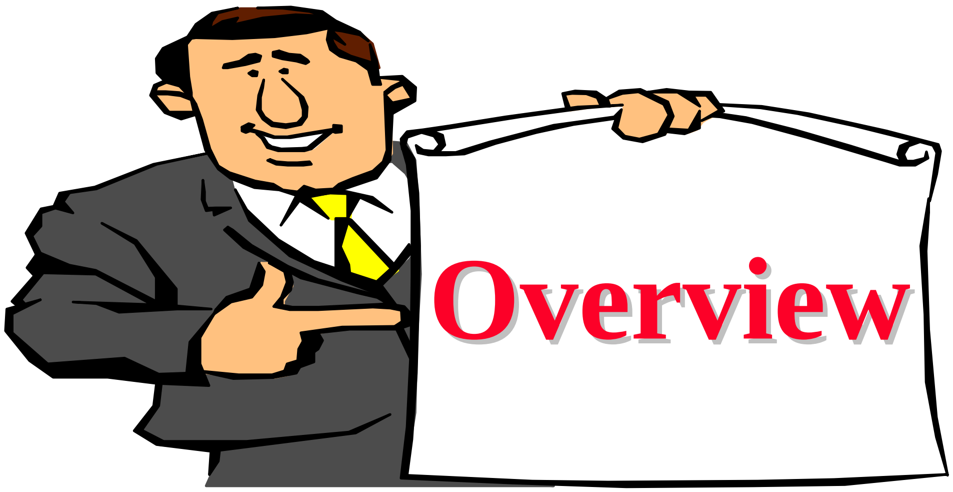
A Comparison of ATM Service Categories

Raj Jain

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



- 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 $\Rightarrow$ 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 ⇒ 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 $\Rightarrow$ Less idle time
- ABR: Any available bandwidth is immediately allocated
- GFR/UBR/VBR: Higher burstiness
  $\Rightarrow$ More queues/loss and More idle times
- CBR: Not suited for bursty traffic

Bursty TCP Traffic - Fairness

Configuration I:

ATM backbone ⇒ VCs between Routers

⇒ Each VC carries multiple TCP flows

- ABR: Most losses in the router not in switches
  ⇒ Key factor is the fairness in the router
  ⇒ 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 ⇒ Aggregated flows
- ABR: Queues in the router. If hierarchically coded and drop preference indication in packets
  ⇒ 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.

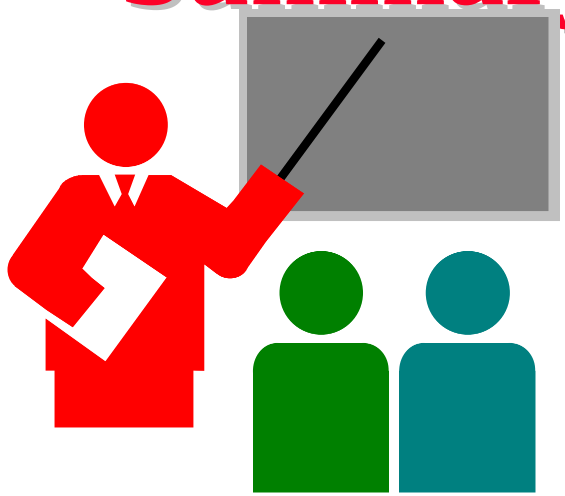
Differentiated Services

- 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 ⇒ 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
  ⇒ Can't handle more than 2 drop preferences

Differentiated Services - Priorities

- Four Queues: With Priority and weights
- Weights ⇒ Guaranteed bandwidth
- ABR/CBR: All queues in the routers
  ⇒ Edge routers can keep multiple priority queues feeding to a single ABR VC
- GFR/VBR/UBR: No queues in the routers
  ⇒ Can't enforce priorities in the router
- GFR: Higher MCR ≠ Higher Priority
  ≠ Higher share of extra bandwidth
- VBR: Higher SCR/PCR ≠ Higher Priority

Summary



- 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
  $\Rightarrow$ Possible to allow multiple drop preferences
- All other classes can't handle more than two levels of drop preferences $\Rightarrow$ ABR may rebound if multiple drop preferences in Differentiated Services

Summary (Cont)

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