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QoS for the IP Multicast Backbone

A look at the enabling technologies - ATM, MPLS, DiffServ…..

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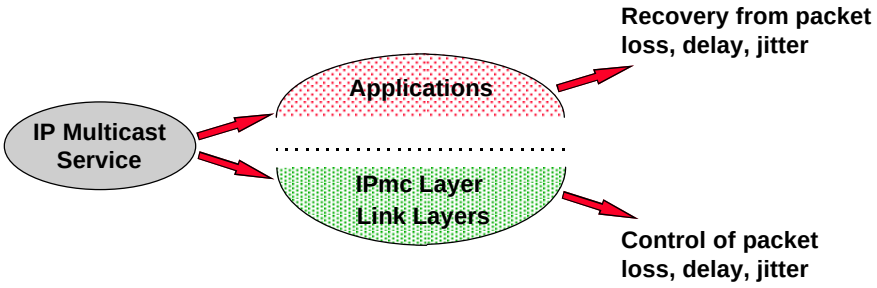
What type of QoS are we talking about?

- "Quality" of service has two components
  - Above the IP layer
  - IP layer and below….. we will focus here



Backbone packet transport issue

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- IP Packet streams vulnerable to congestion
  - Uncontrolled queuing and scheduling behavior during congestion leads to

    loss delay jitter
- IPmc transport is often "2nd-class citizen"
  - Relegated to slower, 'older' routers
  - Tunneled through unicast networks
  - No protection from transient congestion caused by bursty unicast (revenue generating) traffic
- What will change this?
  - Line-rate isolation of unicast traffic and multicast traffic on common switching/routing technologies
  - Operator comfort level

Isolating Unicast and Multicast traffic

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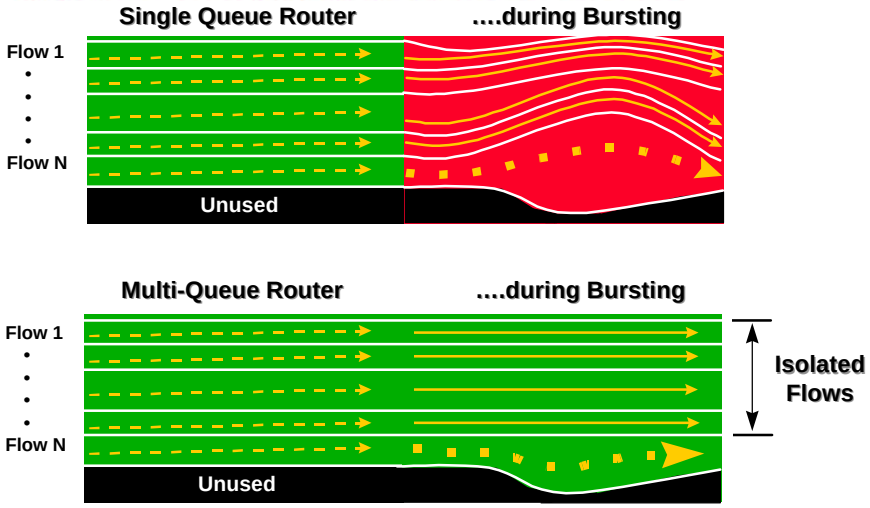

Multi-queue Routers Provide Isolation Between Traffic Classes

Hierarchy of Network QoS

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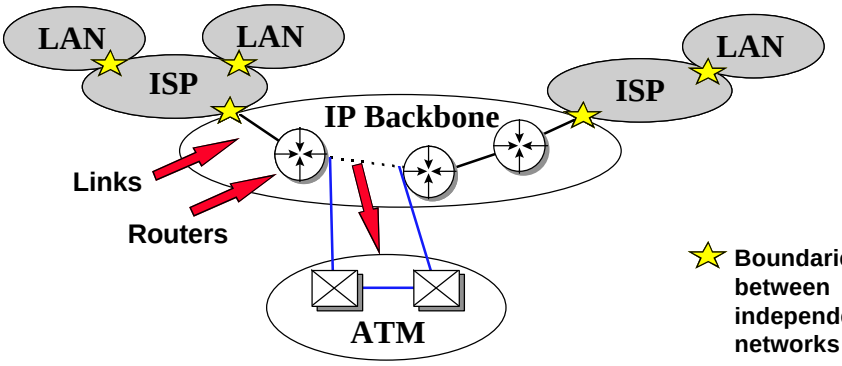
- End to End QoS depends on
  - Edge to Edge QoS
  - Router capabilities (e.g. diffserv, per-flow WFQ,….)
  - Link capabilities (e.g. ATM, MPLS/POS,...)



Managing congestion

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- Bursty and real-time traffic mix at routers/switches
  - Per-Router buffering absorbs transient overloads
  - Small buffers result in excessive packet loss
  - Large buffering leads to excessive delays
- *Need separate QUEUES (buffers) for traffic with different packet loss tolerance and burstiness*
- *Need traffic engineering to force packets along least congested paths*

"CQS" - Classify, Queue, Schedule

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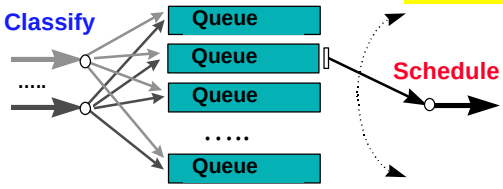
Classify
Establish context of the cells/packets

Queue
Absorb bursts, isolate customers

Schedule
Mediate access to link bandwidth
Ensure bounded delay/jitter



Establishing context

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- A number of popular solutions differ in how they carry context
  - *IP* context is full header (5 or 6 fields)
    - < 2^{104} permutations, multi-dimensional
  - *MPLS* context is carried in Label and CoS (Class of Service)
    - < 2^{20} (*2^3) permutations, index lookup
  - *ATM* context is carried in VPI/VCI
    - < 2^{20} permutations, index lookup
  - *DiffServ* context is carried in "DS" byte
    - < 2^6 permutations, direct/index lookup

Decreasing accuracy of classification

Increasing simplicity of classification

Bandwidth isolation at Link level

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- ATM
  - Non Broadcast Multiple Access (NBMA)
  - Awkward match to IP multicast service model
    - LANE BUS
    - RFC 2022 (MARS)
    - other….
- MultiProtocol Label Switching (MPLS)
  - L2 Switching, with L3 *routing controlled* paths
  - High efficiency POS links, but 'router' QoS needed at merge points
  - Re-use of ATM links, but routers still exist at ingress and egress to other packet links

Inband QoS fields for MPLS over POS

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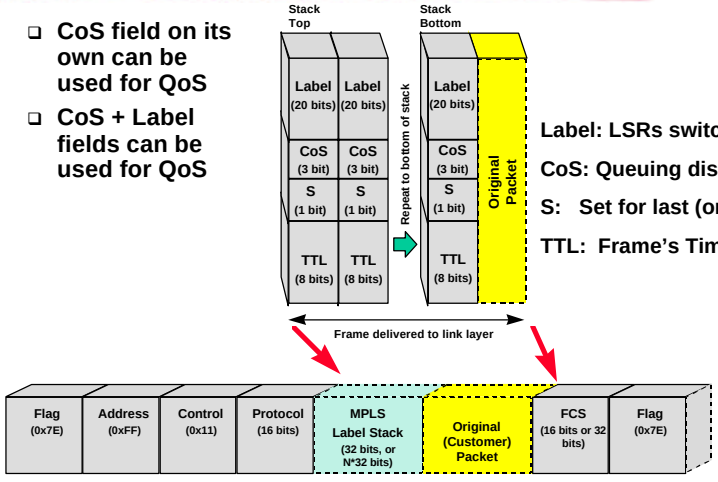
- CoS field on its own can be used for QoS
- CoS + Label fields can be used for QoS



Label: LSRs switch on this

CoS: Queuing discipline

S: Set for last (or only) label

TTL: Frame's Time To Live

Flags:
Opening and closing 0x7E flags belong to HDLC framing

Protocol:
0x0281 MPLS frame
0x0283 MPLS multicast frame

MPLS Label Stack:
One or more 32 bit Label Stack entries

Bandwidth Isolation….. routers at line rate?

- Various schemes, differing granularity
- DiffServ Routers
  - Per-ToS/DS classification/scheduling behaviors
  - Ingress mapping of IP multicast/tunnel traffic to distinct DS bytes
- Flow isolating Routers
  - Class D traffic can be isolated on a per-group basis (native IP multicast)
  - Per-tunnel isolation (classify on IP Src/Dst)
  - With per-tunnel/group WFQ
    - packet loss, jitter, delay are more controllable
- MPLS Flow Isolation
  - LSPs can be used as tunnel substitutes

Difficulties and Trade Offs

- Classification
  - High speeds traditionally require simple mechanism
- Queuing
  - Number of queues and their management is a problem at gigabit rate
- Scheduling
  - Required algorithms (e.g. Weighted Fair Queuing, WFQ) only recently implementable in hardware for variable packet sizes

DiffServ Compromise	MPLS Compromise
Edge: IP header classification	Edge: IP header classification
Core: DS-byte classification	Core: Label [+CoS] classification
Queues: Limited in the core	Queues: Unspecified
Traffic Engineering: Unspecified	Traffic Engineering: Supported

Weakness of limited queues and contexts

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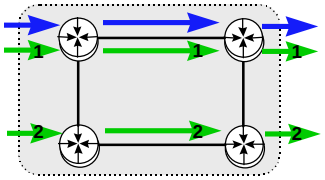
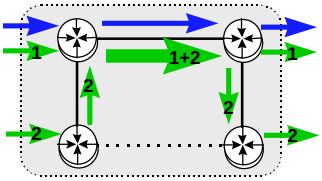
- With only limited 'contexts' for customer traffic:
  - Link utilization is engineered for 'normal' operation
- Failure of Edge shaping or WAN connectivity can re-route traffic in unpleasant ways
  - During the re-route, remaining path sees unicast traffic and multicast tunnels sharing queues in excess of engineered limits
  - Service deteriorates for all traffic on same "level"



Flow 1 and 2 have equal priority level - flow 2 is a multicast tunnel



When re-routed, Flows 1 and 2 map to the same queues

Network Robustness: More Queues and Contexts

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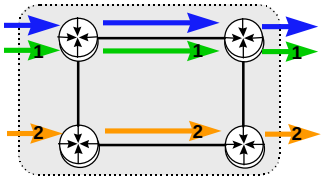
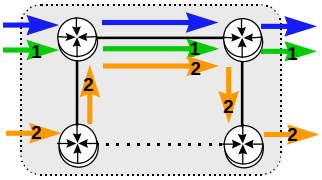
- If tunnels are mapped onto distinct 'contexts'
  - During the re-route, remaining path recognizes distinct 'context' for each tunnel and assigns distinct queues
  - *Potential service deterioration can be 'quarantined' to affect only the re-routed traffic*
- Line-rate WFQ across many queues is key to robust QoS architectures



Flows 1 and 2 have different contexts (e.g. full classification of encapsulating IP header)



When re-routed, Flows 1 and 2 map to different queues. Scheduling ensures isolation

Conclusion

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- Will DiffServ and MPLS help IP Multicast?
  - YES, although greater granularity preferable
- Are gigabit routers developing per-tunnel and per-LSP QoS capabilities?
  - YES
- Is there a good future for IP Multicast QoS?
  - YES