Advanced Computer Networks

Quality of Services

Jianping Pan
Summer 2007

Internet design

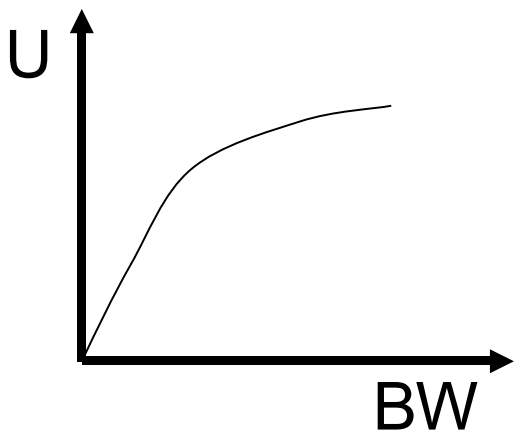
- Current: best-effort services
  - no admission control
  - no delivery guarantee
- Elastic applications
  - tolerate delay/loss and adapt to congestion
  - e.g., bulk data transfer such as FTP, SMTP
- New “real-time” applications
  - “soft” real-time: e.g., multimedia streaming
  - “hard” real-time: e.g., interactive control

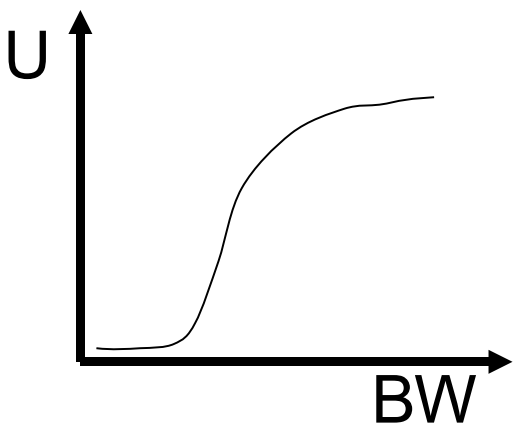
Quality of services

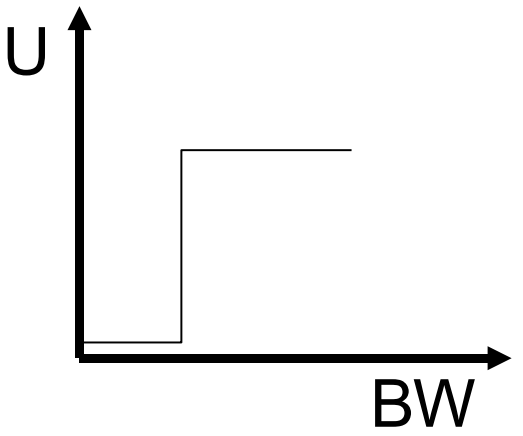
- Application's point of view
  - throughput guarantee
  - delay and jitter bound
    - one-way and/or two-way
  - loss tolerance
- Network's point of view
  - achievable bandwidth
  - packet delay and jitter
  - packet loss rate

Utility functions

- Utility: user satisfaction
  - vs throughput, delay/jitter, loss, etc
- Utility curves
  - e.g., elastic, adaptive, threshold, etc







Ingredients of QoS

- Differentiation
  - be able to treat different (types of) flows differently
  - packet classification, marking
- Protection
  - one flow cannot adversely affect others
  - packet scheduling, policing
- Sharing
  - resource utilization
- Admission control

Integrated services

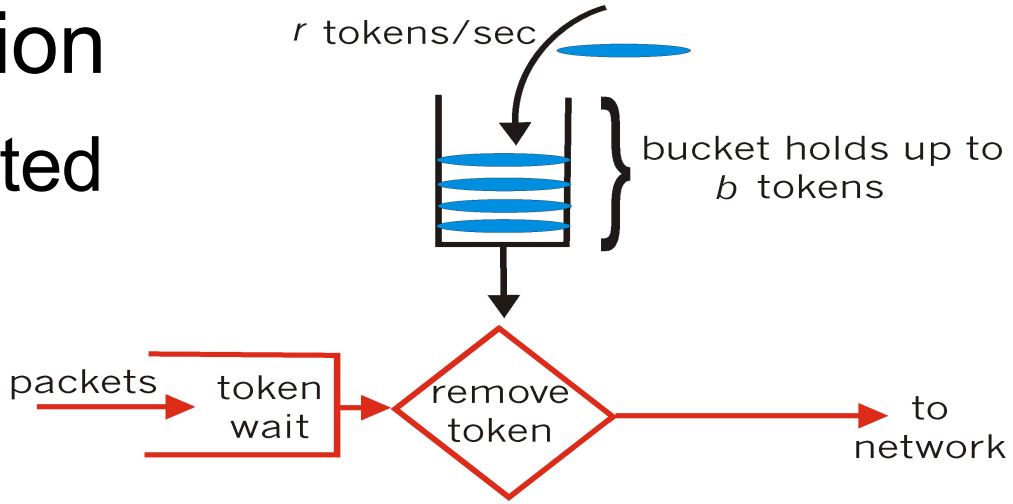
- IETF IntServ
  - per-flow QoS
  - flow: 5-tuple
- Service commitments
  - guaranteed, controlled load, best effort
- Service interfaces
  - T-spec, R-spec
- Packet scheduling
- Admission control

IntServ Services

- Guaranteed services
  - hard real-time applications
  - admission control, resource reservation
  - guaranteed QoS metrics
- Controlled load
  - soft real-time and adaptive application
  - measurement-based admission control
  - performance close to a lightly loaded network
- Best effort

Service interfaces

- T-spec: traffic specification
  - e.g., leaky-bucket regulated
  - (r,b)-regulated
- R-spec
  - e.g., rate reservation
- Signaling protocol
  - e.g., RSVP



Resource reservation

- RSVP messages
  - PATH
    - T-spec, AD-spec
  - RESV
    - T-spec, R-spec
- Receiver-initiated reservation
- Soft-state maintenance
- Multicast-oriented design
  - reservation filters

Packet scheduling

- Guaranteed services
  - (r,b)-regulated traffic
  - WFQ scheduling
  - queuing delay bound: b/r
- Predicted services
  - e.g., FIFO+

Admission control

- Guaranteed services
  - equation-based admission control
  - based on worst case traffic characteristics
    - e.g., peak data rate
- Predicted services
  - measurement-based admission control
  - based on average traffic characteristics

Issues with IntServ

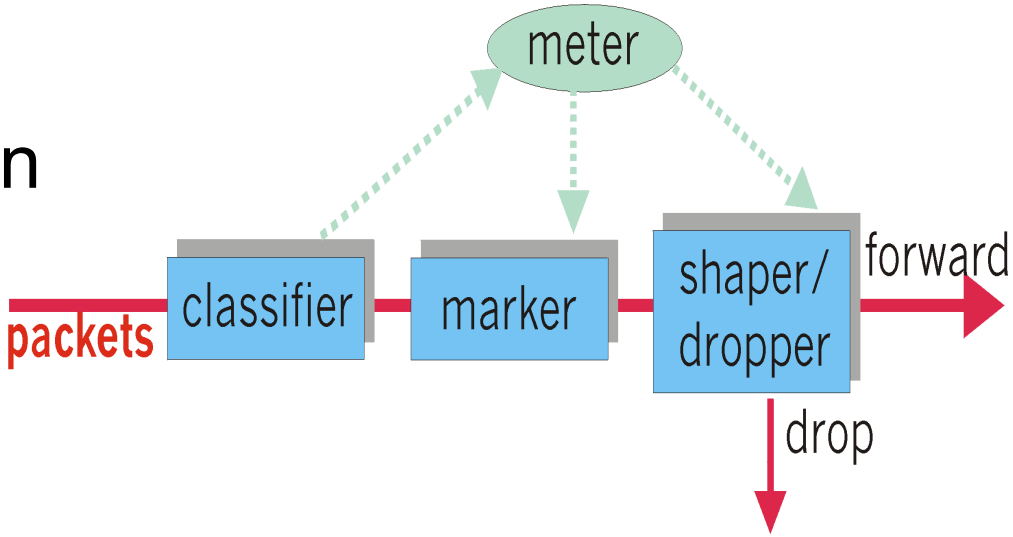
- Per-flow states
  - traffic specification
  - resource reservation
  - packet classification
  - packet scheduling
- Inter-domain issues

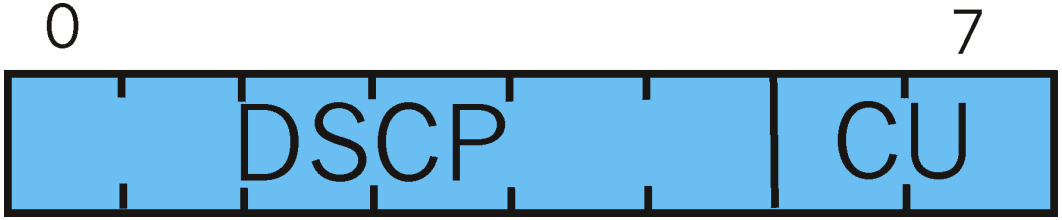
Differentiated services

- DiffServ
  - class-based QoS
  - SLA: service-level agreement between ISPs
- Goals of DiffServ
  - scalability
    - no per-flow states
  - flexibility
    - more than just GS and CL
  - deployability
    - evolution not revolution

Edge routers

- Classification
  - based on flow information
- Metering
  - traffic measurement
- Marking
  - overload IP TOS (type-of-service): DS code point
- Conditioning
  - in-profile: forward
  - out-of-profile: drop or reshaping





Core routers: forwarding

- Expedited forwarding (EF)
  - “virtual-circuit” applications: low-loss/delay/jitter
  - a minimum rate of EF traffic
  - admission based on peak rate
  - nonconforming packets are dropped or reshaped
- Assured forwarding (AF)
  - adaptive applications: gold, silver, bronze services
  - 4 classes of bandwidth/buffer allocation
  - 3 drop preferences in each class
  - nonconforming packets are marked

Student presentation

- Haoling Ma: CSFQ
  - [SSZ98] I. Stoica , S. Shenker , and H. Zhang , "Core -Stateless Fair Queueing: Achieving Approximately Fair Allocations in High Speed Networks" , Proc. ACM SIGCOMM , Vancouver, Canada, September 1998. [CSFQ]

Further discussion

- Research vs engineering approaches
  - QoS provisioning
  - resource overprovisioning

This lecture

- Internet quality of services
  - integrated services: fine-grained
  - differentiated services: coarse-grained
- Explore further
  - IntServ RFC 1633
  - DiffServ RFC 2475

Next lectures

- Network characterization
  - [FFF99] Michalis Faloutsos, Petros Faloutsos, and Christos Faloutsos, "On Power-Law Relationships of the Internet Topology". In Proceedings of SIGCOMM '99.
  - [LAWD04] Lun Li, David Alderson, Walter Willinger, John Doyle. A First-Principles Approach to Understanding the Internet's Router-Level Topology. In SIGCOMM 2004.
- Course projects presentation
  - July 25, July 30 and August 1