

Introduction to Computer Networks

Congestion Overview

(§6.3, §6.5.10)



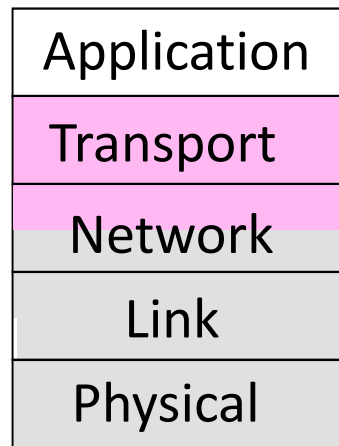
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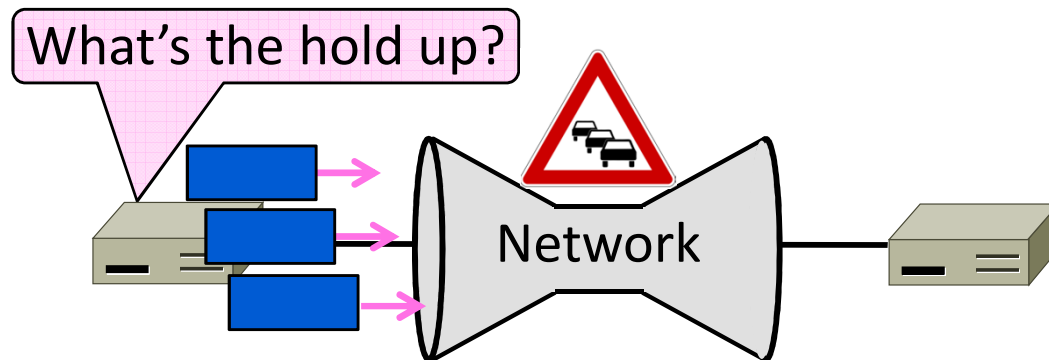
Where we are in the Course

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



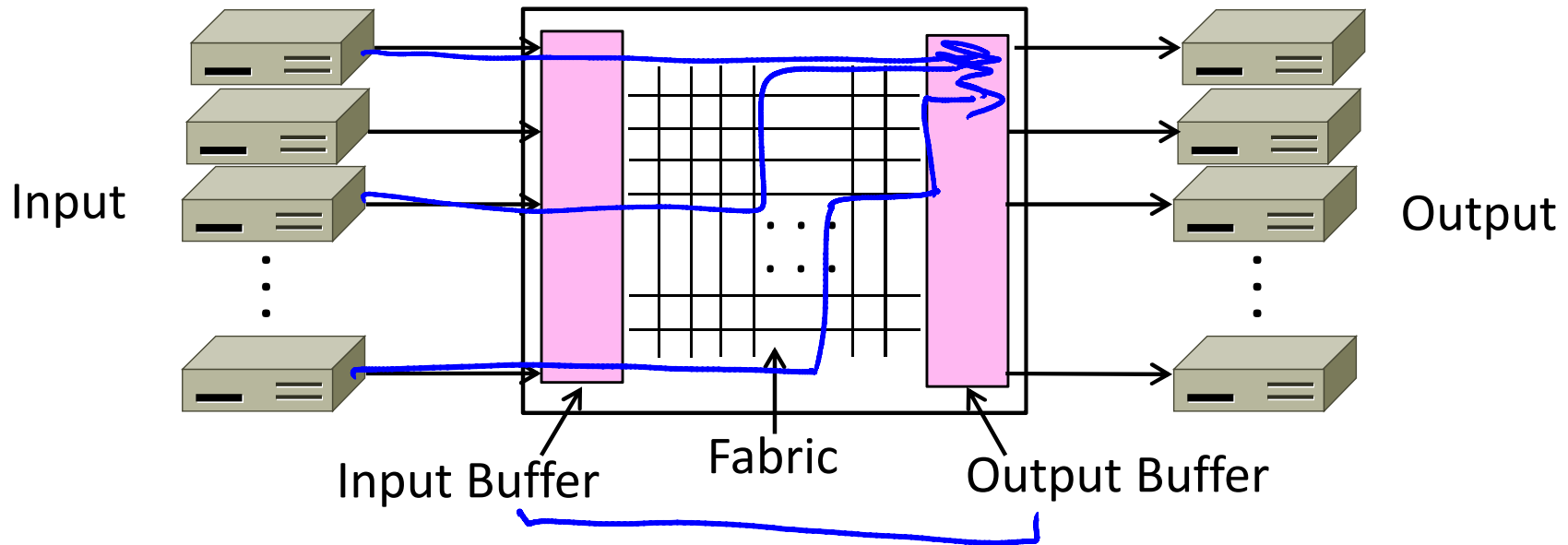
Topic

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



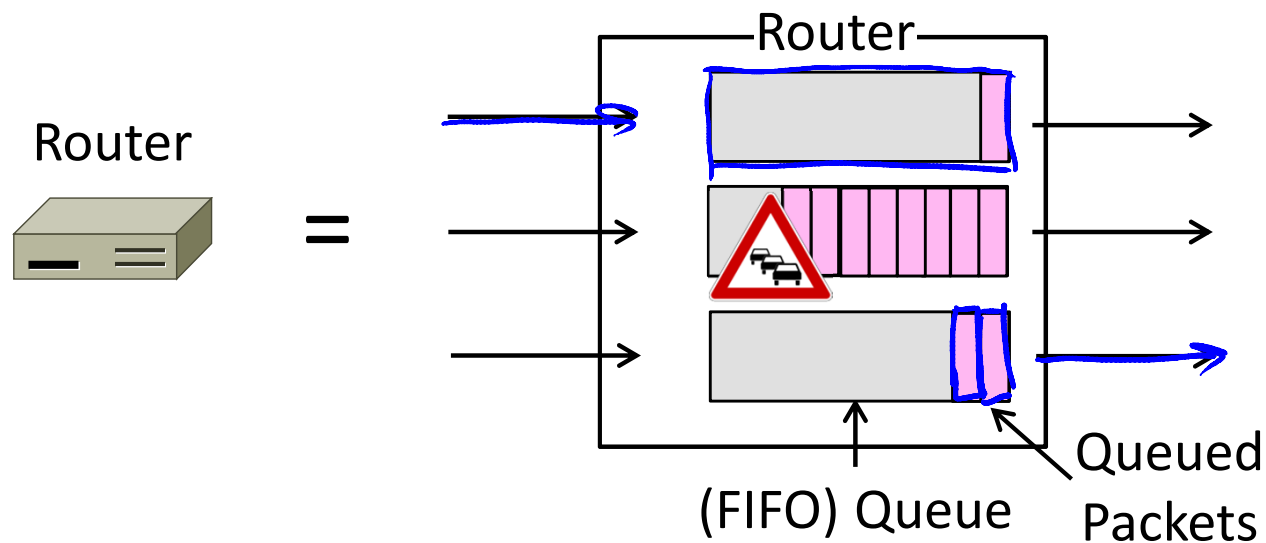
Nature of Congestion

- 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

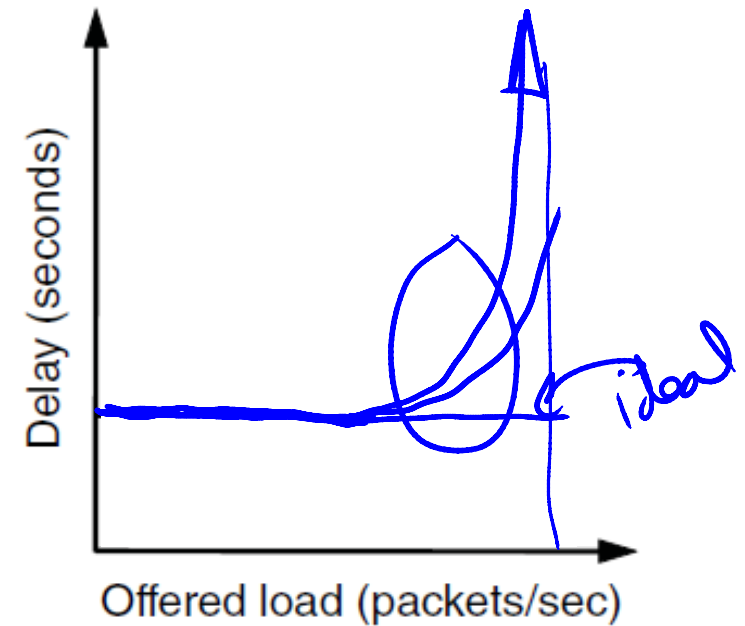
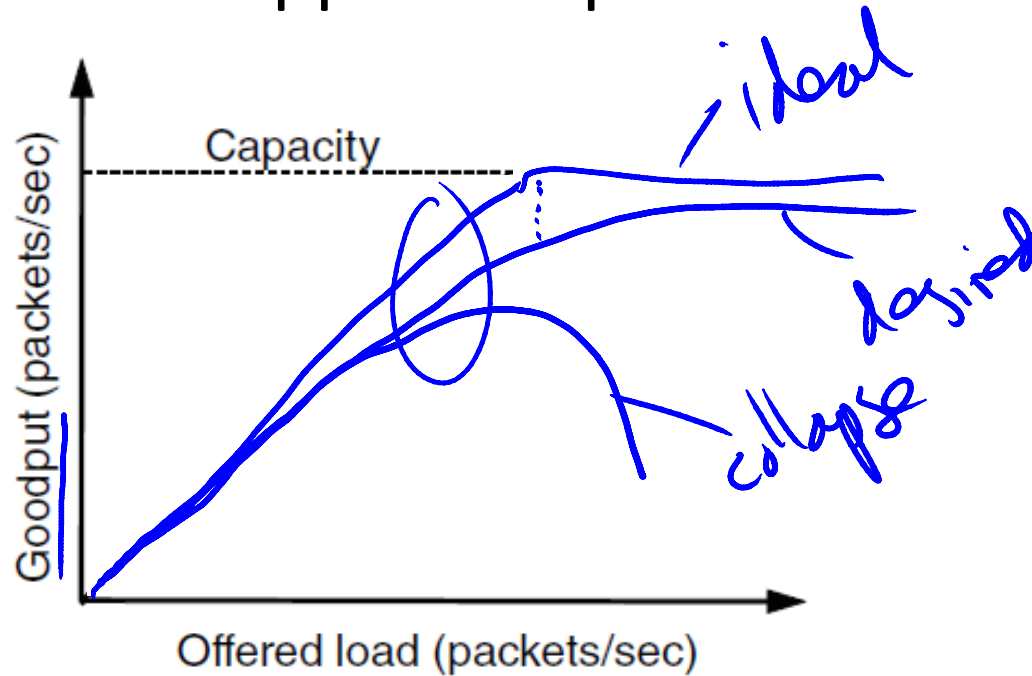


Nature of Congestion (3)

- 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

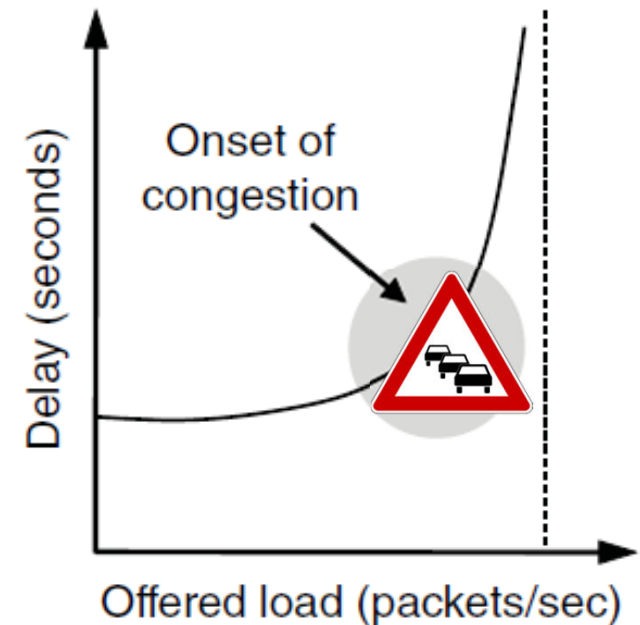
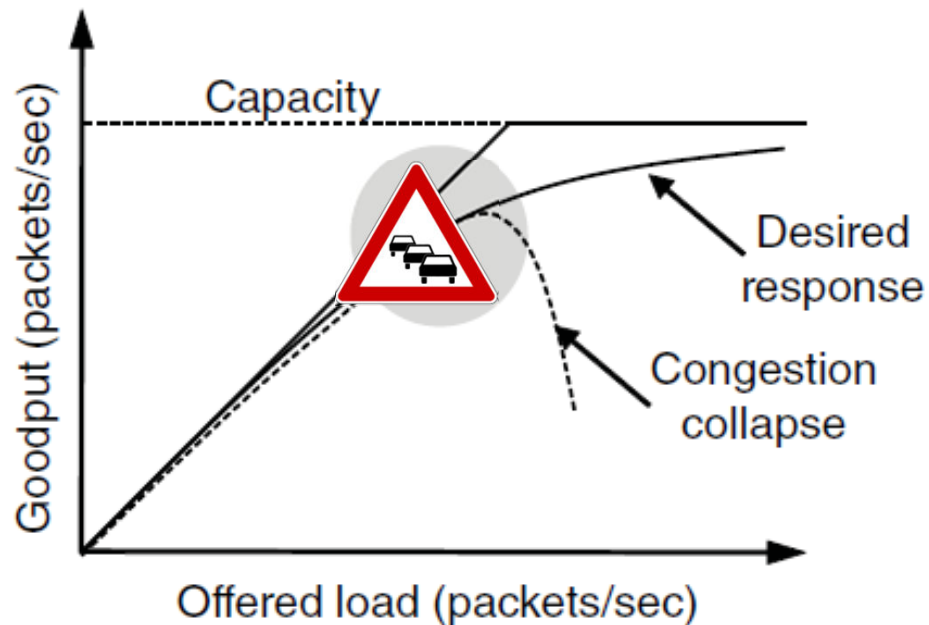
Effects of Congestion

- 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

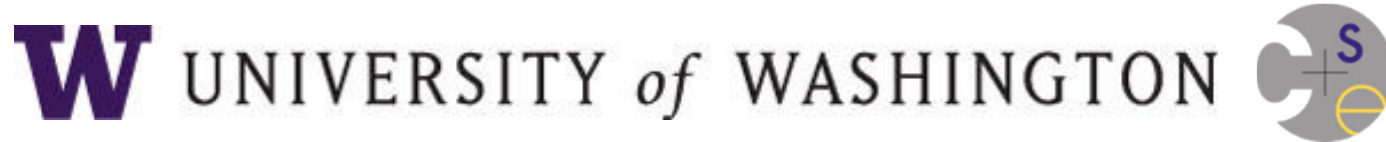
- TCP Fast Retransmit/Recovery

- Congestion Avoidance (ECN)

} This
time

} Next
time

END



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