Quality of Service in Data Networks

Raj Jain

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

These slides are available on-line at:
http://www.cis.ohio-state.edu/~jain/talks/qos9910.htm
Overview

- Ten Networking Trends
- Traffic > Capacity vs Capacity > Traffic
- QoS Design Approaches
- Comparison of QoS Approaches
- Customer Perspective of QoS
- QoS Debates
- Voice and Data: Back to the Future
- ATM QoS: What we learnt?
- QoS Components
Ten Networking Trends

1. Faster Media
2. More Traffic
3. Traffic > Capacity
4. Data > Voice
5. ATM in Backbone
6. Everything over IP
7. Differentiation Not Integration
8. Back to Routing From Switching
9. Traffic Engineering
10. Other Trends
In 1990, the memory will be so cheap that you will not have to worry about paging, swapping, virtual memory, memory hierarchy, and....
Trend 3: Traffic > Capacity

Expensive Bandwidth
- Sharing
- Multicast
- Virtual Private Networks
- More efficient use (L3)
- Need QoS
- Likely in WANs

Cheap Bandwidth
- No sharing
- Unicast
- Private Networks
- Less efficient use
- QoS less of an issue
- Possible in LANs
QoS Design Approaches

- Massive Bandwidth vs Managed Bandwidth
- Per-Flow vs Aggregate
- Source-Controlled vs Receiver Controlled
- Soft State vs Hard State
- Path based vs Access based
- Quantitative vs Qualitative
- Absolute vs Relative
- End-to-end vs Per-hop
- Static vs Feedback-based
- Homogeneous multicast vs heterogeneous multicast
- 1-to-n multicast vs n-to-1 multicast
## Comparison of QoS Approaches

<table>
<thead>
<tr>
<th>Issue</th>
<th>ATM</th>
<th>IntServ</th>
<th>DiffServ</th>
<th>MPLS</th>
<th>IEEE 802.3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive Bandwidth vs Managed Bandwidth</td>
<td>Managed</td>
<td>Managed</td>
<td>Massive</td>
<td>Managed</td>
<td>Massive</td>
</tr>
<tr>
<td>Per-Flow vs Aggregate</td>
<td>Both</td>
<td>Per-flow</td>
<td>Aggregate</td>
<td>Both</td>
<td>Aggregate</td>
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<tr>
<td>Source-Controlled vs Receiver Controlled</td>
<td>Unicast</td>
<td>Receiver</td>
<td>Ingress</td>
<td>Both</td>
<td>Source</td>
</tr>
<tr>
<td>Source, Multicast both</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft State vs Hard State</td>
<td>Hard</td>
<td>Soft</td>
<td>None</td>
<td>Hard</td>
<td>Hard</td>
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<tr>
<td>Path based vs Access based</td>
<td>Path</td>
<td>Path</td>
<td>Access</td>
<td>Path</td>
<td>Access</td>
</tr>
<tr>
<td>Quantitative vs Qualitative</td>
<td>Quantitative</td>
<td>Quantitative</td>
<td>Mostly qualitative</td>
<td>Both</td>
<td>Qualitative</td>
</tr>
<tr>
<td>Absolute vs Relative</td>
<td>Absolute</td>
<td>Absolute</td>
<td>Mostly Relative</td>
<td>Absolute + relative</td>
<td>Relative</td>
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</table>

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## Comparison (Cont)

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<td>end-end</td>
<td>Per-hop</td>
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<td>Per-hop</td>
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<tr>
<td>Static vs Feedback-based</td>
<td>Both</td>
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<td>Homogeneous multicast vs</td>
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<td>N/A</td>
<td>Homogeneous</td>
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<td>heterogeneous multicast</td>
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<td>geneous</td>
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<tr>
<td>1-to-n vs n-to-1 multicast</td>
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<td>1-to-n</td>
<td>N/A</td>
<td>Both</td>
<td>Both</td>
</tr>
</tbody>
</table>
ATM QoS

Too much too soon
Customer Perspective of QoS

1. Aggregation OK
2. Isolation required

Residential Customer
ISP
2nd tier ISP
Carrier
Fiber/Infrastructure Provider

Corporate Customer
Enterprise Network
QoS Debates

- Diffserv may be ok for enterprise backbone but not for carriers.
- Need a fundamental change in QoS metrics
  Customer specifiable, measurable, aggregateable, realizable, and thorough (voice+data)
- Can not rely on end-to-end TCP controls
Voice and Data: Back to the Future

<table>
<thead>
<tr>
<th>People</th>
<th>Cargo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lots of Money</td>
<td>Little Money</td>
</tr>
<tr>
<td>Little space</td>
<td>Need lots of space</td>
</tr>
<tr>
<td>Time critical</td>
<td>Time Not critical</td>
</tr>
<tr>
<td>Solutions: Cars, Planes</td>
<td>Solutions: Trucks, Rail, Ships, Cargo Plane</td>
</tr>
</tbody>
</table>

- Share the media but not transport
- In less developed countries, people may be treated like cargo.
QoS Components

1. Signaling and Admission control
2. Shaping
3. Policing
4. Routing
5. Scheduling
6. Buffer Management
7. Traffic Monitoring and feedback
QoS Components

- Shaping, Policing, Marking/classification
- Policies
- Scheduling and drop policies
- Routing: QoS based, Explicit, Parallel, Local
- Traffic aggregation: Virtual leased line
  Not Microflow/flows or aggregates with common headers
Either extreme (per-flow or aggregate) is not sufficient. Need intermediate aggregates.

Aggregation based on IP addresses and TCP port numbers is ok for enterprise but not for carrier backbone.

Need virtual leased lines in the backbone.

MPLS provides the aggregation, parallel explicit paths. Must avoid becoming too complex and too late.
Thank You!