CIS 457 - Data Communications

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Images taken from Kurose and Ross book

Delay and Packet Loss

Previously had simple model of delay relying only on transmission rate over links

Other factors come into play, particularly traffic on the network

Packet moves through series of links and routers on its way from host to destination

Four types of delay occur at *each* router

- nodal processing delay
- queueing delay
- transmission delay
- propagation delay

We previously considered mainly transmission delay

Nodal processing delay

Router examines header and decides where to forward packet (routers have more than one outbound link)

Other processing, such as error correction, may be performed

Generally on the order of microseconds

Queueing delay

Time spent stored in router, waiting to be transmitted

Each outgoing link can transmit just one message at a time

Length of queueing delay depends on amount of traffic in network

Typically takes microseconds to milliseconds

Transmission delay

Each link has fixed transmission rate of R bits/sec

Entire rate is used on single packet at a time

If packet is L bits, transmission delay is L/R seconds

Typically microseconds to milliseconds

Propagation delay

Time packet spends travelling on the wire (or other medium)

Various links have different speeds at which information propagates

As distance between nodes increases, so does propagation delay

Propagation delay computed as distance/speed

On wide-area networks, typically milliseconds

Transmission vs propagation delay

Transmission and propagation delay are sometimes confused, but they are very different

Transmission delay is a function of transmission rate and packet size

Propagation delay is a function of distance and has nothing to do with transmission rate or packet size

Book uses tollbooths as an analogy

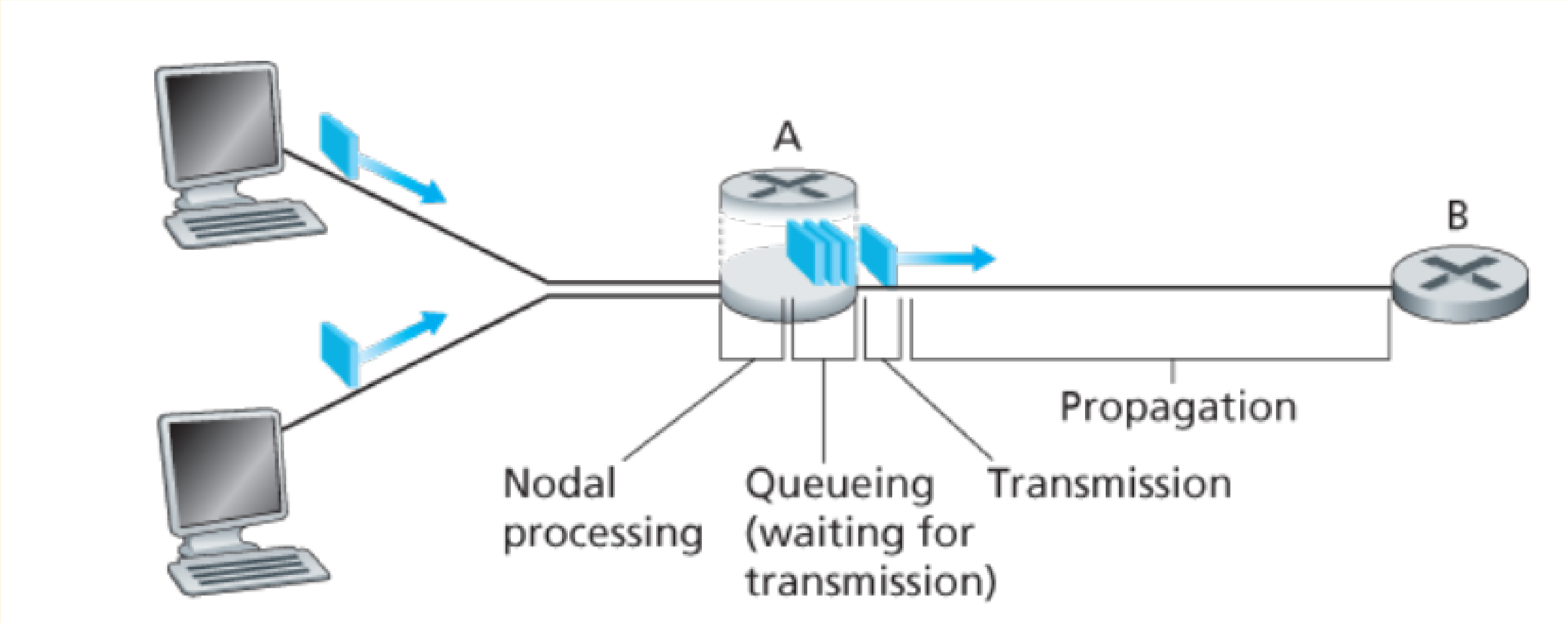
Transmission vs propagation delay

Assume tollbooth services 1 car per 10 seconds

Distance between tollbooths is 35 miles, and speed limit is 70 miles/hour

"Transmission delay" is time to get through tollbooth and back onto road (assume there is no line at booth): 10 seconds

"Propagation delay" is time to drive between booths: 30 minutes


A
B
Propagation
Nodal
processing
Queueing
(waiting for
transmission)
Transmission

Total nodal delay is sum of all four types of delay

How much each term affects total delay depends on particular network

For example, if using a satellite uplink, propagation delay may be very important, whereas it will not be as important on a local area network

Whereas other delays are more-or-less fixed for particular network, queueing delay is not

Often consider average queueing delay to determine delay in network, but even that can be misleading

Does not just matter how much traffic, but also when traffic tends to arrive

- is traffic "bursty" (tends to come all at once)
- or steady (is roughly the same at all times)?

Also, transmission rate of link will determine how long it takes to get packets out of router and therefore how quickly queues grow

Let a be average arrival rate in packets/sec

Assume all packets are same size: L bits

Then, traffic comes in to router at La bits/sec

Traffic goes out of router at rate of link: R bits/sec

Quantity La/R is **traffic density**

Ratio of traffic flowing in to traffic flowing out

If traffic density is greater than 1, more data is coming in to router than out

If traffic density is less than 1, more data is going out of router than coming in

If $La/R > 1$, queueing delay will approach infinity

Packets are coming in faster than they can be removed, so queue can never shrink

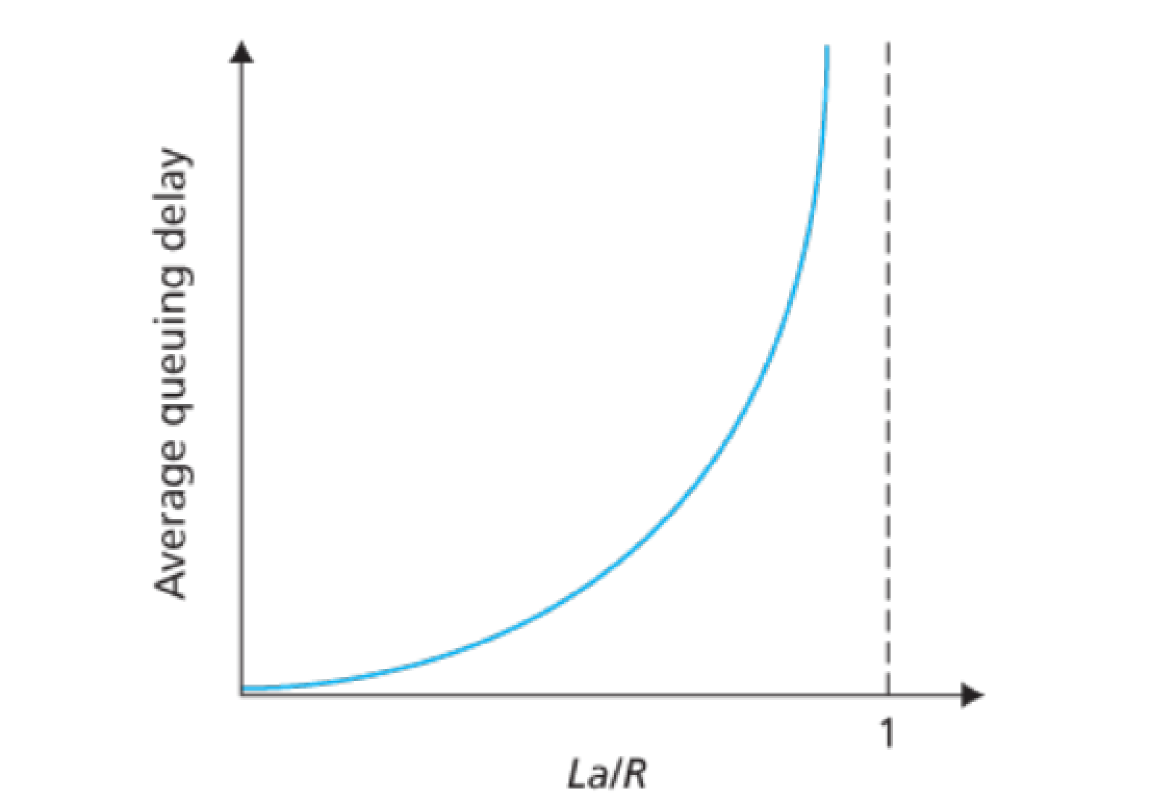
In reality, queue size is finite, so this results in packets being **dropped** by router (also called **lost packets**)

If $La/R < 1$, need to know two more things to determine amount of traffic

- is traffic bursty?
- how close is traffic density to 1?

If traffic comes in steadily, router can send out everything that comes in (because $R > La$), so no queue will exist

If traffic comes in bursts, router will temporarily not be able to keep up with incoming traffic, so queueing delays will occur


Average queuing delay
1
La/R

In general, low traffic intensity means low queueing delay

As intensity nears 1, small increases in intensity make large difference in delay

This is akin to normally-crowded highway where traffic increases just a bit -- usually enough of a problem to cause large delays