CIS 457 - Data Communications

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Images taken from Kurose and Ross book

Network Congestion

As traffic increases, routers in network eventually will not be able to keep up

Excess traffic leads to high queuing delays and, eventually, dropped packets

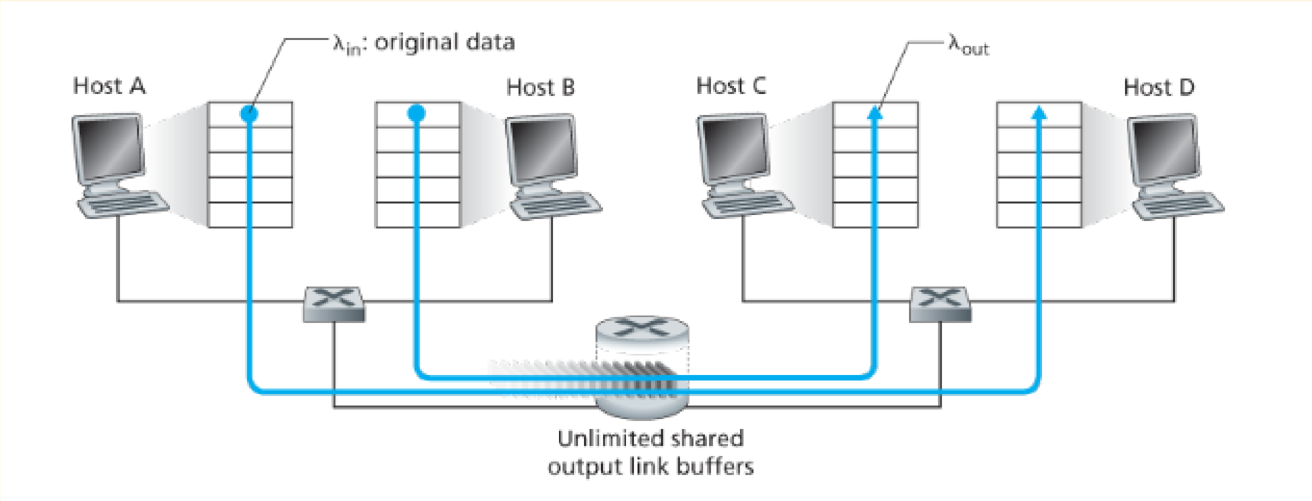
We will look at a few idealized networks to examine effects of congestion

First, assume network with no packet loss

In this case, there will be no retransmissions, which is good for congestion

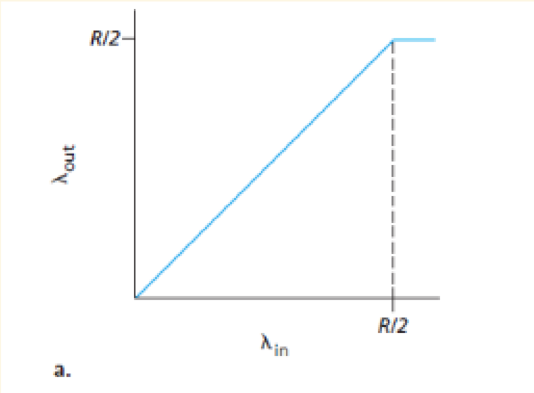
Also, assume buffers are unlimited so packets are never dropped at routers

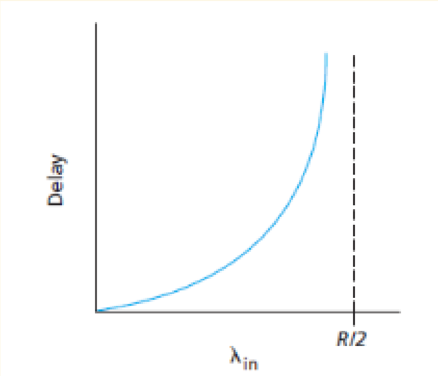
Very simple network: just one router



λin: original data
λout
Host A
Host B
Host C
Host D
Unlimited shared
output link buffers

Rates for single sender and receiver





Delay
R/2
λin

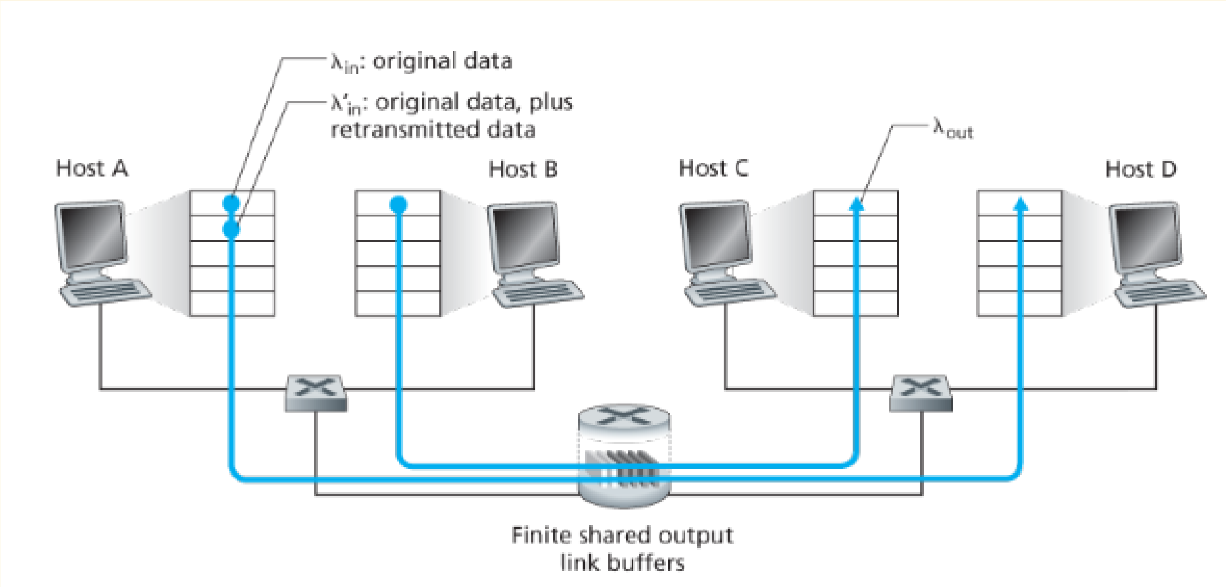
Even in idealized scenario, results in unbounded queuing delays as traffic increases

Next, assume buffers are finite, so packet loss can occur, and any dropped packets are retransmitted

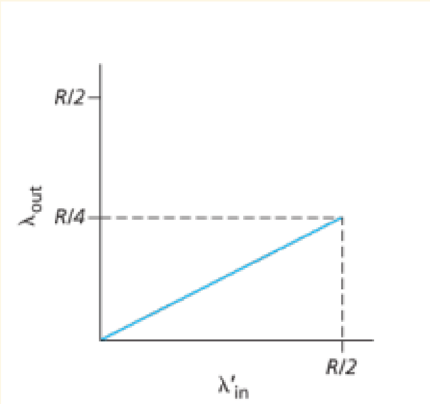
These retransmissions take up bandwidth that could otherwise be used for new data

Even worse, as queuing delays increase, even packets that are *not* dropped will time out and be re-sent

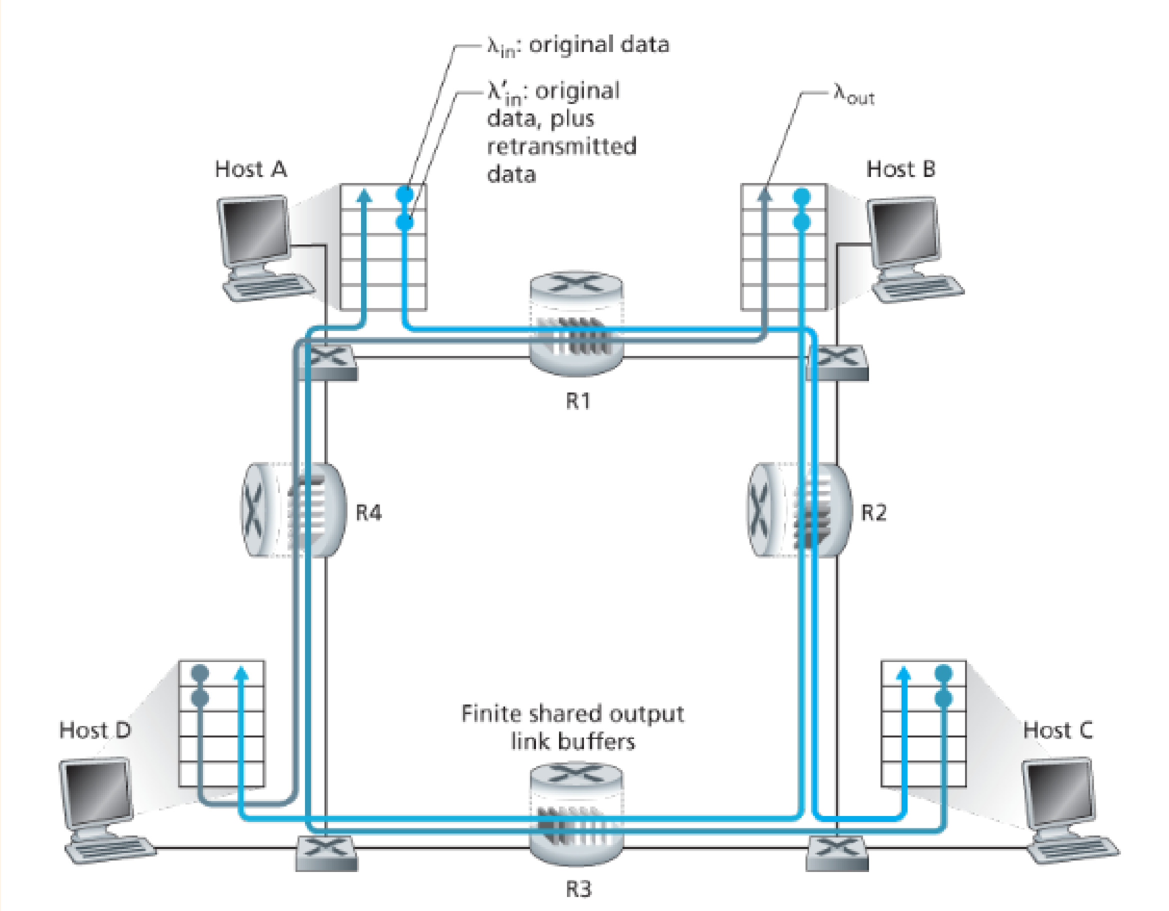
These unnecessary resends further decrease useful bandwidth


λin: original data
λ'in: original data, plus
retransmitted data
λout
Host A
Host B
Host C
Host D
Finite shared output
link buffers

Assuming packets forwarded on average twice



Next, consider slightly larger network with finite buffers



λ_{in}: original data
λ'_{in}: original data, plus retransmitted data
λ_{out}
Host A
Host B
R1
R4
R2
Host D
Finite shared output link buffers
Host C
R3

Consider increasing amount of traffic from A -> C and B -> D

A -> C traffic goes through R1 and then R2

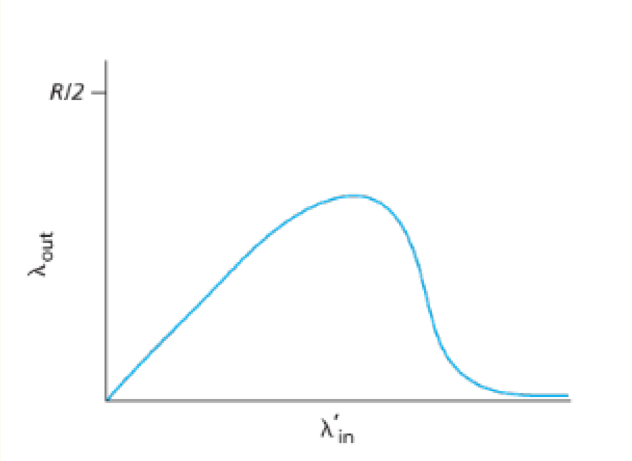
B -> D traffic goes through R2 and then R3

Both paths share R2, but A has rate limited by R1 -> R2 link, whereas B may have more bandwidth on B -> R2 link

As hosts increase sending, A cannot send more to R2 than R1 link has capacity for, but B can send as much as it wants

Leads to packets from B crowding out packets from A, which results in high packet-loss rate for A at R2

In the limit, effective rate for A -> C connection goes to 0


R/2
λout
λ′in

By the time they are dropped at R2, packets from A have already gone through R1

Many packets going through R1 and never reaching destination

Result is even more waste of transmission capacity of R1

If hosts send data into network unchecked, everyone ends up worse off

We next examine mechanisms for congestion control