

Lecture 20:

Traffic Management

CSE 123: Computer Networks
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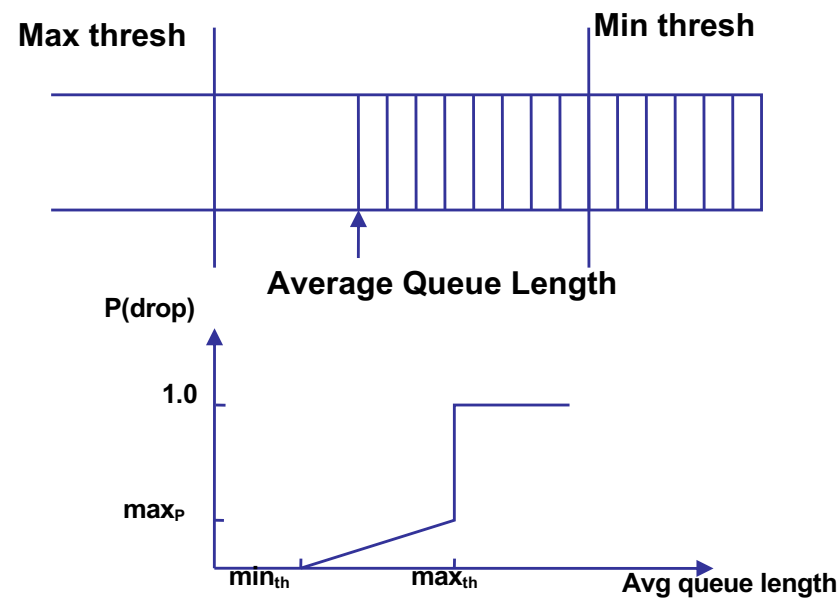


Lecture 20 Overview



- Dealing with non-responsive traffic
 - ◆ Token bucket
 - ◆ Policing and shaping
- Scheduling
 - ◆ (Weighted) Fair Queuing

RED Operation

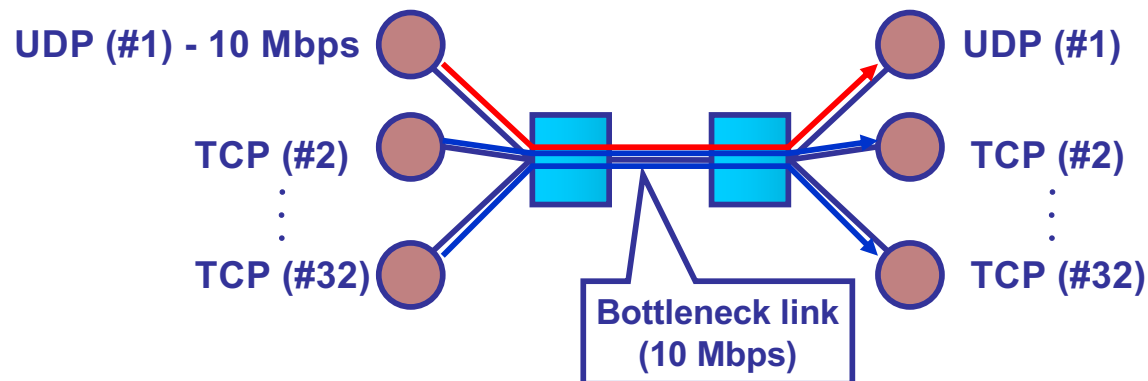


- Encourages responsive flows to slow down

Non-responsive Senders



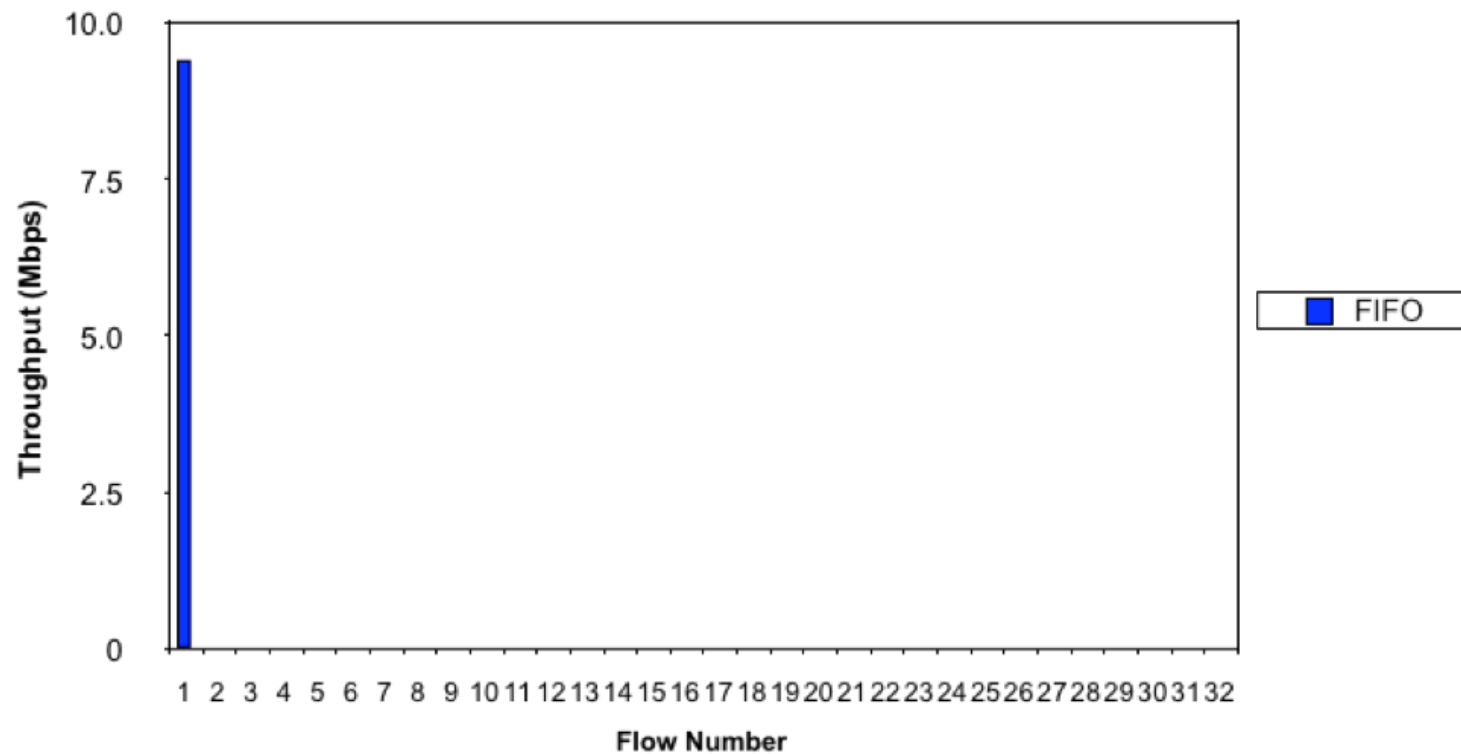
1 UDP and 31 TCPs sharing a 10 Mbps link



How will the bottleneck link be shared?

- A. All flows share equally (1/3.2 Mbps)
- B. Each TCP gets 1/3.1 Mbps, UDP gets ~0 Mbps
- C. UDP gets 10 Mbps, Each TCP gets ~0 Mbps
- D. Depends on the identity of the sender/receivers

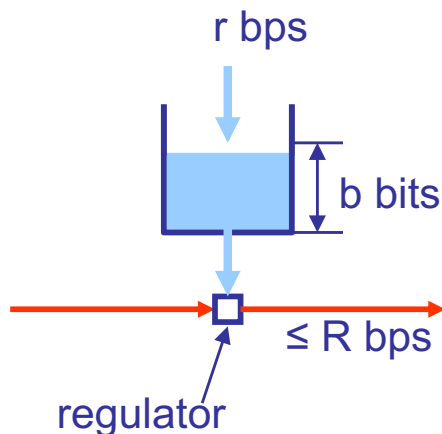
UDP vs. TCP



Token Bucket Basics



- Parameters
 - ♦ r – average rate, i.e., rate at which tokens fill the bucket
 - ♦ b – bucket depth (limits size of burst)
 - ♦ R – maximum link capacity or peak rate (optional parameter)
- A packet can be transmitted only when sufficient tokens are available



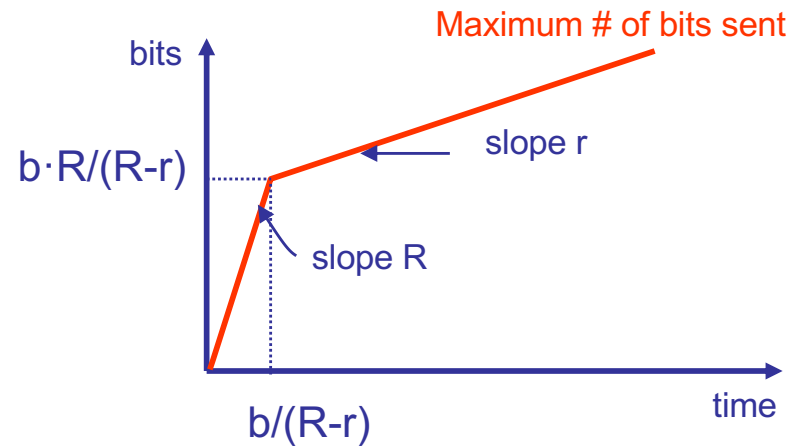
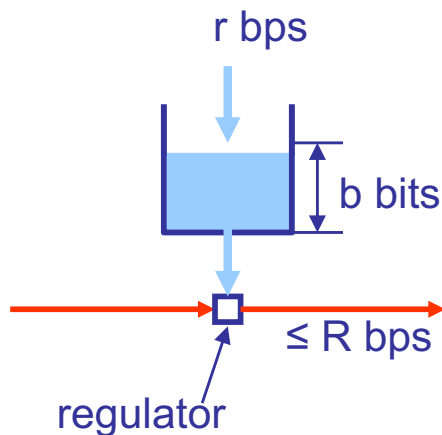
How fast can packets actually be sent?

- A. At most b bps**
- B. At most r bps**
- C. At most $(r+b)$ bps**
- D. At most R bps**

Token Bucket Basics



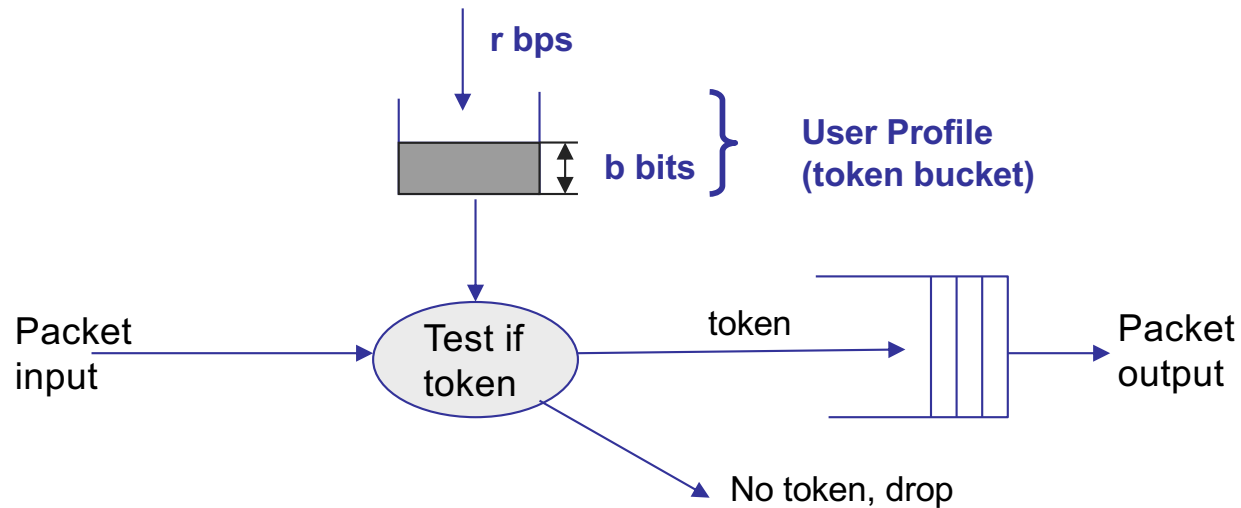
- Parameters
 - r – average rate, i.e., rate at which tokens fill the bucket
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- A packet can be transmitted only when sufficient tokens are available



Traffic Policing



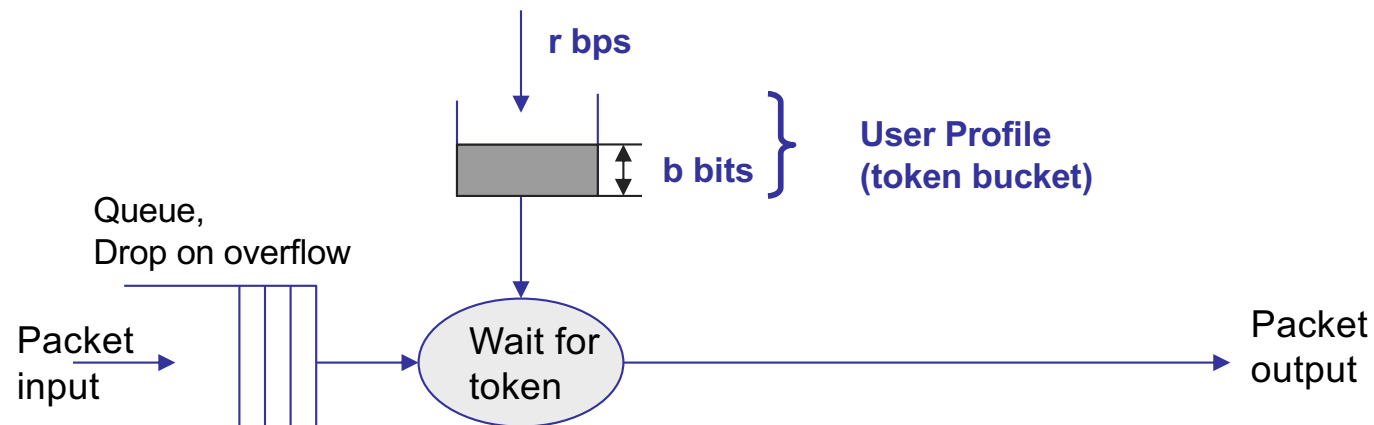
- Drop packets that don't meet **user profile**
- Output limited to average of r bps and bursts of b



Traffic Shaping



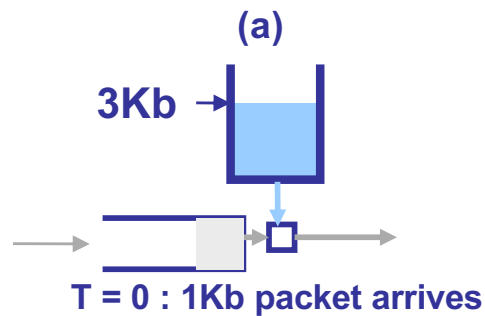
- Shape packets according to user profile
- Output limited to average of r bps and bursts of b



Shaping Example



- $r = 100$ Kbps; $b = 3$ Kb; $R = 500$ Kbps



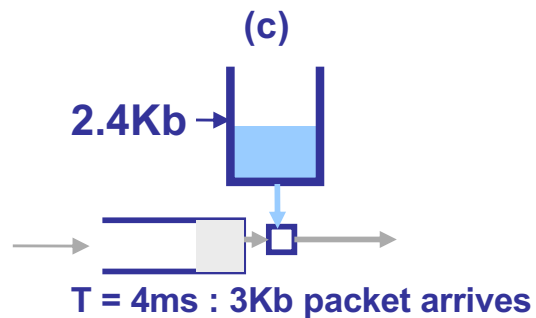
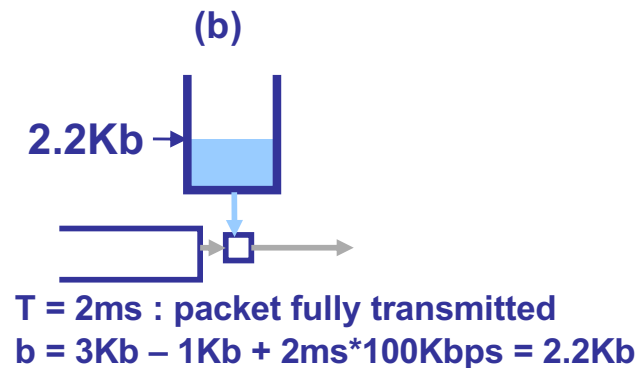
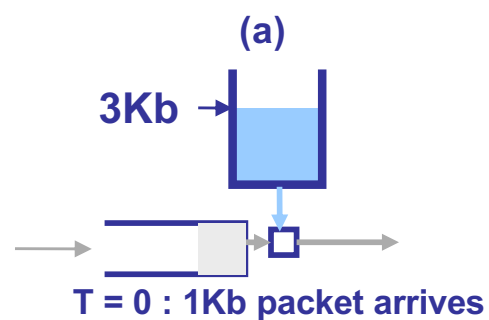
How full is the bucket when the packet fully departs?

- A. 3 Kb
- B. 2.2 Kb
- C. 2 Kb
- D. 0 Kb

Shaping Example



- $r = 100 \text{ Kbps}$; $b = 3 \text{ Kb}$; $R = 500 \text{ Kbps}$



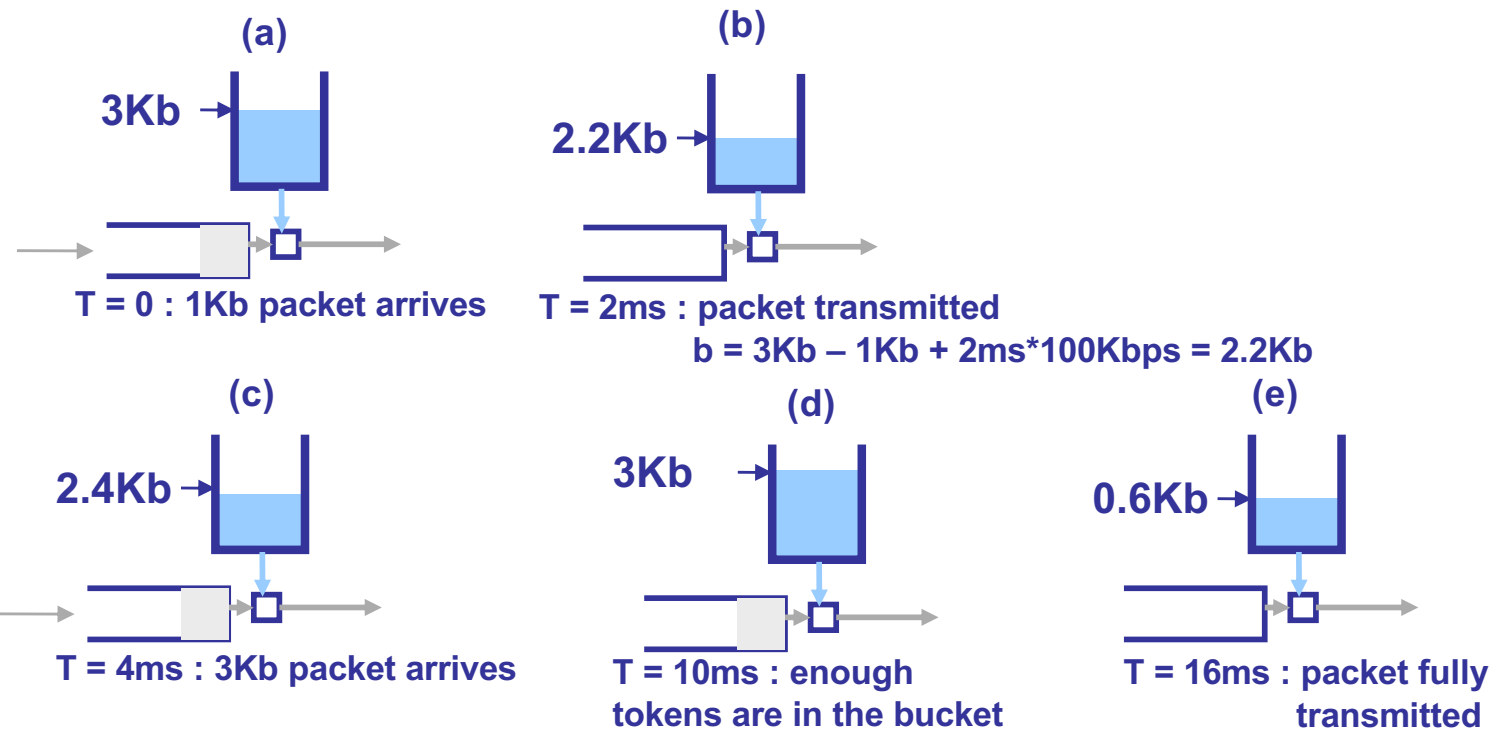
When does this packet start leaving?

- A. $T = 4 \text{ ms}$
- B. $T = 5.2 \text{ ms}$
- C. $T = 10 \text{ ms}$
- D. $T = 16 \text{ ms}$

Shaping Example



- $r = 100 \text{ Kbps}$; $b = 3 \text{ Kb}$; $R = 500 \text{ Kbps}$

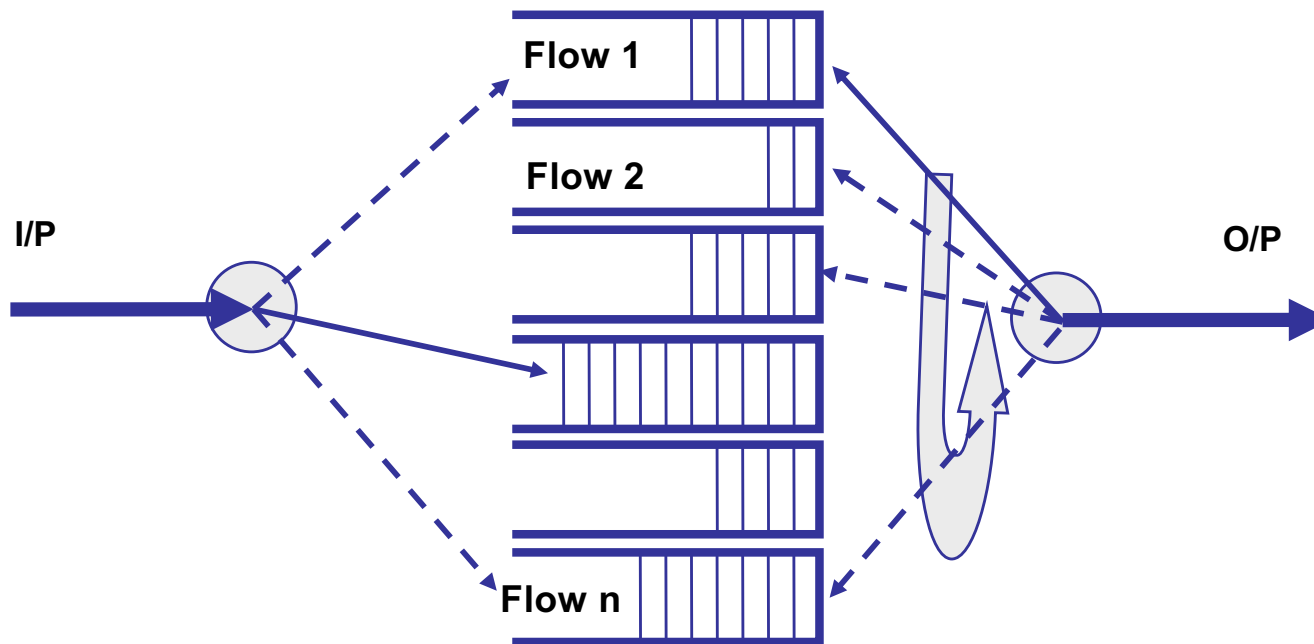


Scheduling



- So far we've done flow-based traffic management
 - ♦ Limit the rate of one flow regardless of the load in the network
- In general, need **scheduling**
 - ♦ Dynamically allocate resources when multiple flows compete
 - ♦ Give each “flow” (or traffic class) own queue (at least theoretically)
- Weighted fair queuing
 - ♦ Proportional share scheduling
 - ♦ Schedule round-robins among queues in proportion to some weight parameter

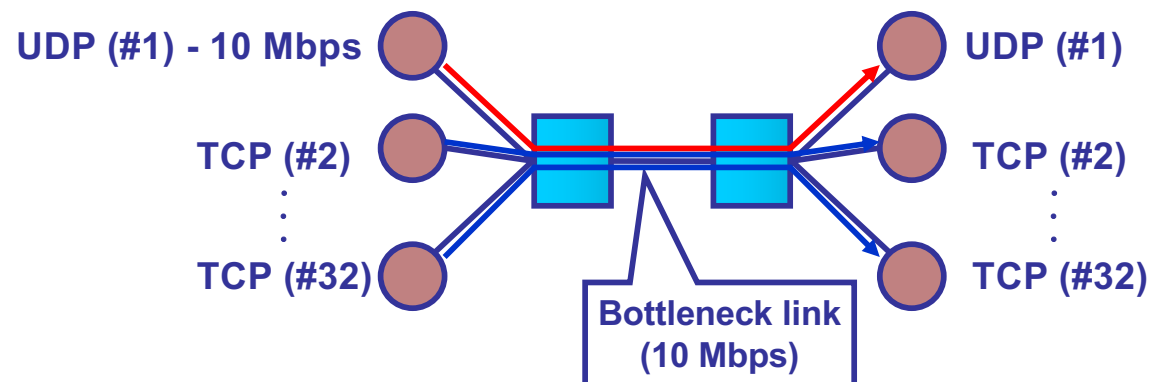
(Weighted) Fair Queuing



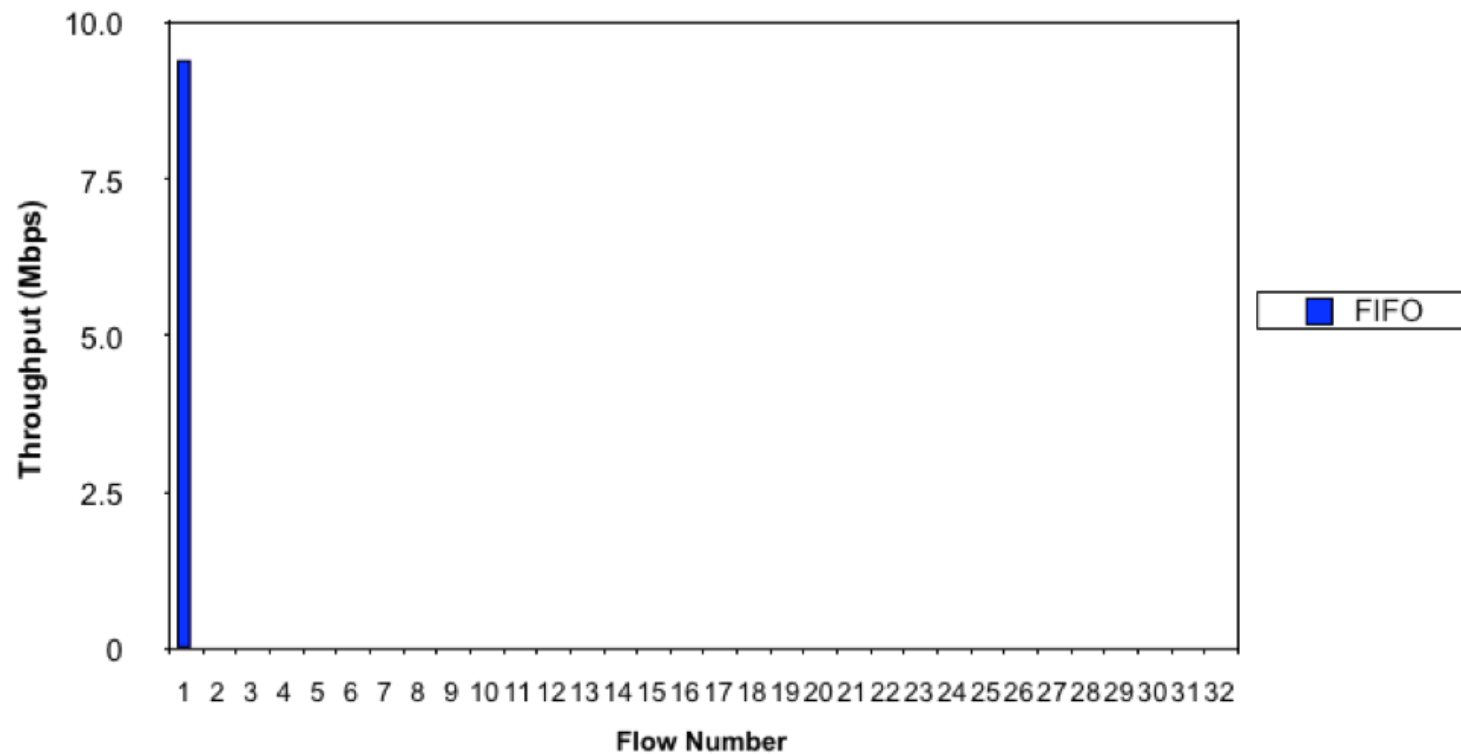
Our Previous Example



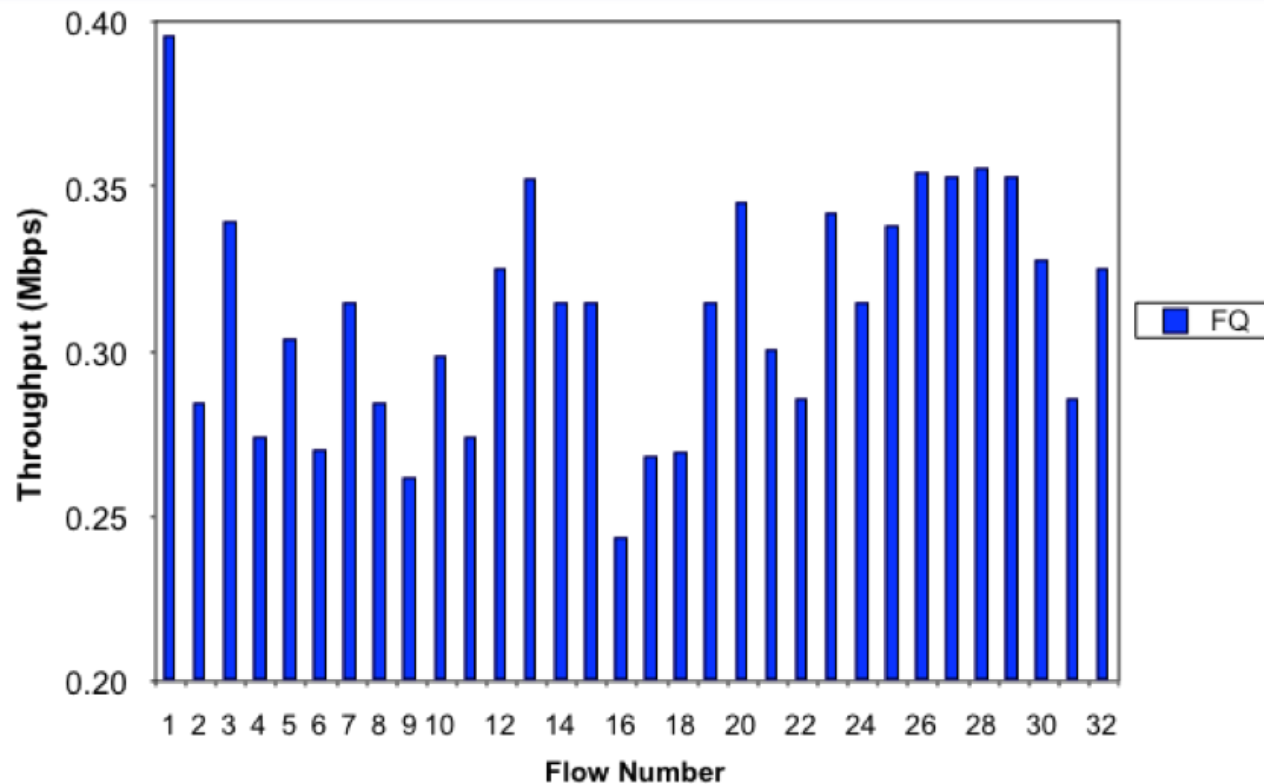
1 UDP (10 Mbps) and 31 TCPs sharing a 10 Mbps line



UDP vs. TCP w/FIFO



TCP vs. UDP w/Fair Queuing



Fair Queuing



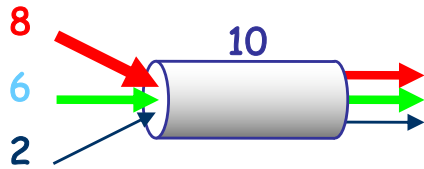
- Maintain a queue for each flow
 - ♦ What is a flow?
- Implements **max-min fairness**: each flow receives $\min(r_i, f)$, where
 - ♦ r_i – flow arrival rate
 - ♦ f – link fair rate (see next slide)
- **Weighted Fair Queuing** (WFQ) – associate a weight with each flow to divvy bandwidth up non-equally

Fair Rate Computation



- If link congested, compute f such that

$$\sum_i \min(r_i, f) = C$$



What should f be in this example?

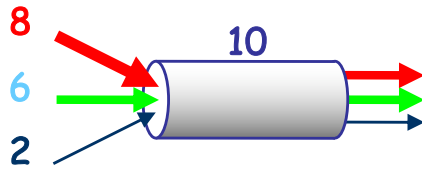
- A. 10/3
- B. 6
- C. 4
- D. 2

Fair Rate Computation



- If link congested, compute f such that

$$\sum_i \min(r_i, f) = C$$



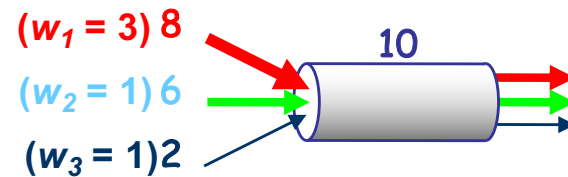
$f = 4$:
 $\min(8, 4) = 4$
 $\min(6, 4) = 4$
 $\min(2, 4) = 2$



Another Example

- Associate a weight w_i with each flow i
- If link congested, compute f such that

$$\sum_i \min(r_i, f \times w_i) = C$$



$$\begin{aligned} f &= 2: \\ \min(8, 2 \times 3) &= 6 \\ \min(6, 2 \times 1) &= 2 \\ \min(2, 2 \times 1) &= 2 \end{aligned}$$

Flow i is guaranteed to be allocated a rate $\geq w_i \cdot C / (\sum_k w_k)$



If $\sum_k w_k \leq C$, flow i is guaranteed to be allocated a rate $\geq w_i$

For next time...



- Read P&D 6.3-4
- Get going on Project 2b