Quality of Service In Data Networks

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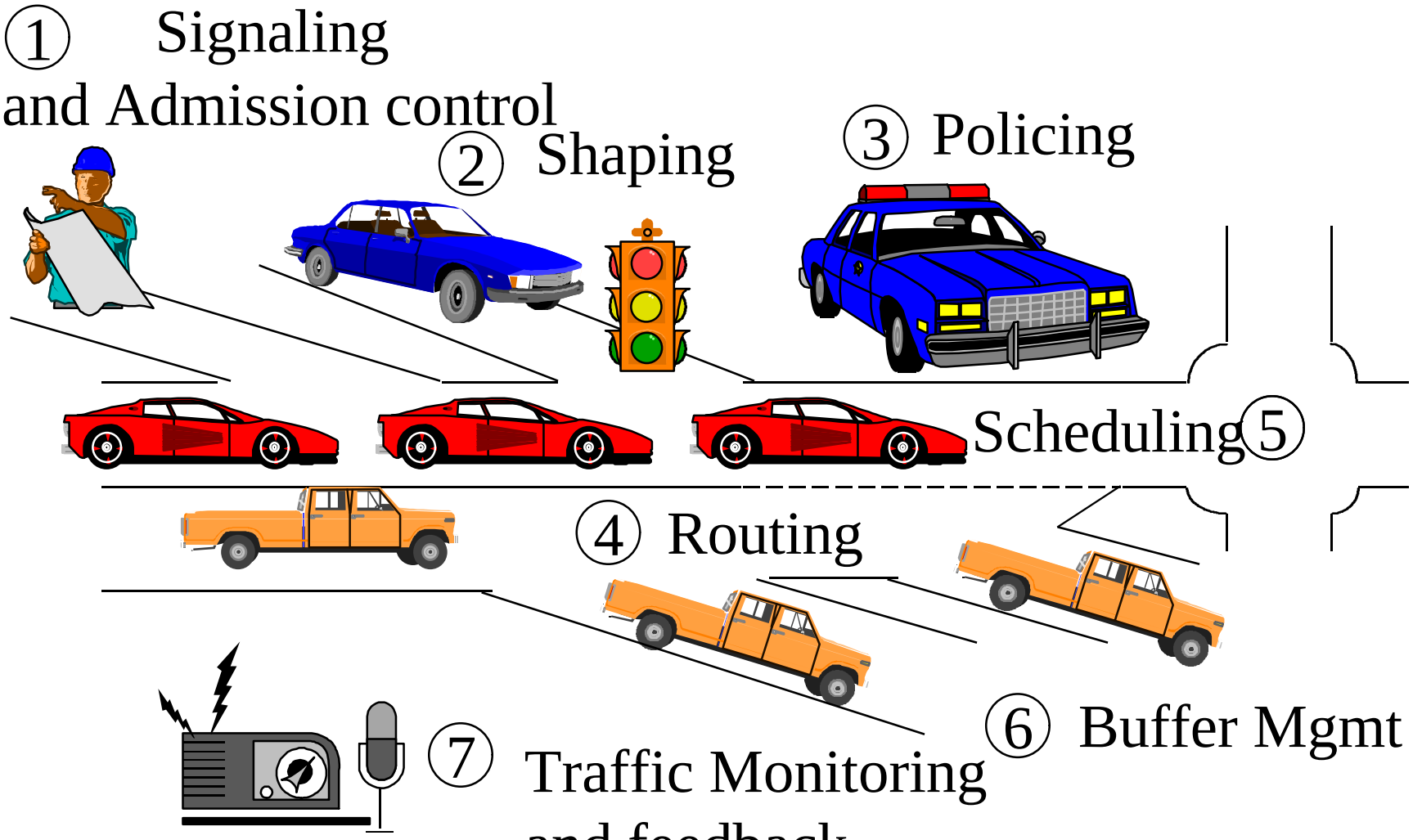
Overview

- ATM QoS and Issues
- Integrated services/RSVP and Issues
- Differentiated Services and Issues
- QoS using MPLS
- End-to-end QoS

QoS Components



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ATM QoS: Issues

- Can't easily specify QoS: What is the CDV required for a movie?
- Signaling too complex ⇒ Need Lightweight Signaling
- Need priority or weight among VCs to map DiffServ and 802.1D
- Need Group Address
- Need Heterogeneous Point-to-Multipoint: Variegated VCs
- Can't easily aggregate QoS: VP = Σ VCs
- Need QoS Renegotiation

Integrated Services

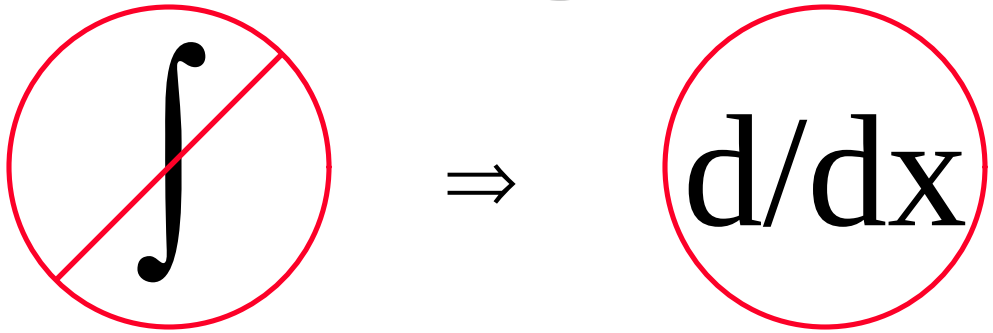
1. **Best Effort Service**: Like UBR.
2. **Controlled-Load Service**: Performance as good as in an unloaded datagram network. No quantitative assurances. Like nrt-VBR or UBR w MCR
3. **Guaranteed Service**: rt-VBR
   - Firm bound on data throughput and delay.
   - Like CBR or rt-VBR

- Need a signaling protocol: RSVP
- Design philosophy similar to ATM
  - Per-flow
  - End-to-end
  - Signaling

Problems with IntServ+RSVP

- Complexity in routers: classification, scheduling
- Not scalable with # of flows
  $\Rightarrow$ Not suitable for backbone.
- Need a concept of "Virtual Paths" or aggregated flow groups for the backbone.
- Need policy controls: Who can make reservations?
  $\Rightarrow$ RSVP admission policy (rap) working group.
- Receiver Based:
  Need sender control/notifications in some cases.
- Soft State: Need route/path pinning (stability).
- No negotiation and backtracking
- Note: RSVP is being revived for MPLS and DiffServ

Trend: Differentiation Not Integration



- DiffServ to standardize IPv4 ToS byte's first six bits
- Packets gets marked at network ingress
  Marking ⇒ treatment (behavior) in rest of the net
  Six bits ⇒ 64 different per-hop behaviors (PHB)

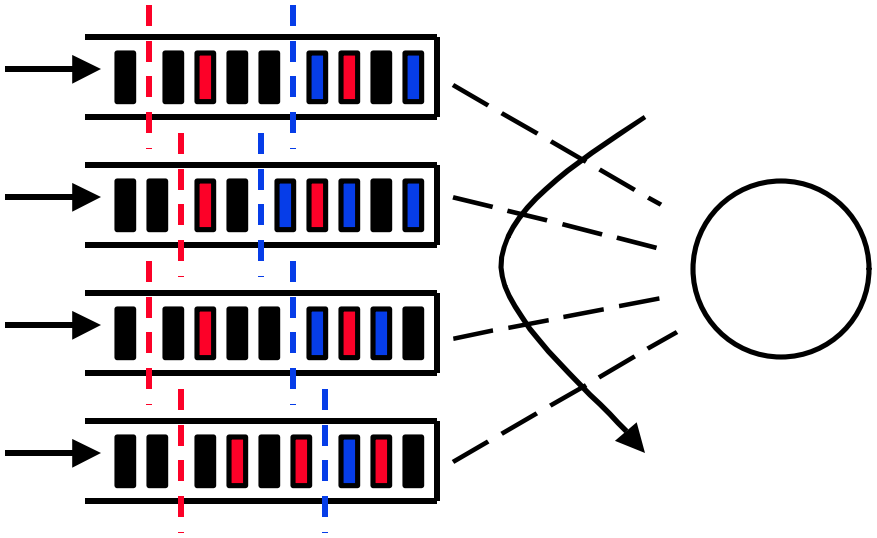
DiffServ (Cont)

- Per-hop behavior = % of link bandwidth, Priority
- Services: End-to-end. Voice, Video, ...
  - Transport: Delivery, Express Delivery,...
    Best effort, controlled load, guaranteed service
- DS group will not develop services
  They will standardize "Per-Hop Behaviors"
- Marking based on static "Service Level Agreements" (SLAs). Avoid signaling.

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
  $\Rightarrow$ Highest data priority (if priority queueing)
- Code point: 101 110

Assured Forwarding



- PHB Group
- Four Classes: No particular ordering
- Three drop preference per class

Assured Forwarding (Cont)

- DS nodes SHOULD implement all 4 classes and MUST accept all 3 drop preferences. Can implement 2 drop preferences.
- Similar to nrt-VBR/ABR/GFR
- Code Points:

Drop Prec.	Class 1	Class 2	Class 3	Class 4
Low	010 000	011 000	100 000	101 000
Medium	010 010	011 010	100 010	101 010
High	010 100	011 100	100 100	101 100

- Avoids 11x000 (used for network control)

Problems with DiffServ

- End-to-end ≠ Σ per-Hop
  Designing end-to-end services with weighted guarantees at individual hops is difficult.
  Only Expedited Forwarding will work.
- Designed for static Service Level Agreements (SLAs)
  Both the network topology and traffic are highly dynamic.
- How to ensure resource availability inside the network?
- DiffServ is unidirectional ⇒ No receiver control

DiffServ Problems (Cont)

- 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.
  - Long flows (voice and video sessions) need per-flow guarantees.
  - High-bandwidth flows (1 Mbps video) need per-flow guarantees.

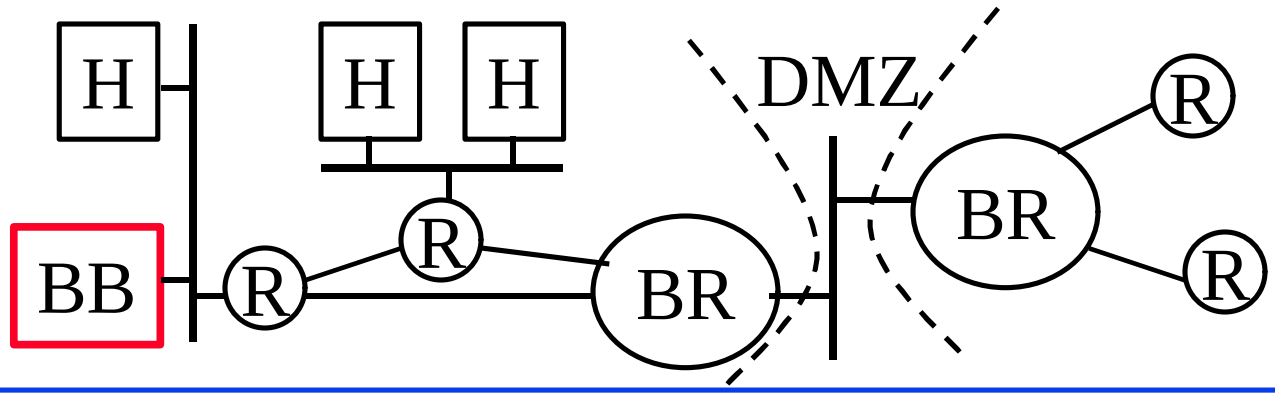
$\Rightarrow$ DiffServ alone is not sufficient for backbone.
Signaling via RSVP will be required.

MPLS Mechanisms for QoS

- Explicit Routing: Multiple label switched paths (LSPs) can be used in parallel to the same egress.
- Signaling, Admission Control, Routing: Each LSP can have priority, preemption, policing, overbooking
- Constrained based routing of LSPs
  Allows both Traffic constraints and Resource Constraints (Resource Attributes)
- Hierarchical division of the problem (Label Stacks)
- Danger: Too much too soon…again

Bandwidth Broker

- Repository of policy database. Includes authentication
- Users request bandwidth from BB
- BB sends authorizations to leaf/border routers
  Tells what to mark.
- Ideally, need to account for bandwidth usage along the path
- BB allocates only boundary or bottleneck

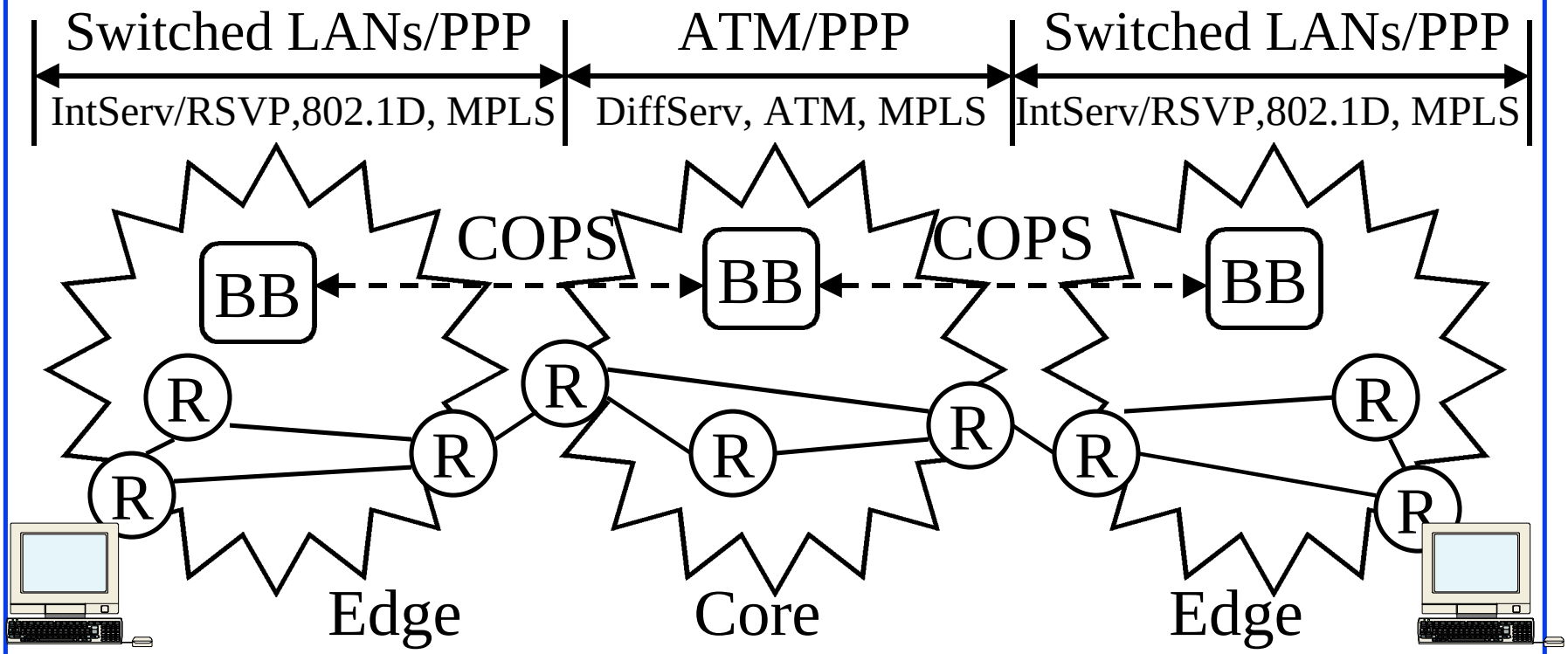


IEEE 802.1D Model

- Massive bandwidth. Simple priorities will do.
- **Up to eight priorities**: Strict.
  1 Background
  2 Spare
  0 Best Effort
  3 Excellent Effort
  4 Control load
  5 Video (Less than 100 ms latency and jitter)
  6 Voice (Less than 10 ms latency and jitter)
  7 Network Control

End-to-end View

- ATM/PPP backbone, Switched LANs/PPP in Stub
- IntServ/RSVP, 802.1D, MPLS in Stub networks
- DiffServ, ATM, MPLS in the core



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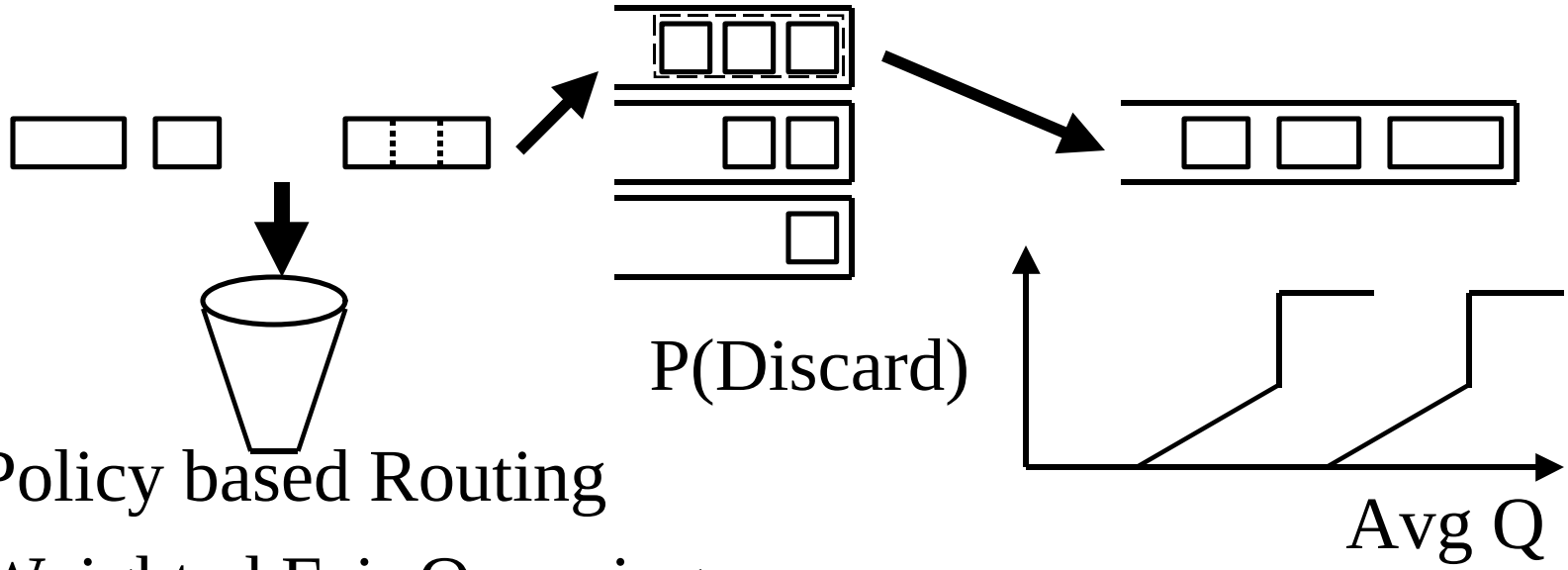
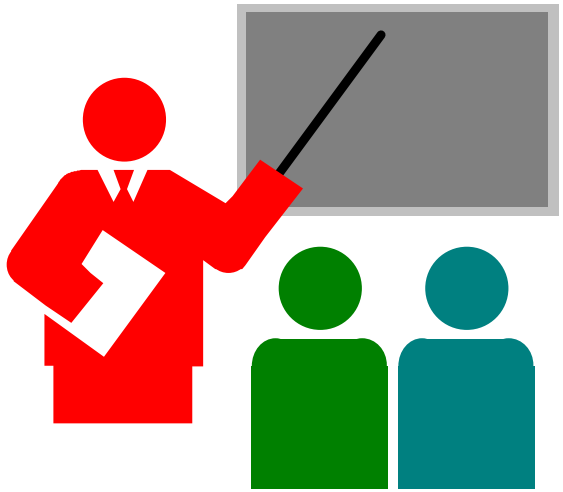
Additional Mechanisms



- Policy based Routing
- Weighted Fair Queueing
- Weighted Random Early Detection
- Link Fragmentation and Interleaving
- These internal mechanisms do not require standardization

Summary



- ATM: CBR, VBR, ABR, UBR, GFR
- Integrated Services: GS = rtVBR, CLS = nrt-VBR
- Signaling protocol: RSVP
- Differentiated Services will use the DS byte
- MPLS allows traffic engineering and is most promising
- 802.1D allows priority

References

- For a detailed list of references see: refs/ipqs_ref.htm
- Integrated Services Overview, http://www.cis.ohio-state.edu/~jain/cis788-97/integrated_services/index.htm
- Multimedia over IP (RSVP, RTP, RTCP, RTSP), http://www.cis.ohio-state.edu/~jain/cis788-97/ip_multimedia/index.htm
- Additional papers and presentations on QoS are at: http://www.cis.ohio-state.edu/~jain/