Traffic Management and QoS Issues for Large High-Speed Networks

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This presentation is available on-line:
http://www.cis.ohio-state.edu/~jain/talks/nas_ipg.htm
Overview

- 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 $\Rightarrow$ Distances are increasing
- WDM OC-768 Networks $= 39.8 \text{ Tb/s}$
  $\Rightarrow$ Bandwidth is increasing
  $\Rightarrow$ 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

① CAC
② Shaping
③ UPC
④ Scheduling
⑤ Selective
⑥ Frame Discard
⑦ Traffic Monitoring and feedback
ATM Traffic Mgmt Functions

- Connection Admission Control (CAC):
  Can quality of service be supported?
- 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
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

Today          ATM
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 some 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

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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: $\text{Min } T = \Sigma \text{Min } T_i$

- Examples of non-Additive Guarantees:
  - Maximum Throughput: $\text{Max } T \leq \Sigma \text{Max } T_i$
  - Delay: $D \neq \Sigma D_i$
  - Delay variation: $\sigma_D \neq \Sigma \sigma_{D_i}$
  - 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 $\Rightarrow$ Variability $\Rightarrow$ Overbooking $\Rightarrow$ Feedback
- Solution w/o Charging/quota policies
  Charging or Quota $\Rightarrow$ Fairness of excess
- Guarantees $\Rightarrow$ Stability of paths
  $\Rightarrow$ 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
  $\Rightarrow$ IP is the common network layer
  $\Rightarrow$ IP must be fixed first
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.
QoS required for some packets in a flow. Relative QoS or Aggregate QoS are a beginning, not the end.

Need aggregateable 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