A Comparison of ATM Service Categories

Raj Jain

Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/
Overview

- Comparison of CBR, VBR, ABR, UBR, GFR
  - Complexity
  - Buffering
  - Efficiency for TCP Traffic
  - Fairness for TCP Traffic
  - UDP Traffic
  - Differentiated Services
Issues

- Services: CBR, VBR, ABR (with MCR), UBR (no MCR), GFR (with MCR)
- UBR with MCR has characteristics in-between UBR and GFR
- VBR ⇒ nrt-VBR (except in voice discussion)
- Metrics: Cost/Complexity, Performance (throughput, buffering, fairness)
- Applications: Data (TCP or UDP), Voice, Differentiated Services
- Configurations: Backbone ATM, end-to-end ATM
- Note: No absolute answers. Only points for a debate.
Complexity

- Note: Service categories are listed best first.
- CAC (Provisioning): UBR, CBR, ABR, GFR, VBR
- Policing: UBR, CBR, VBR, GFR, ABR
- Meeting Service Guarantees in Switches (Resource Allocation algorithm):
  CBR, nrt-VBR, rt-VBR, UBR (need frame boundaries), GFR, ABR
- VC Aggregation: CBR, UBR, ABR, GFR (different frame sizes), VBR
- Queueing (# of queues for n VCs): UBR (1), CBR/VBR/ABR/GFR (n)
Complexity (Cont)

- Complexity of Implementation
  (Switch cost, NIC cost):
  CBR, UBR, VBR, ABR, GFR
Switch Buffering

- CBR: Almost no buffering
- ABR: Low buffering
- VBR/GFR/UBR: High buffering
Router or End-system Buffering

- Depends on the type of traffic
- UBR, GFR, VBR: Traffic immediately enters the ATM network $\Rightarrow$ Low buffering
- CBR: Queues depend upon peak traffic rate and PCR
- ABR:
  - Queues in the end systems or routers
  - Ack regulation schemes can control required buffering for TCP
Use of Extra Router Buffering

- **ABR/CBR**: Routers can buffer when the backbone network is congested. Waiting is generally better than loss.
- **GFR/VBR/UBR**: Router does not know about network congestion. Extra memory does not help.
Bursty TCP Traffic: Bandwidth Utilization

- High Utilization ⇒ Less idle time
- ABR: Any available bandwidth is immediately allocated
- GFR/UBR/VBR: Higher burstiness ⇒ More queues/loss and More idle times
- CBR: Not suited for bursty traffic
Bursty TCP Traffic - Fairness

Configuration I:

ATM backbone $\Rightarrow$ VCs between Routers
$\Rightarrow$ Each VC carries multiple TCP flows

- ABR: Most losses in the router not in switches
  $\Rightarrow$ Key factor is the fairness in the router
  $\Rightarrow$ Proper RED can make it fair

- CBR: Queues in routers (as in ABR)

- VBR/GFR/UBR:
  Not fair since most losses in ATM switches.
  Fair buffer allocation (FBA) can ensure fairness
  among VCs but not among flows in the same VC.
Bursty TCP Traffic - Fairness

Configuration II:
- ATM end-to-end $\Rightarrow$ 1 VC per TCP flow
- ABR: No losses
- CBR: No losses
- GFR: Switches can fairly distribute losses using per-VC queueing or FBA
- UBR: Switches probably will not have separate UBR queues $\Rightarrow$ Low Fairness unless FBA
Bursty UDP Data Traffic

- Metric: Throughput or Efficiency
- Several Client-Server transaction applications use UDP.
- Data → Loss Sensitive → Retransmission
- UDP → No Slow Start → Losses can continue → Losses are more expensive than in TCP
- Other conclusions are similar to TCP
Loss-tolerant UDP Traffic

- Example: Voice over IP
- Loss-tolerant generally implies delay sensitive
- ATM backbone $\Rightarrow$ Aggregated flows
- ABR: Queues in the router. If hierarchically coded and drop preference indication in packets $\Rightarrow$ Routers can drop the low priority packets
- CBR: Low efficiency due to traffic variability. But Routers can drop the low priority packets.
- GFR/VBR/UBR: Packets may enter ATM network and dropped there. CLP bit coded by drop preference.
Differentiated Services

- Details of DS are yet to be finalized.
- Currently 4 queues and 3 drop preferences (July IETF Meeting)
- ATM has only two drop preferences: CLP = 0 or 1
- ABR: Queues in the Router $\Rightarrow$ Routers can set different thresholds for different drop preferences
- CBR: Queues in the router. But not as efficient as ABR for Bursty traffic.
- GFR/VBR/UBR: Queues in side the network $\Rightarrow$ Can't handle more than 2 drop preferences
Differentiated Services - Priorities

- Four Queues: With Priority and weights
- Weights $\Rightarrow$ Guaranteed bandwidth
- ABR/CBR: All queues in the routers
  $\Rightarrow$ Edge routers can keep multiple priority queues feeding to a single ABR VC
- GFR/VBR/UBR: No queues in the routers
  $\Rightarrow$ Can't enforce priorities in the router
- GFR: Higher MCR $\neq$ Higher Priority
  $\neq$ Higher share of extra bandwidth
- VBR: Higher SCR/PCR $\neq$ Higher Priority
ABR: Key Distinction is feedback
⇒ Network is congestion free and maximally utilized

ABR gives more control to edge-routers.
Routers have more control over drop policies

Other services depend more upon ATM switches
⇒ Fairness difficult to achieve if one VC contains multiple TCP flows
Summary (Cont)

- With ABR it is possible to make use of added buffering in the routers
- For Bursty Data: ABR > GFR > VBR > UBR > CBR
- Because of implementation complexity GFR may dominate in the short term
- With ABR, it is possible to implement multiple hierarchical levels of coding
  ⇒ Possible to allow multiple drop preferences
- All other classes can't handle more than two levels of drop preferences ⇒ ABR may rebound if multiple drop preferences in Differentiated Services
Summary (Cont)

- Large careers need ABR to keep queues manageable in the network