

# Computer Networks Homework #10

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# Quality of Service Building Blocks

- Q: Name three building blocks of Quality of Service?
- **Classification:** distinguish one flow/class from another
- **Policing:** ensure the traffic is in conformant to the contracted parameters
- **Scheduling:** ensure the QoS guarantees (e.g., bandwidth, delay)
- **Admission control and resource reservation:** check if resource requirements can be met and admit or deny flows accordingly

# Scheduling Policies

- Q: Name and characterize four scheduling policies that were introduced in the lecture.
- **First In First Out (FIFO)**
  - Packets are sent in order of arrival
  - If queue is full, discard either
    - Newly arriving packets
    - Packets based on priority
    - Random packets

# Scheduling Policies (cont'd)

- Priority Scheduling
  - Packets are sent in order of priority
- Round Robin
  - Packets are sent alternating between different classes
- Weighted Fair Queuing
  - Combination of Priority Scheduling and Round Robin
  - Weighted amount of packets sent from each class every cycle

# Policing

- Q: What are the criteria that policing mechanisms can use to control a data stream?
- (Long term) Average Rate
  - E.g. 6,000 packets per min (ppm)
- Peak Rate
  - E.g. 6,000 ppm on avg but limited to 1,500 packets per sec (pps) peak rate
- (Max.) Burst Size
  - E.g. 500 packets

# Packet Scheduling

- Q: Illustrate in what sequence packets from three different queues (a, b, c) can be sent from a sending buffer that implements a WFQ scheduling policy. Suppose the weights for the queues are 0.25, 0.25, and 0.5.
- How could the sequence look like if there are no packets in queue 'c'?
- abcc abcc abcc -or- acbc acbc acbc
- abab abab abab

# Token Bucket

- Q: Consider a token bucket that is filled with a rate of 1,000 tokens/min and has a size of 500 tokens. Each bit of data consumes one token. Does a flow of 20bps conform to this bucket?
- 20 bit per second = 1,200 bit per minute  
→ excess of 200 bit per minute
- => The flow does not conform to this bucket
- However: If the bucket is full, flow has 2.5 min to adjust (500 tokens / 200 tokens/min)

# Delay Guarantees

- Q: Assume a router maintains QoS guarantees for two data flows. Flow a is policed by a token bucket with a capacity of 100 tokens a fill rate of 20 token/sec. Flow b is policed by a token bucket with a capacity of 200 tokens and a fill rate of 12 token/sec. The router uses weighted fair queuing to schedule the packets with a weight of 3 for flow a and a weight of 2 for flow b. It's sending rate is 40 packets/sec. What is the upper bound delay that the router can guarantee for both flows?



# Delay Guarantees (sol.)

- Flow A
  - 20 tokens/sec plus 100 tokens if filled
  - Worst case: 100 tokens worth of traffic instantaneously => Queue for A fills up with 100 packets
  - Outgoing rate is 40 packets/sec of which A is allocated at least  $3/5$  => 24 packets/sec
  - Worst case: A has average (incoming) flow rate of 20 packets/sec => only at least 4 packets/sec can be removed from the queue
  - Last packet in the queue will be delivered after  $100/4 = 25$  sec

# Delay Guarantees (sol.)

- Flow B
  - 12 tokens/sec plus 200 tokens if filled
  - Worst case: 200 tokens worth of traffic instantaneously => Queue for B fills up with 200 packets
  - Outgoing rate is 40 packets/sec of which B is allocated at least  $2/5$  => 16 packets/sec
  - Worst case: B has average (incoming) flow rate of 12 packets/sec => only at least 4 packets/sec can be removed from the queue
  - Last packet in the queue will be delivered after  $200/4 = 50$  sec

# IntServ and DiffServ

- Q: Briefly compare the IntServ to the DiffServ architecture.

Criteria	DiffServ	IntServ
Based on	Aggregated service classes	Single flow
Level of control	Coarse-grained	Fine-grained
Basic principle	Traffic classification	Resource reservation
States	Edge: per flow Core: none	Every node: per flow
Setup	Per class (long-term)	Per flow
Scalability	Average	Bad

# Thank you

Any questions?