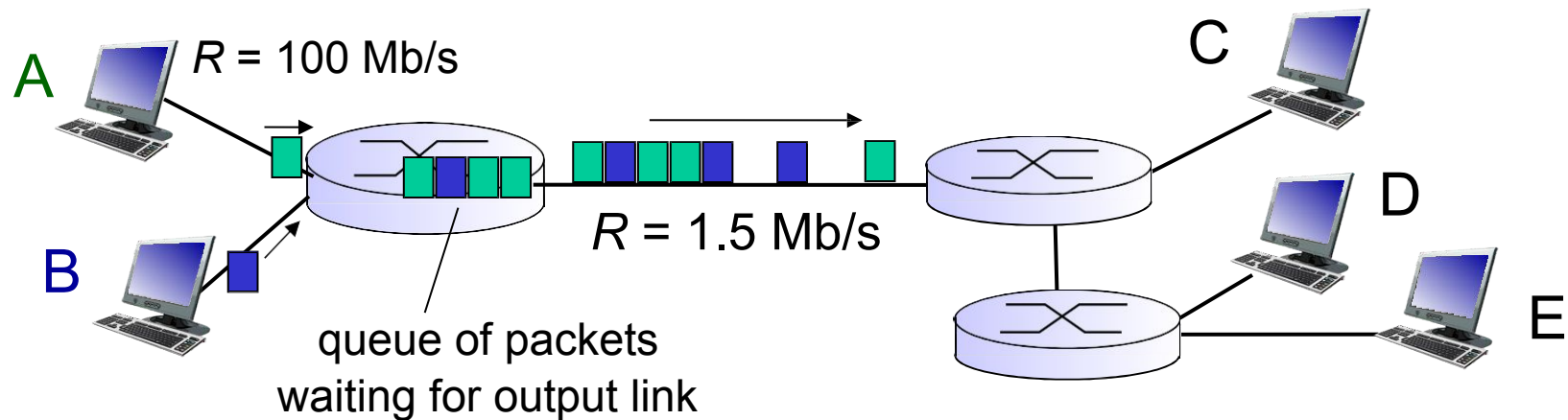# Packet Switching: queueing delay, loss
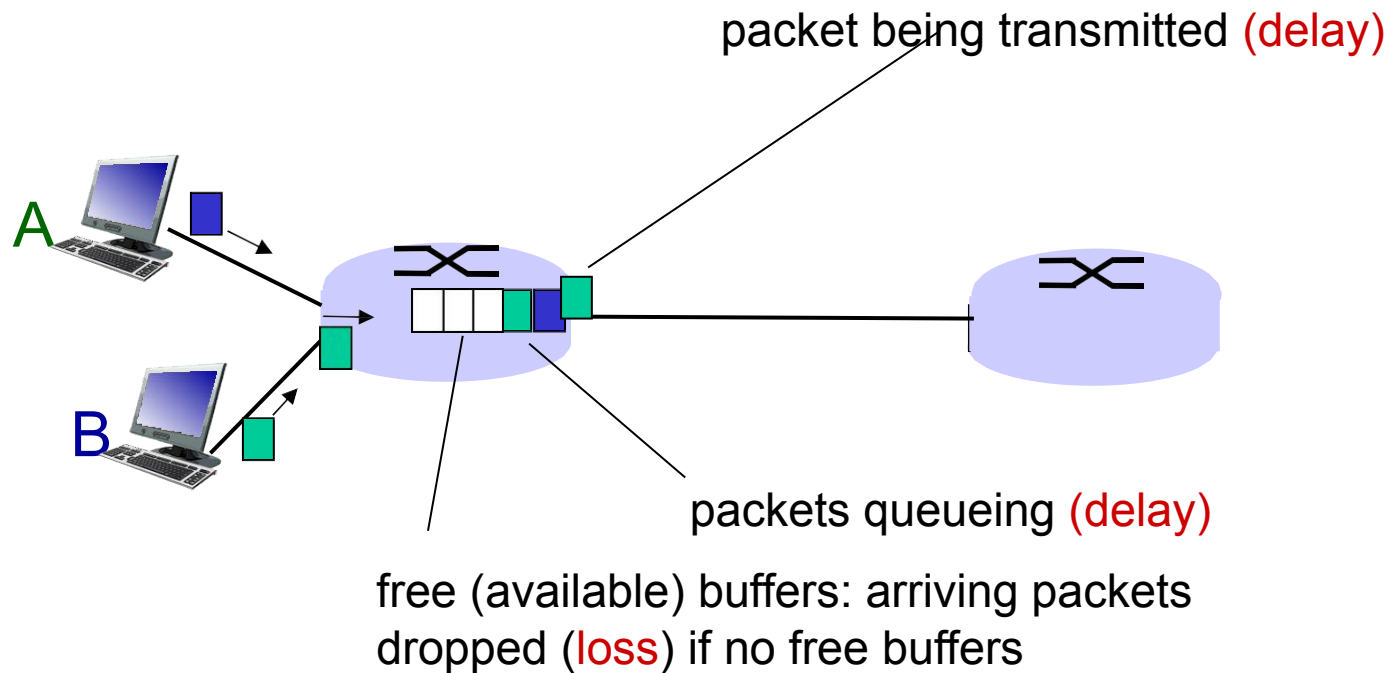

queuing and loss:

❖ If arrival rate (in bits) to link exceeds transmission rate of link for a period of time:
  ▪ packets will queue, wait to be transmitted on link
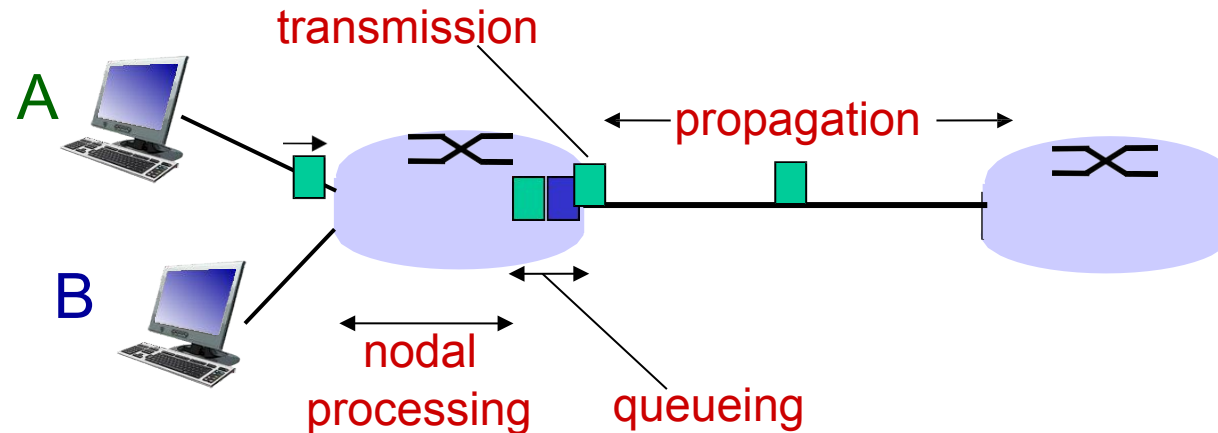 ▪ packets can be dropped (lost) if memory (buffer) fills up

How do loss and delay occur?

packets *queue* in router buffers

❖ packet arrival rate to link (temporarily) exceeds output link capacity

❖ packets queue, wait for turn

packet being transmitted (delay)

A

B

packets queueing (delay)

free (available) buffers: arriving packets dropped (loss) if no free buffers

Four sources of packet delay

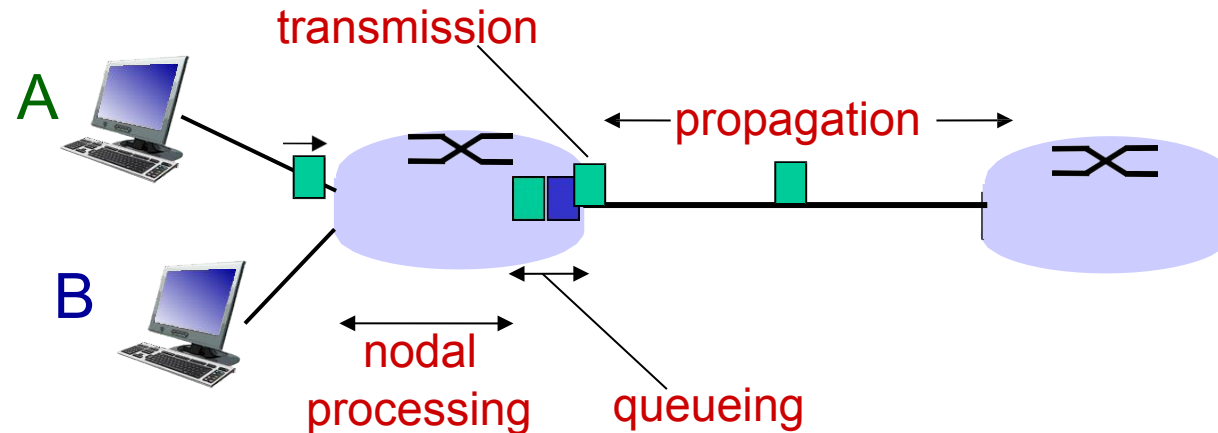$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

d_{proc}: nodal processing
- check bit errors
- determine output link
- typically $<$ msec

d_{queue}: queueing delay
- time waiting at output link for transmission
- depends on congestion level of router

Four sources of packet delay

$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$
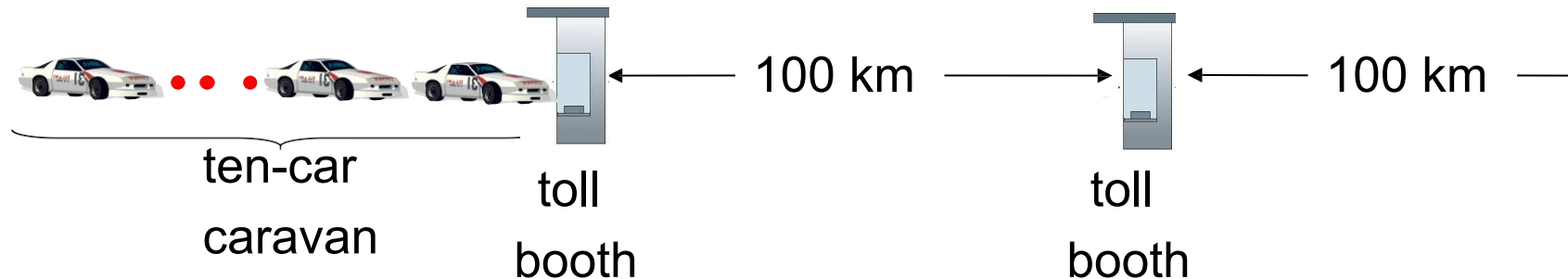
d_{trans}: transmission delay:
- *L*: packet length (bits)
- *R*: link *bandwidth (bps)*
- $d_{trans} = L/R$

d_{trans} and d_{prop} *very* different

d_{prop}: propagation delay:
- *d*: length of physical link
- *s*: propagation speed in medium ($\sim 2 \times 10^8$ m/sec)
- $d_{prop} = d/s$

Caravan analogy

ten-car caravan

toll booth

100 km

toll booth

100 km

- ❖ cars "propagate" at 100 km/hr
- ❖ toll booth takes 12 sec to service car (bit transmission time)
- ❖ car~bit; caravan ~ packet
- ❖ *Q:How long until caravan is lined up before 2nd toll booth?*

- ▪ time to "push" entire caravan through toll booth onto highway = 12*10 = 120 sec
- ▪ time for last car to propagate from 1st to 2nd toll both: 100km/(100km/hr)= 1 hr
- ▪ *A:62 minutes*

Caravan analogy (more)

ten-car caravan — toll booth — 100 km — toll booth — 100 km
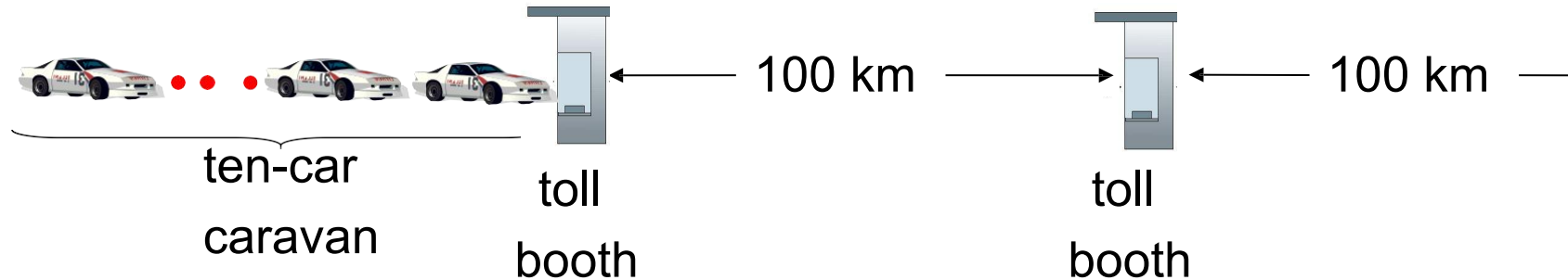
- ❖ suppose cars now "propagate" at 1000 km/hr
- ❖ and suppose toll booth now takes one min to service a car

- ❖ *Q:*Will cars arrive to 2nd booth before all cars serviced at first booth?

  - *A:Yes!* after 6 min, 1st car arrives at second booth; three cars still at 1st booth.

Queueing delay (revisited)

- *R:*link bandwidth (bps)

- *L:*packet length (bits)

- a: average packet arrival rate

average queueing delay (y-axis)

traffic intensity = La/R (x-axis), 1, La/R
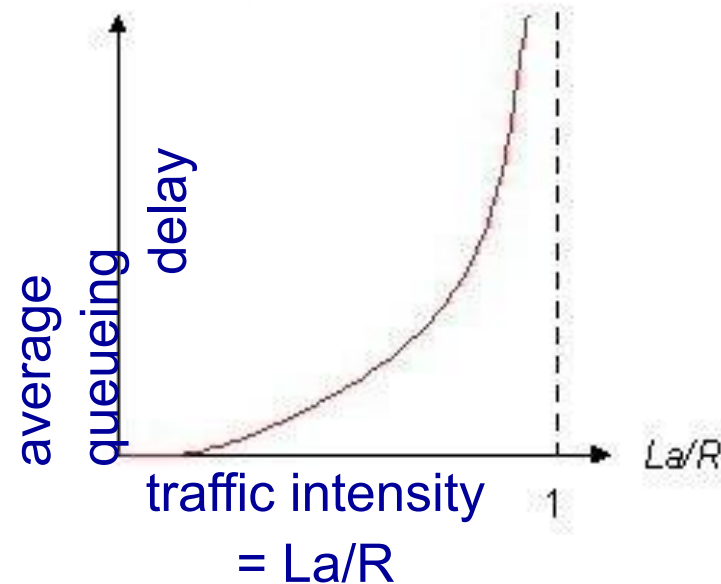
- *La/R ~* 0: avg. queueing delay small
- *La/R - >* 1: avg. queueing delay large
- *La/R >* 1: more "work" arriving than can be serviced, average delay infinite!

La/R ~ 0

La/R -> 1