CSC4200/5200 – COMPUTER NETWORKING

NETWORK PERFORMANCE

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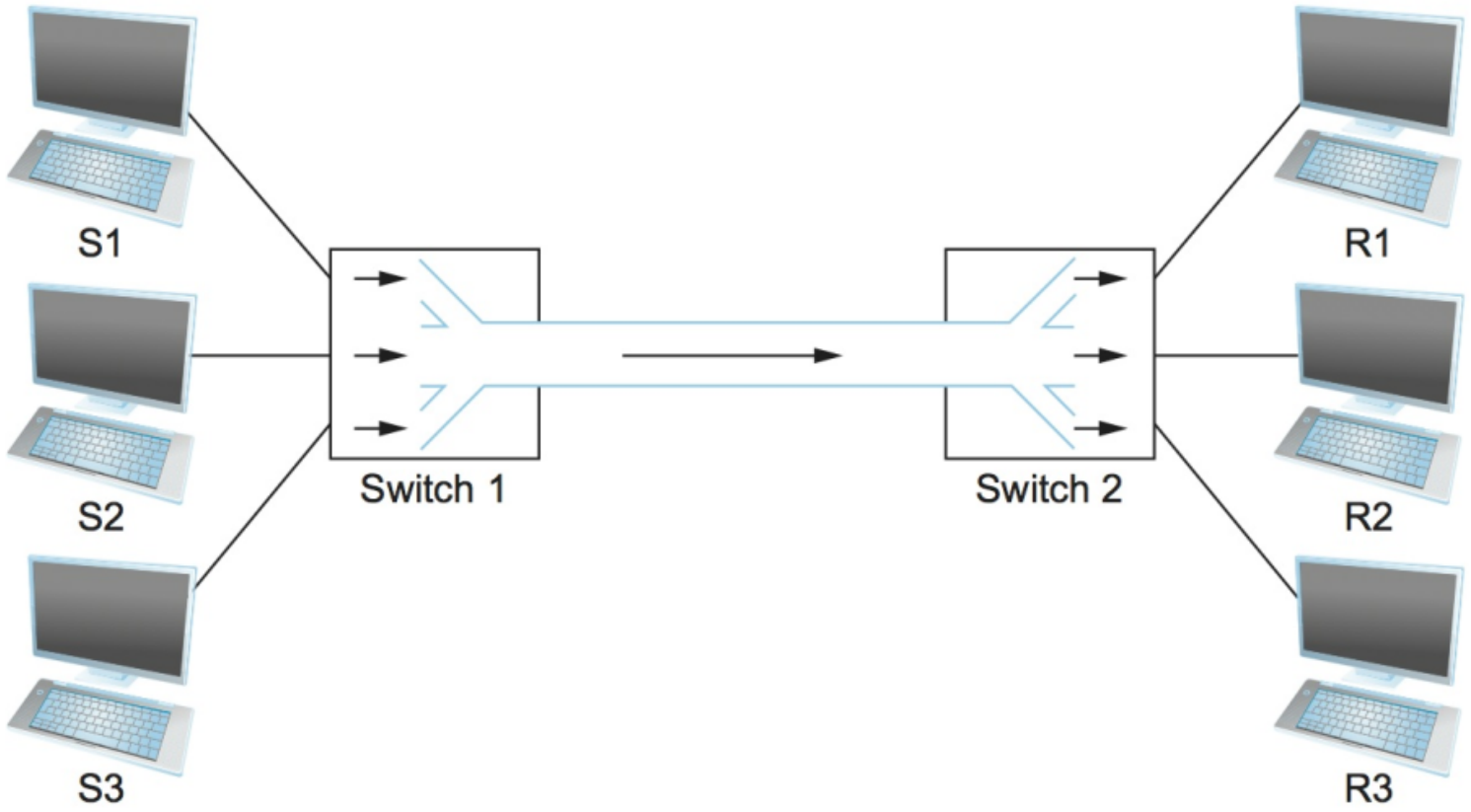
Recap - Circuit Switching – TDM and FDM



What are the problems?

Circuit vs Packet Switching

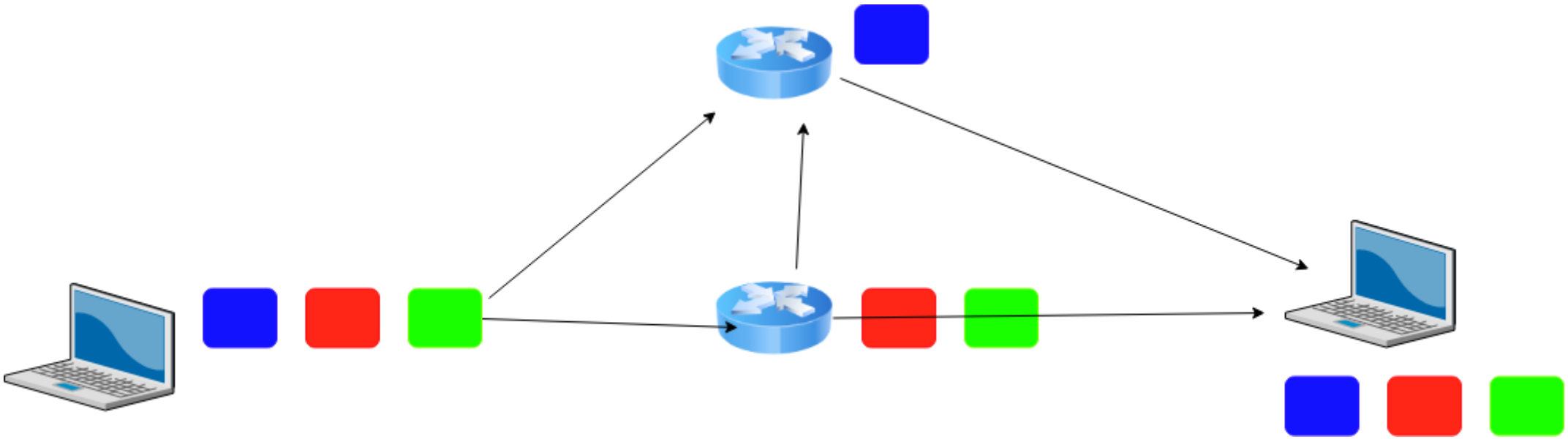
Circuit Switching

- Dedicated resource divided among participants
- Requires setup, guaranteed performance (unless the link breaks)

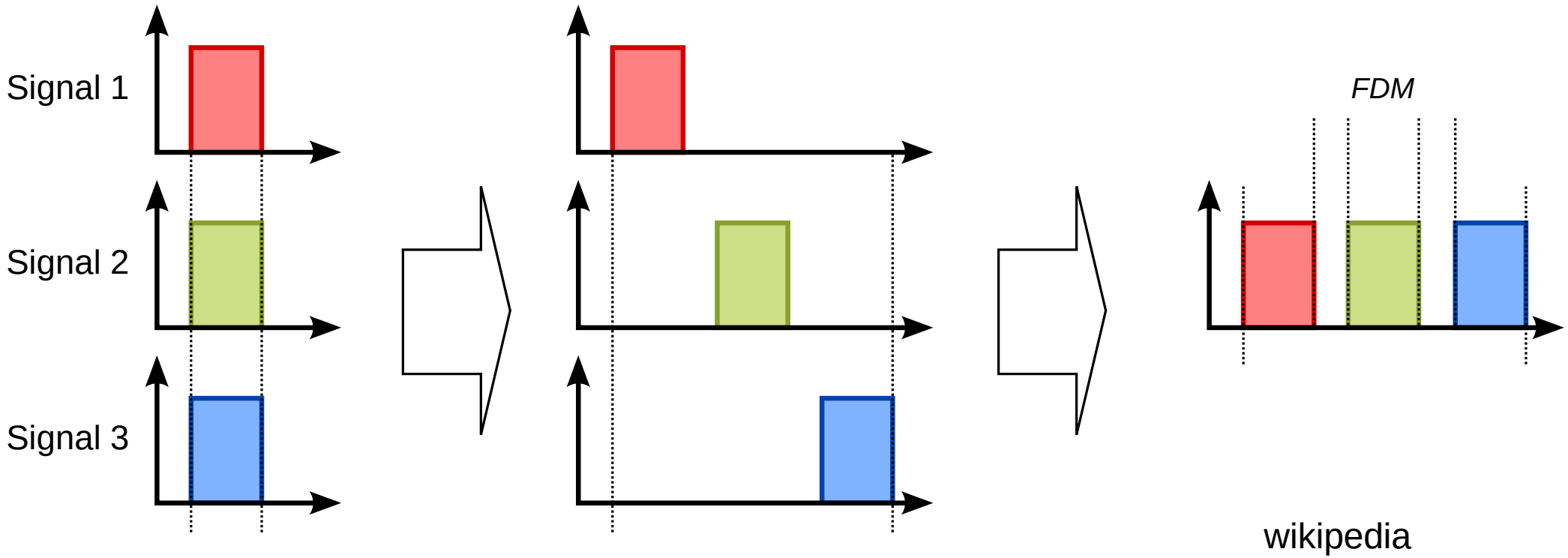
Packet Switching

- Shared resource
- Use small chunks of data (packets), send as soon as possible
- Store-and-forward packets

Packet Switching



Frequency Division Multiplexing for Circuit Switching

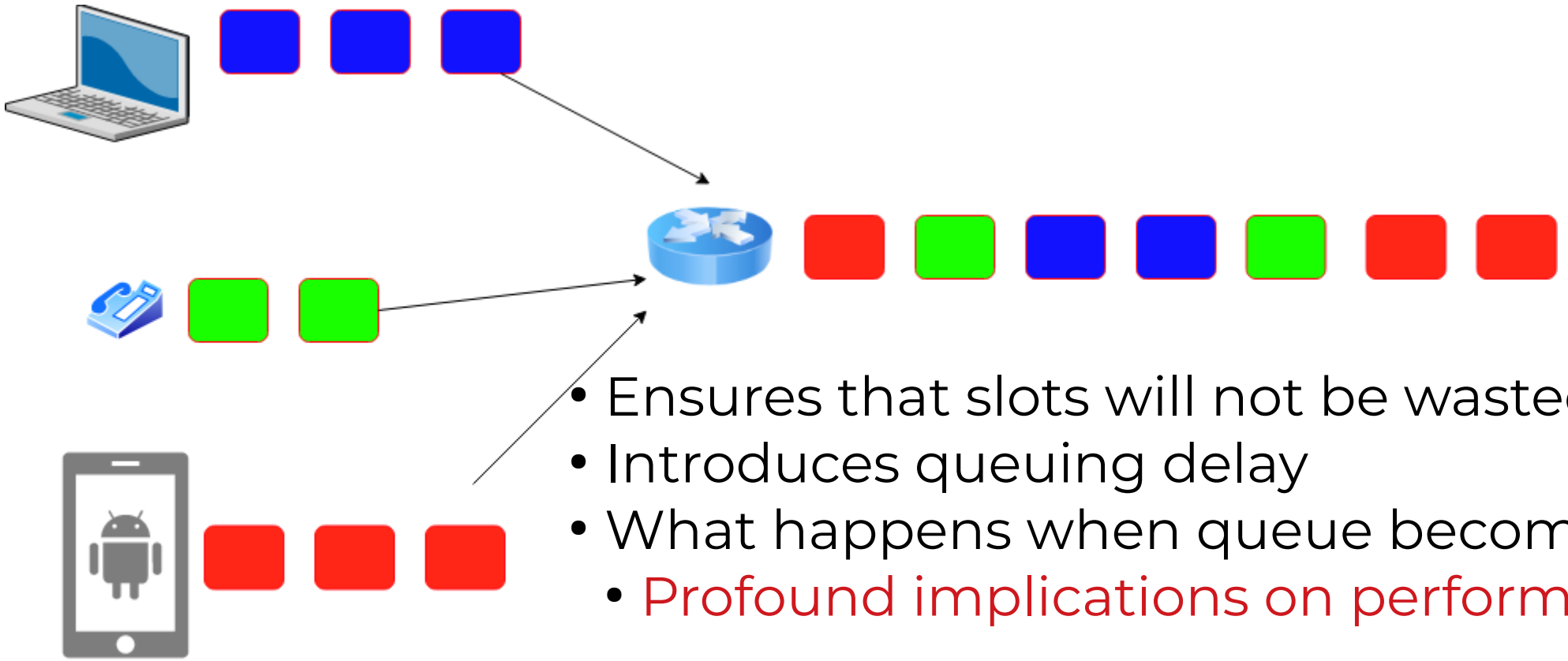


wikipedia

Time Division Multiplexing for Circuit Switching

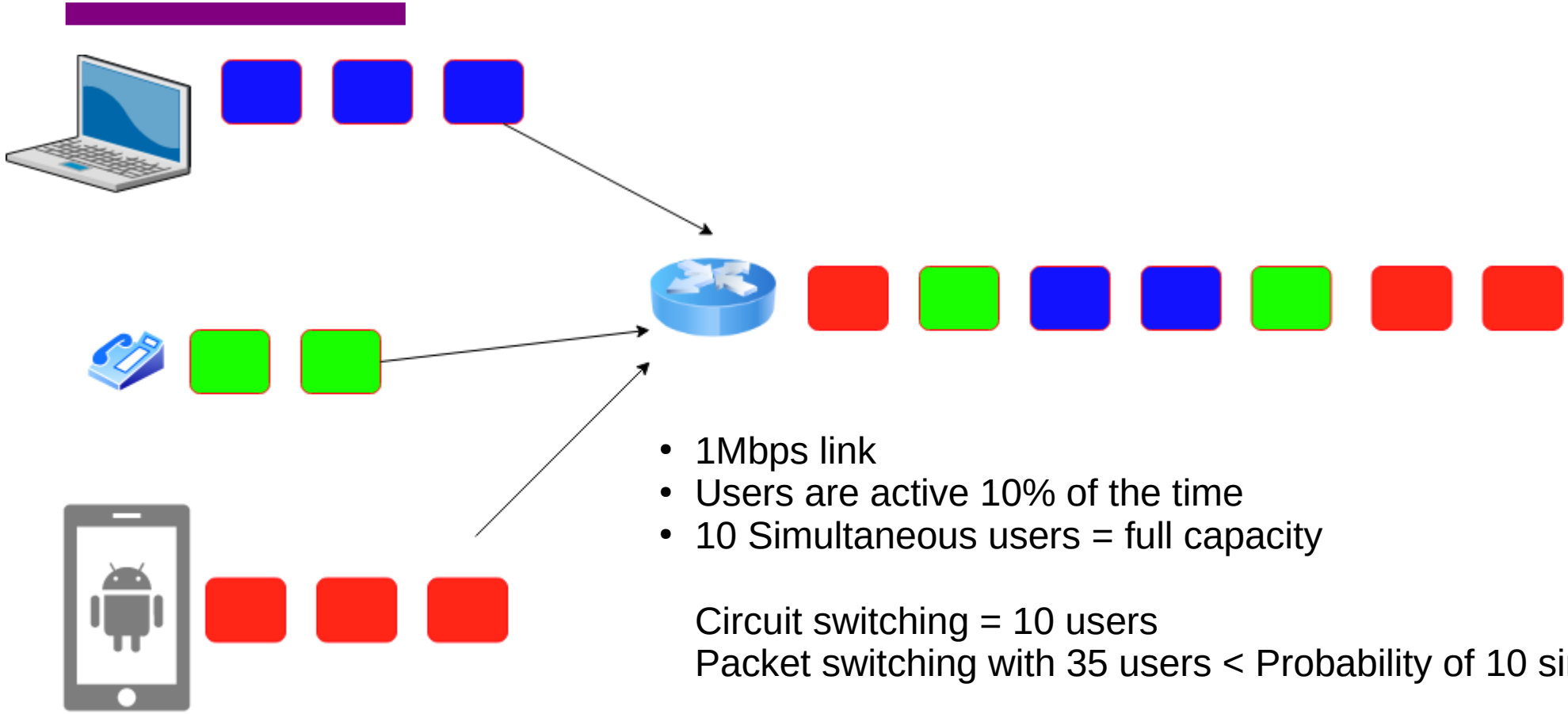
wikipedia

Statistical Multiplexing for Packet Switching



- Ensures that slots will not be wasted
- Introduces queuing delay
- What happens when queue becomes full?
  - Profound implications on performance

How many users can you support?

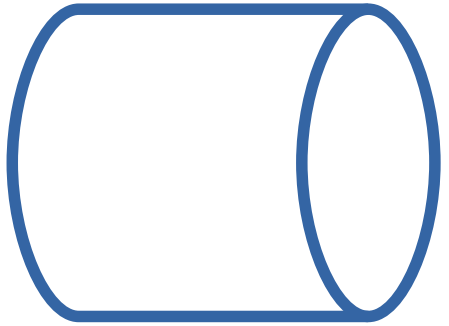


- 1Mbps link
- Users are active 10% of the time
- 10 Simultaneous users = full capacity

Circuit switching = 10 users
Packet switching with 35 users < Probability of 10 sim. Users < 0.0004

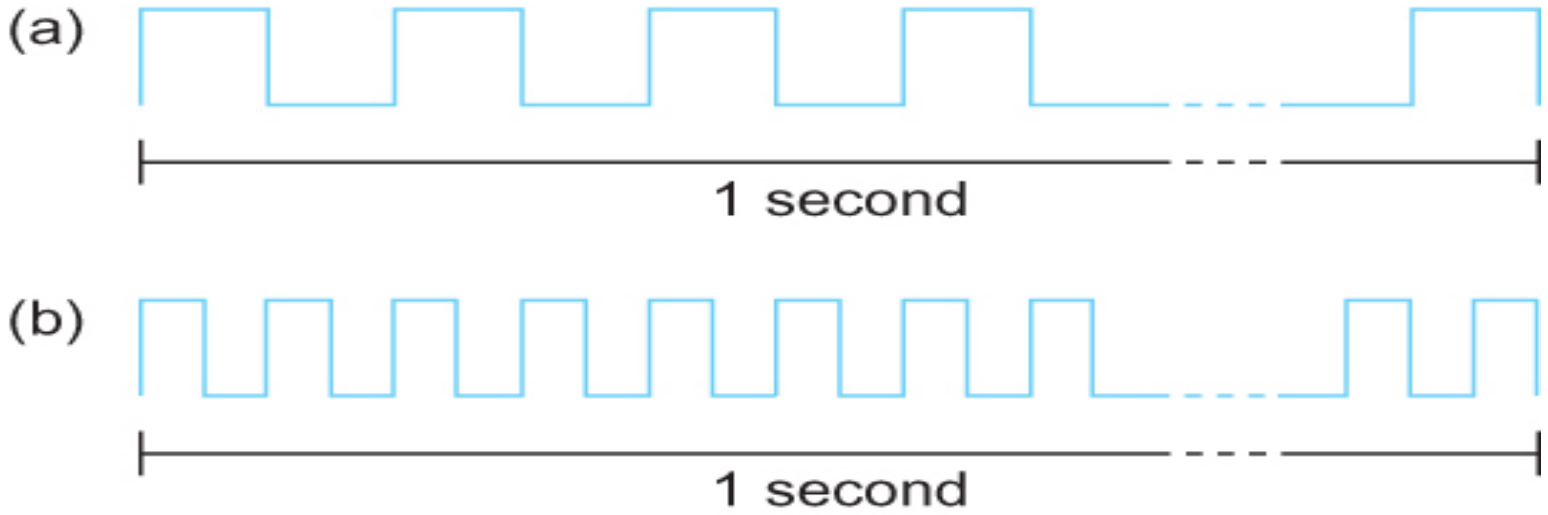
https://math.stackexchange.com/questions/918861/probability-problem-in-networking

Performance - 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 - Bandwidth



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

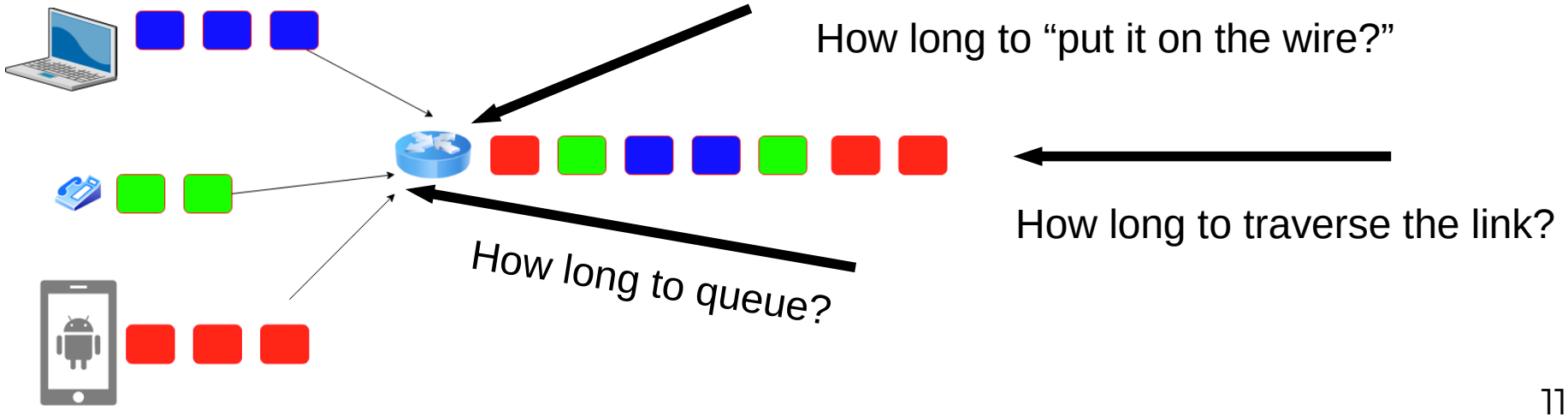
(a) bits transmitted at 1Mbps (each bit 1 μs wide);

(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!

Performance - Latency

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



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 – 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 – Example

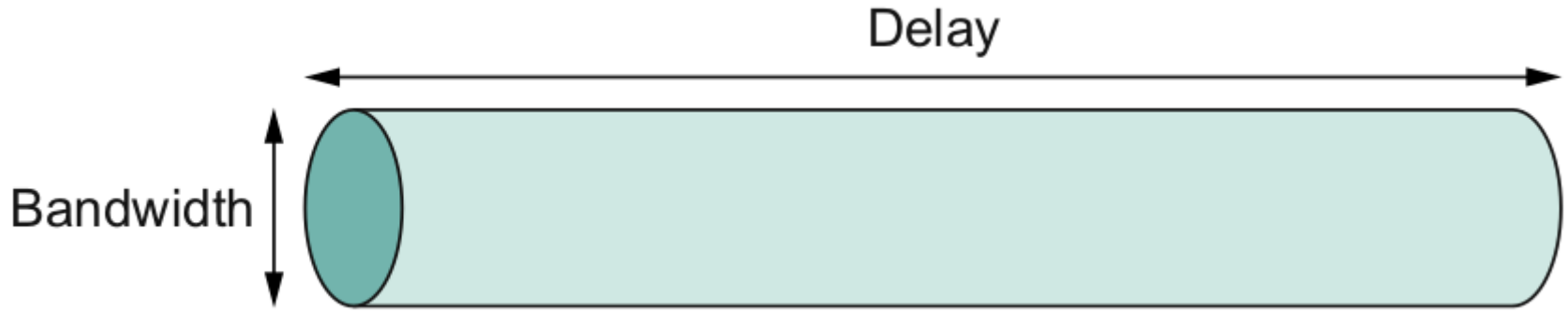
- Calculate the total time required to transfer a 1000-KB file in the following case, assuming bandwidth is 1.5 Mbps, an RTT of 50 ms, a packet size of 1 KB data, and an initial 2 × RTT of “handshaking” before data is sent. (Peterson-Davie Exercise 3, Chapter 1)

  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**
- **Transmission delay = All bits on the wire**

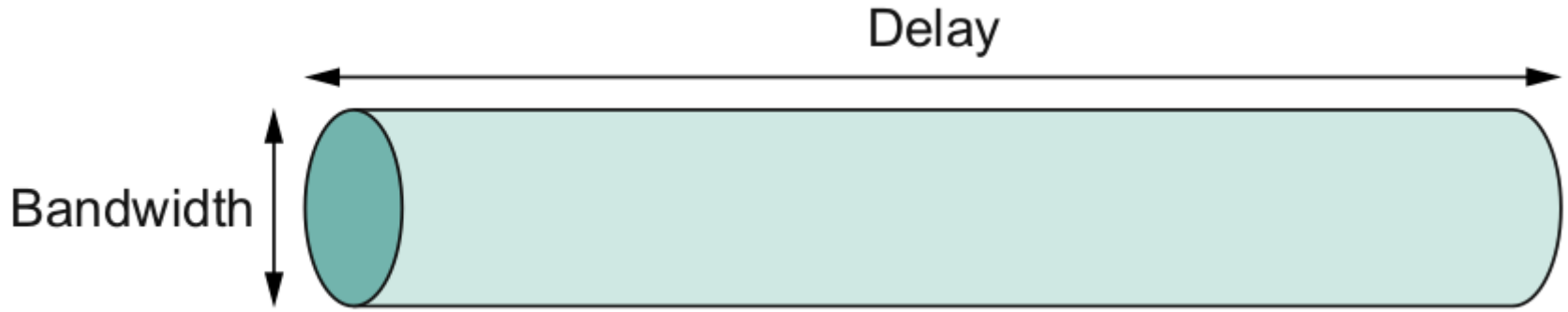
Bandwidth x Delay Product



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!

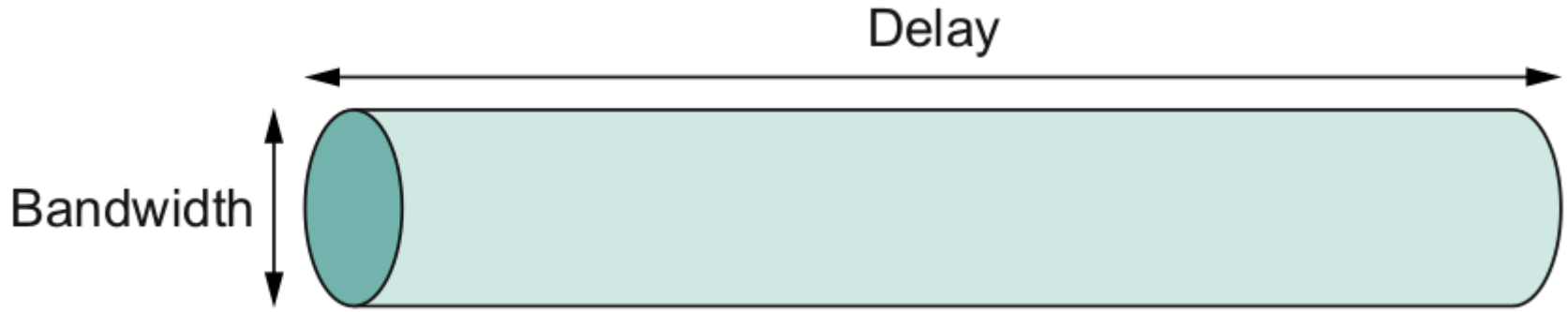
Bandwidth x Delay Product - Example



Bandwidth = 50Mbps
Latency = 100ms

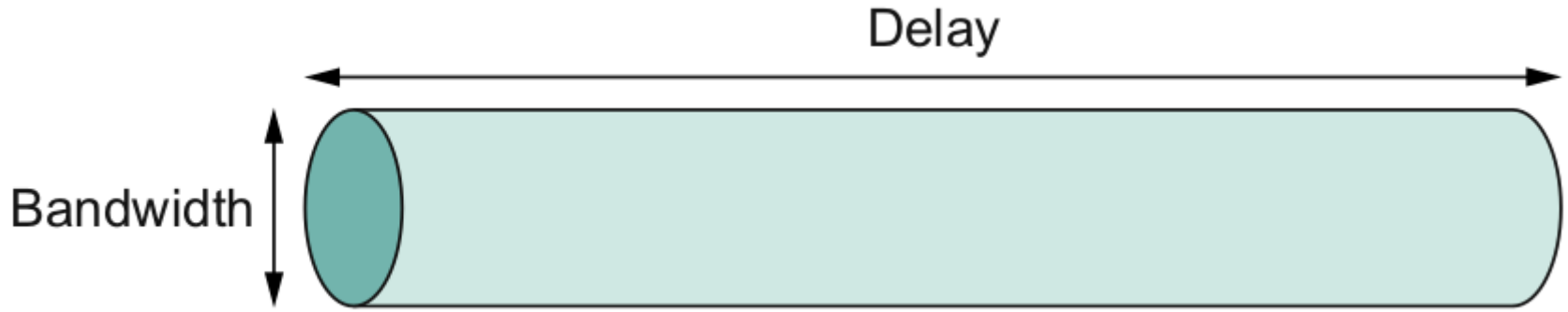
BandwidthxDelay = $50x10^{6}x100x10^{-3} = 5x10^{6}$ bits = 625 kilobytes

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

Bit rate of curiosity: 32000bits/second
Delay = 14 minutes each way
BxD = ?

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?

Next Steps

- Read Chapter 1

- Next lecture – Network performance basics