CIS 457 - Data Communications

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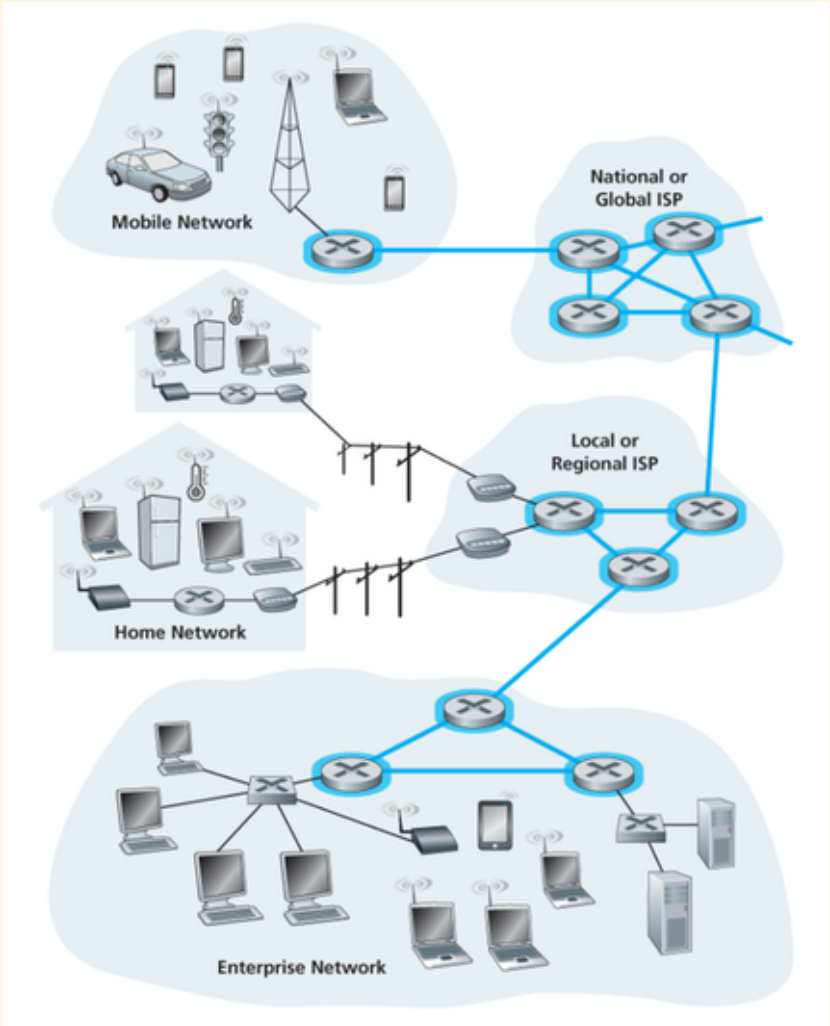
Images taken from Kurose and Ross book

Network Core

The network edge is where hosts reside and useful work is performed

The network core is a group of packet switches and links


Mobile Network
National or
Global ISP
Local or
Regional ISP
Home Network
Enterprise Network

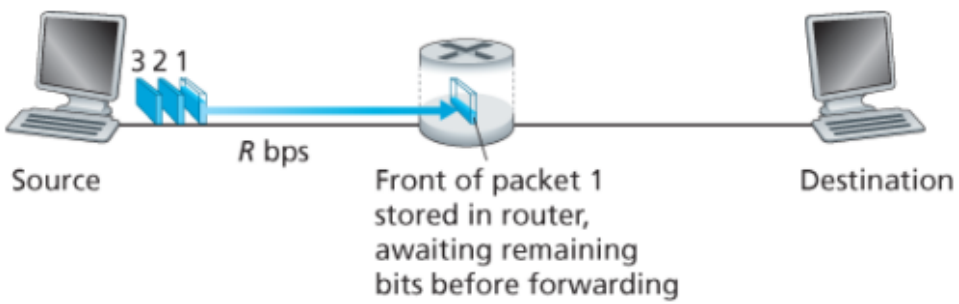
Packets (chunks of data exchanged by end systems) travel through the packet switches and links

When a packet is transmitted over a particular link, it uses the full transmission rate of the link

If packet is L bits and transmission rate of link is R bits/sec, it takes L/R seconds to transmit packet (though we will see a more detailed model later)

Store-and-forward transmission -- packet switch must reeive entire packet before beginning to send first bit of packet onto outbound link

Most packet switches use this type of transmission


3 2 1
R bps
Source
Front of packet 1
stored in router,
awaiting remaining
bits before forwarding
Destination

To see effect of store-and-forward, we consider very simple model of transmission with no propogation delay along wire

Sending from one entity to an adjacent entity takes exactly as long as it takes to get bits onto wire (L/R seconds)

First bit of first packet is received instantly by router, but cannot be forwarded yet because entire packet has not arrived

At time L/R, entire packet has arrived and been saved at router, so packet can be sent to destination

This takes another L/R, resulting in 2L/R total time

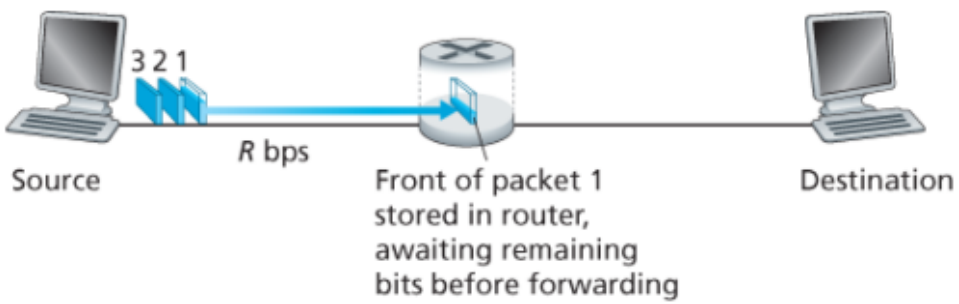
If router did not need to wait and could begin transmitting as soon as bits arrived, router would not cause any slowdown

Entire process would take L/R seconds

However, this is infeasible because routers generally perform processing on packet to determine where to send it

Previous computation was for sending one packet (of several bits)

Next, want to determine how long until all three packets arrive at destination


3 2 1
R bps
Source
Front of packet 1
stored in router,
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Destination

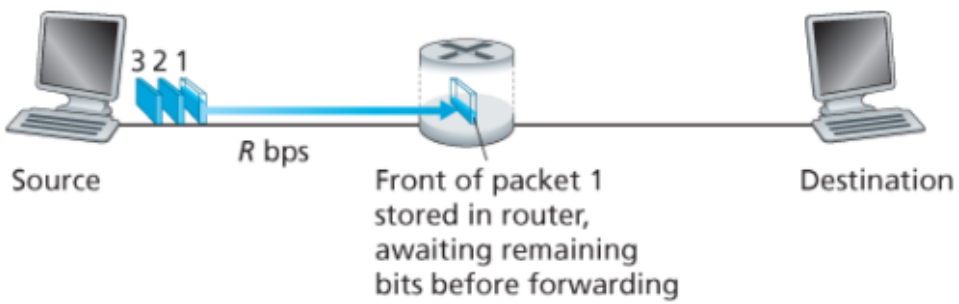
At time L/R, router has received first packet

Router begins transmitting first packet to destination

At the same time, source begins sending second packet to router

It takes exactly as long for source to send as for router to send

At time 2L/R, packet 1 has been delivered and packet 2 has arrived at router


3 2 1
R bps
Source
Front of packet 1
stored in router,
awaiting remaining
bits before forwarding
Destination

Every L/R seconds, same thing happens: router sends packet to destination and gets new packet from source

Delivering all three takes

- 1*(L/R) for router to receive packet
- 3*(L/R) for router to deliver the three packets

4*(L/R) total

That is time required to send 3 packets over 2 links

In general, if sending just one packet over N links (so, N - 1 routers in path), how long will it take?

Packet must be tranferred to first router, then second, ..., up to N-1st router

Packet must be sent from N-1st router to destination

$(N-1)*(L/R) + L/R = NL/R$

It takes NL/R seconds to send single packet over N links

Queueing delays

So far have considered just one source of delay when sending packet across network

Other delays may occur due to other traffic on network

If packet is ready to be sent out on communication link but there is already another packet being transferred, new packet must wait in **output buffer** (a.k.a. **output queue**)

Time spent waiting in output buffer is considered **queueing delay**

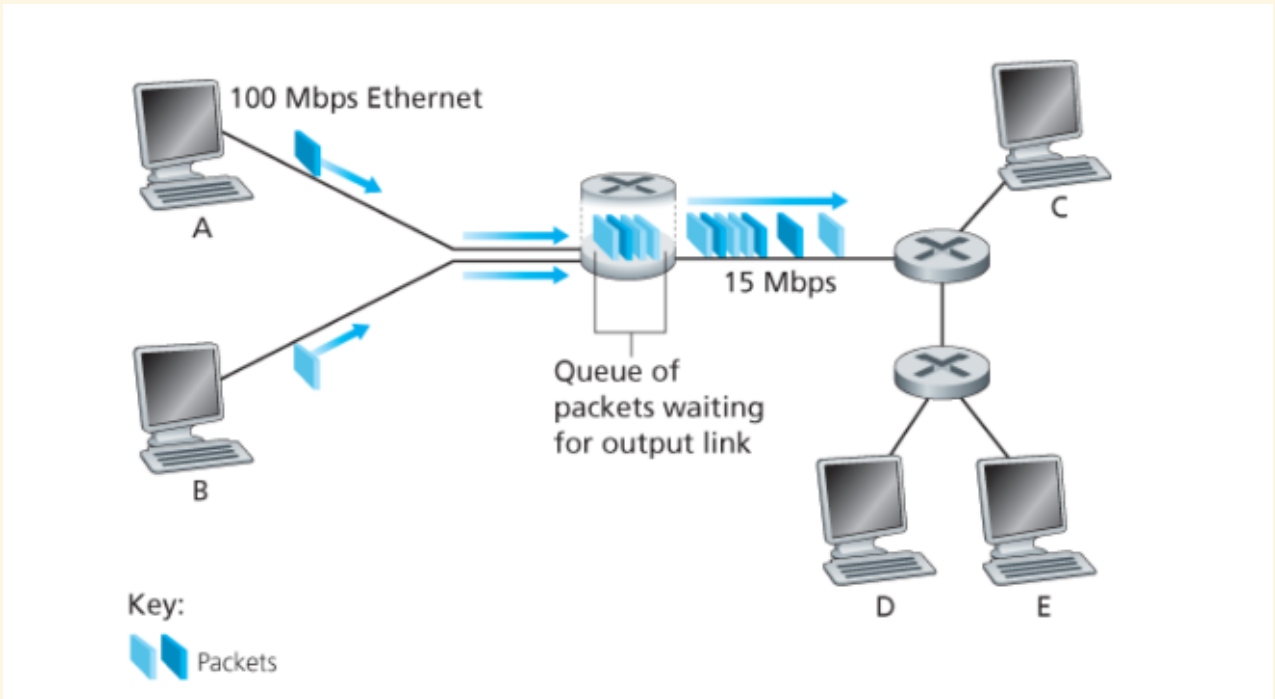
Unlike store-and-forward delay, queueing delays are variable

When network is highly congested, queueing delays can be very long

Space in output queue is finite

If too many packets end up in queue at once, buffer will not be able to hold them all

Packet loss will occur if new message arrives at full queue -- either that message or an older one in queue will be dropped


100 Mbps Ethernet
A
B
C
D
E
15 Mbps
Queue of
packets waiting
for output link
Key:
Packets