scalable with # of flows.  
Number of flows in the backbone may be large.  
 $\Rightarrow$  Suitable for small private networks
- ❑ Need a concept of “Virtual Paths” or aggregated flow groups for the backbone
- ❑ Need policy controls: Who can make reservations?  
Support for accounting and security.  
 $\Rightarrow$  RSVP admission policy (rap) working group.

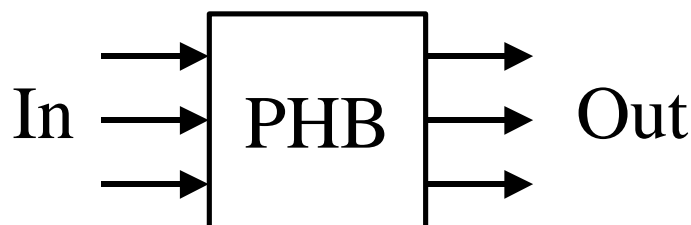
# Problems (Cont)

- ❑ Receiver Based: Need sender control/notifications in some cases. Which receiver pays for shared part of the tree?
- ❑ Soft State: Need route/path pinning (stability). Limit number of changes during a session.
- ❑ RSVP does not have negotiation and backtracking
- ❑ Throughput and delay guarantees require support of lower layers. Shared Ethernet  $\Rightarrow$  IP can't do GS or CLS. Need switched full-duplex LANs.
- ❑ Can't easily do RSVP on ATM either
- ❑ Most of these arguments also apply to integrated services.

# Differentiated Services

|     |         |            |     |        |         |
|-----|---------|------------|-----|--------|---------|
| Ver | Hdr Len | Precedence | ToS | Unused | Tot Len |
| 4b  | 4b      | 3b         | 4b  | 1b     | 16b     |

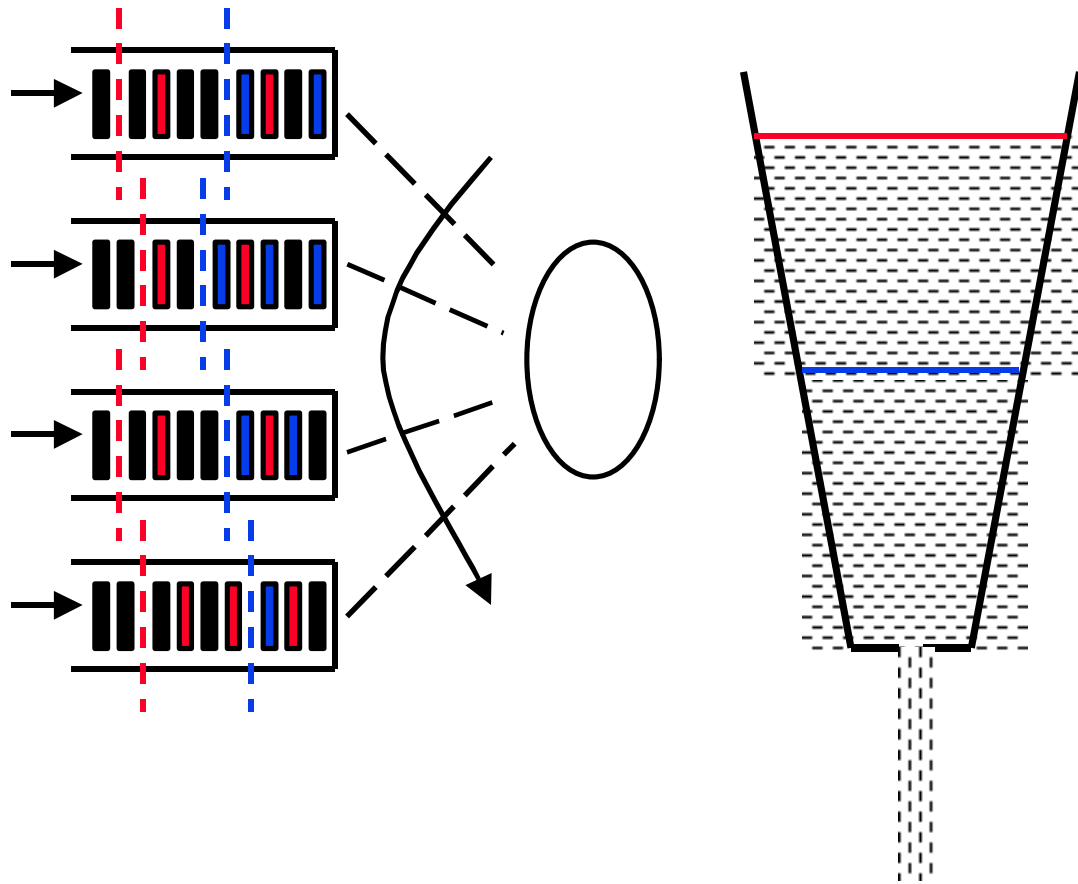
- ❑ IPv4: 3-bit precedence + 4-bit ToS
- ❑ Many vendors use IP precedence bits but the service varies  $\Rightarrow$  Need a standard  $\Rightarrow$  Differentiated Services
- ❑ DS working group formed February 1998
- ❑ Charter: Define ds byte (IPv4 ToS field)
- ❑ Per-Hop Behavior: Externally Observable Forwarding Behavior, e.g., x% of link bandwidth, or priority



# Expedited Forwarding

- ❑ Also known as “Premium Service”
- ❑ Virtual leased line
- ❑ Similar to CBR
- ❑ Guaranteed minimum service rate
- ❑ Policed: Arrival rate  $<$  Minimum Service Rate
- ❑ Not affected by other data PHBs  
⇒ Highest data priority (if priority queueing)

# Assured Forwarding



- ❑ PHB Group
- ❑ Four Classes: Decreasing weights in WFR/WFQ
- ❑ Three drop preference per class (one rate and two bucket sizes)

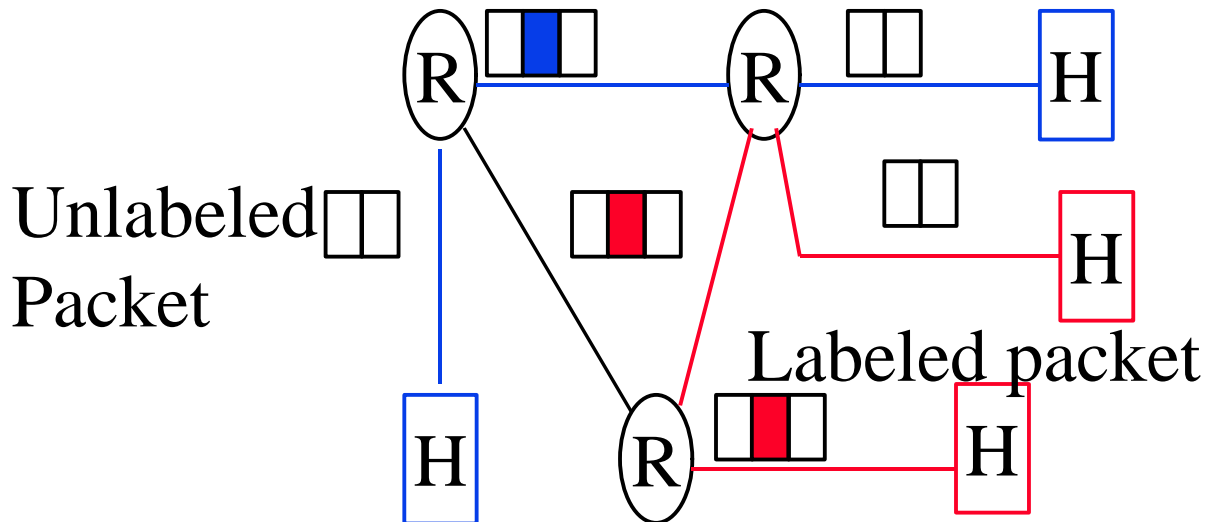
# DiffServ: Issues

- ❑ per-hop  $\Rightarrow$  Need at every hop  
One non-DiffServ hop can spoil all QoS
- ❑ End-to-end  $\neq \Sigma$  per-Hop  
Designing end-to-end services with weighted guarantees at individual hops is difficult. Only EF will work.
- ❑ QoS is for the aggregate not micro-flows. Not intended/useful for end users. Only ISPs.
  - ❑ Large number of short flows are better handled by aggregates.

# DiffServ Issues (Cont)

- Long flows (voice and video sessions) need per-flow guarantees.
- High-bandwidth flows (1 Mbps video) need per-flow guarantees.
- All IETF approaches are open loop control  $\Rightarrow$  Drop.  
Closed loop control  $\Rightarrow$  Wait at source  
Data prefers waiting  $\Rightarrow$  Feedback
- Guarantees  $\Rightarrow$  Stability of paths  
 $\Rightarrow$  Connections (hard or soft)  
Need route pinning or connections.

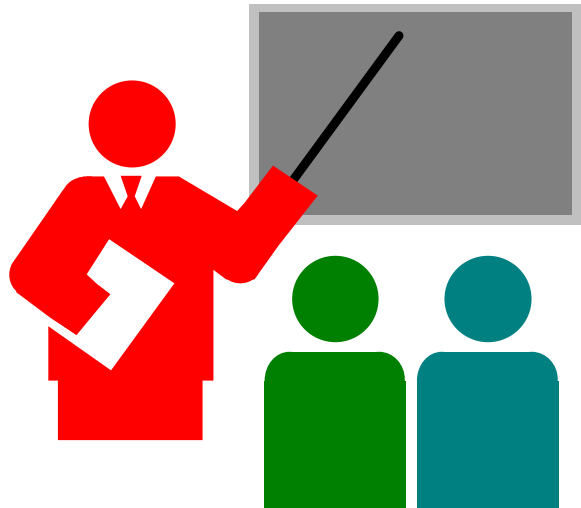
# Multiprotocol Label Switching



- ❑ Entry “label switch router (LSR)” attaches a label to the packet based on the route
- ❑ Other LSRs switch packets based on labels. Do not need to look inside
- ❑ Labels have local significance  
⇒ Different label at each hop (similar to VC #)
- ❑ Exit LSR strips off the label

# Traffic Engineering Using MPLS

- ❑ Traffic Engineering
  - = Performance Optimization
  - = Efficient resource allocation,
  - Path splitting
  - ⇒ Maximum throughput, Min delay, min loss
  - ⇒ Quality of service
- ❑ In MPLS networks:
  - “Traffic Trunks” = SVCs
  - Traffic trunks are routable entities like VCs
- ❑ Multiple trunks can be used in parallel to the same egress.
- ❑ Each traffic trunk can have a set of associated characteristics, e.g., priority, preemption, policing, overbooking



## Summary

- ❑ Multiple drop preferences does not help data (TCP) or Voice/Video
- ❑ Voice/video need multiple leaky bucket rates for layered/scalable coding.
- ❑ Need additivity or mathematical aggregatability.  
CBR (EF) should be the first step for IP.
- ❑ Excess allocation is useful with closed loop. Network/application dynamics  
⇒ Need closed loop