

# **CSC4200/5200 – COMPUTER NETWORKING**

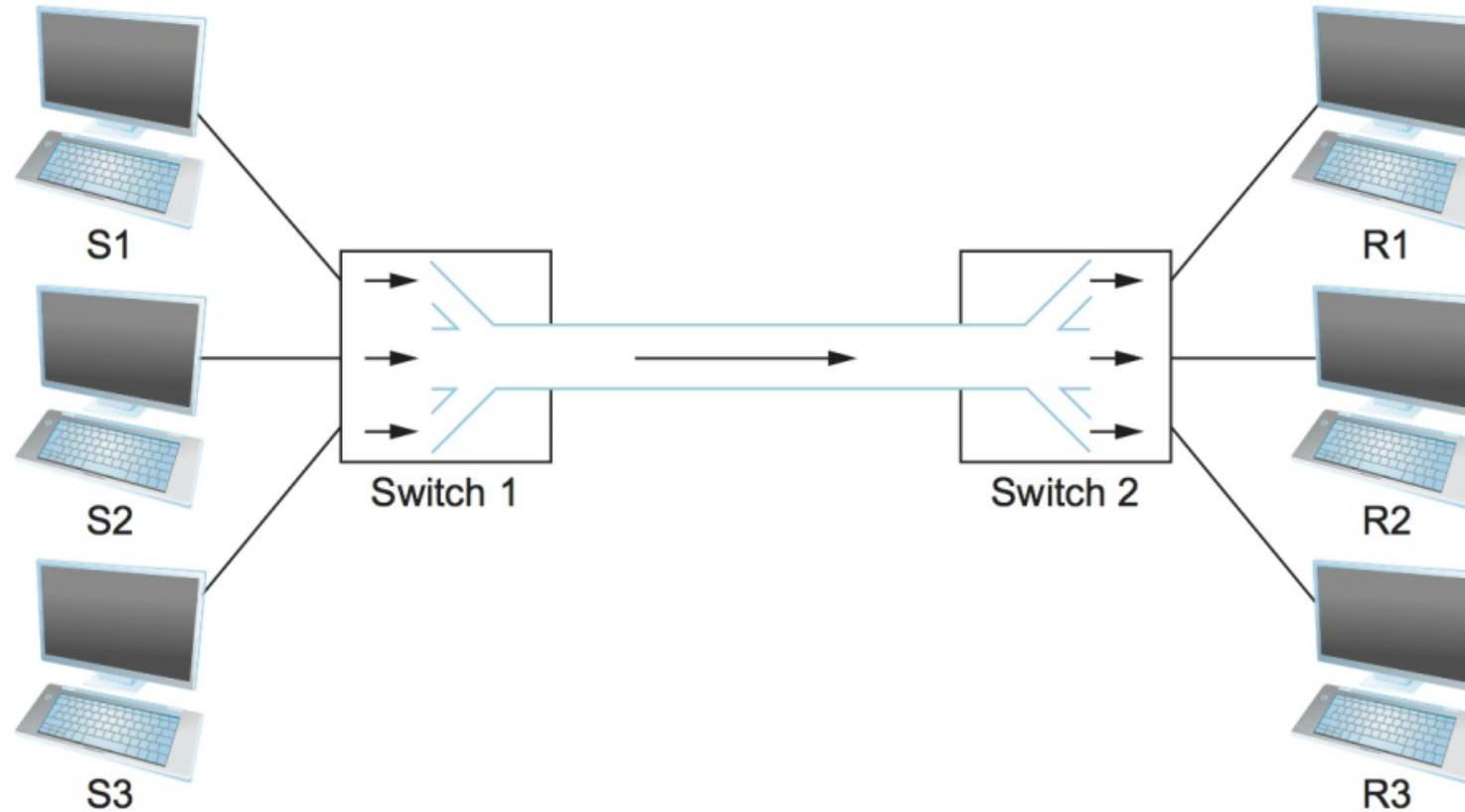
## **NETWORK PERFORMANCE**

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# Recap - Circuit Switching – TDM and FDM

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**What are the problems?**

# Circuit vs Packet Switching

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## Circuit Switching

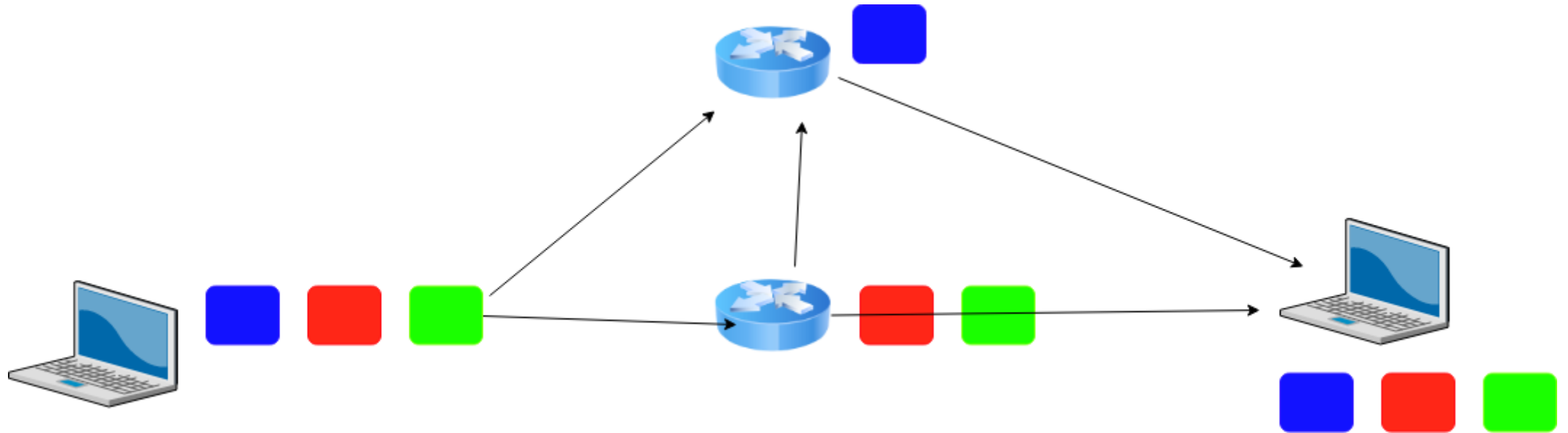
- Dedicated resource divided among participants
- Requires setup, guaranteed performance (unless the link breaks)

## Packet Switching

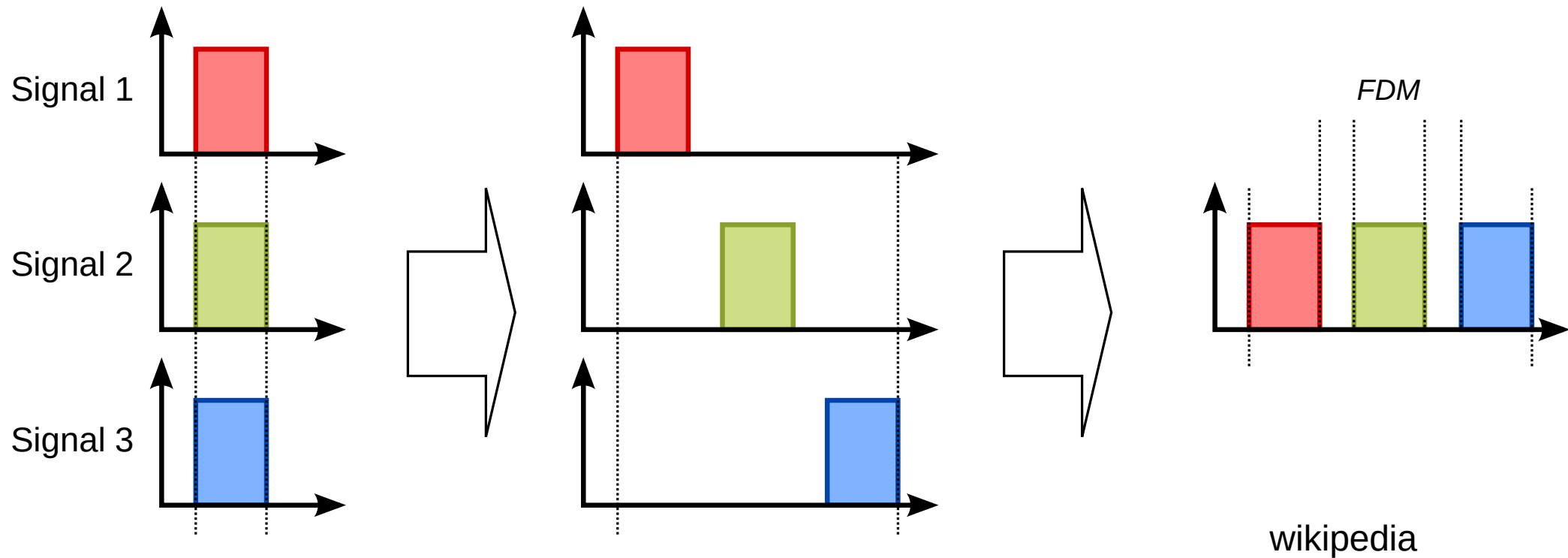
- Shared resource
- Use small chunks of data (packets), send as soon as possible
- Store-and-forward packets

# Packet Switching

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# Frequency Division Multiplexing for Circuit Switching



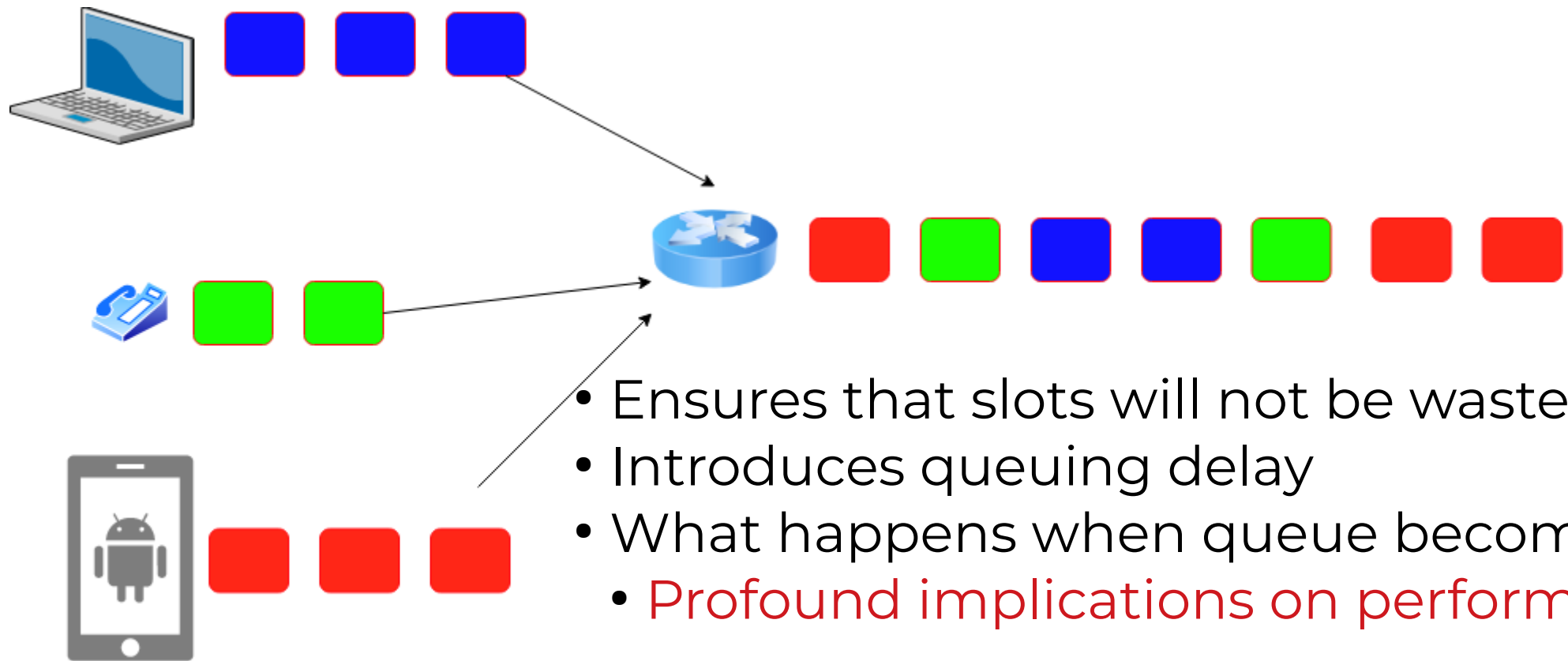
# Time Division Multiplexing for Circuit Switching



wikipedia

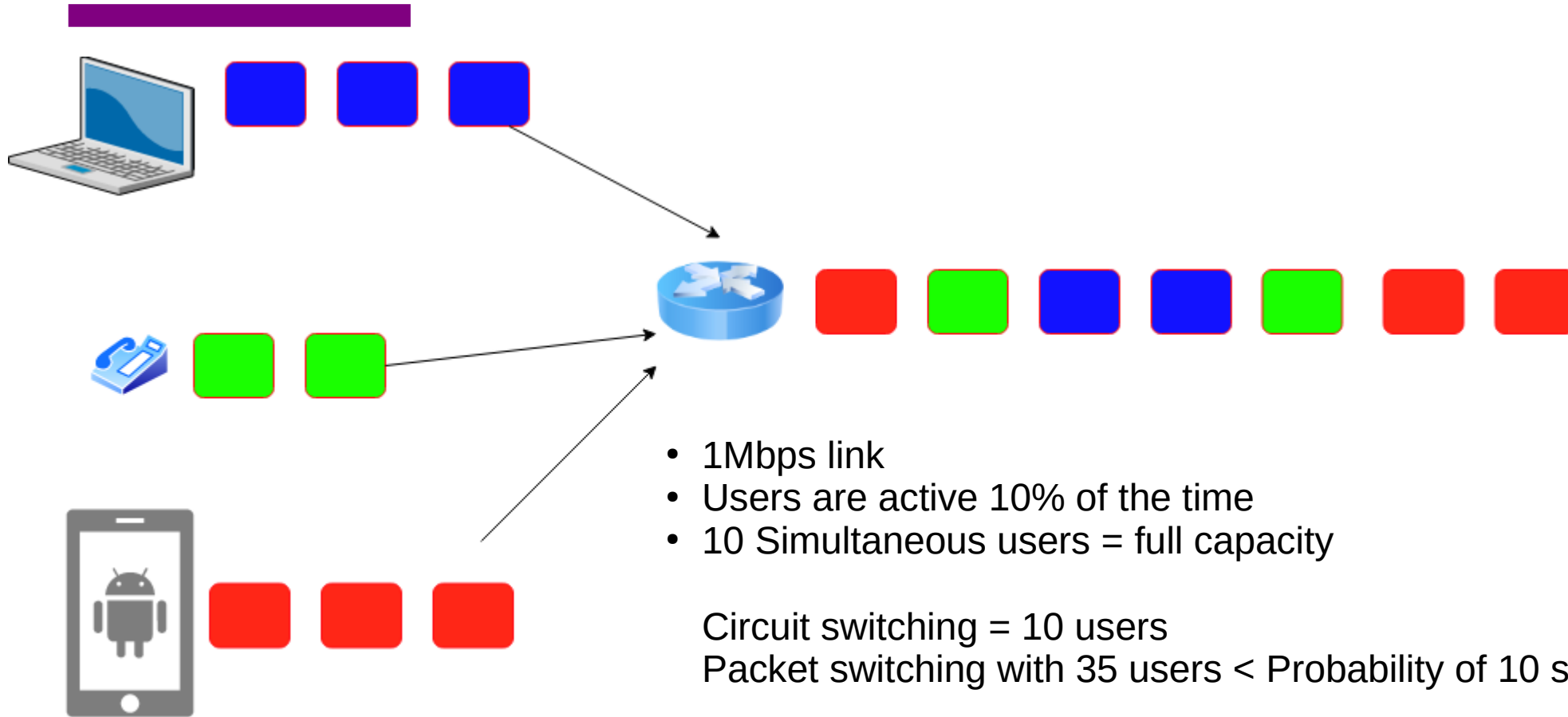
# Statistical Multiplexing for Packet Switching

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- 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

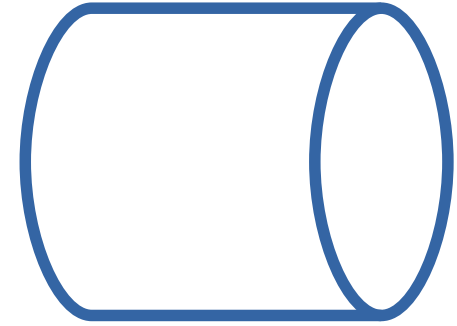
<https://math.stackexchange.com/questions/918861/probability-problem-in-networking>



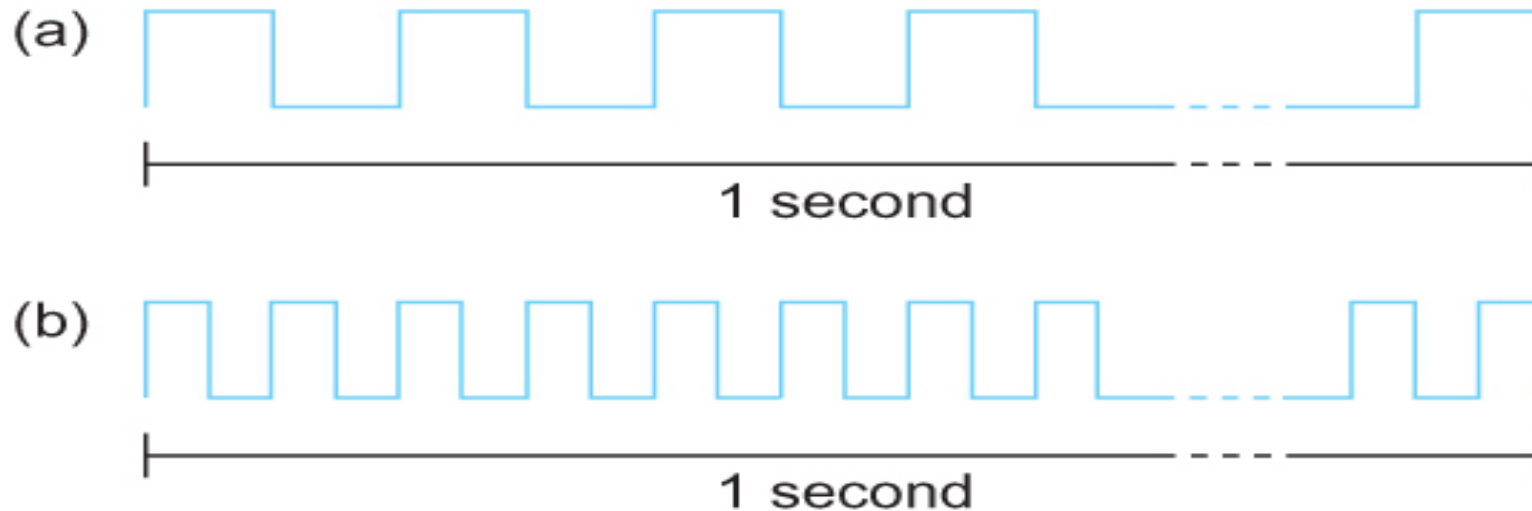
# Performance - Bandwidth and Latency

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- **Bandwidth = Size of the network pipe**
- **Latency = Delay in sending packets**
- **Throughput = How fast you 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:

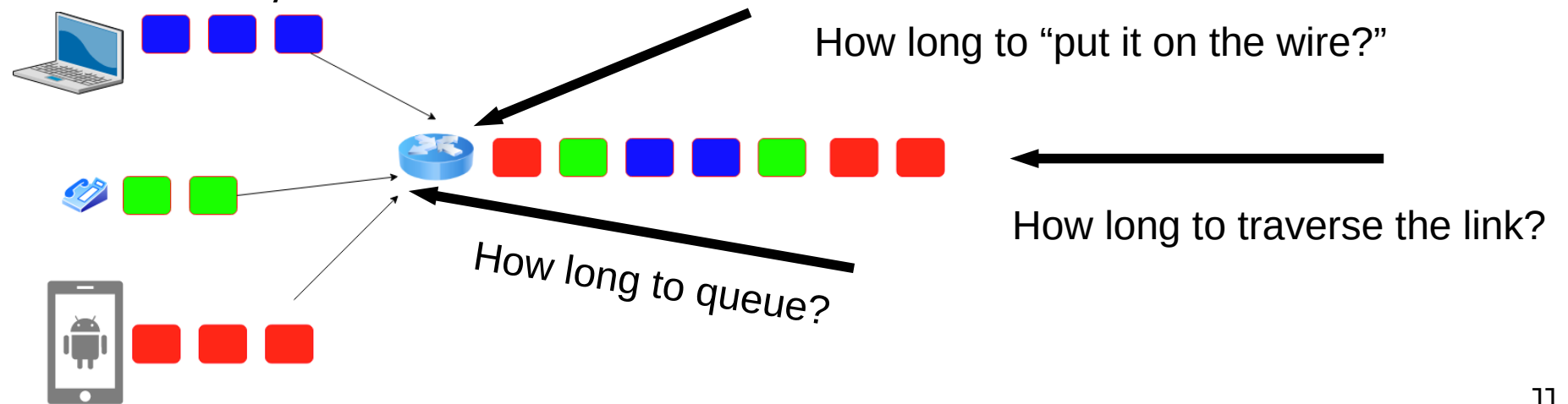
(a) bits transmitted at 1Mbps (each bit 1  $\mu$ s wide);

(b) bits transmitted at 2Mbps (each bit 0.5  $\mu$ s 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 =  $AL/R$



$AL/R \sim 0$



$AL/R \sim 1$

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

# Performance – Terminology

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- 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

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- 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 =  $2 \times 50\text{ms} + (1000 \times 1024 \times 8) / (1.5 \times 1000 \times 1000) \text{ second} + 50/2\text{ms} + 0 = 5.586\text{seconds}$

# Next Steps

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- Read Chapter 1
- Next lecture – Network performance contd and Link Layer