Traffic Management and QoS Issues for Large High-Speed Networks

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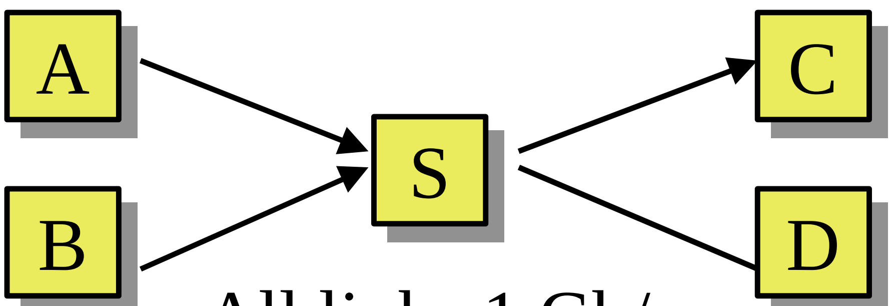
- Why Traffic Management
- Traffic Management in ATM: Strength and Weaknesses
- Traffic Management in IP
- Quality of Service: Current approaches and problems

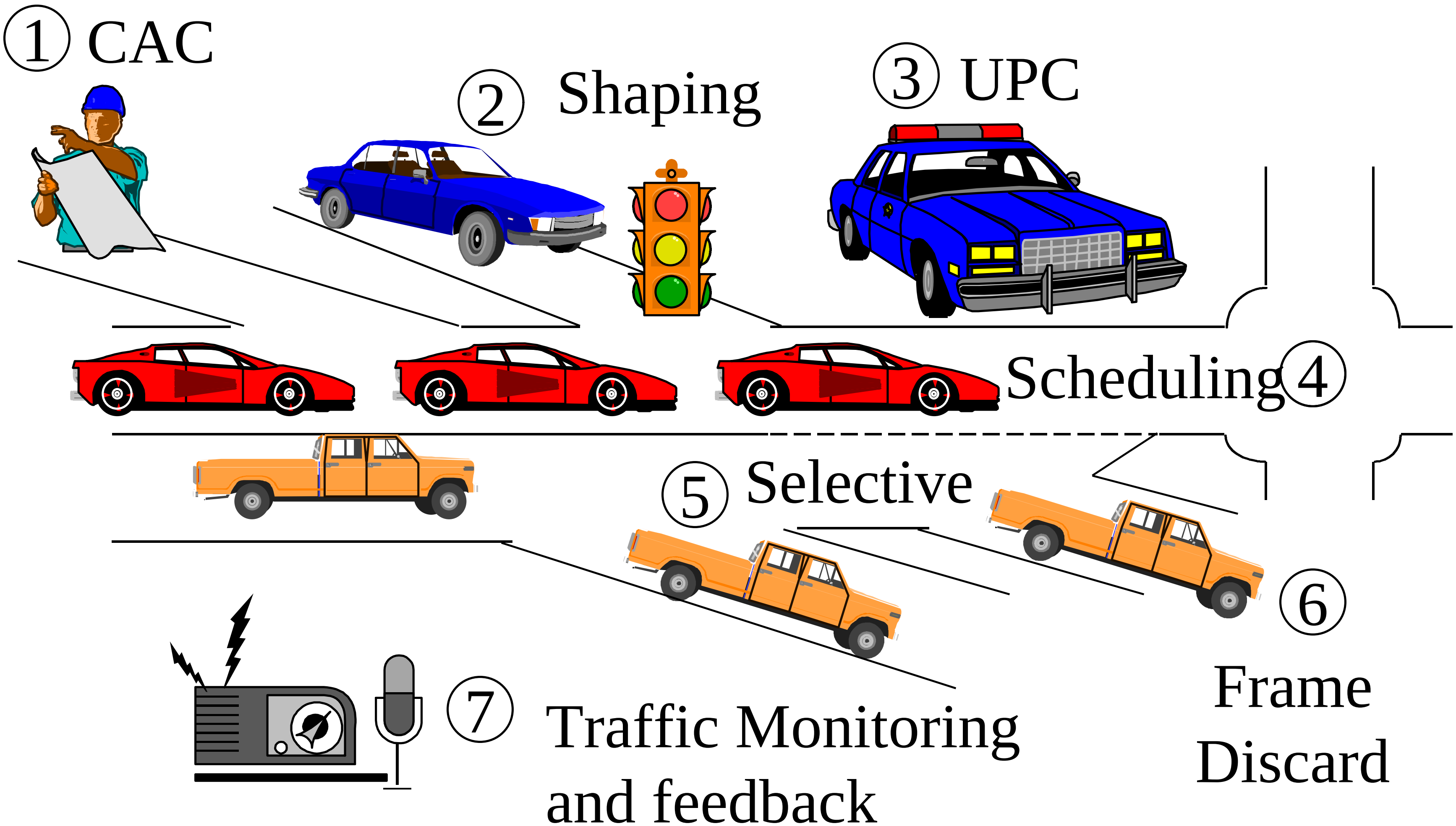
Trends

- Inter-Planetary Networks ⇒ Distances are increasing
- WDM OC-768 Networks = 39.8 Tb/s
  ⇒ Bandwidth is increasing
  ⇒ Large Bandwidth-Delay Product (LBDP) Networks
- Information Power Grid is an LBDP network
- Traffic Management is Important for LBDP networks



All links 1 Gb/s

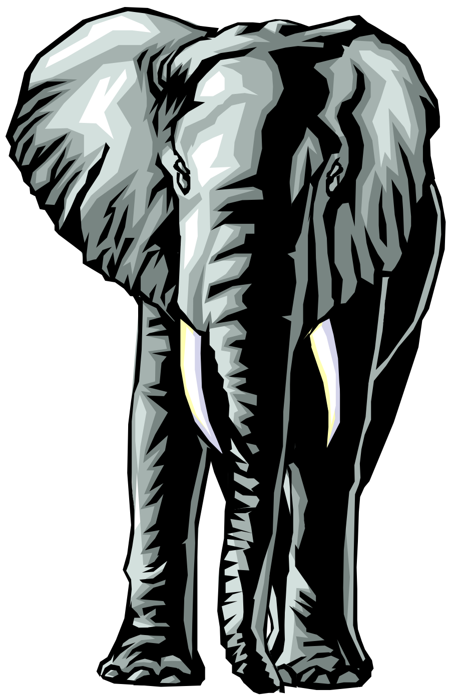
Traffic Management on the Info Superhighway

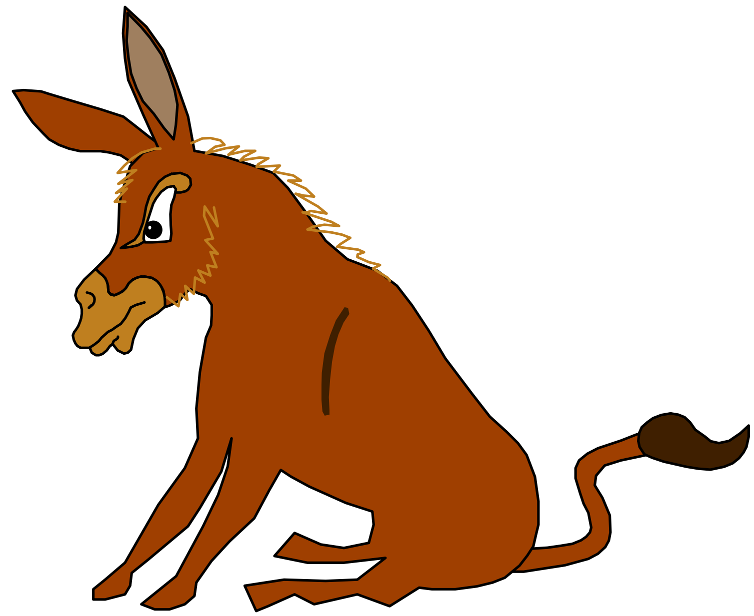


ATM Traffic Mgmt Functions

- Connection Admission Control (CAC):
  Can quality of service be supported?
- Traffic Shaping: Limit burst length. Space-out cells.
- Usage Parameter Control (UPC):
  Monitor and control traffic at the network entrance.
- Network Resource Management:
  Scheduling, Queueing, resource reservation
- Priority Control: Cell Loss Priority (CLP)
- Selective Cell Discarding: Frame Discard
- Feedback Controls: Network tells the source to increase or decrease its load.

ABR vs UBR





- ABR Feedback ⇒ No queues in the network.
- ABR is useful even when ATM is only in the backbone. Queues in the edge routers ⇒ Allows IP routers to implement IP-specific TM/QoS policies

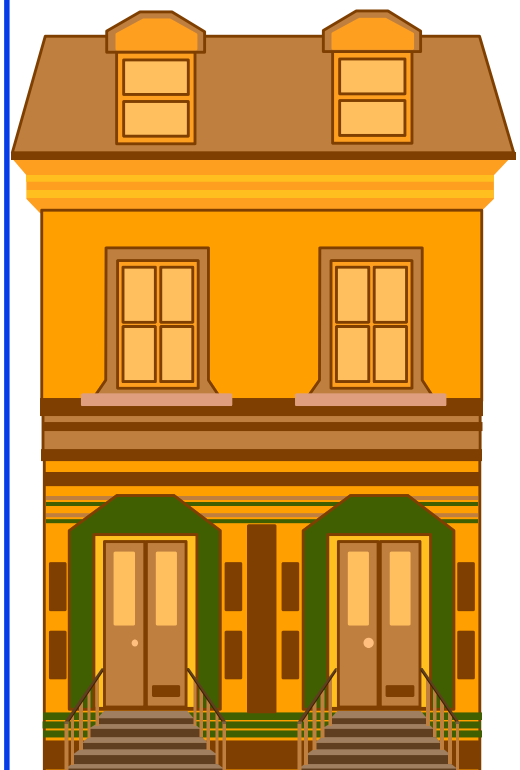
Why Explicit Feedback?

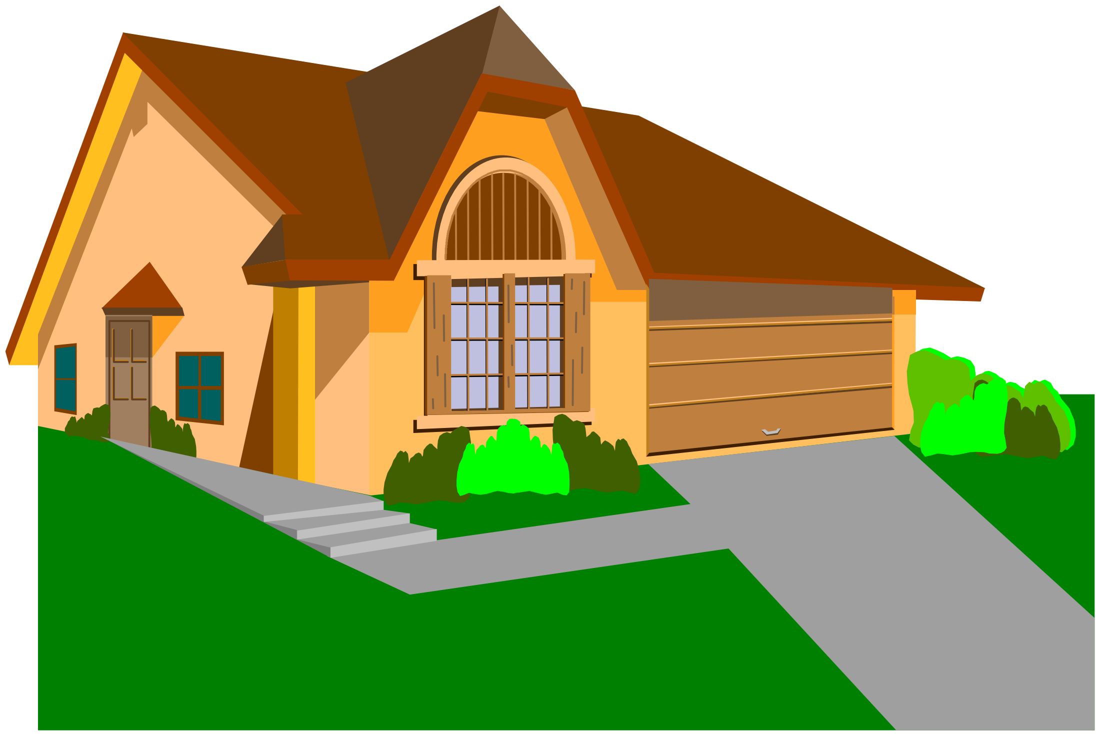
- Longer-distance networks
  ⇒ Can't afford too many round-trips
  ⇒ Explicit information is better

ATM vs IP: Key Distinctions

- Traffic Management:
  Explicit Rate vs Loss based
  Traffic management is a must for high-speed or long distance.
- QoS:
  - Classes: Service Categories, Integrated/Differentiated services
  - Signaling: Coming to IP in the form of RSVP
  - PNNI: QoS based routing QOSPF
- Switching: Coming soon to IP in the form of MPLS
- Cells: Fixed size or small size is not important

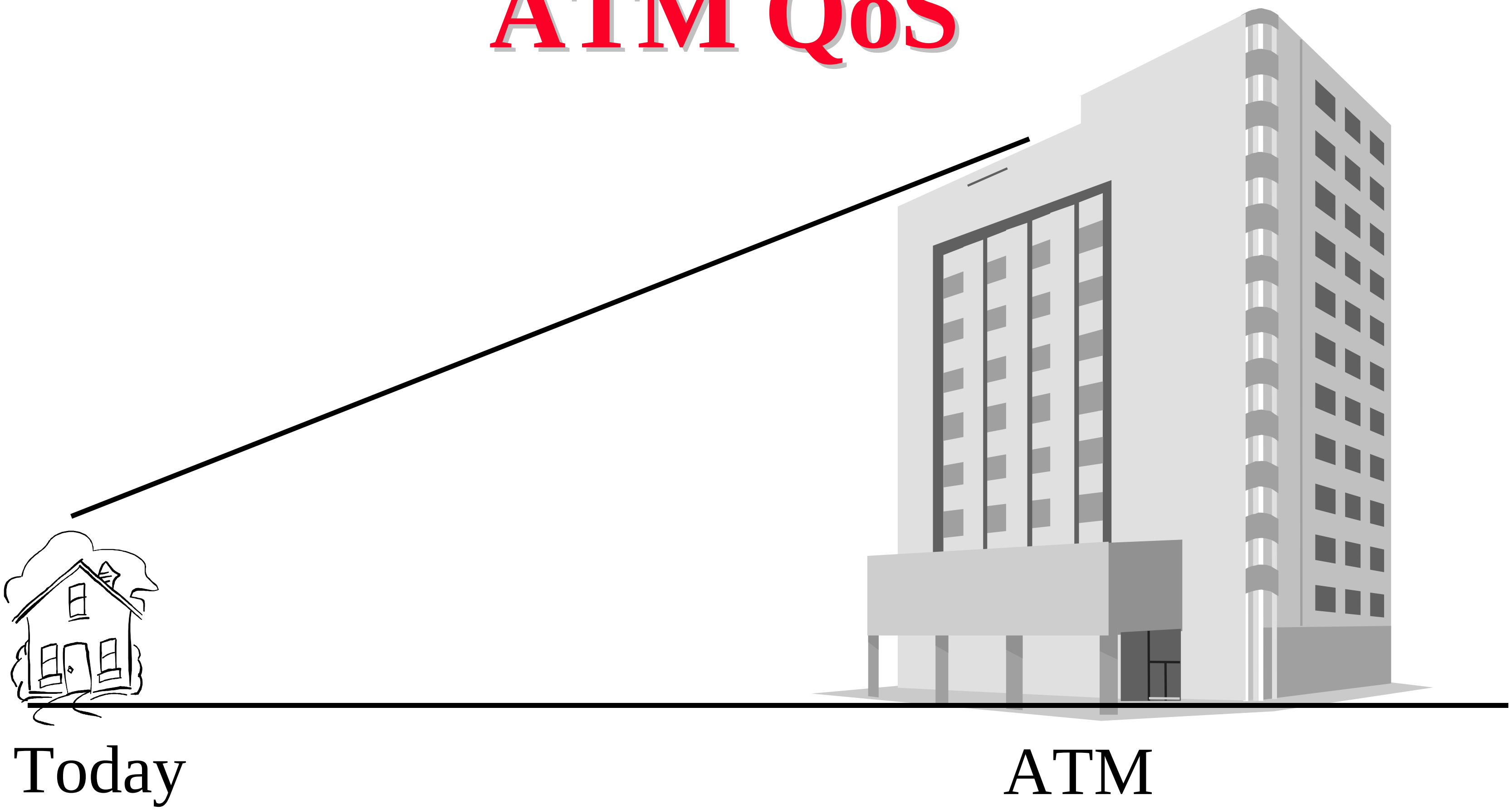
Old House vs New House





- New needs:
  Solution 1: Fix the old house (cheaper initially)
  Solution 2: Buy a new house (pays off over a long run)

ATM QoS



Too much too soon

ATM TM and QoS: Problems

- Multicasting:
  - 1-to-n, n-to-1, n-to-n
  - Multicast ABR
- QoS for applications not easy to specify:
  What rate (SCR, and PCR), burst size, delay, delay variation (CDV) to use for real-time video?

QoS Issue 1: Absolute vs Relative

- Today we have 2 choices:
  Absolute (leased line) or none (best effort)
- Would an applications/users/organizations/ISPs be happy with relative QoS?
- Most applications/users/organizations/ISPs want <u>some</u> absolute QoS
- Priority = Relative
- Relative ≠ Guarantee
- Strict priority ok only under mild congestion or if 2nd priority needs no guarantees

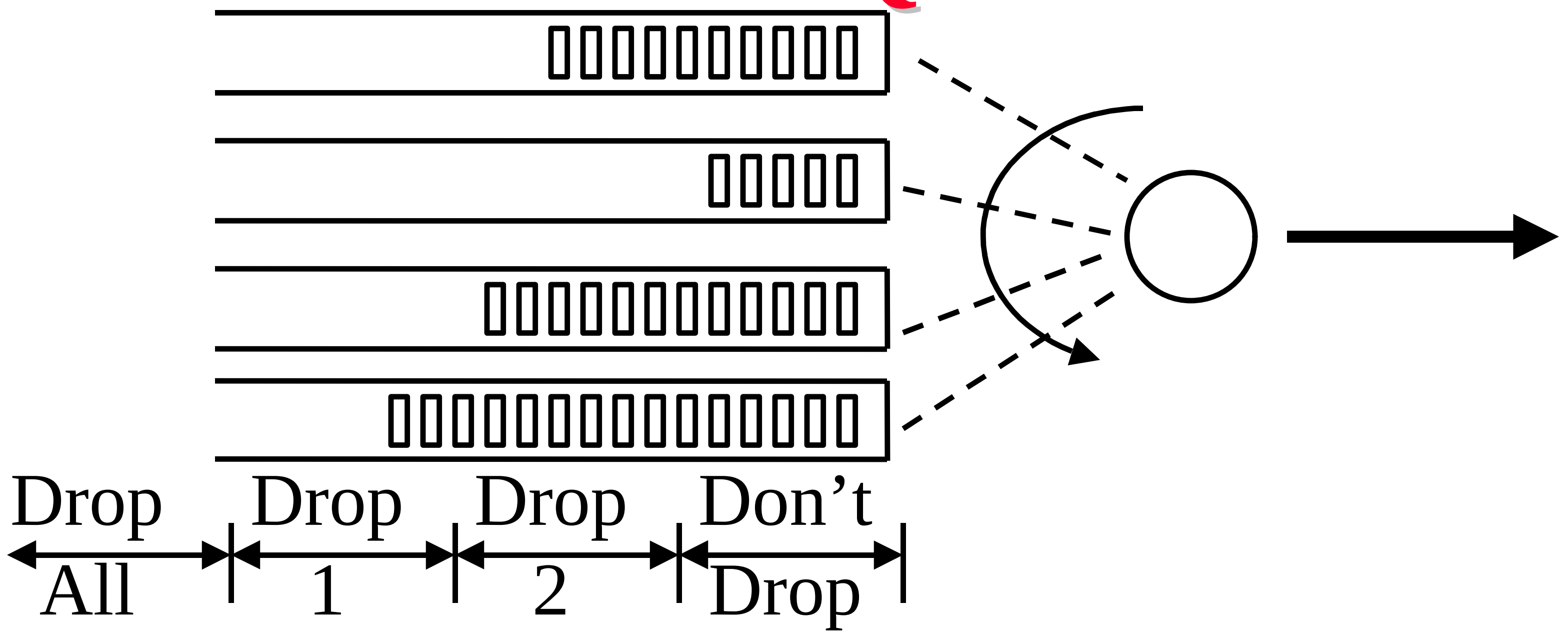
QoS Issue 2: Per-Flow vs Aggregate

- QoS belongs to application instances
  (not to applications/port #, users/IP Address, sites/IP prefix).
- Not all FTPs are equally important.
- Each application/user/site has some high priority packets and some low priority packets.
  ⇒ What an user needs is a sub-flow level QoS
  What an ISPs needs is to be able to aggregate flows

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

DiffServ QoS



- Based on ToS (or DS byte) in the packet
- 4 Queues
- Up to 3 Drop preferences for each queue
- Queues are served by Weighted Fair Queueing (WFQ)

IEEE 802.1p QoS

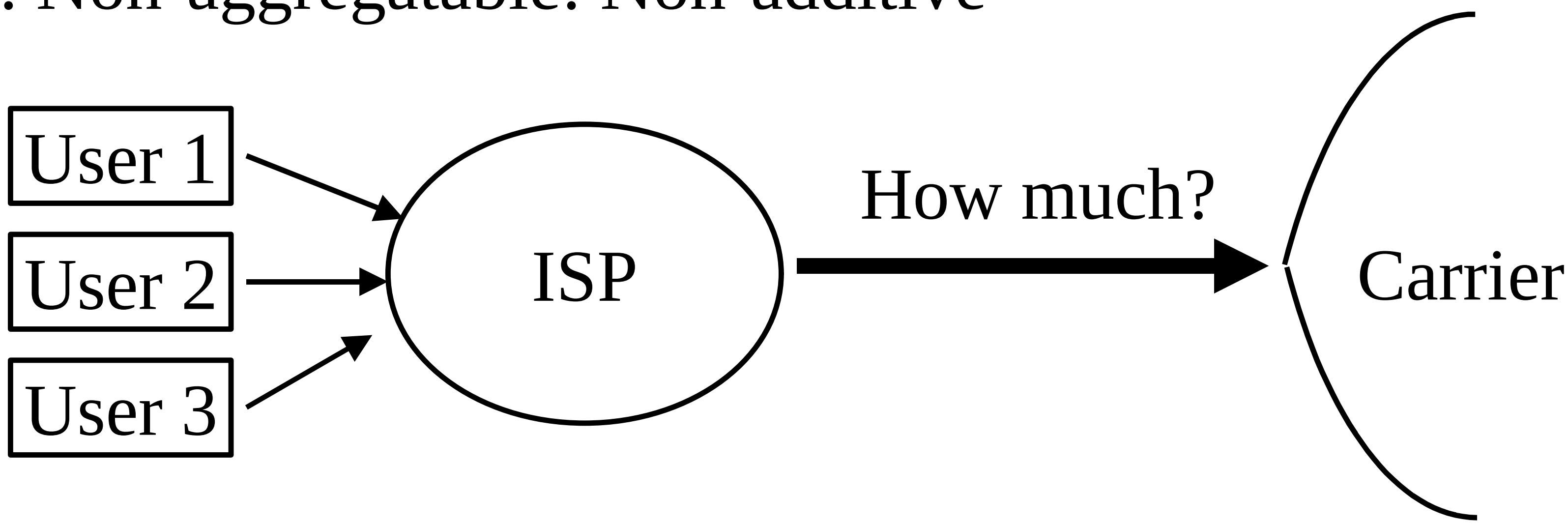
- Up to 8 Priorities (Strict)
- Local only. No coordination among stations.
- IP precedence, similarly, allows 8 classes
- MPLS, similarly, allows 8 classes

Current Approaches: Summary

Issue	ATM	IntServ	IEEE 802.1p	DiffServ
Absolute/ Relative	Absolute	Absolute	Relative	Relative
Per-Flow vs Aggregate	Per-Flow	Per-flow	Aggregate	Aggregate
Metrics	Throughput, Delay, CDV, Loss	Throughput	None	Weight (Throughput)
End-to-end/ datalink	End-to-end → Datalink	End-to-end → Edge	Datalink	Backbone

Current Approaches: Problems

1. Non-Specifiable:
   SCR/Burst size for real-time VBR video
2. Non-measurable:
   Priority or relative QoS
3. Non-aggregatable: Non-additive



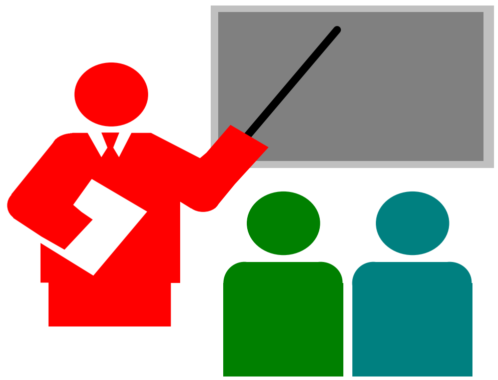
Additivity

- Examples of Additive Guarantees:
  - Throughput: $T = \Sigma T_i$
  - Minimum Throughput: Min $T = \Sigma$ Min T_i
- Examples of non-Additive Guarantees:
  - Maximum Throughput: Max $T \leq \Sigma$ Max T_i
  - Delay: $D \neq \Sigma D_i$
  - Delay variation: $\sigma_D \neq \Sigma \sigma_{Di}$
  - Loss Rate: $L \neq \Sigma L_i$
    $L \approx \Sigma(n_i / \Sigma n_i)L_i$ but n_i's are not known in advance

Why is the Problem Difficult?

- Bursty ⇒ Variability ⇒ Overbooking ⇒ Feedback
- Solution w/o Charging/quota policies
  Charging or Quota ⇒ Fairness of excess
- Guarantees ⇒ Stability of paths
  ⇒ Connections (hard or soft)
- Must account for realistic Service Level Agreements
- Must allow legacy and new technologies
- QoS at Datalink, Network, Transport, and Application layer
- No common datalink, transport, or applications
  ⇒ IP is the common network layer
  ⇒ IP must be fixed first

Summary



- Traffic management is important for large high-speed networks like Information Power Grid
- ATM traffic management, although sophisticated, needs work on multicasting
- The key distinction of ATM is it's traffic management. We need to develop similar techniques for IP

Summary (Cont)

- QoS required for some packets in a flow. Relative QoS or Aggregate QoS are a beginning, not the end.
- Need aggreegateable QoS to solve the per-flow vs aggregate debate

References

- For a detailed list of references see: http://www.cis.ohio-state.edu/~jain/refs/ipqs_ref.htm
- See also http://www.cis.ohio-state.edu/~jain/talks/ipqos.htm