CS120: Computer Networks

Lecture 17. Congestion Control 1

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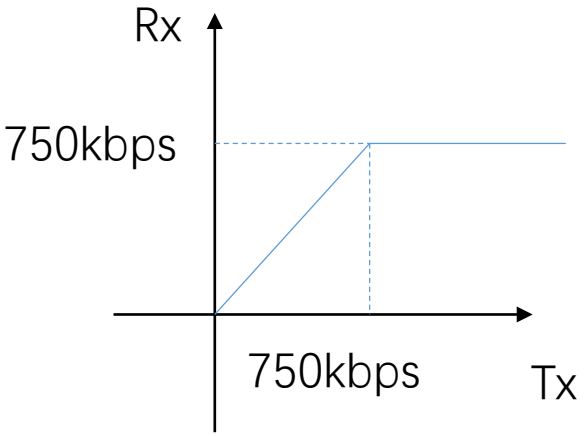
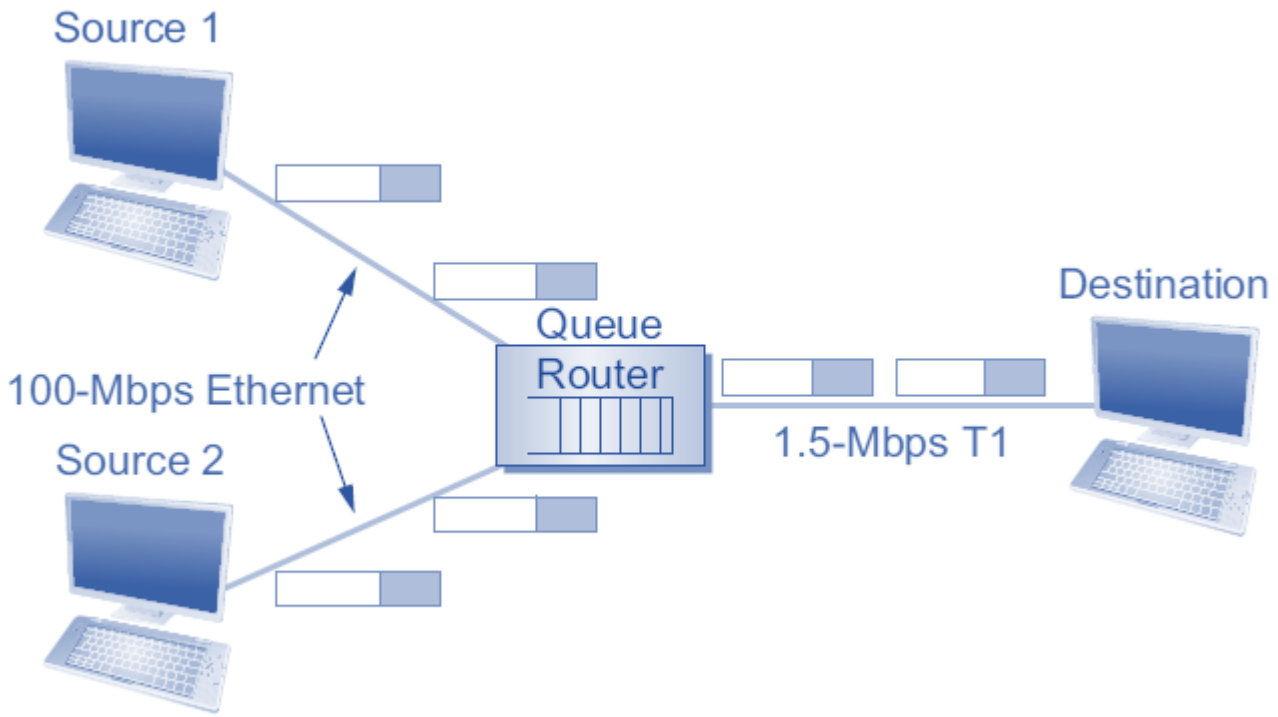
Transmission Control Protocol (TCP)

- RFC: 793,1122,1323, 2018, 2581
- Goal: Reliable, In-order Delivery
  - Connection oriented
  - Flow control
  - ➢Congestion control
- Core Algorithm: Sliding Window

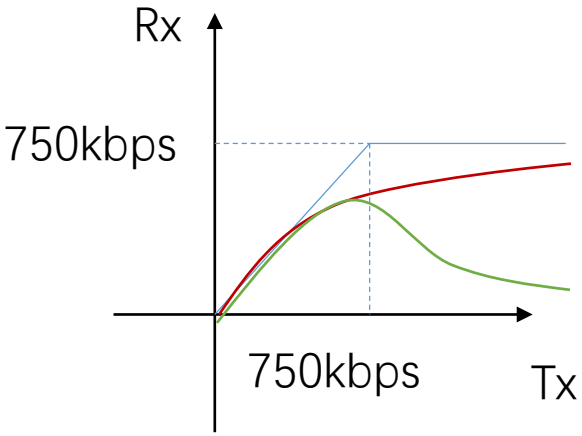
Congestion in Network



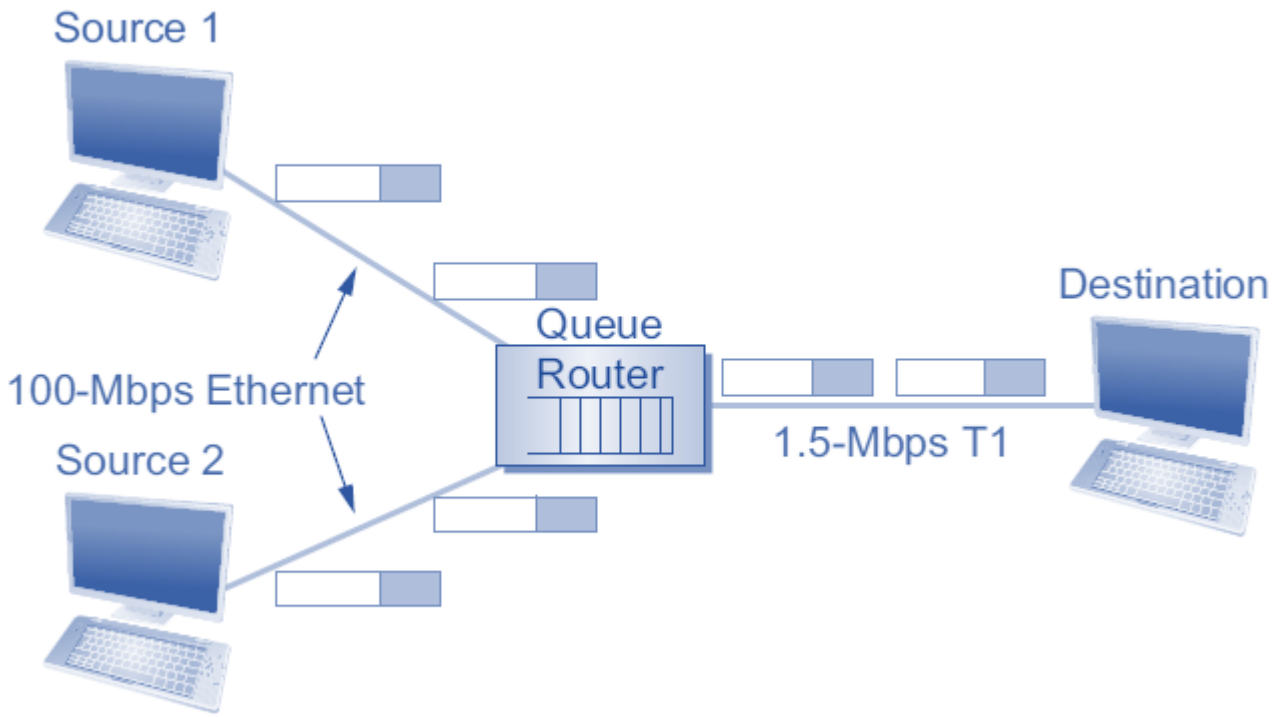
Ideal Case



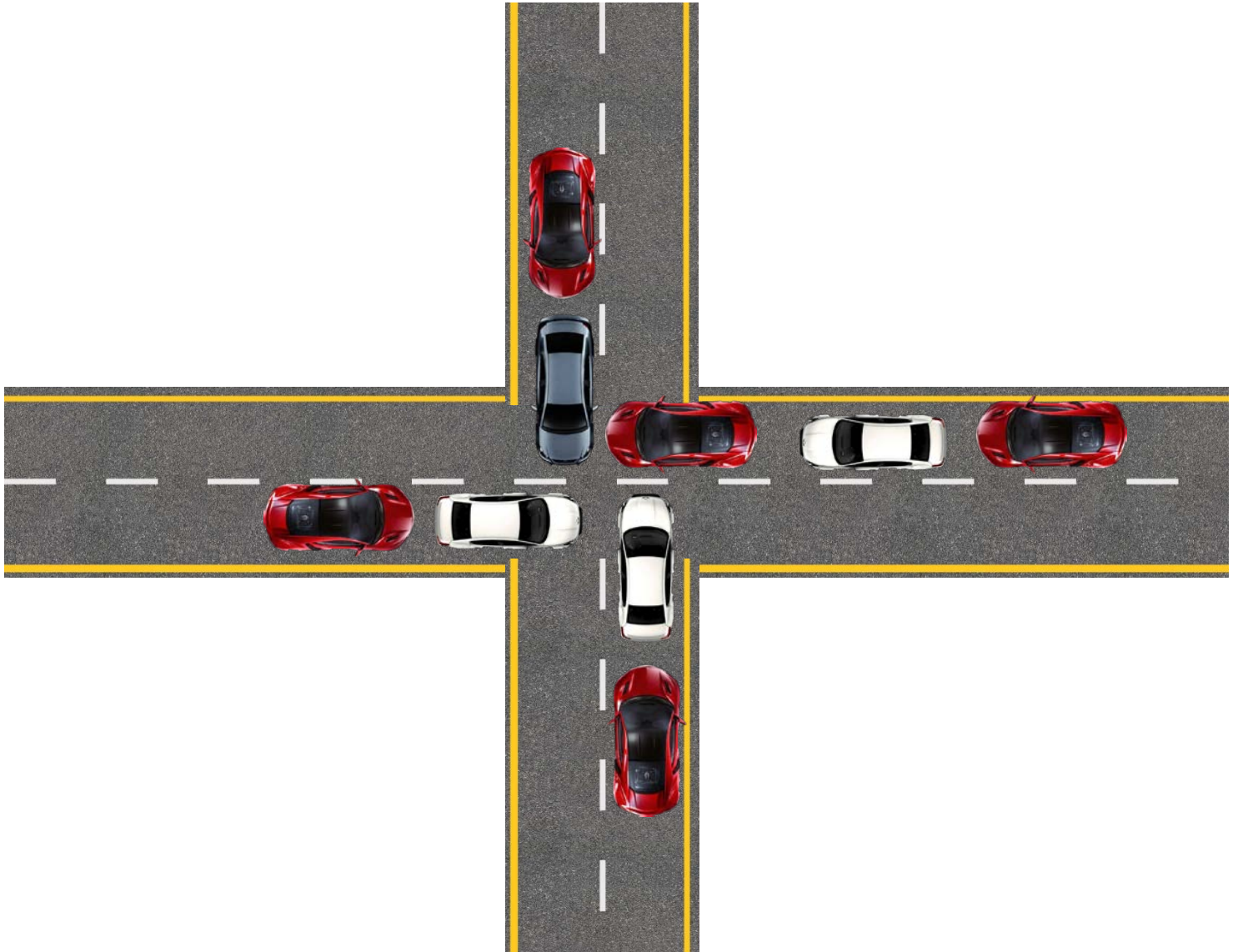
Congestion in Network



Actual Case

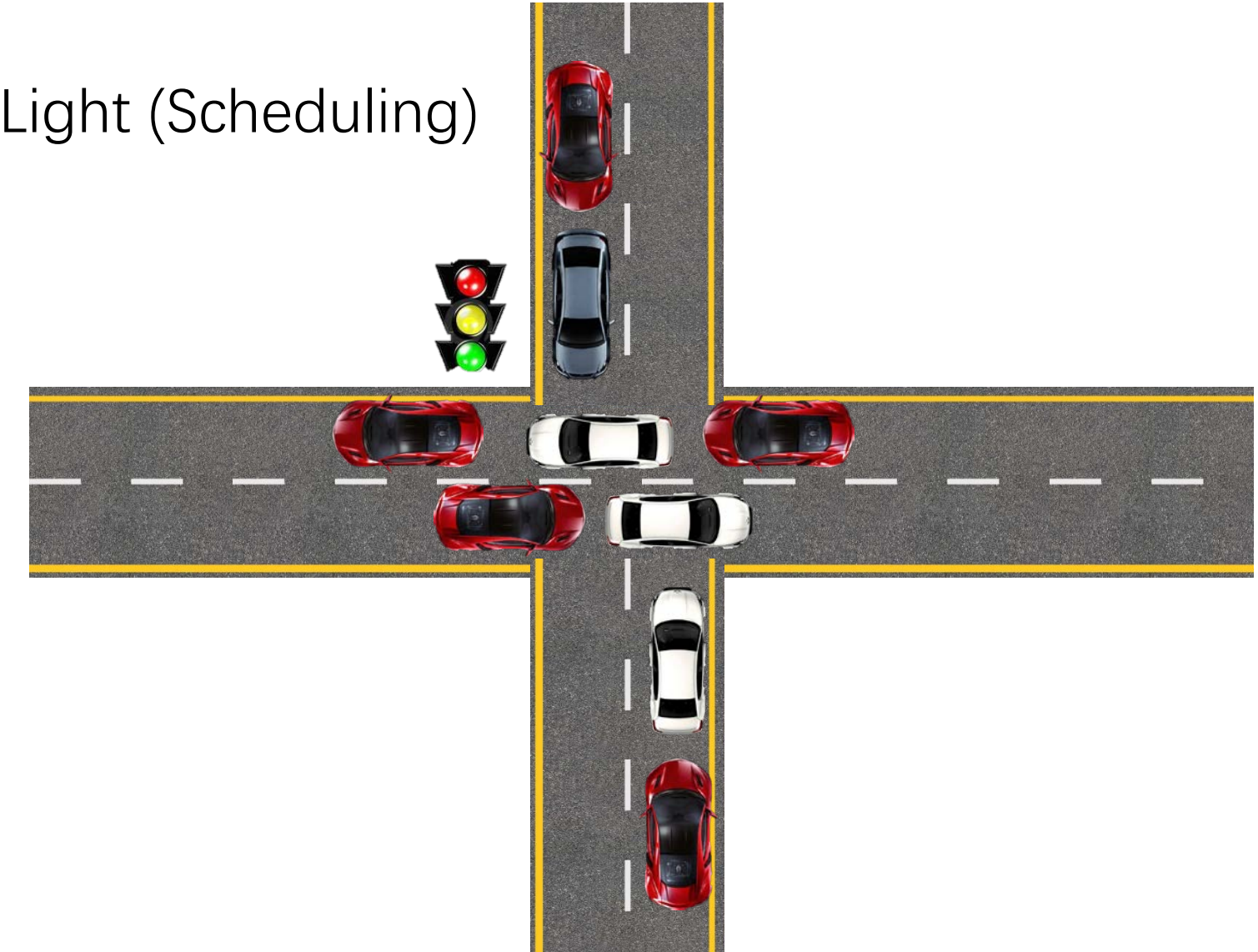


Congestion in Roads



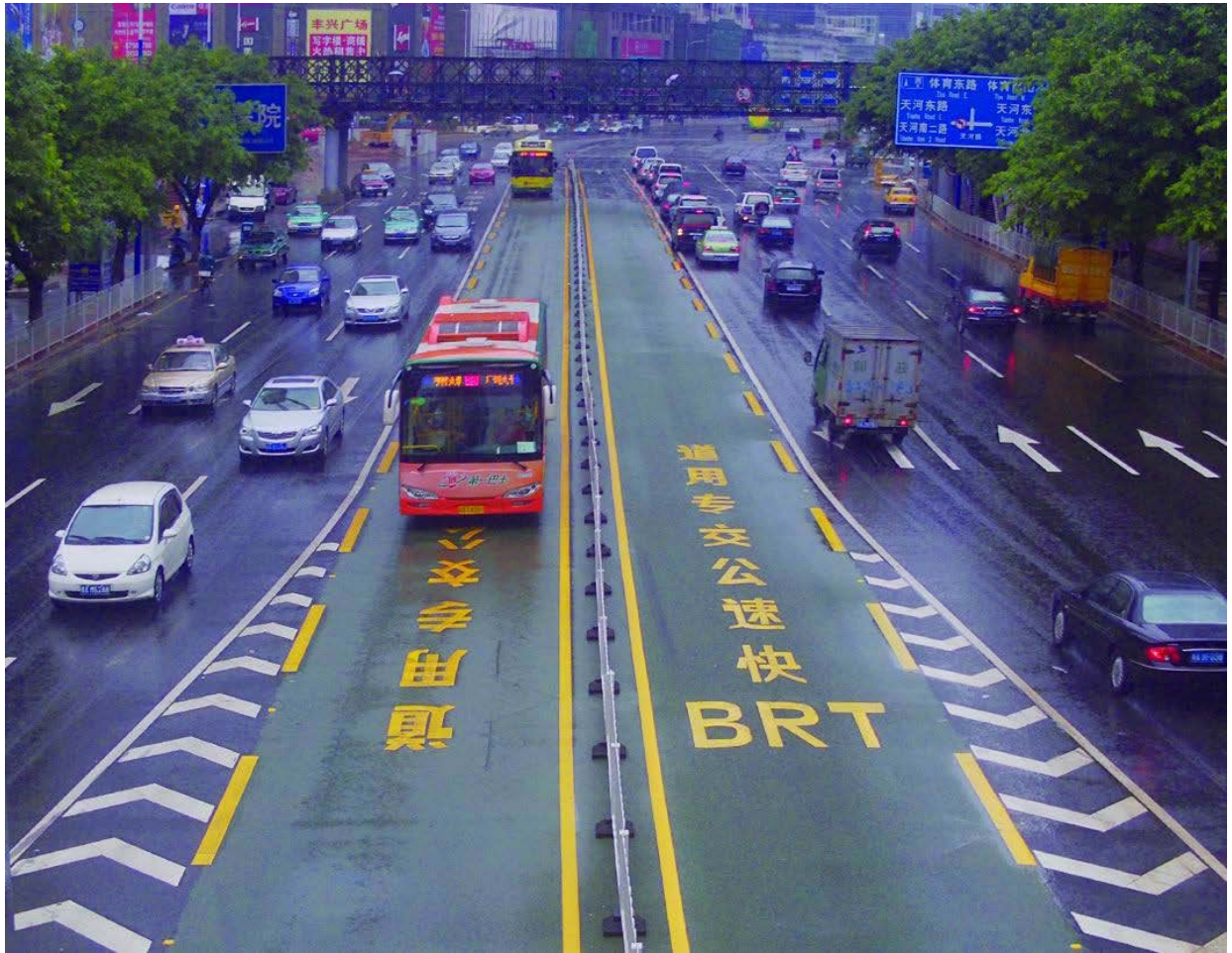
How to Avoid Congestion ?

- Traffic Light (Scheduling)



How to Avoid Congestion ?

- Priority Lane (Reservation)



How to Avoid Congestion ?

How to Avoid Congestion ?

- Traffic Light => Time Allocation
- Priority Lane => Space Allocation
- Traffic Map => Time and Space Allocation

Congestion Control and Resource Allocation

- Two Sides of the Same Coin
  - Control congestion if (and when) is occurs: reactive
  - Pre-allocate resources so at to avoid congestion: proactive
- Resources in Network
  - Bandwidth
  - Router Queue Buffer

Resource Allocation in Telephone Network

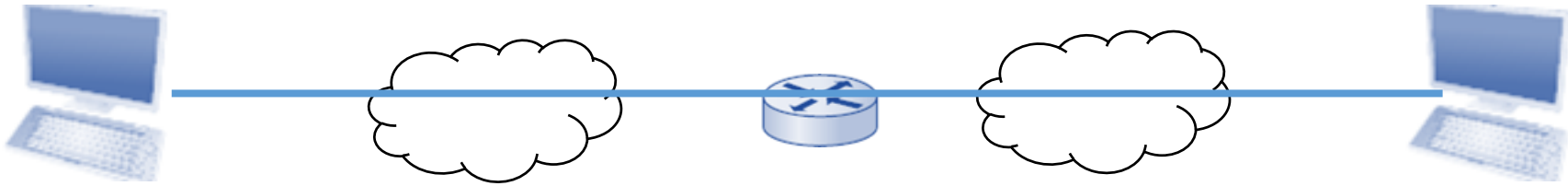
- Call blocking
  - A “session” is blocked if the network resource is not enough
  - No congestion
  - Less effective in utilizing network resources

Discussion Space

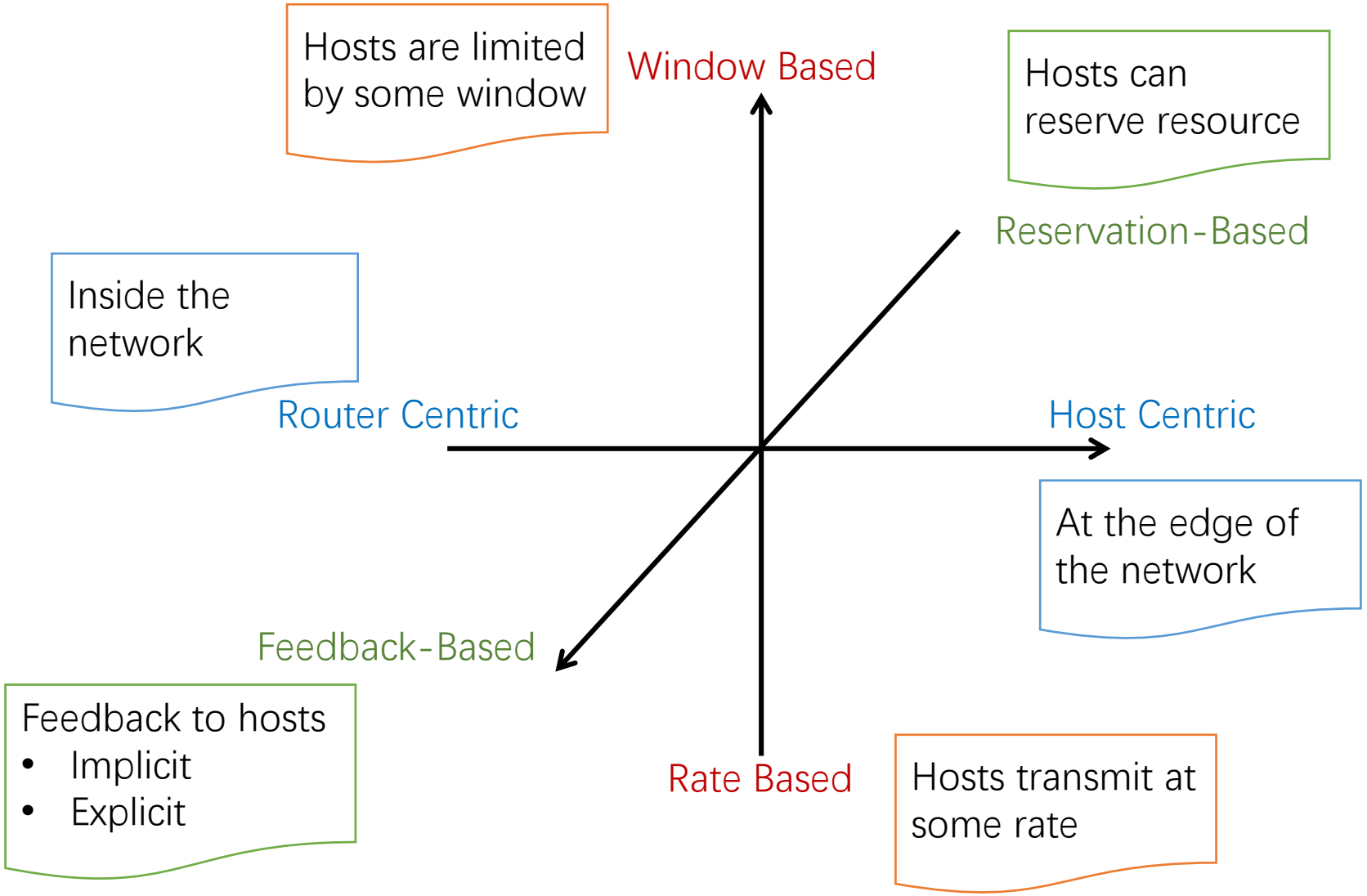
- Network Model
  - Packet switched network
    - e.g. IP
  - Connectionless
    - Basic decision element: flow
      - A sequence of packets sent between source/destination pair and following the same route
    - Router is able to keep soft state of the flow
      - Soft state information can be used to make resource reservation decision for the flow, but unlike virtual circuit, providing no strict guarantee
  - Service Model
    - Best effort
    - Qualities of Service (QoS)

Congestion Control and Resource Allocation

- Two Sides of the Same Coin
  - Control congestion if (and when) is occurs: reactive
  - Pre-allocate resources so at to avoid congestion: proactive
- Resources in Network
  - Bandwidth
  - Router Queue Buffer
- Two Places of Implementation
  - Hosts at the edges of the network (transport protocol)
  - Routers inside the network (queuing discipline)

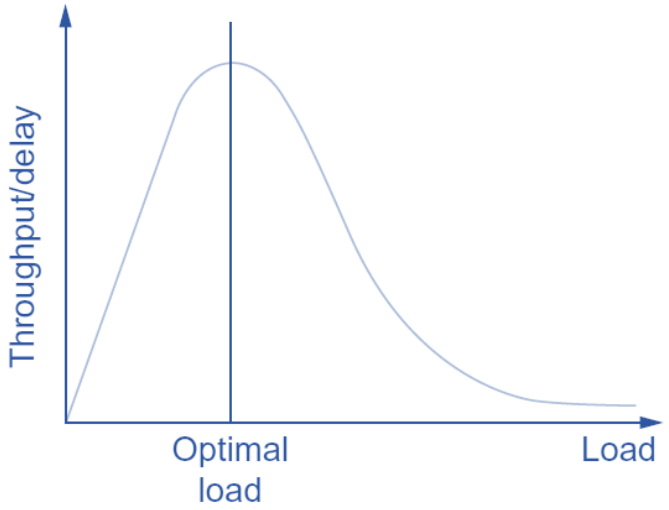


Resource Allocation Methods



Evaluation Criteria

- Performance
  - Throughput
  - Delay
  - Power = Throughput/Delay
- Fairness
  - Fairness Index
    - $f(x_1 \ldots x_n) = \frac{(\sum x_i)^2}{n * \sum x_i^2}$



Congestion Control

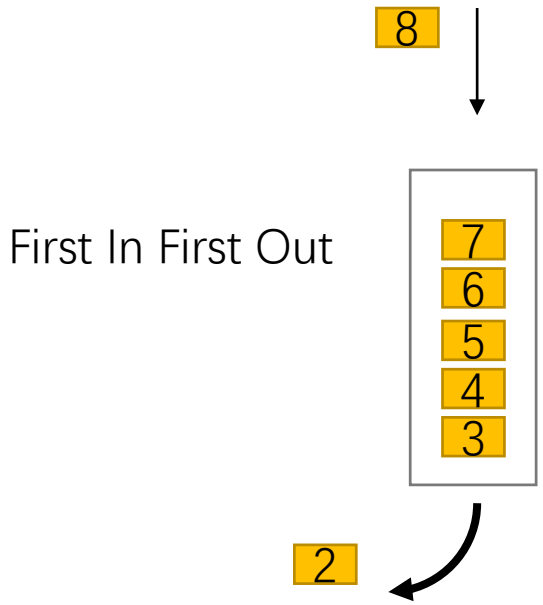
- Queuing Disciplines
- TCP Congestion Control Algorithm
  - Congestion Control
  - Congestion Avoidance
- QoS

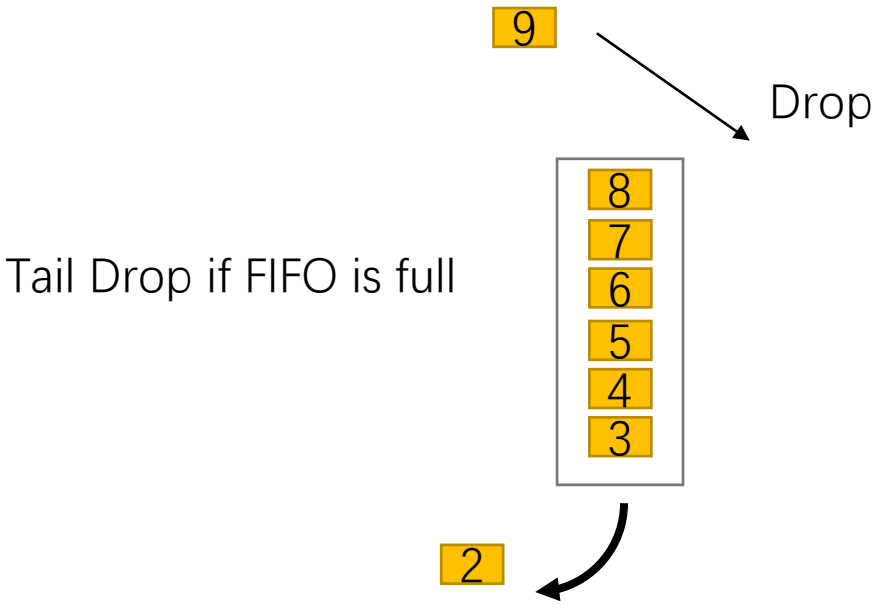
Queuing Discipline

- Why ?
  - Queuing discipline in routers determines how packets are transmitted
- Network Resource
  - Bandwidth
    - Which packets get transmitted
  - Queue Buffer
    - Which packets get discarded

Queuing Discipline

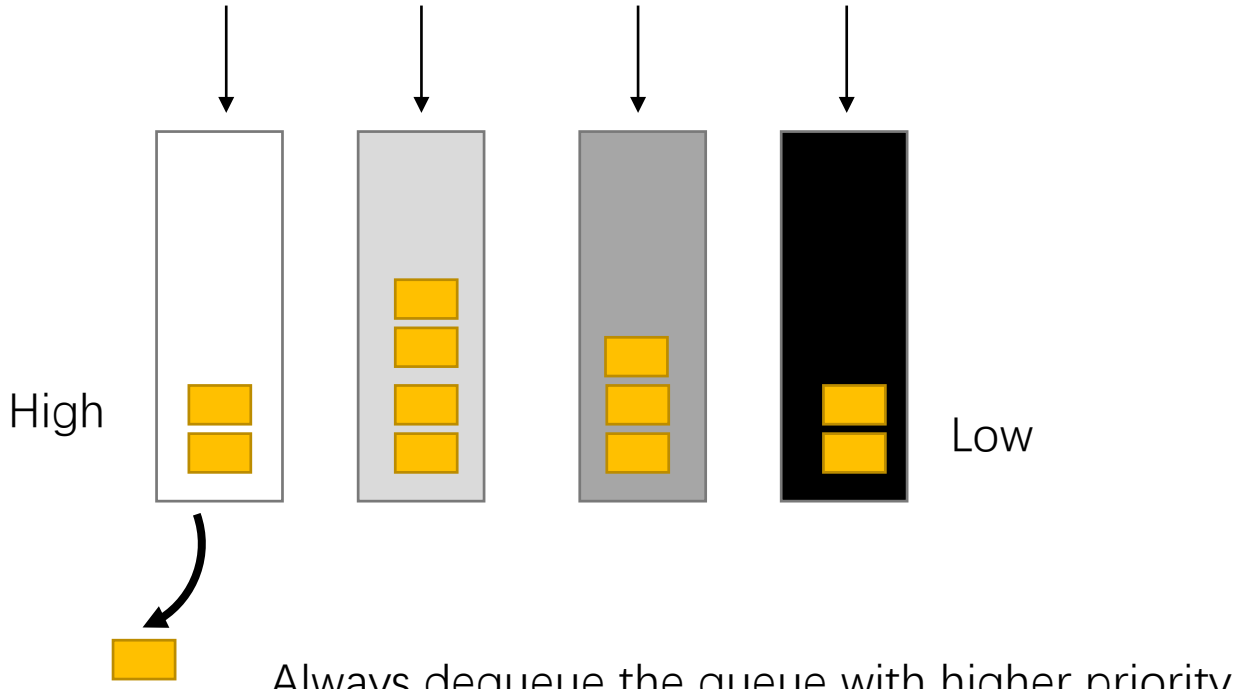
- First-In-First-Out (FIFO)





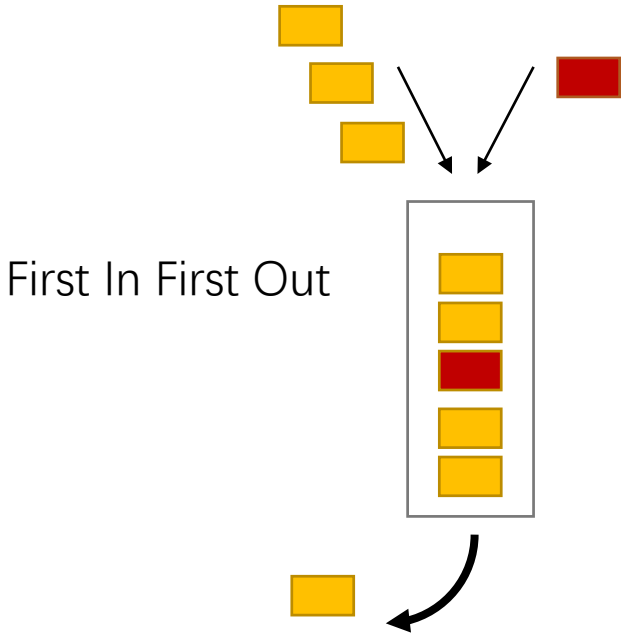
Queuing Discipline

- First-In-First-Out (FIFO) with Priority



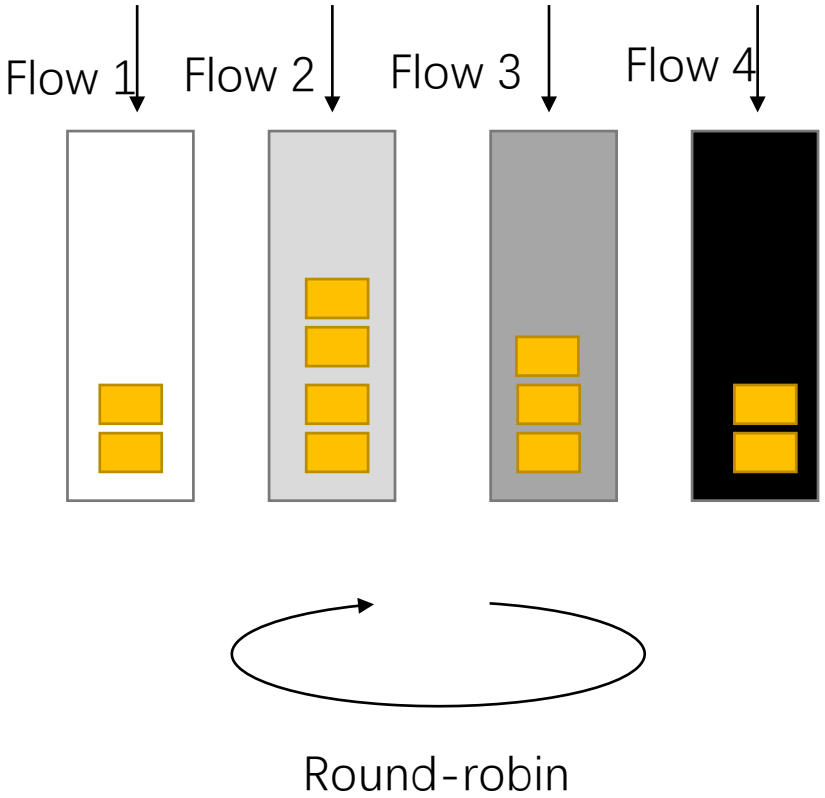
Queuing Discipline

- Problems in FIFO
  - Too simple to provide resource allocation polices (to avoid congestion)
  - Hard to enforce every network source/flow to follow the same behavior
    - eg. yellow src does not follow congestion control (UDP), can occupy more network source



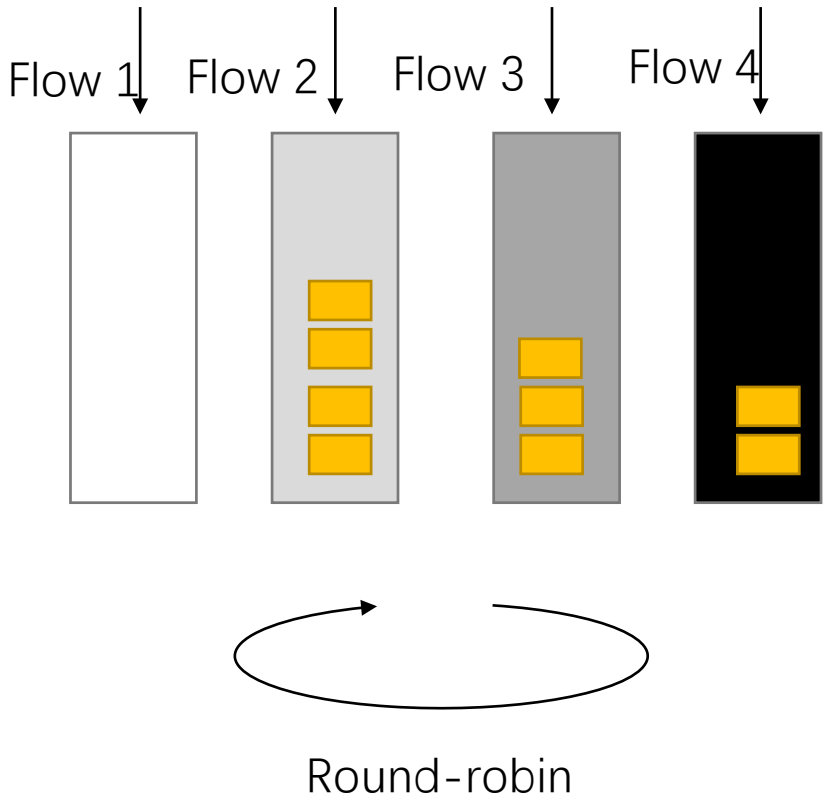
Queuing Discipline

- Fair Queuing (FQ)
  - Each flow gets 1/4 output bandwidth



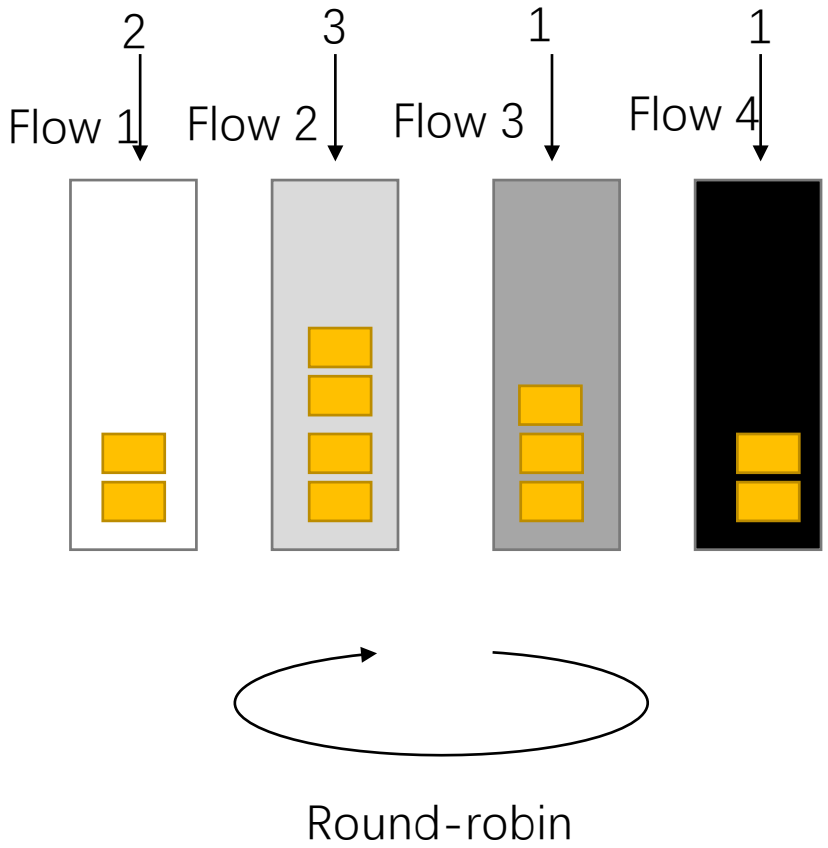
Queuing Discipline

- Fair Queuing (FQ)
  - Each flow gets 1/3 output bandwidth



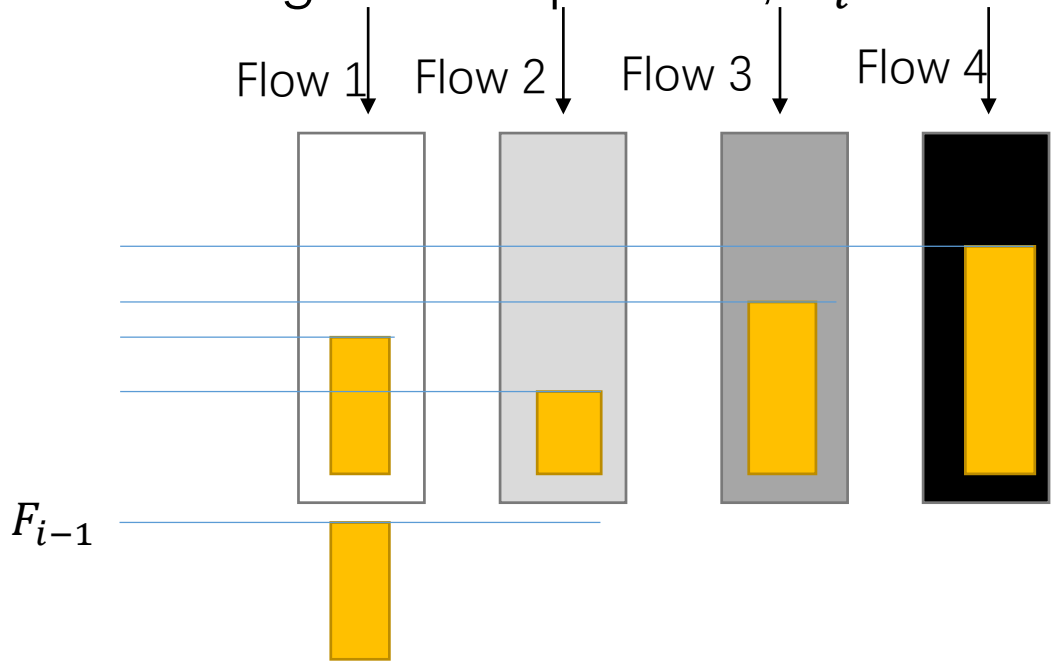
Queuing Discipline

- Weighted Fair Queuing (FQ)
  - Flows with higher weight get more output bandwidth (2/7, 3/7, 1/7, 1/7)



Queuing Discipline

- Bit-Level Fair Queuing (FQ)
  - Schedule according to finish time of packet i: $F_i = \max(F_{i-1}, A_i) + P_i$
  - P_i is the transmitting time of packet i, A_i is the arriving time of packet i



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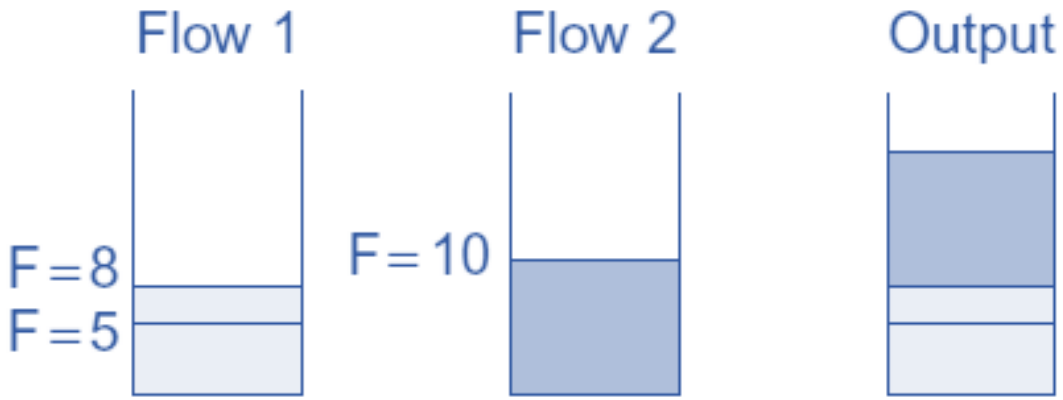

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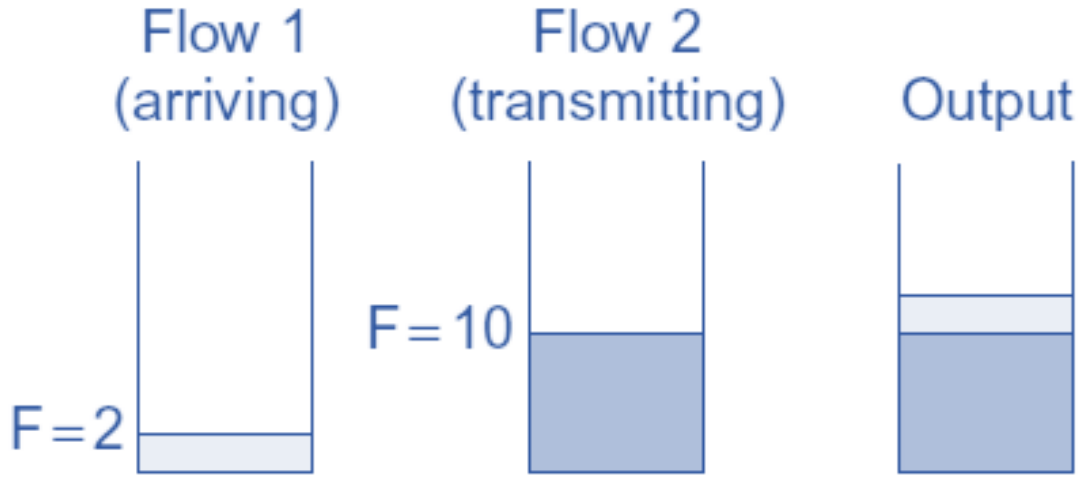

No Preemption

Reference

- Textbook 6.1 & 6.2
- http://www2.ic.uff.br/~michael/kr1999/3-transport/3_06-principles_congestion.htm