CSC4200/5200 – COMPUTER NETWORKING

NETWORK PERFORMANCE BASICS

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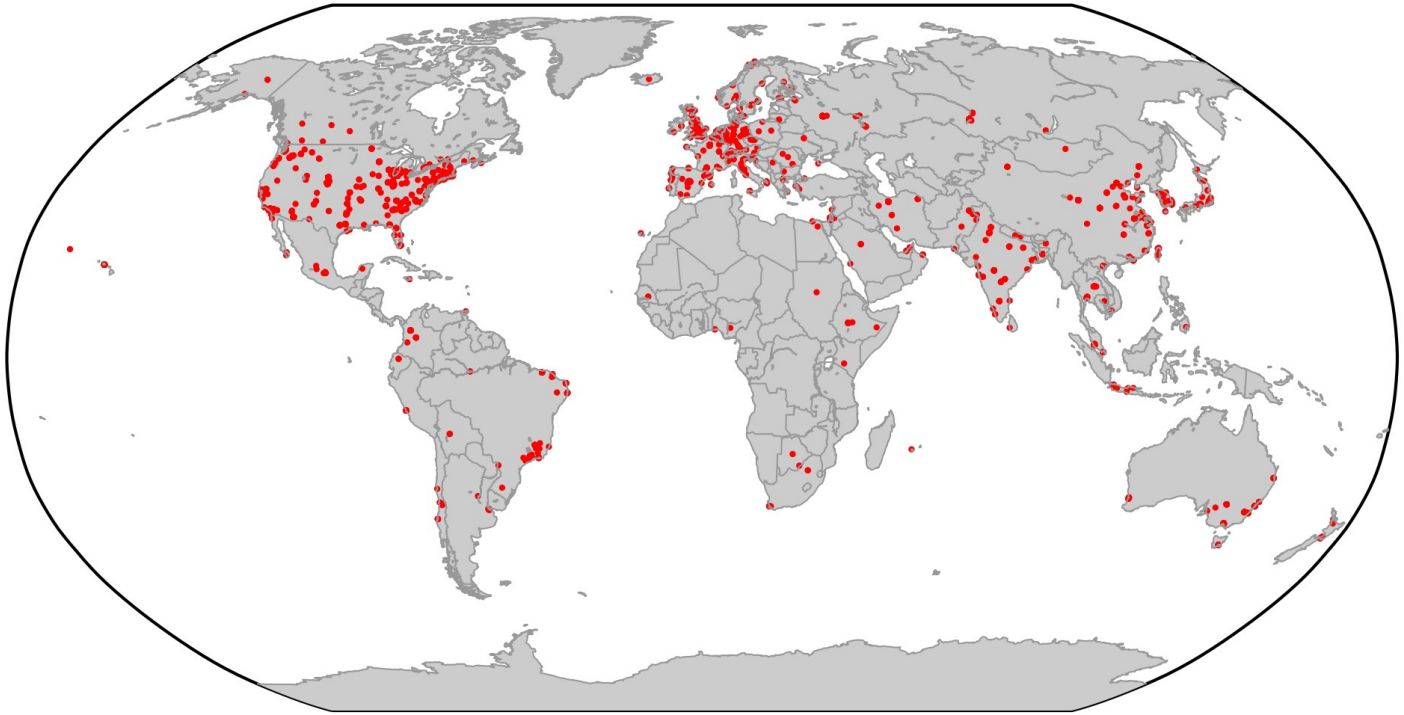
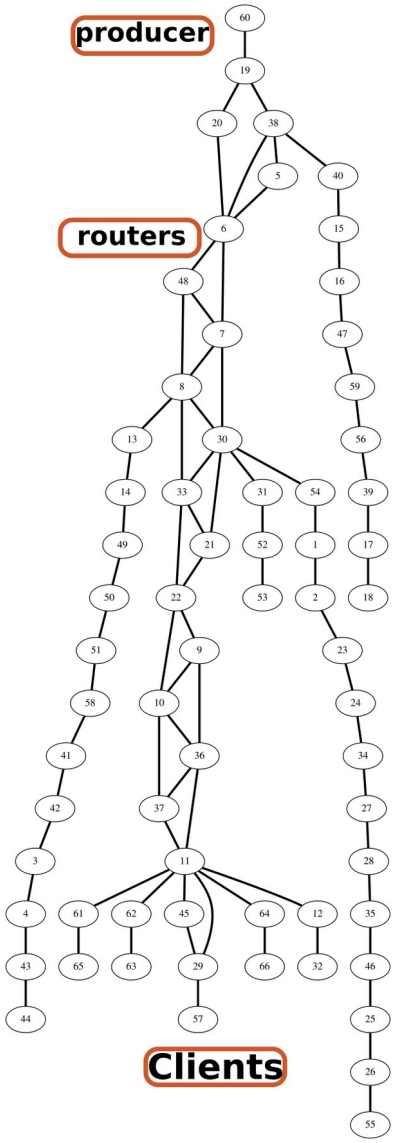
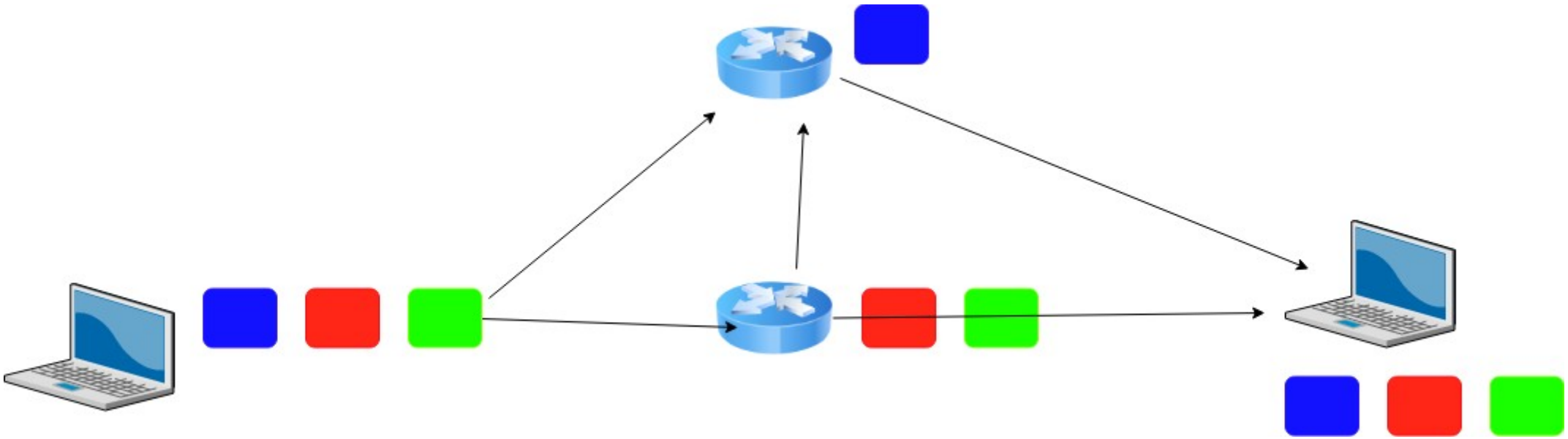
Recap – Network = Graph (Nodes + Links)





Packet Switching on the Internet



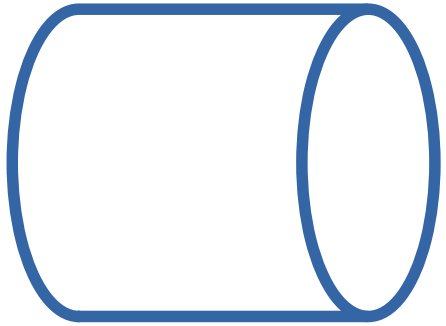
Performance – Terminology

- Bits = b
- Bytes = B
- Kilobytes = KB (1024 Bytes or 1000Bytes)
- Megabytes = MB (1024KB or 1000KB)

- Ask ECE folks = 1000, 1Mbps = 1000*1000Bps

- Ask CS folks = 1024, 1MB = 1024*1024Bytes

Performance Basics - Bandwidth Latency



- Bandwidth = Size of the network pipe
- Latency = Delay in sending packets
- Throughput = How fast your can send data, function of both bandwidth and latency (and other things)

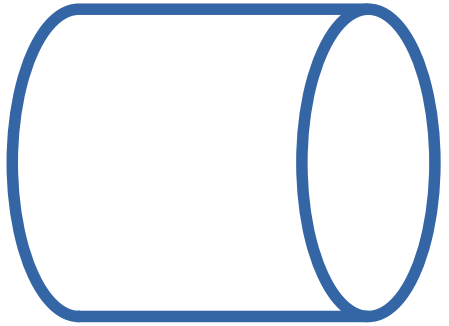
Bandwidth

Which one has more bandwidth?

Throughput

Which one has more trhoughput?

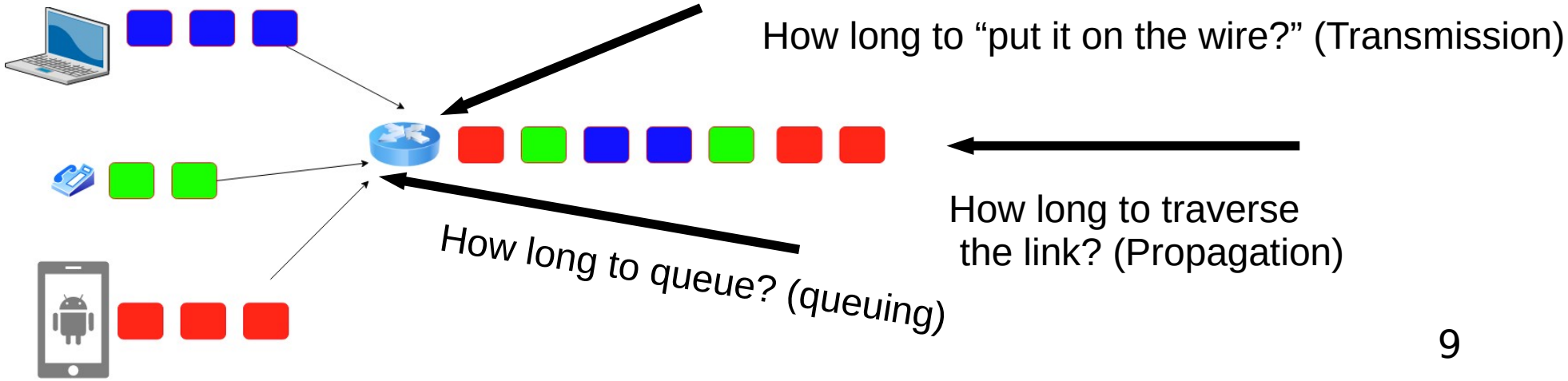
Performance Basics - Bandwidth and Latency



- Bandwidth = Size of the network pipe
- Latency = Delay in sending packets
- Throughput = How fast your can send data, function of both bandwidth and latency (and other things)

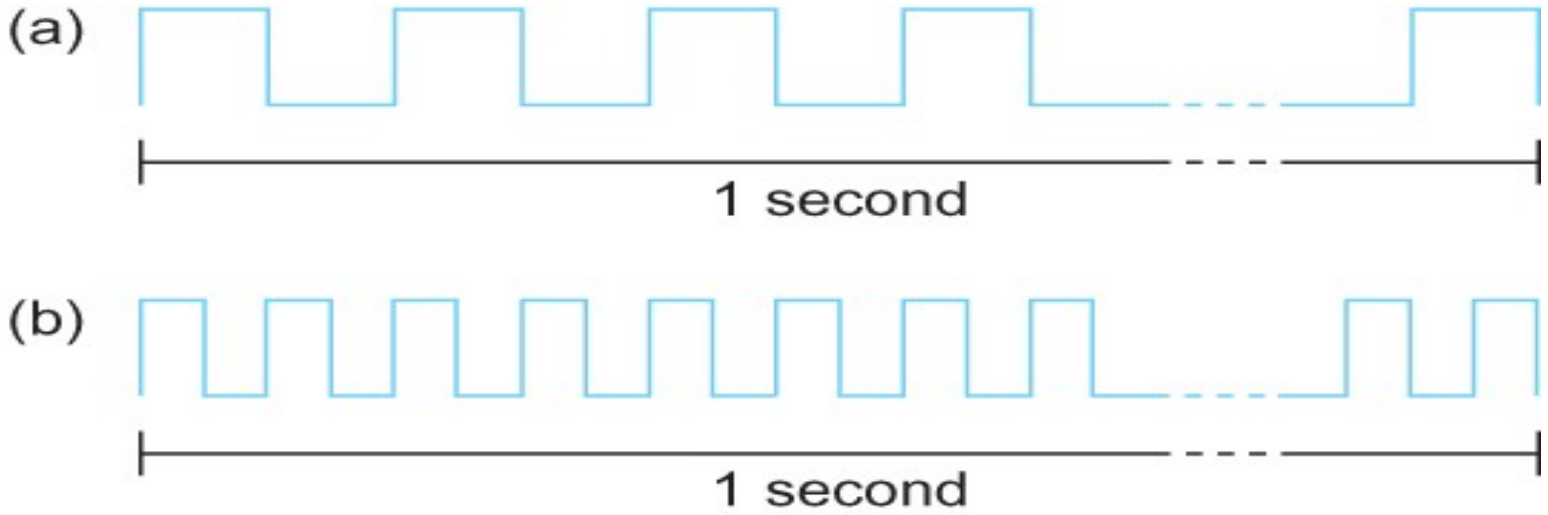
Performance - Latency

- Latency = Propagation Delay + Transmission Delay + Queuing Delay
- Propagation = Distance/Speed Of Light (in Copper or Fiber)
- Transmit = Size/Bandwidth



Performance - Latency

Performance – Bandwidth - bits/second



Bits transmitted at a particular bandwidth can be regarded as having some width:

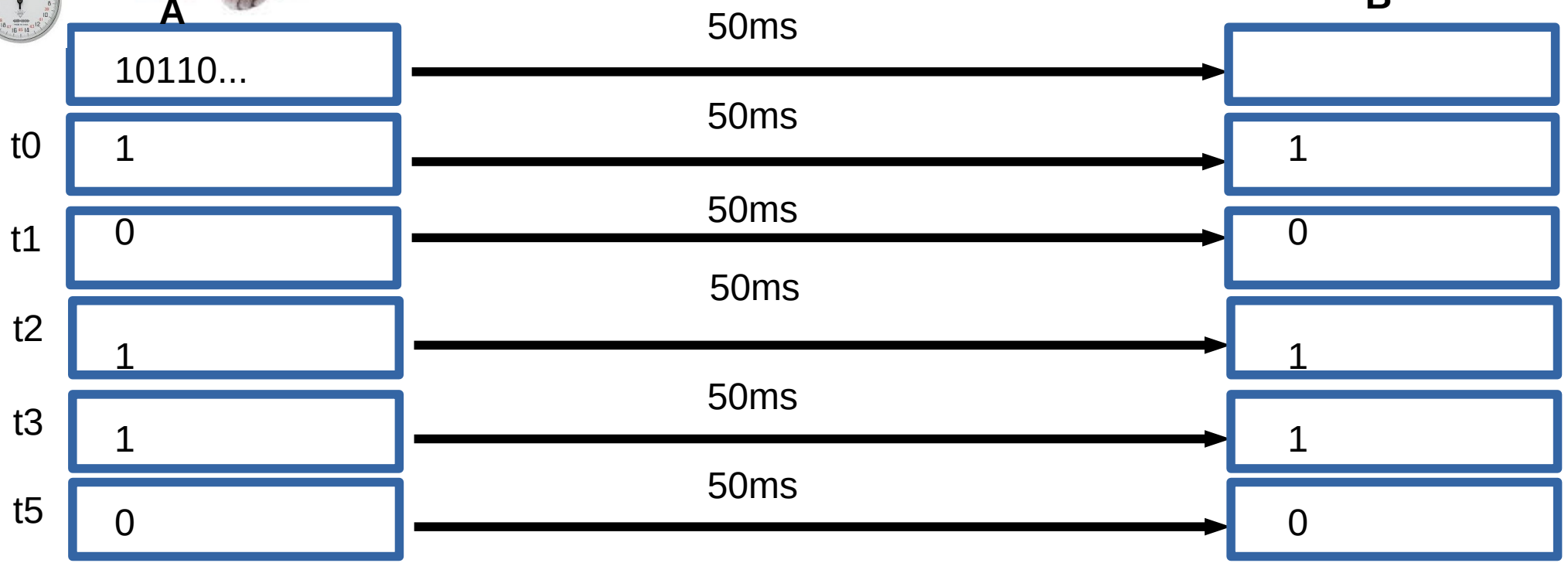
(a) bits transmitted at 1Mbps (each bit 1 μs wide);

(b) bits transmitted at 2Mbps (each bit 0.5 μs wide).

Packets are made of bits – each bit need some time to be processed at the router. This is transmission delay!

Propagation delay

Packets are made of bits. All bits must make it the next router before it can be forwarded.
Propagation delay = 50ms (time it takes for a bit to go from A to B)
Transmission delay = 1 ms (time it takes for each bit to be converted into signal)



Performance – Queuing Delay

- R: link bandwidth (bps)
- L: packet length (bits)
- A: Average packet arrival rate
- Traffic delay = AL/R

AL/R ~ 0

AL/R ~ 1

Everyone in the front has to be serviced first!!!!!

Performance – Example

- Calculate the total time required to transfer a 1000-KB file using 1KB packets. Assuming bandwidth is 1.5 Mbps, the RTT of 50 ms, an initial 2 × RTT of “handshaking” before any data is sent.

  Delay = Handshake + Transmission + Propagation + Queuing

  Delay = 2*50ms + (1000*1024*8)/(1.5*1000*1000) second + 50/2ms + 0 = 5.586seconds

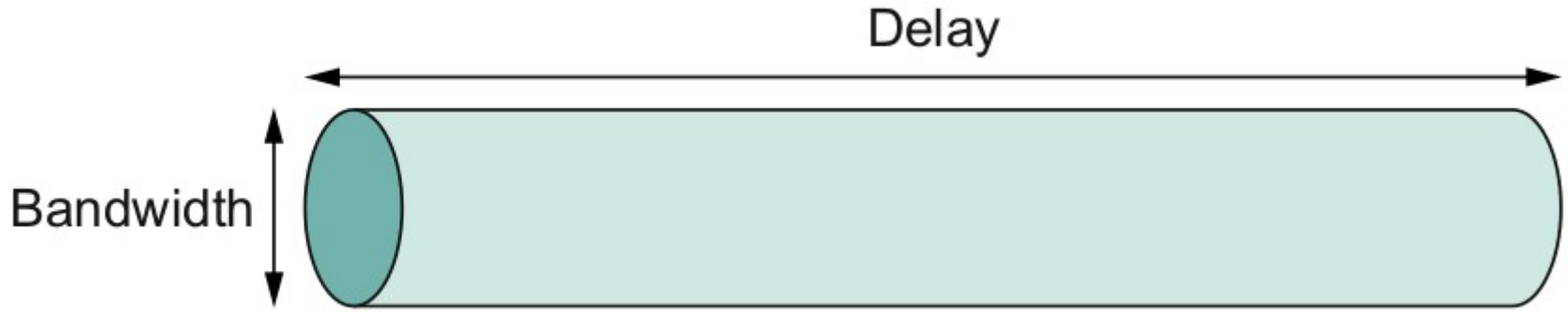
- **Propagation delay = First bit from sender to receiver**
- **Transmission delay = All bits on the wire**

Bandwidth x Delay Product

Capacity of a network pipe = Bandwidth (bits) x **Two way** Delay (Seconds) (a.k.a RTT or Round Trip Delay)

This is the amount of bits that a pipe can hold!

Bandwidth x Delay Product - Example



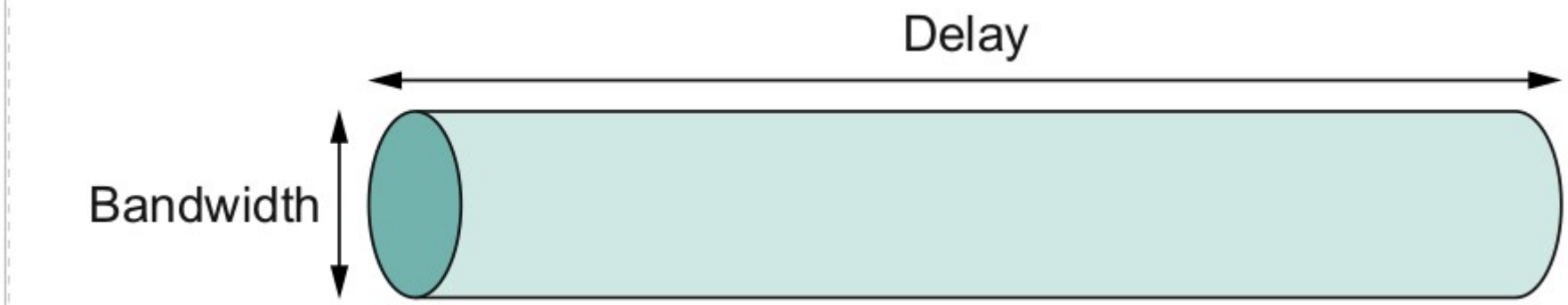
Bandwidth = 50Mbps
Latency = 100ms

Bandwidth x Delay = $50x10^{6}x100x10^{-3} = 5x10^{6}$ bits = 625 kilobytes

Bandwidth x Delay - Some more examples

Bandwidth = 54Mbps (Wireless G)
RTT = 1ms
How much data can the pipe hold?
BxD = $54x10^{6}x1x10^{-3}$

Bandwidth x Delay – Mars Rover

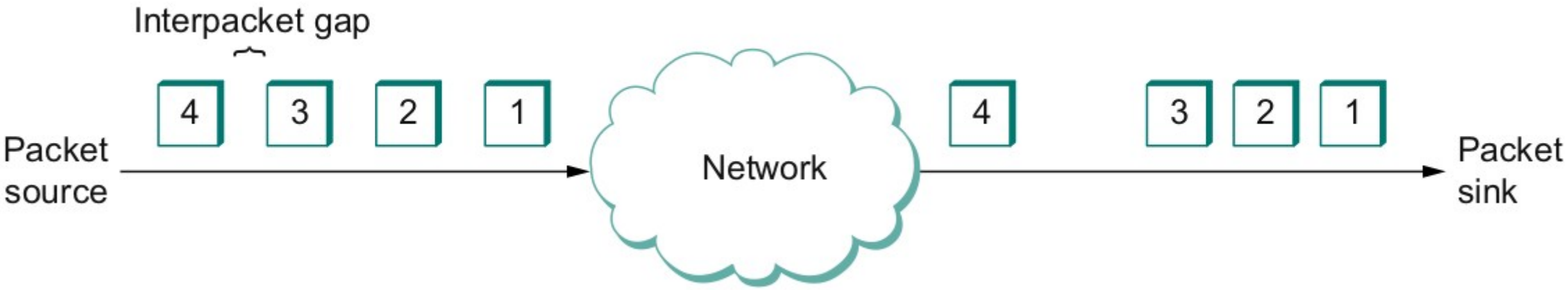


https://mars.nasa.gov/msl/mission/communications/

https://www.youtube.com/watch?v=NGgzq8eXZOQ

Breakout:
- Bit rate of curiosity: 32000bits/second
- Delay = 14 minutes each way
- BxD = 32000*14*60*2

And one more thing - Jitter



Also called Interpacket gap

- why does it happen (which artifact of packet switching?)
- why is it important (think video applications)?
- How do you solve this?

Performance – Example

- Calculate the total time required to transfer a 1000-KB file in the following case, assuming bandwidth is 1.5 Mbps, an RTT of 50 ms, a packet size of 1 KB data, and an initial 2 × RTT of “handshaking” before data is sent. (Peterson-Davie Exercise 3, Chapter 1)

  Delay = Handshake + Transmission + Propagation + Queuing

  Delay = 2*50ms + (1000*1024*8)/(1.5*1000*1000) second + 50/2ms + 0 = 5.586seconds

- **Propagation delay = First bit from sender to receiver**

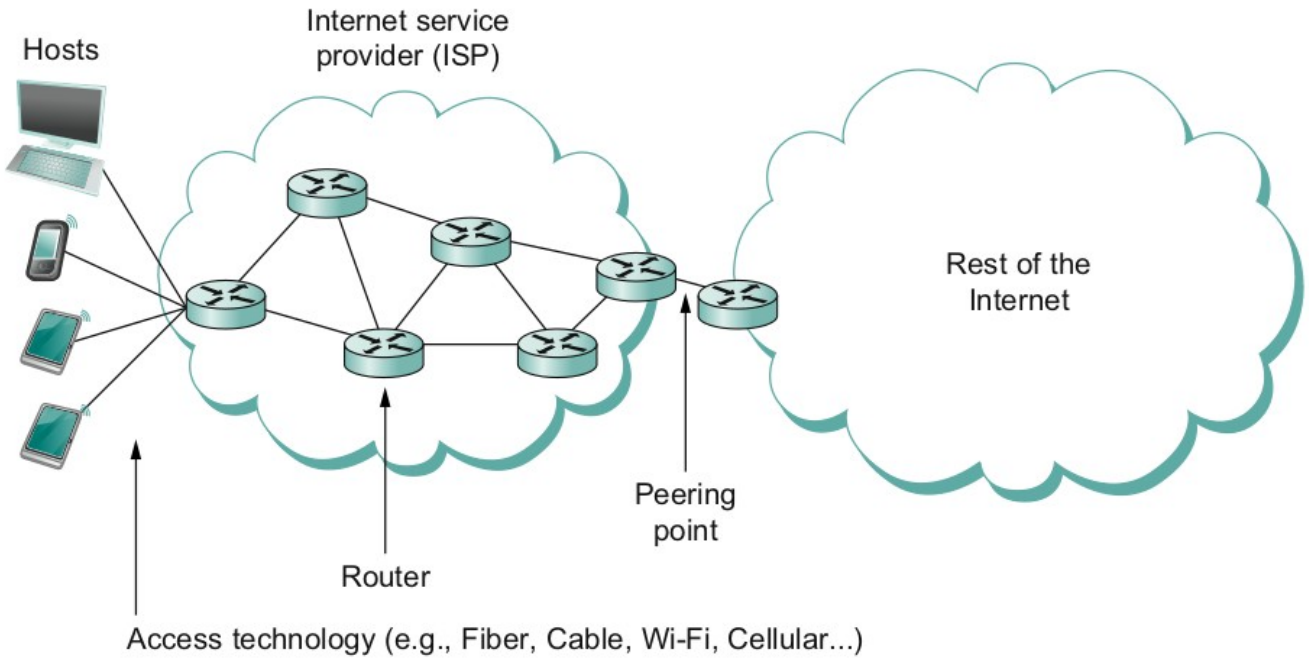
Performance – Example

- Calculate the total time required to transfer a 1.5-MB file in the following cases, assuming an RTT of 80 ms, bandwidth= 10Mbps, a packet size of 1 KB data, and an initial 2 × RTT of “handshaking” before data is sent:

  Delay = Handshake + Transmission + Propagation + Queuing

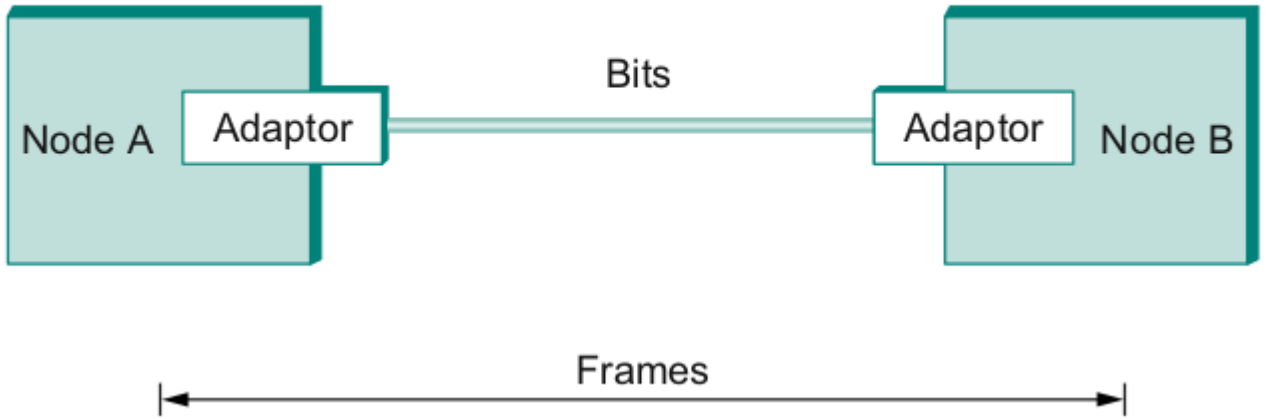
- **Propagation delay = First bit from sender to receiver**

What does it take to create a link?



- Common abstractions
  - Why?

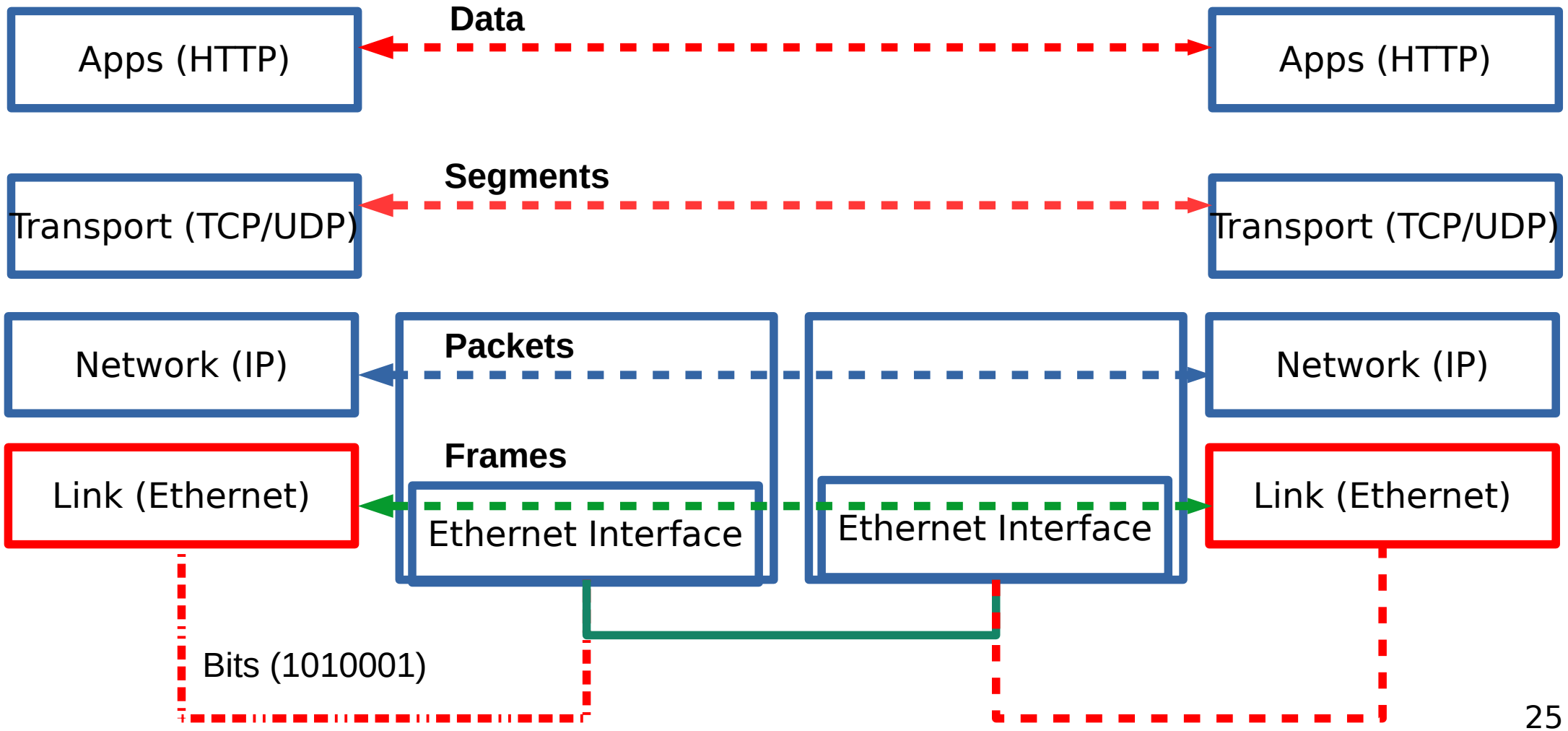
Frames – bag of bits



- Sending side – encapsulation, add error check bits, flow control
- Receiving side – extract frames, check for error, flow control

Reading Assignment

- Read Section 1.5:
  - https://book.systemsapproach.org/foundation/performance.html#performance
  - ~30Mins


Apps (HTTP)
Data
Apps (HTTP)
Transport (TCP/UDP)
Segments
Transport (TCP/UDP)
Network (IP)
Packets
Network (IP)
Link (Ethernet)
Frames
Ethernet Interface
Ethernet Interface
Link (Ethernet)
Bits (1010001)