Computer Networks

Congestion Overview

(§6.3, §6.5.10)

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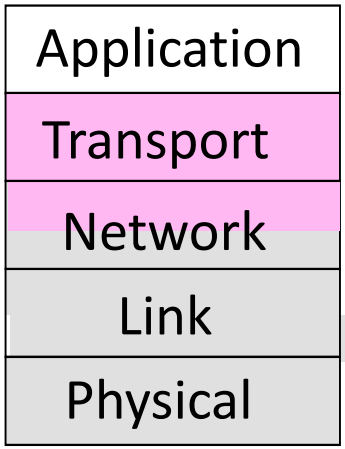
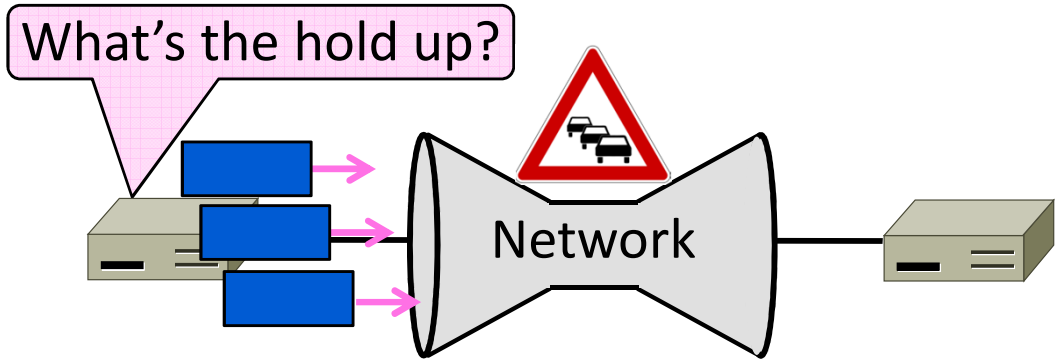
Where we are in the Course

- More fun in the Transport Layer!
  - The mystery of congestion control
  - Depends on the Network layer too



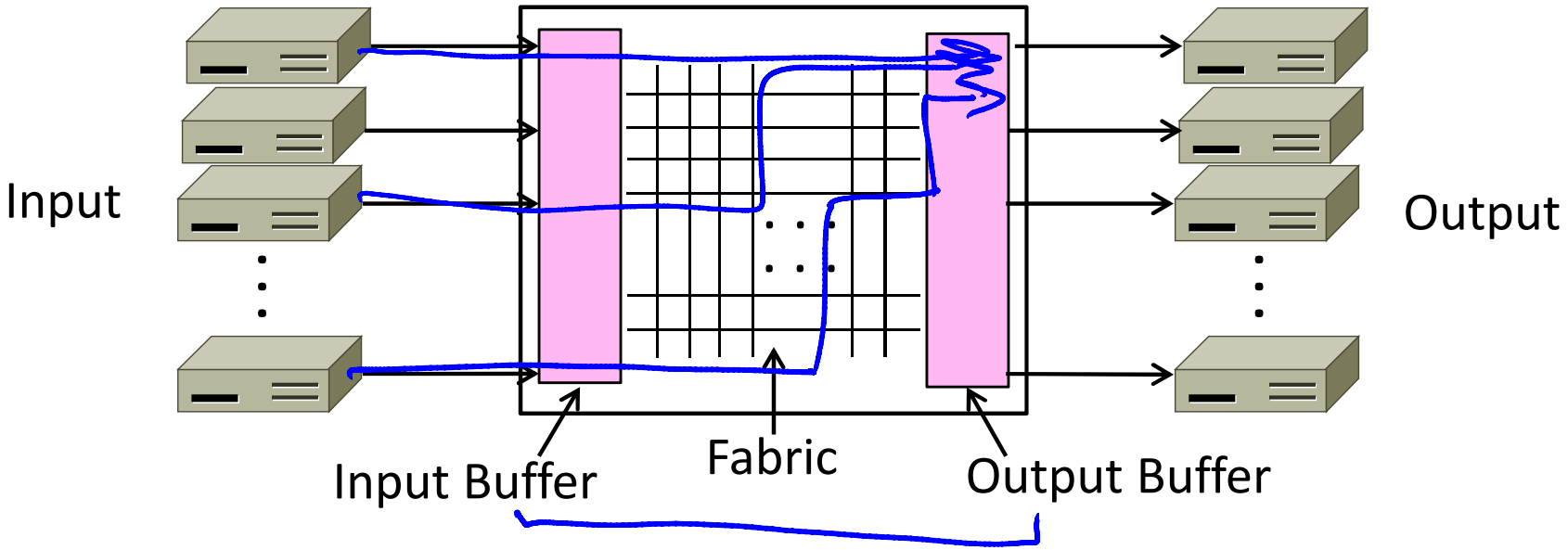
Topic

- Understanding congestion, a "traffic jam" in the network
  - Later we will learn how to control it



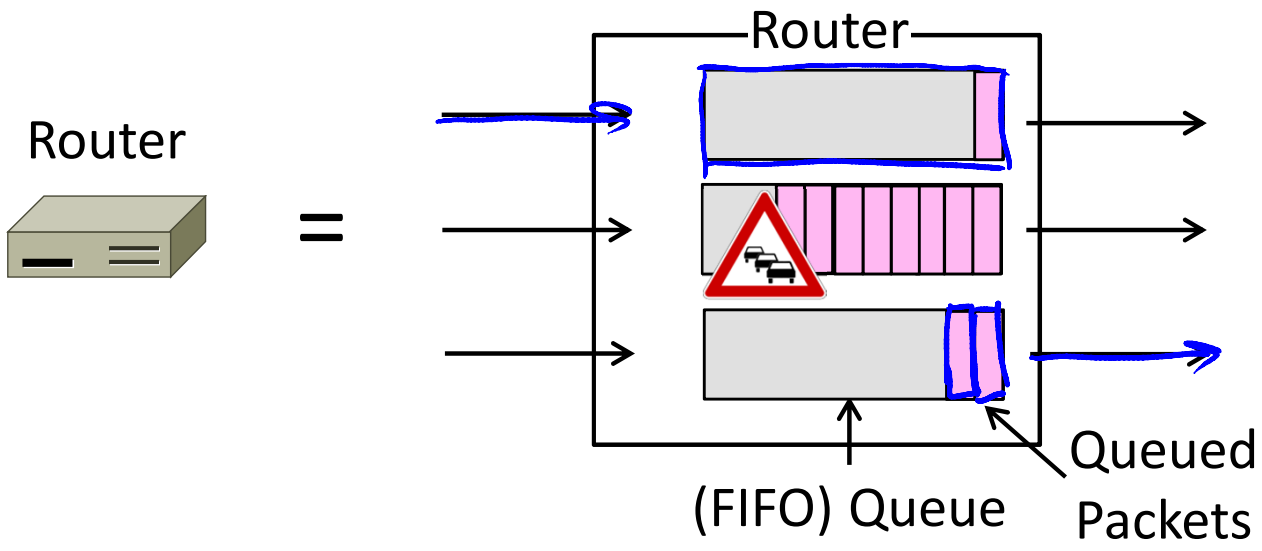
Nature of Congestion

- Routers/switches have internal buffering for contention



Nature of Congestion (2)

- Simplified view of per port output queues
  - Typically FIFO (First In First Out), discard when full

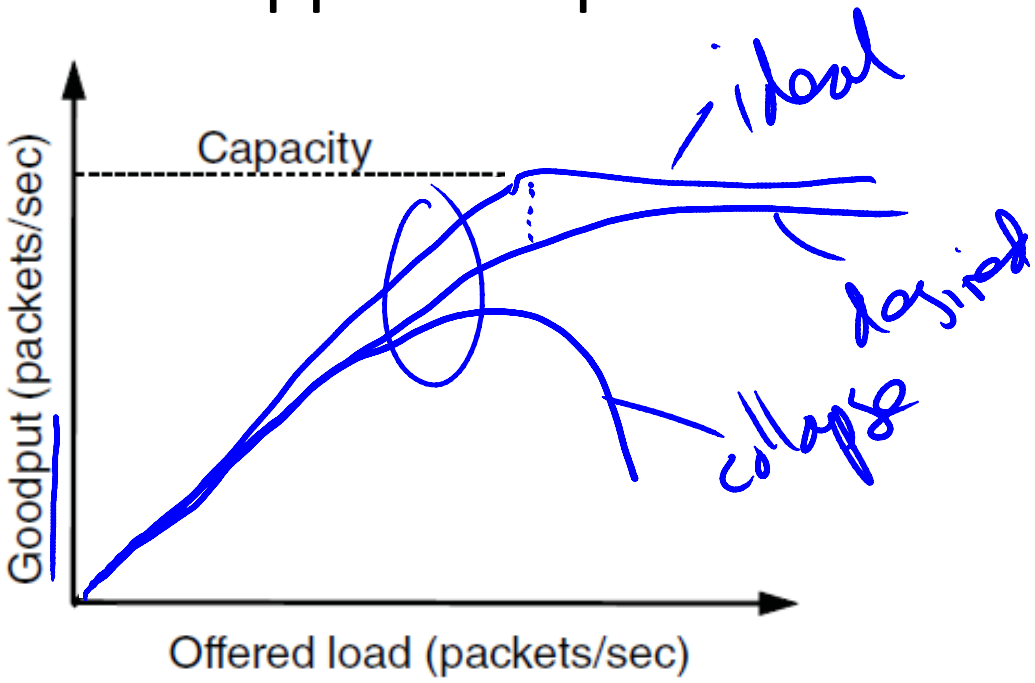


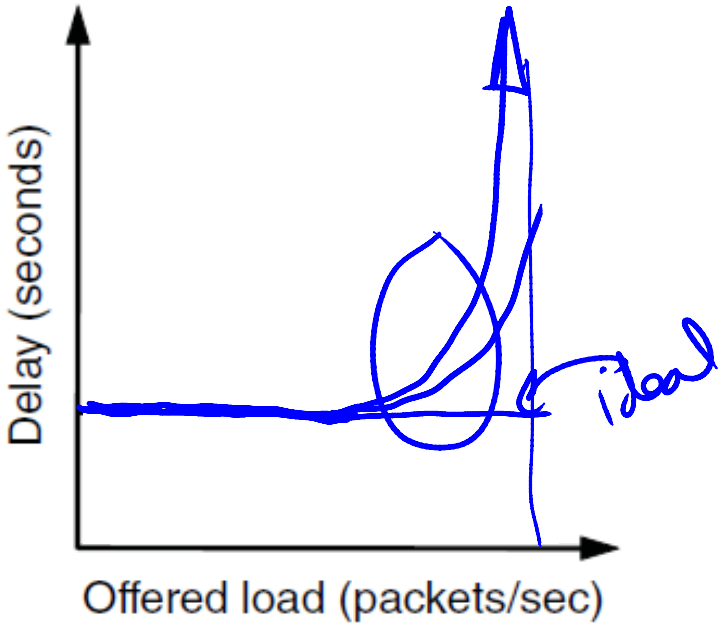
Nature of Congestion (3)

- Queues help by absorbing bursts when input > output rate
- But if input > output rate persistently, queue will overflow
  - This is congestion
- Congestion is a function of the traffic patterns – can occur even if every link have the same capacity

Effects of Congestion

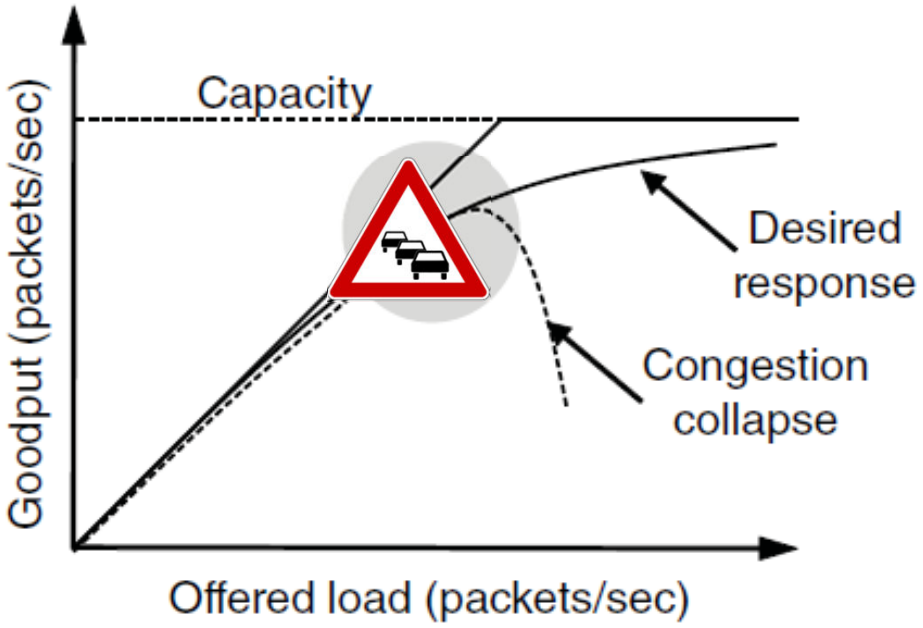
- What happens to performance as we increase the load?

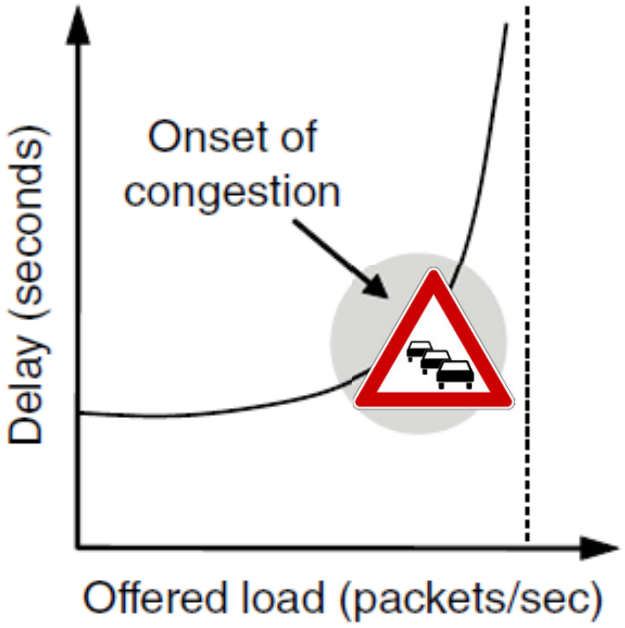




Effects of Congestion (2)

- What happens to performance as we increase the load?





Effects of Congestion (3)

- As offered load rises, congestion occurs as queues begin to fill:
  - Delay and loss rise sharply with more load
  - Throughput falls below load (due to loss)
  - Goodput may fall below throughput (due to spurious retransmissions)

- None of the above is good!
  - Want to operate network just before the onset of congestion

Bandwidth Allocation

- Important task for network is to allocate its capacity to senders
  - Good allocation is efficient and fair
- Efficient means most capacity is used but there is no congestion
- Fair means every sender gets a reasonable share the network

Bandwidth Allocation (2)

- Key observation:
  - In an effective solution, Transport and Network layers must work together
- Network layer witnesses congestion
  - Only it can provide direct feedback
- Transport layer causes congestion
  - Only it can reduce offered load

Bandwidth Allocation (3)

- Why is it hard? (Just split equally!)
  - Number of senders and their offered load is constantly changing
  - Senders may lack capacity in different parts of the network
  - Network is distributed; no single party has an overall picture of its state

Bandwidth Allocation (4)

- Solution context:
  - Senders adapt concurrently based on their own view of the network
  - Design this adaption so the network usage as a whole is efficient and fair
  - Adaption is continuous since offered loads continue to change over time

Topics

- Nature of congestion
- Fair allocations
- AIMD control law
- TCP Congestion Control history
- ACK clocking
- TCP Slow-start
- TCP Fast Retransmit/Recovery
- Congestion Avoidance (ECN)

This time

Next time

END