Overview of Computers

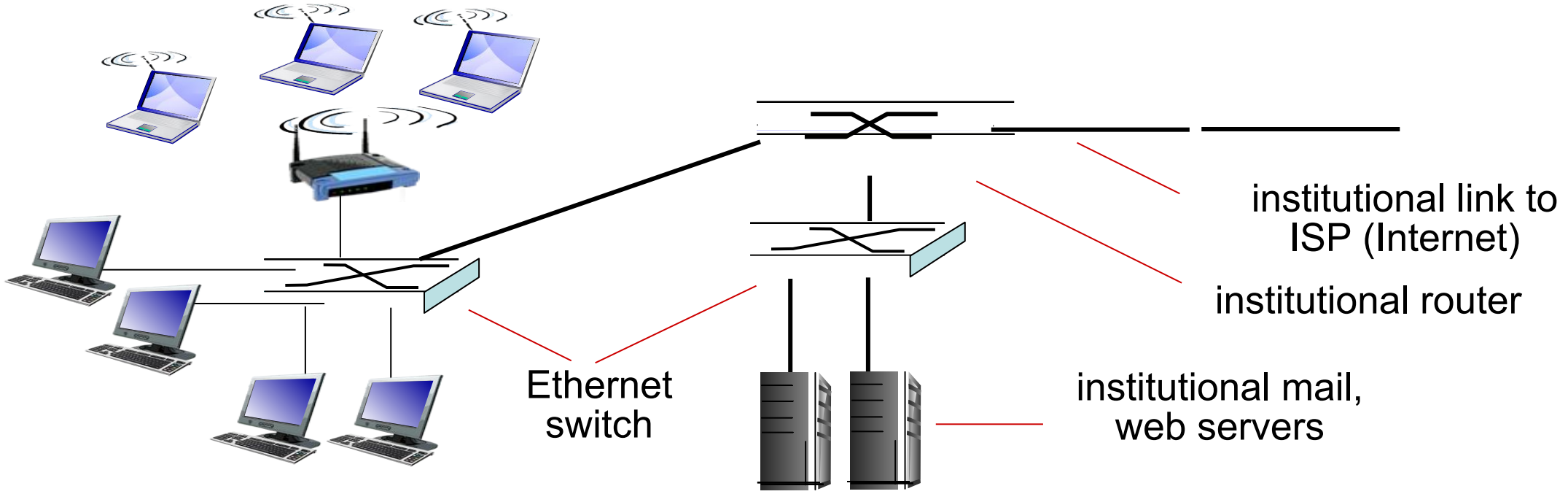
Module-IV

Computer Networks

Contents

- Introduction to Computer Networks
- Networks and Types of Networks
- Protocol Layers
- Ethernet

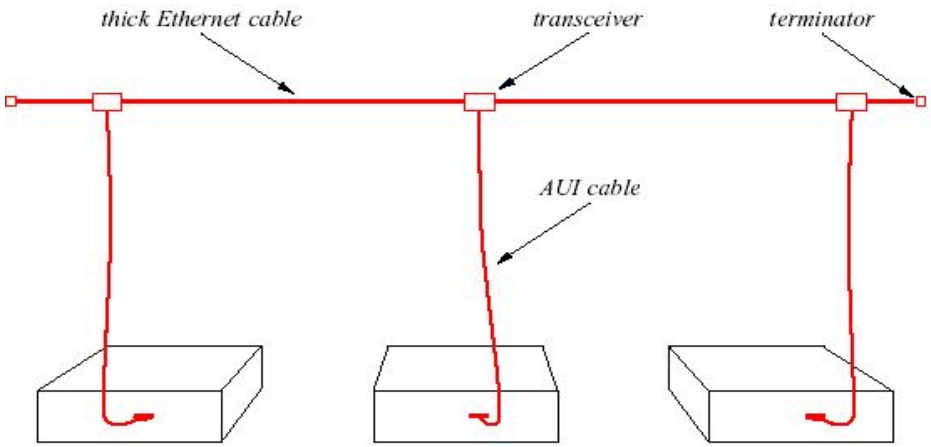
Enterprise access networks (Ethernet)

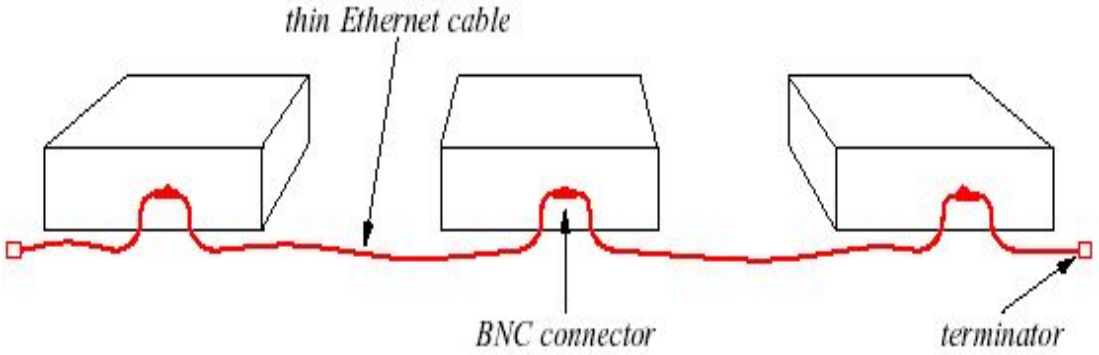


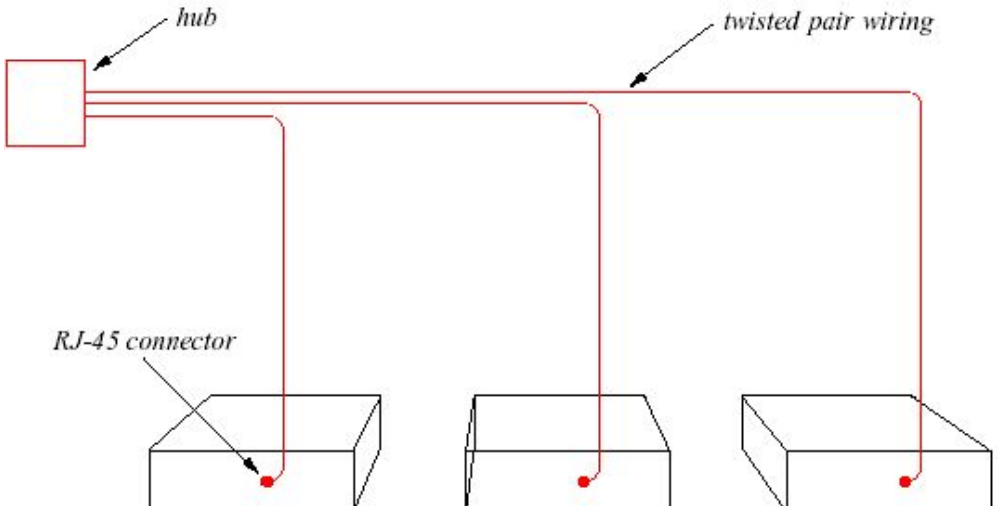
- typically used in companies, universities, etc
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- today, end systems typically connect into Ethernet switch

Ethernet Generations

- Original Ethernet:
  - Coaxial cable (10Base5)
  - Thicknet.
- Next Generation:
  - Thin coax cable (10Base2)
  - Thinnet.
- Modern Ethernet:
  - Twisted pair ethernet (10BaseT)
  - Uses hub: physical star but logical bus.

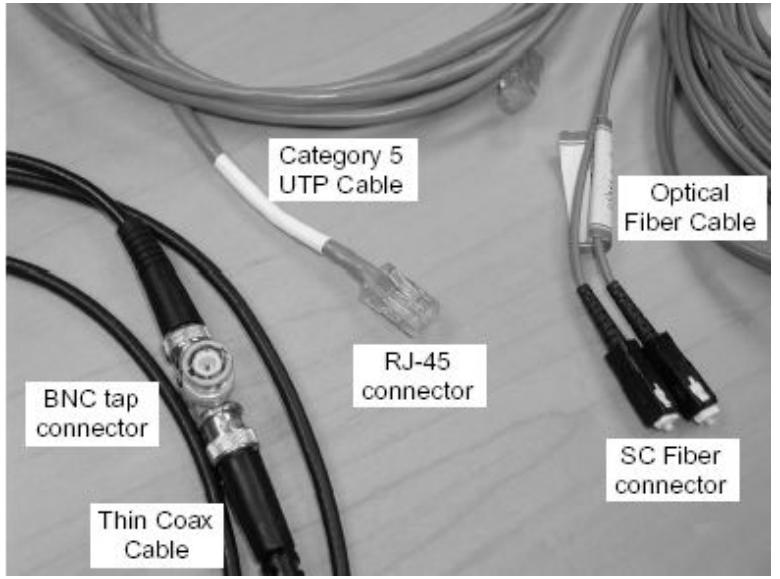


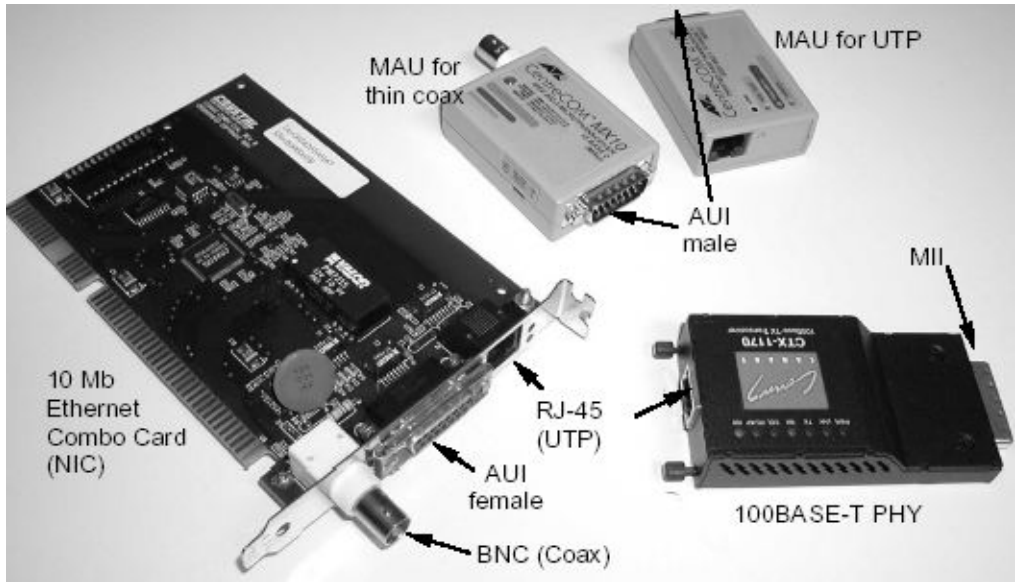




Ethernet Components

- NIC – Network Interface Card
  - Integrated Tx/Rx – direct interface to medium.
- MAU – Media Attachment Unit
  - Attaches network interface to the medium (integrated into NIC).
- AUI – Attachment Unit Interface
  - Decouple physical layer -reuse MAC design with different media.
- MII – Media Independent Interface
  - Like AUI for gigabit / faster ethernets.



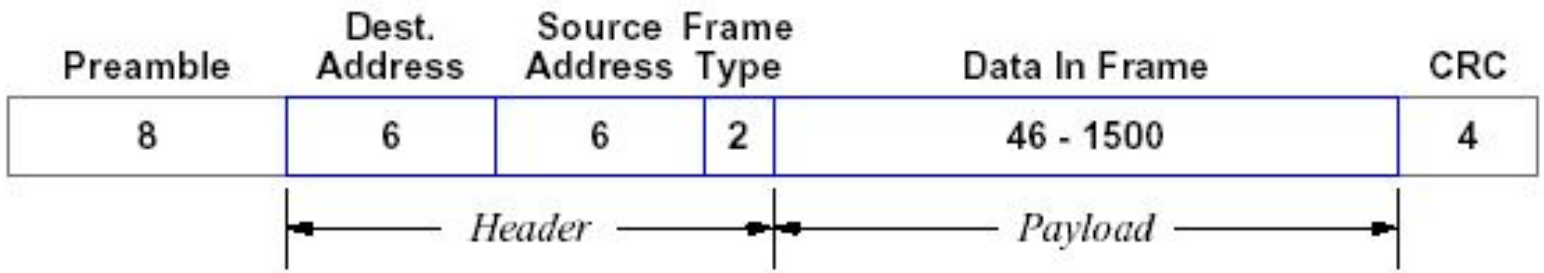


Ethernet Addressing

- 48-bit address
- Address assigned when NIC card is manufactured.
- Packets can be sent to
  - Single address – Unicast
  - All stations on network – Broadcast (address = all 1s.)
  - Subset of stations – Multicast

- Broadcast (address = all 1s.)
  - All receivers accepts unicast / broadcats.
- Half addresses reserved for multicast (2^{47})
  - NIC can accepts zero or more multicasts.

Ethernet Frame



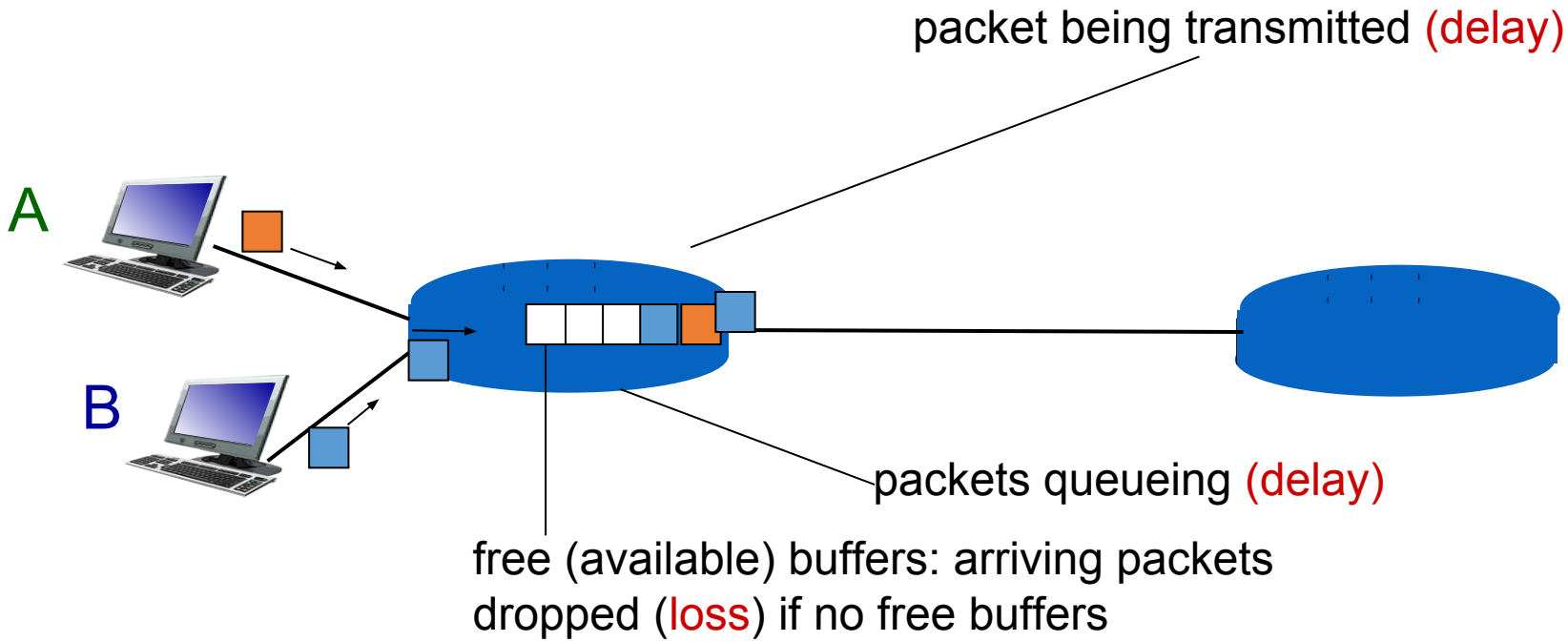
Recent Developments

- **100Base-FX**
  - LED light source / MMF / 2 km max distance.
  - Modal dispersion – limited bandwidth
- **100Base-SX** (IEEE 802.3z)
  - Short wavelength laser (850 nm)
  - Max distance = 5 km.
- **100Base-LX**
  - Long wavelength laser (1310 nm)
  - Max distance = 5 km.

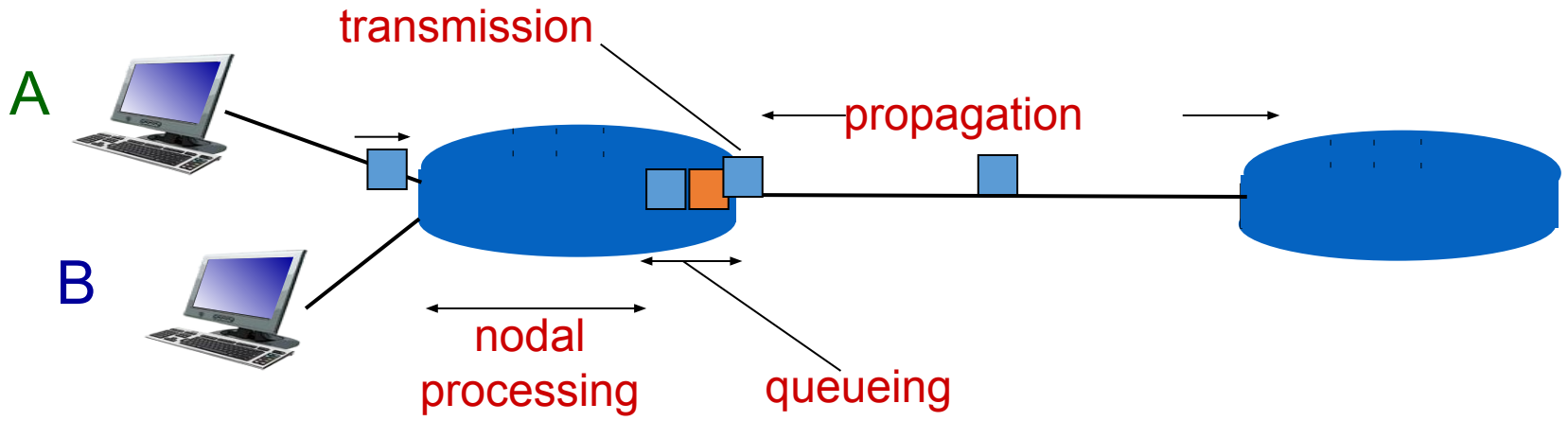
How do loss and delay occur?

packets *queue* in router buffers

- packet arrival rate to link (temporarily) exceeds output link capacity
- packets queue, wait for turn



Four sources of packet delay



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

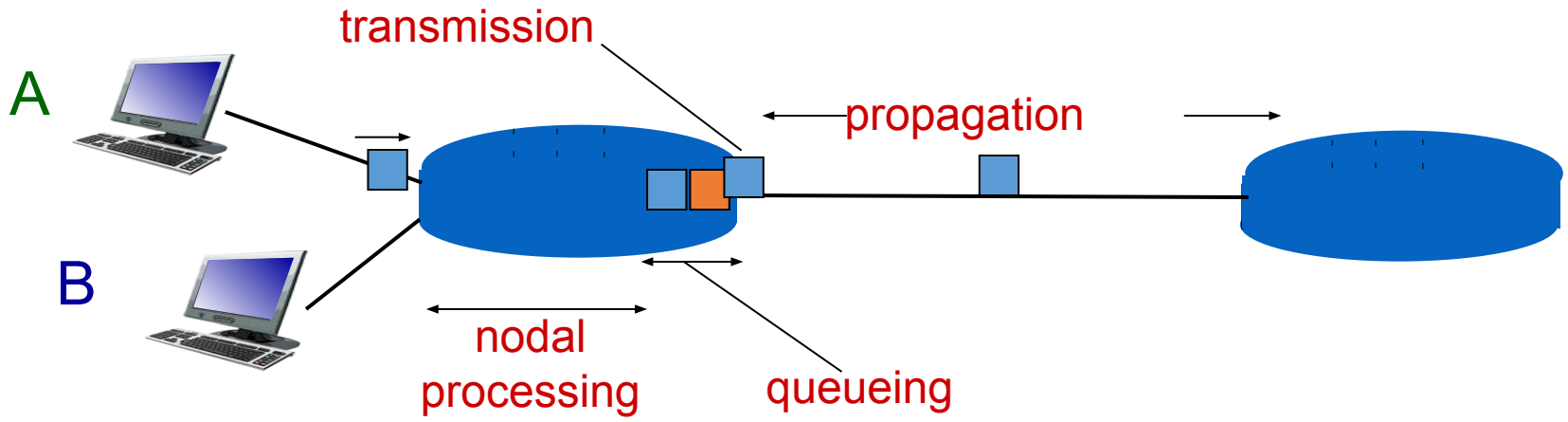
d_{proc}: nodal processing

- 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_{prop}: propagation delay:

- d: length of physical link
- s: propagation speed in medium (~2×10^8 m/sec)
- $d_{prop} = d/s$

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

* Check out the Java applet for an interactive animation on trans vs. prop delay

Processing Delay

- Time required to examine the packets header
  - Determines where to direct the packet
  - Check for errors
- Order of microseconds

Queuing Delay

- If a router is busy in processing and transmitting a packet, a freshly arrived packet has to wait in queue (buffer) for its turn.
- No queuing delay if the router is idle.
- Queuing delay varies with time and location. In general, it is a random variable.
- Order of microseconds to milliseconds.

Transmission Delay

- Time required to push the packet into the link
- If the length of the packet is L bits and transmission rate of the link is R bps, then

$$\text{Transmission delay} = \frac{L}{R}$$

- Order of microseconds to milliseconds

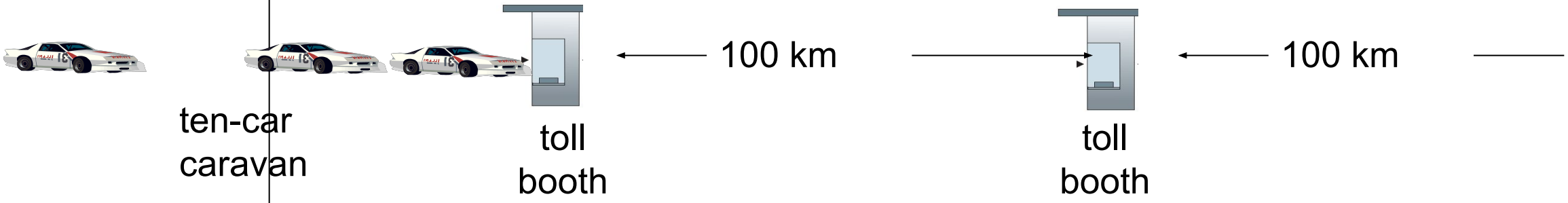
Propagation Delay

- Time required to propagate from one end of the link to the other end
- The propagation speed depends on the physical link between the routers
- In general, propagation speed s, is in the order of $2 \times 10^8 - 3 \times 10^8 m/s$.
- Propagation speed depends on the distance bewteen the routers, d
- Propagation delay $= \frac{d}{s}$

Traffic Intensity

- Queuing delays are random in nature
- Arrivals to a queue are also random in nature
- Traffic intensity is an indication of queuing delay
- Let a be the average number of packets arriving at a queue
- Each packet is of length L bits adn transmission rate is R bps
- Traffic intensity $= \frac{La}{R}$

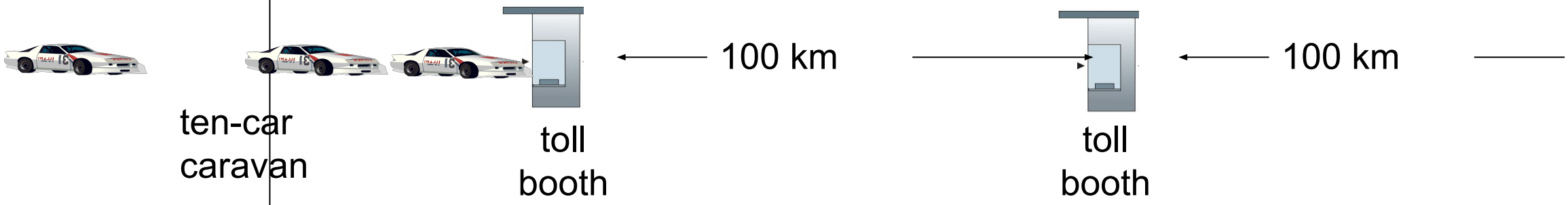
Caravan analogy



- 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)

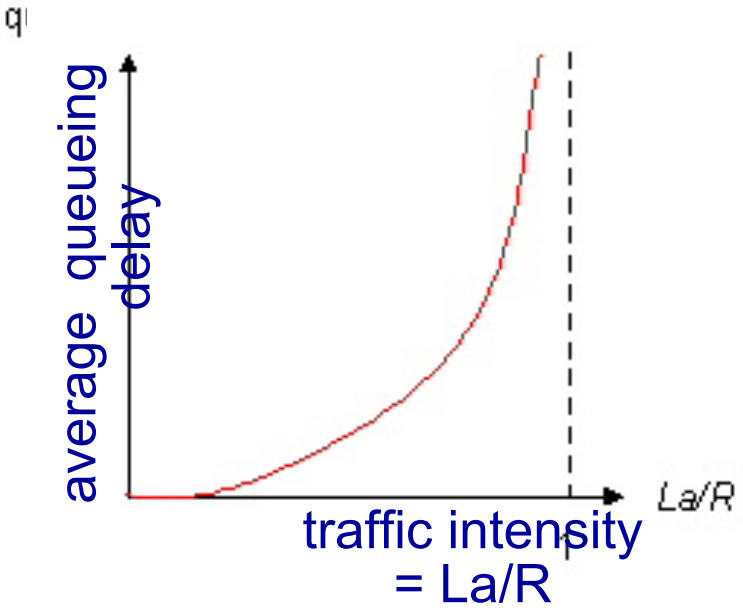


- suppose cars now "propagate" at 1000 km/hr
- and suppose toll booth now takes one min to service a car
- *Q:* Will cars arrive to 2nd booth before all cars serviced at first booth?

  - *A: Yes!* after 7 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



- *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!

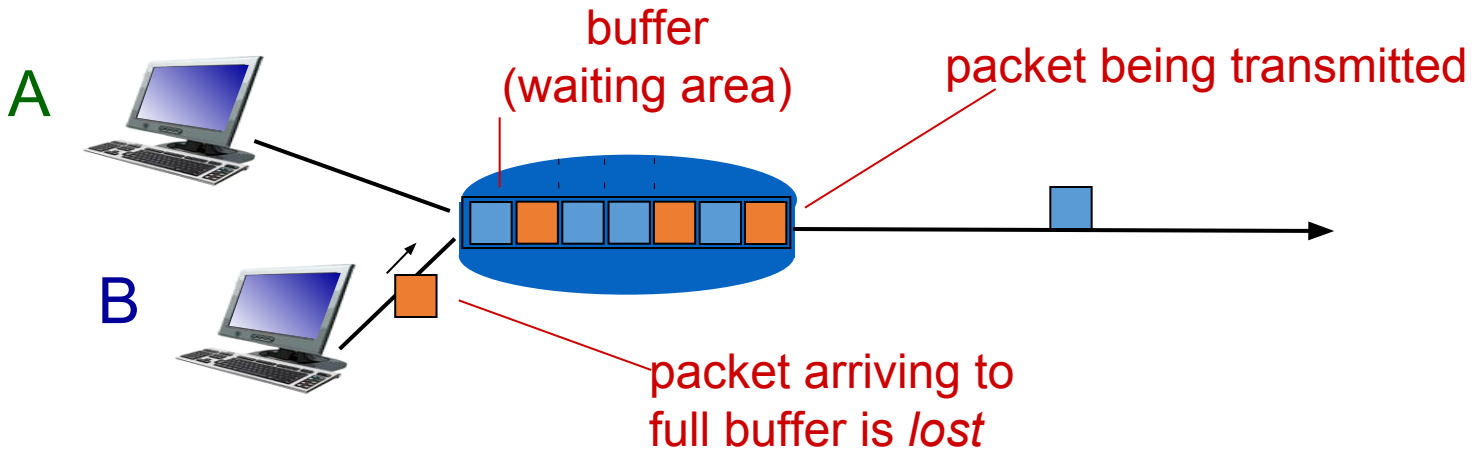
La/R ~ 0

La/R -> 1

* Check out the Java applet for an interactive animation on queuing and loss

Packet loss

- queue (aka buffer) preceding link in buffer has finite capacity
- packet arriving to full queue dropped (aka lost)
- lost packet may be retransmitted by previous node, by source end system, or not at all



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