Lecture 18: Buffering & Scheduling

CSE 123: Computer Networks

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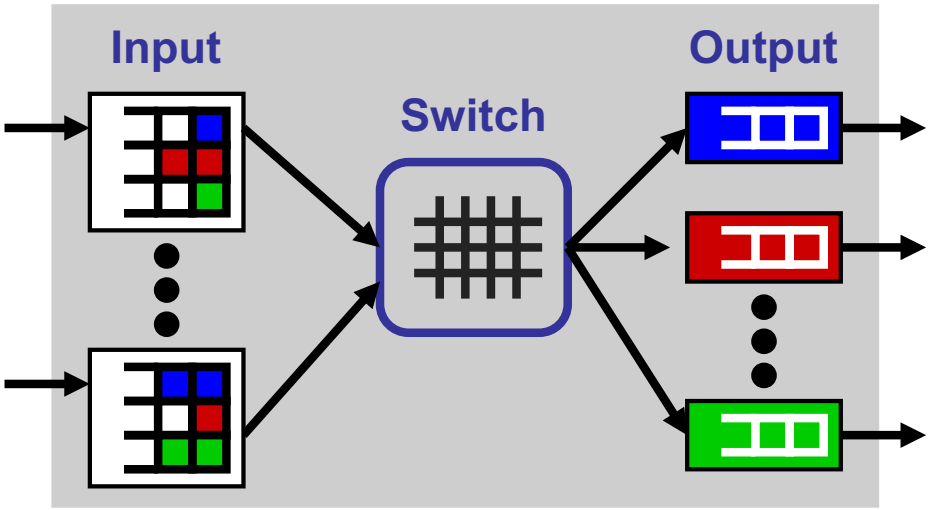
Lecture 18 Overview

- Buffer Management
  - FIFO
  - RED
- Traffic Policing/Scheduling

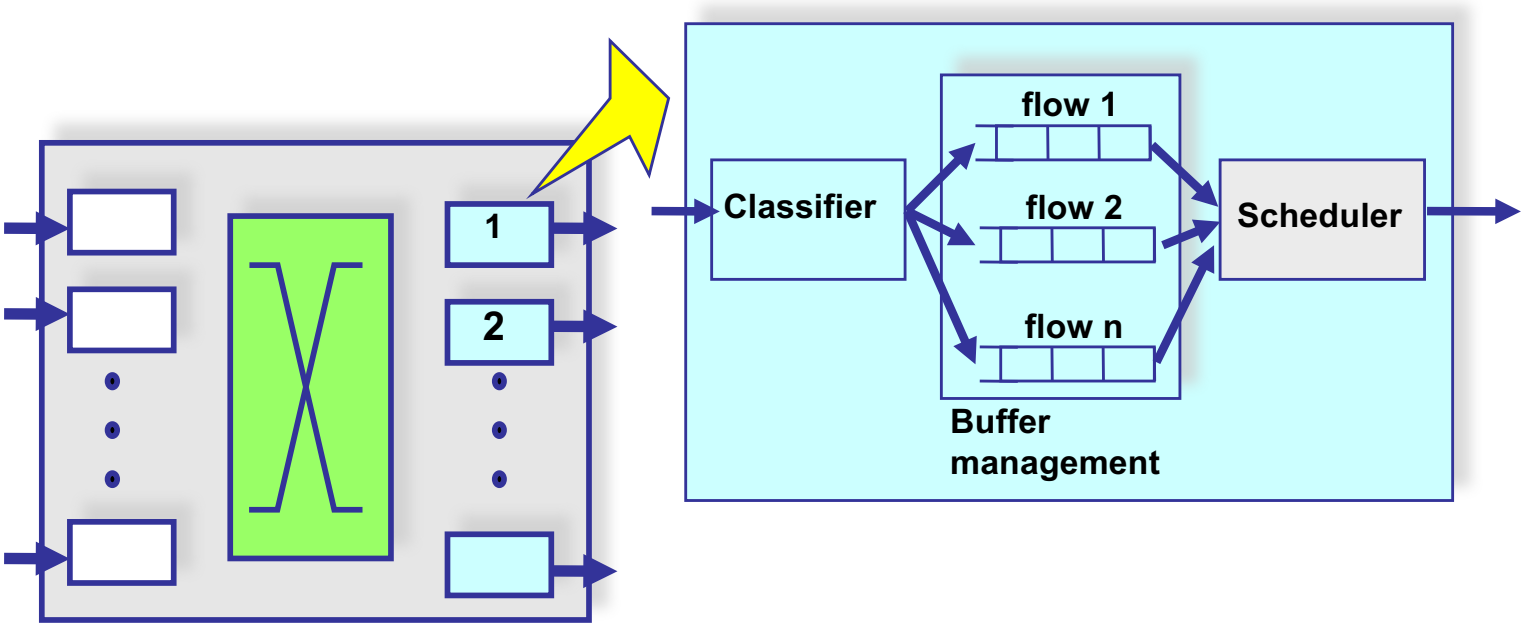
Typical high-performance router

- IQ + VoQ + OQ
  - Speedup of 2
  - Central scheduler
  - Fixed-sized internal cells
- Pro
  - Can achieve utilization of 1
  - Can scale to > Tb/s
- Con
  - Multiple congestion points
  - Complexity



Key Router Challenges

- Buffer management: which packet to drop when?
  - We only have finite-length queues
- Scheduling: which packet to transmit next?



Basic Buffer Management

- FIFO + drop-tail
  - Simplest choice
  - Used widely in the Internet
- FIFO (first-in-first-out)
  - Implies single class of traffic
- Drop-tail
  - Arriving packets get dropped when queue is full regardless of flow or importance
- Important distinction:
  - FIFO: scheduling discipline
  - Drop-tail: drop policy

FIFO/Drop-Tail Problems

- Leaves responsibility of congestion control completely to the edges (e.g., TCP)
- Does not separate between different flows
- No policing: send more packets → get more service
- Synchronization: end hosts react to same events

Active Queue Management

- Design active router queue management to aid congestion control

- Why?
  - Router has unified view of queuing behavior
  - Routers see actual queue occupancy (distinguish queue delay and propagation delay)
  - Routers can decide on transient congestion, based on workload

Design Objectives

- Keep throughput high and delay low
  - High power (throughput/delay)
- Accommodate bursts
- Queue size should reflect ability to accept bursts rather than steady-state queuing
- Improve TCP performance with minimal hardware changes in router

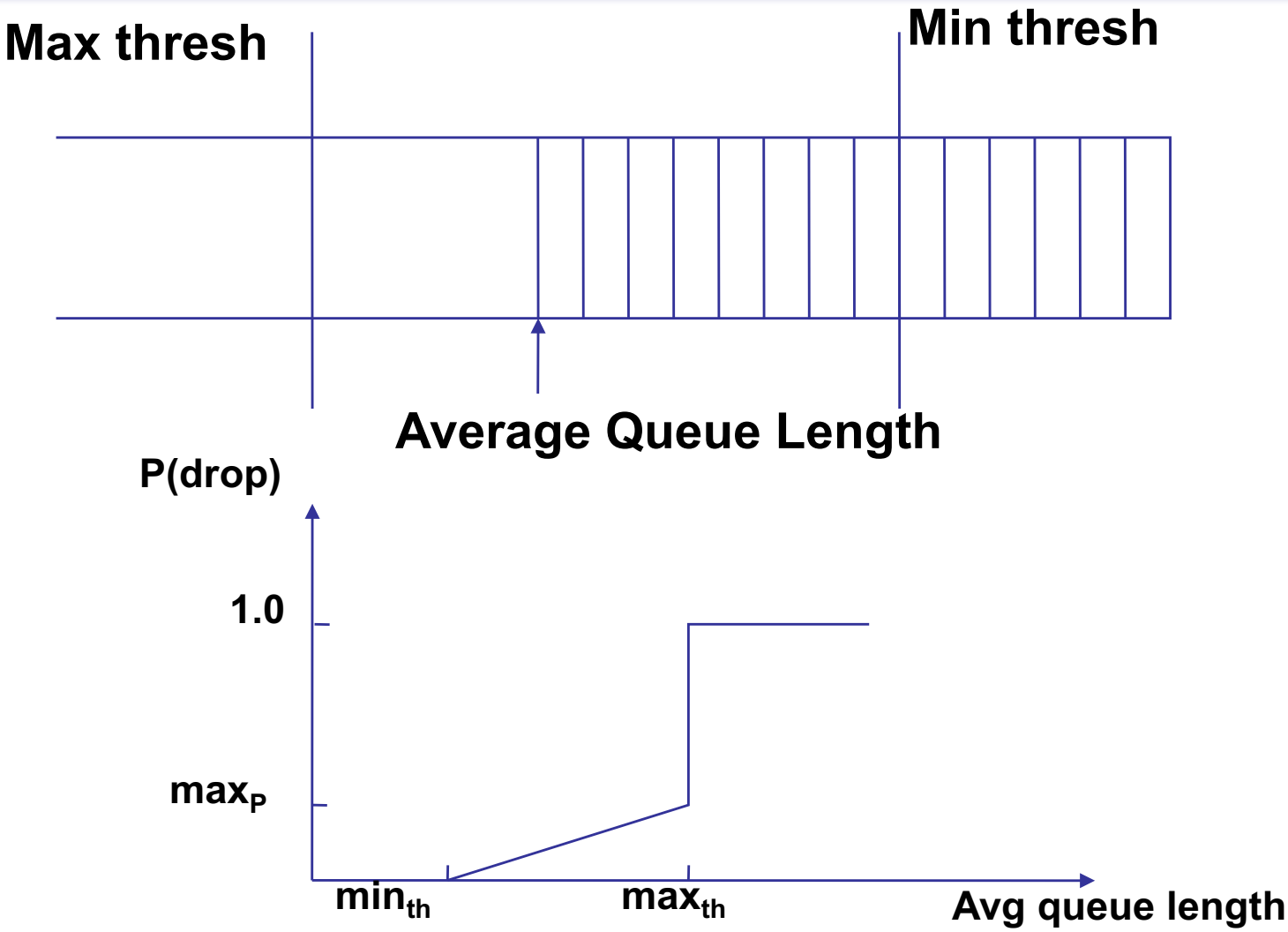
Random Early Detection

- Detect incipient congestion
- *Assume* hosts respond to lost packets
- Avoid window synchronization
  - Randomly mark packets
- Avoid bias against bursty traffic

RED Algorithm

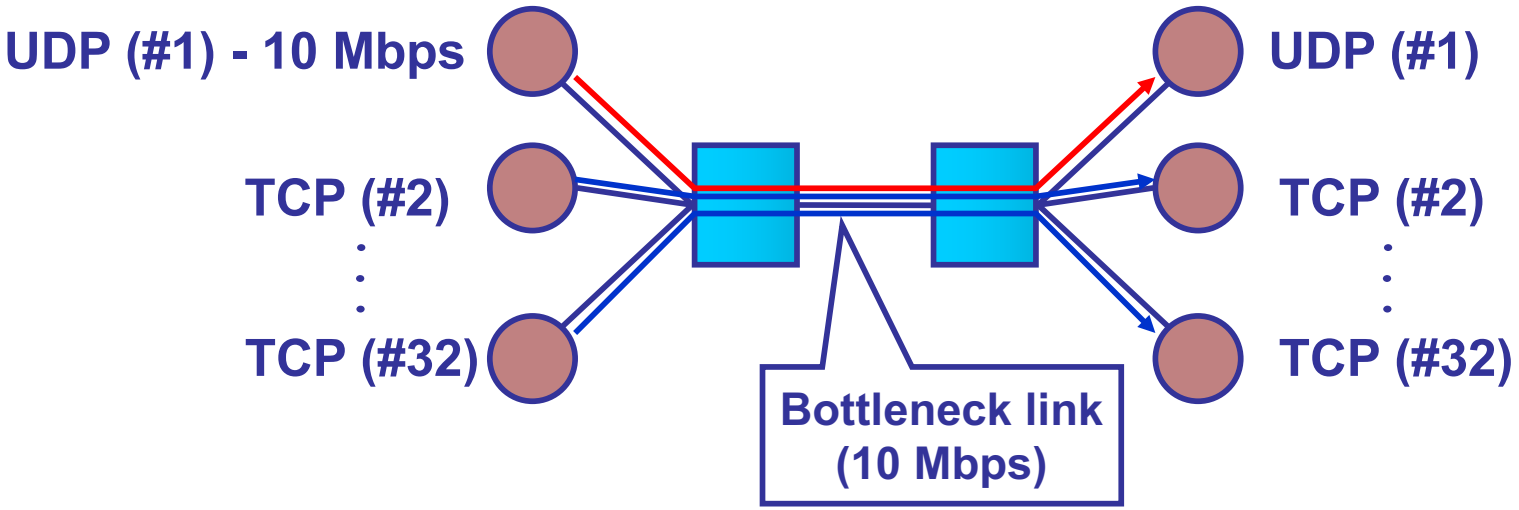
- Maintain running average of queue length in router
- If avg < min_{th} do nothing
  - Low queuing, send packets through
- If avg > max_{th}, drop packet
  - Protection from misbehaving sources
- Else drop/mark packet in a manner proportional to queue length
  - Notify sources of incipient congestion
  - Dropping vs Marking tradeoff (Explicit Congestion Notification)

RED Operation

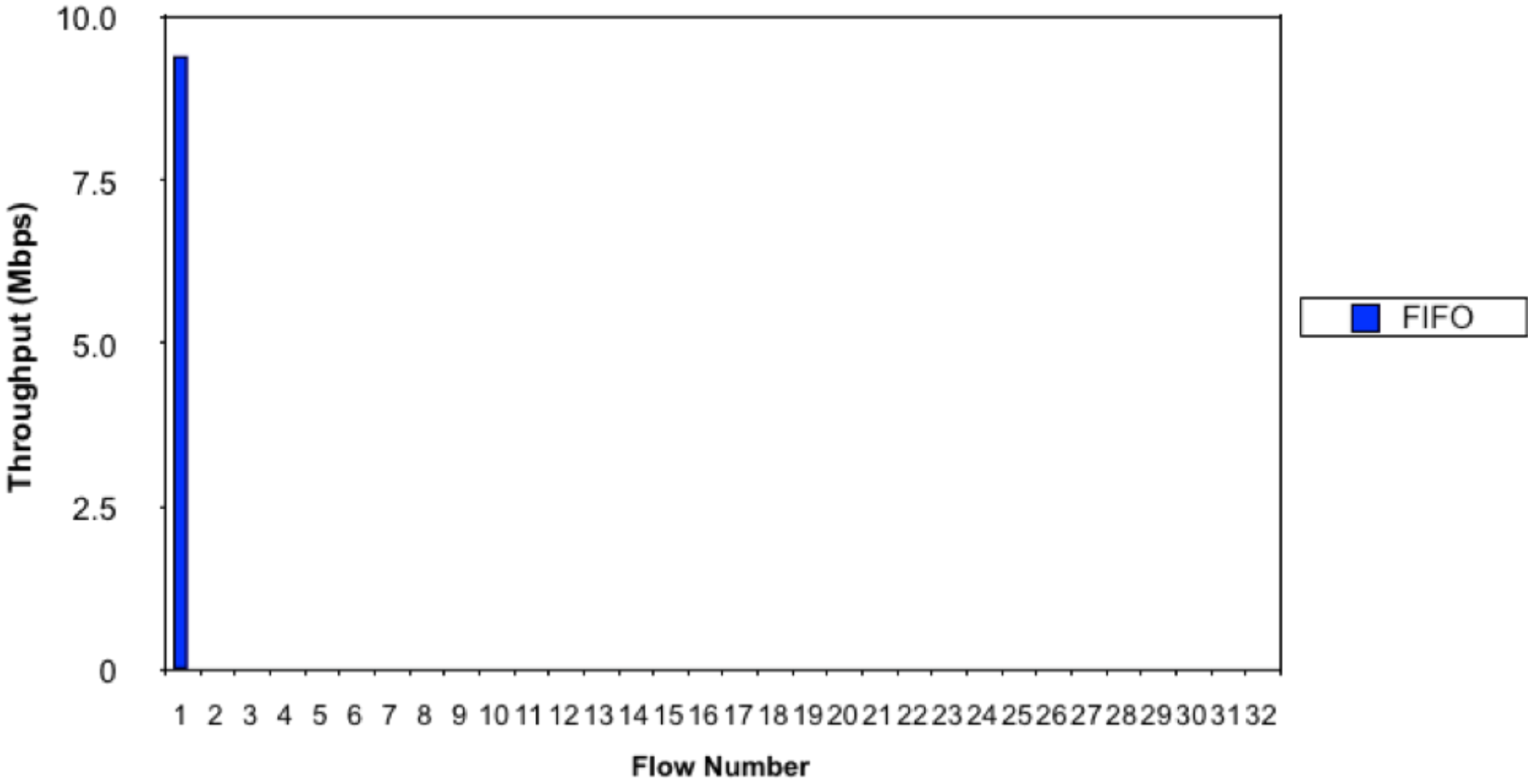


Non-responsive Senders

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

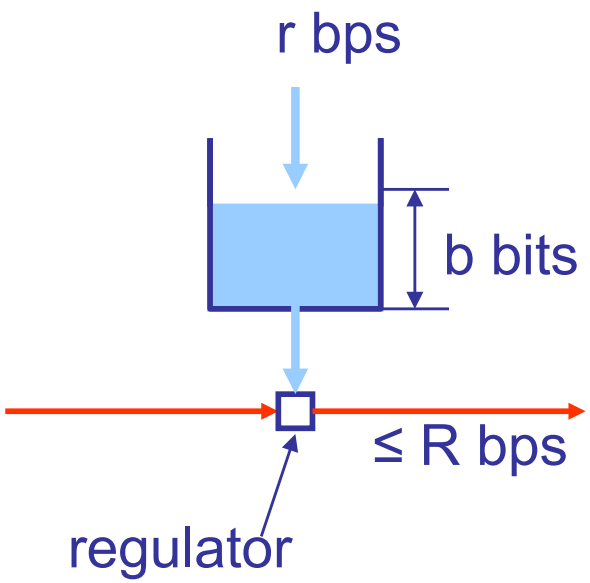


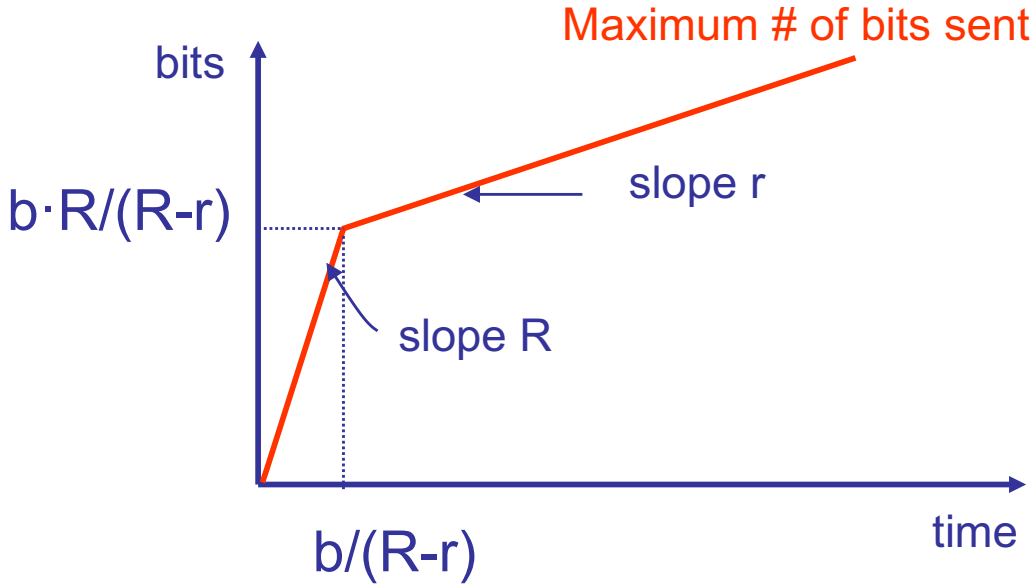
UDP *vs.* TCP


10.0
7.5
5.0
2.5
0
Throughput (Mbps)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Flow Number
FIFO

Token Bucket Basics

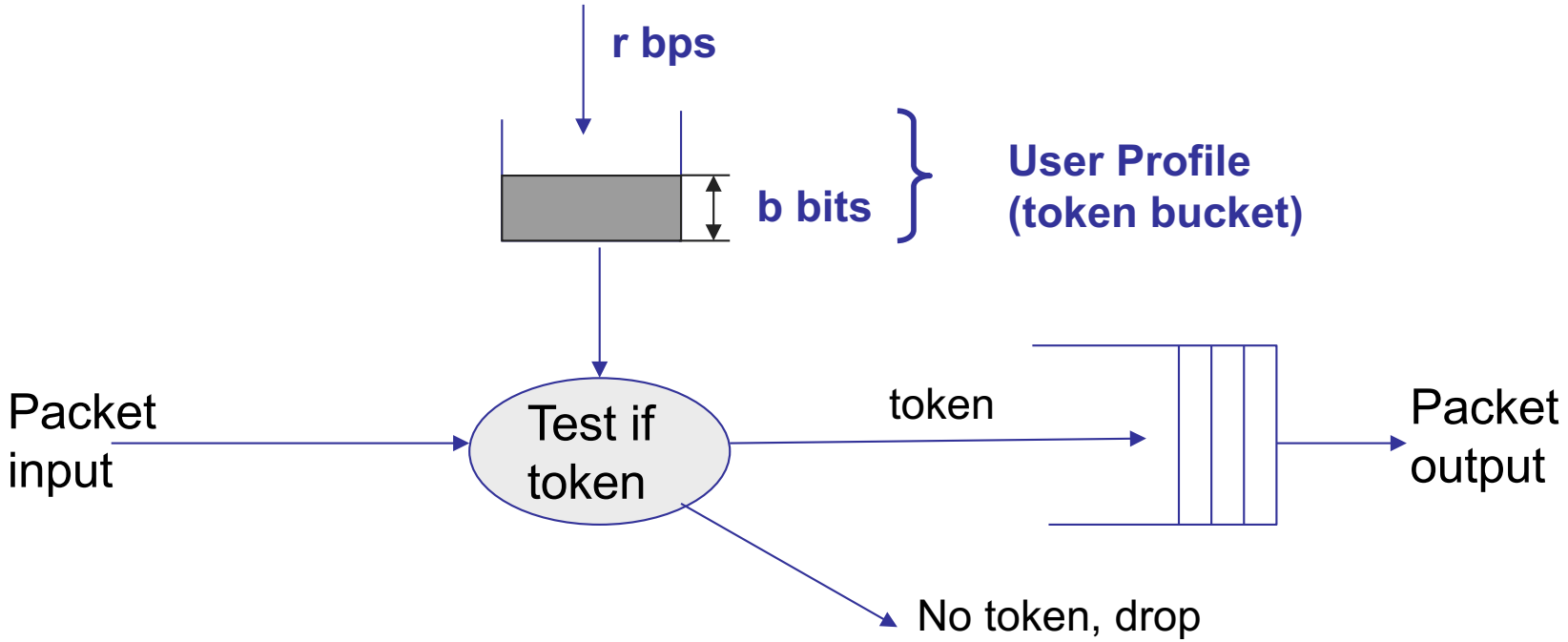
- Parameters
  - r – average rate, i.e., rate at which tokens fill the bucket
  - b – bucket depth (limits size of burst)
  - R – maximum link capacity or peak rate (optional parameter)
- A bit can be transmitted only when a token is available





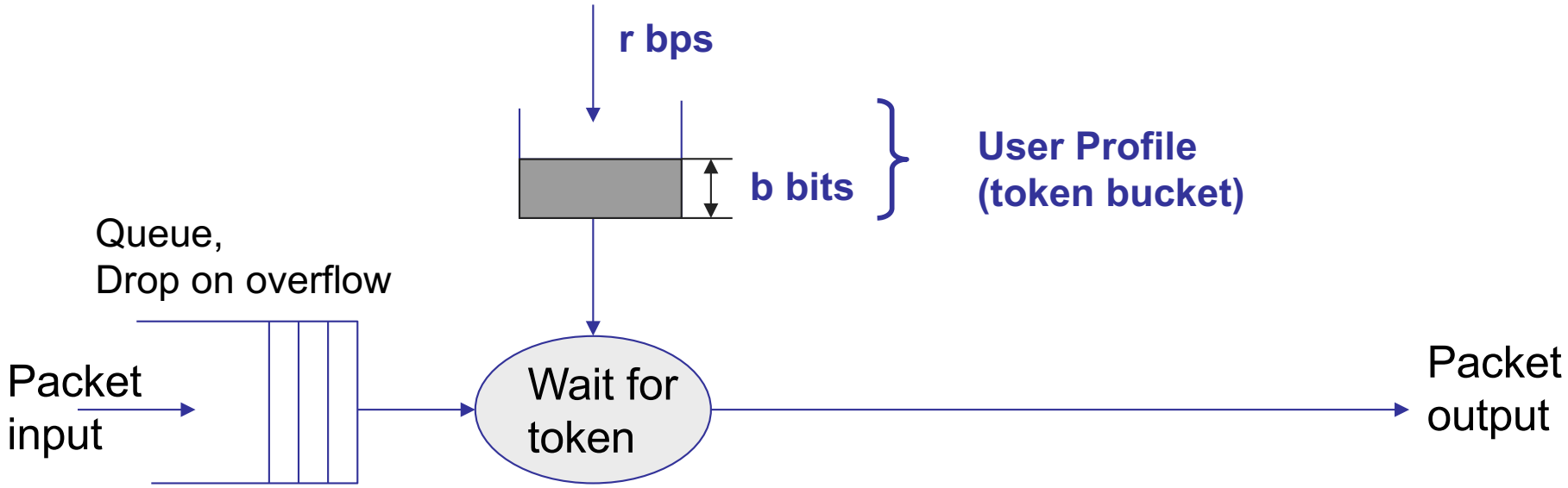
Traffic Policing

- 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*



For next time…

- Read Ch. 6.3-4 in P&D