Quality of Service

Principles, IntServ, RSVP, DiffServ
Improving QOS in IP Networks

- IETF groups are working on proposals to provide better QOS control in IP networks, i.e., going beyond best effort to provide some assurance for QOS.
- Work in Progress includes RSVP, Differentiated Services, and Integrated Services.
- Simple model for sharing and congestion studies:
Principles for QOS Guarantees

- Consider a phone application at 1Mbps and an FTP application sharing a 1.5 Mbps link.
  - bursts of FTP can congest the router and cause audio packets to be dropped.
  - want to give priority to audio over FTP
- PRINCIPLE 1: Marking of packets is needed for router to distinguish between different classes; and new router policy to treat packets accordingly
Principles for QOS Guarantees (more)

- Applications misbehave (audio sends packets at a rate higher than 1Mbps assumed above);
- PRINCIPLE 2: provide protection (isolation) for one class from other classes
- Require Policing Mechanisms to ensure sources adhere to bandwidth requirements; Marking and Policing need to be done at the edges:
Principles for QOS Guarantees (more)

- Alternative to Marking and Policing: allocate a set portion of bandwidth to each application flow; can lead to inefficient use of bandwidth if one of the flows does not use its allocation.
- PRINCIPLE 3: While providing isolation, it is desirable to use resources as efficiently as possible.
Principles for QOS Guarantees (more)

- Cannot support traffic beyond link capacity
- **PRINCIPLE 4:** Need a Call Admission Process; application flow declares its needs, network may block call if it cannot satisfy the needs
Summary

QoS for networked applications

- Packet classification
- Isolation, scheduling, and policing
- High resource utilization
- Call admission
Scheduling And Policing Mechanisms

- **Scheduling**: choosing the next packet for transmission on a link can be done following a number of policies;
- **FIFO**: in order of arrival to the queue; packets that arrive to a full buffer are either discarded, or a discard policy is used to determine which packet to discard among the arrival and those already queued.

![Diagram of packet scheduling](image)
Scheduling Policies

- Priority Queuing: classes have different priorities; class may depend on explicit marking or other header info, e.g., IP source or destination, TCP Port numbers, etc.
- Transmit a packet from the highest priority class with a non-empty queue
- Preemptive and non-preemptive versions
Scheduling Policies (more)

- Round Robin: scan class queues serving one from each class that has a non-empty queue
Scheduling Policies (more)

- Weighted Fair Queuing: is a generalized Round Robin in which an attempt is made to provide a class with a differentiated amount of service over a given period of time.
Policing Mechanisms

● Three criteria:
  – (Long term) Average Rate (100 packets per sec or 6000 packets per min?), crucial aspect is the interval length
  – Peak Rate: e.g., 6000 p p minute Avg and 1500 p p sec Peak
  – (Max.) Burst Size: Max. number of packets sent consecutively, ie over a short period of time
Policing Mechanisms

- Token Bucket mechanism, provides a means for limiting input to specified Burst Size and Average Rate.
Policing Mechanisms (more)

- Bucket can hold $b$ tokens; tokens are generated at a rate of $r \text{ token/sec}$ unless the bucket is full of tokens.
- Over an interval of length $t$, the number of packets that are admitted is less than or equal to $(r t + b)$.
- Token bucket and WFQ can be combined to provide an upper bound on delay.
Integrated Services

- An architecture for providing QoS guarantees in IP networks for individual application sessions
- relies on resource reservation, and routers need to maintain state info (Virtual Circuit??), maintaining records of allocated resources and responding to new Call setup requests on that basis
Call Admission

- Session must first declare its QOS requirement and characterize the traffic it will send through the network
- **R-spec**: defines the QOS being requested
- **T-spec**: defines the traffic characteristics
- A signaling protocol is needed to carry the R-spec and T-spec to the routers where reservation is required; RSVP is a leading candidate for such signaling protocol
Call Admission

- Call Admission: routers will admit calls based on their R-spec and T-spec and base on the current resource allocated at the routers to other calls.

1. Request: specify
   - traffic (Tspec)
   - guarantee (Rspec)

2. Element considers
   - unreserved resources
   - required resources

3. Reply: whether or not request can be satisfied
Integrated Services: Classes

- **Guaranteed QOS:** this class is provided with firm bounds on queuing delay at a router; envisioned for hard real-time applications that are highly sensitive to end-to-end delay expectation and variance.

- **Controlled Load:** this class is provided a QOS closely approximating that provided by an unloaded router; envisioned for today’s IP network real-time applications which perform well in an unloaded network.
Differentiated Services

- Intended to address the following difficulties with Intserv and RSVP;
- **Scalability**: maintaining states by routers in high speed networks is difficult due to the very large number of flows
- **Flexible Service Models**: Intserv has only two classes, want to provide more qualitative service classes; want to provide ‘relative’ service distinction (Platinum, Gold, Silver, Lead …)
- **Simpler signaling**: (than RSVP) applications and users may only want to specify a more qualitative notion of service
Differentiated Services

- **Approach:**
  - Only simple functions in the core, and relatively complex functions at edge routers (or hosts)
  - Do not define service classes, instead provides functional components with which service classes can be built
Edge Functions

- At DS-capable host or first DS-capable router
- **Classification**: edge node marks packets according to classification rules to be specified (manually by admin, or by some TBD protocol)
- **Traffic Conditioning**: edge node may delay and then forward or may discard
Core Functions

- **Forwarding**: according to “Per-Hop-Behavior” or PHB specified for the particular packet class; such PHB is strictly based on class marking (no other header fields can be used to influence PHB)

- **BIG ADVANTAGE**: No state info to be maintained by routers!
Classification and Conditioning

- Packet is marked in the Type of Service (TOS) in IPv4, and Traffic Class in IPv6
- 6 bits used for Differentiated Service Code Point (DSCP) and determine PHB that the packet will receive
- 2 bits are currently unused
Classification and Conditioning

- It may be desirable to limit traffic injection rate of some class; user declares traffic profile (e.g., rate and burst size); traffic is metered and shaped if non-conforming.
Forwarding (PHB)

- PHB result in a different observable (measurable) forwarding performance behavior
- PHB does not specify what mechanisms to use to ensure required PHB performance behavior
- Examples:
  - Class A gets x% of outgoing link bandwidth over time intervals of a specified length
  - Class A packets leave first before packets from class B
Forwarding (PHB)

- PHBs under consideration:
  - Expedited Forwarding: departure rate of packets from a class equals or exceeds a specified rate (logical link with a minimum guaranteed rate)
  - Assured Forwarding: 4 classes, each guaranteed a minimum amount of bandwidth and buffering; each with three drop preference partitions
Differentiated Services Issues

- AF and EF are not even in a standard track yet... research ongoing
- “Virtual Leased lines” and “Olympic” services are being discussed
- Impact of crossing multiple ASs and routers that are not DS-capable