Introduction to Networks, Links

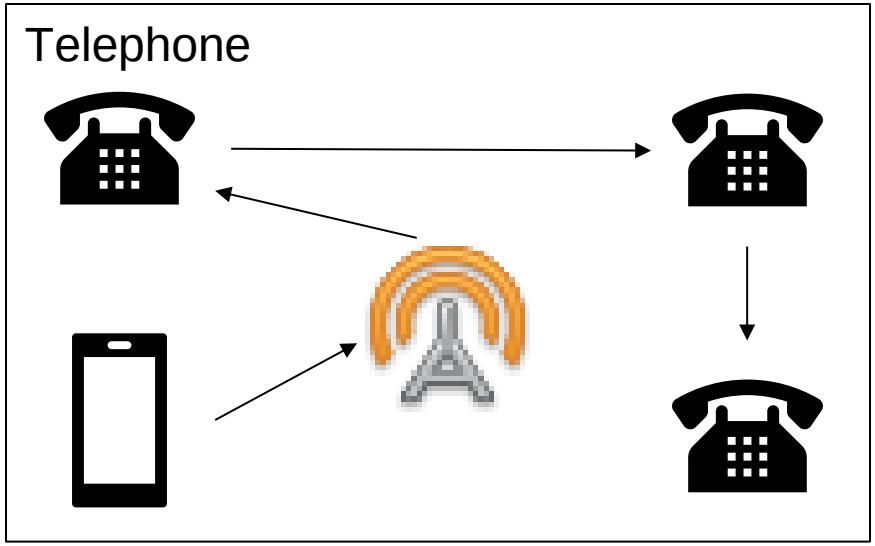
6 November 2024
Lecture 1

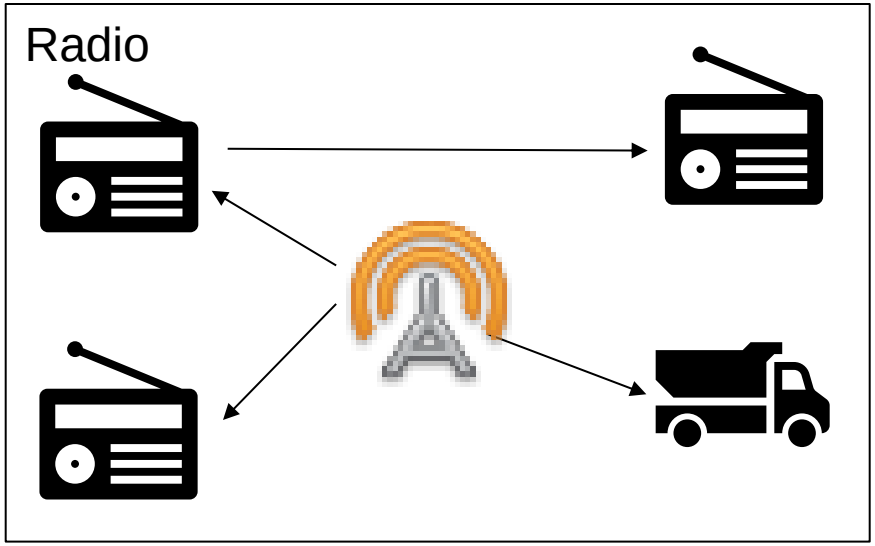
Slides Credits: Steve Zdancewic (UPenn)

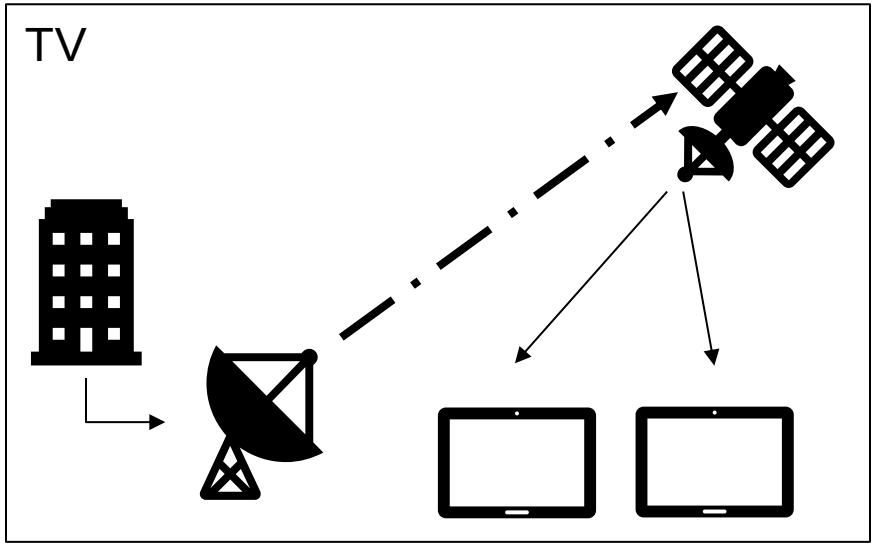
Topics for Today

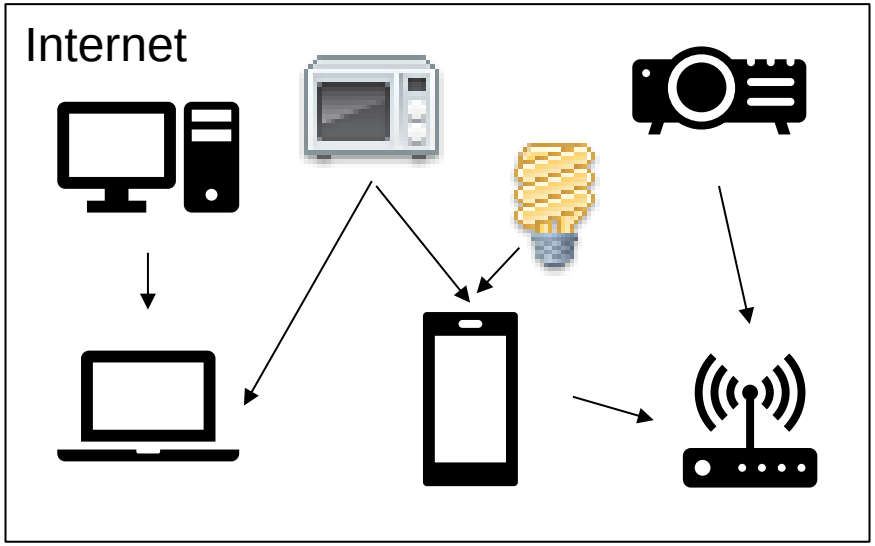
- What is a network?
  - Connectivity
  - Efficient Resource Sharing
  - Functionality
  - Performance

Four Networks







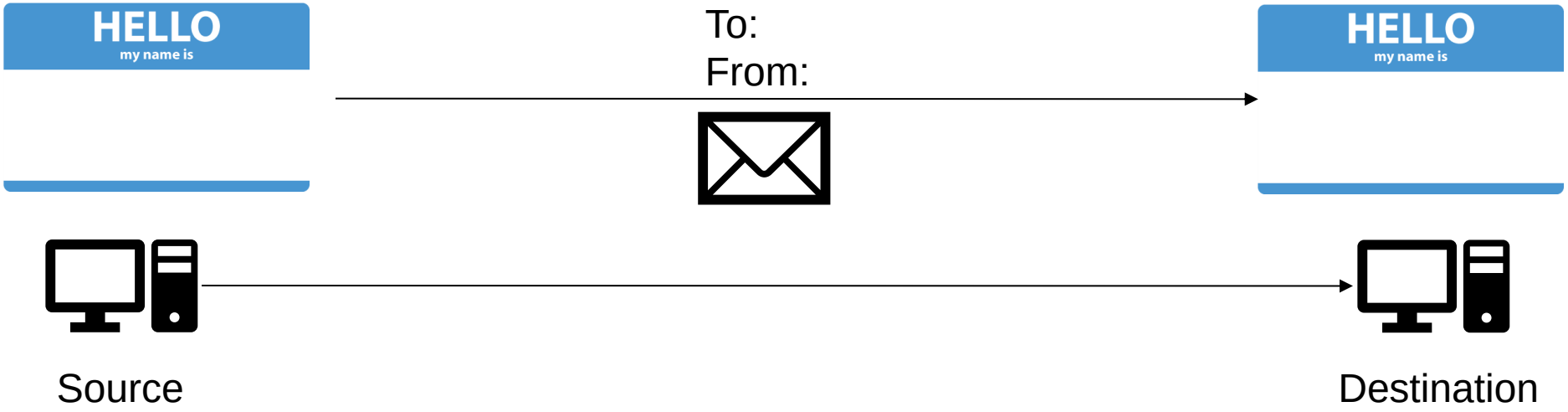


Requirement: Connectivity

- Goal of a network is to get information from one place to another
  - Source
  - Destination

  } Specified by an *address*

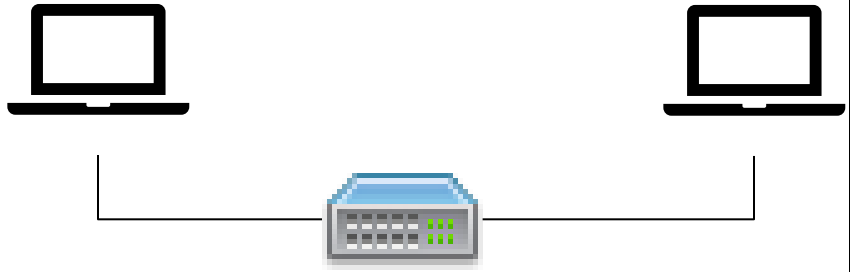
  - *Nodes* or *Hosts*



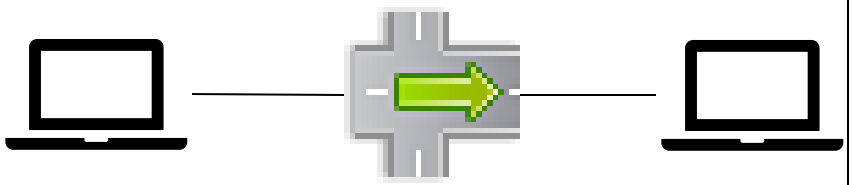
Network paths

Direct

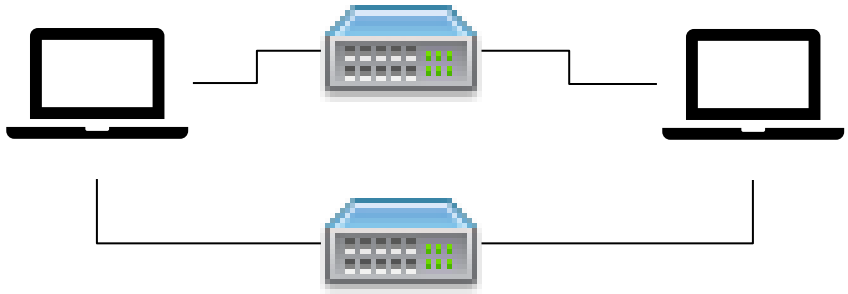
Indirect (Hops)



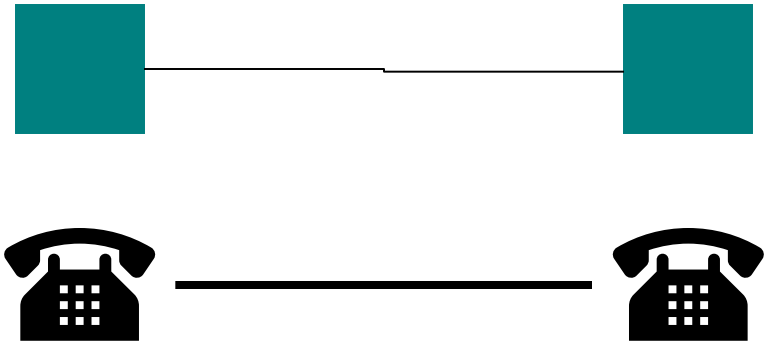
Static



Dynamic (Dis/Appear)

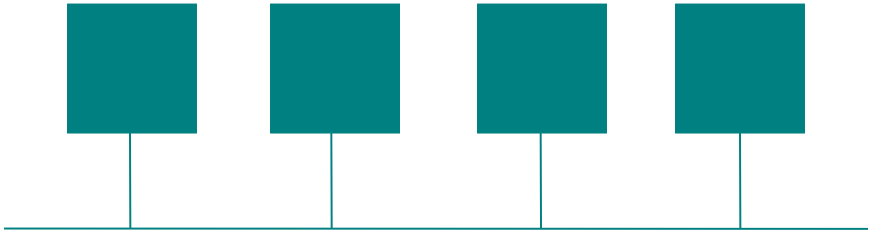


Connectivity: Direct Links



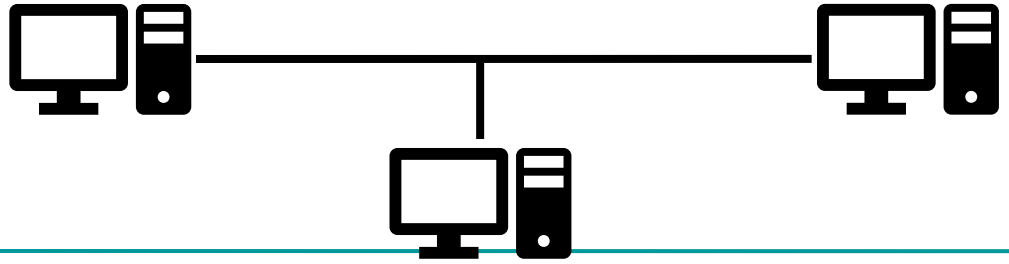
Point to Point

e.g. telephone

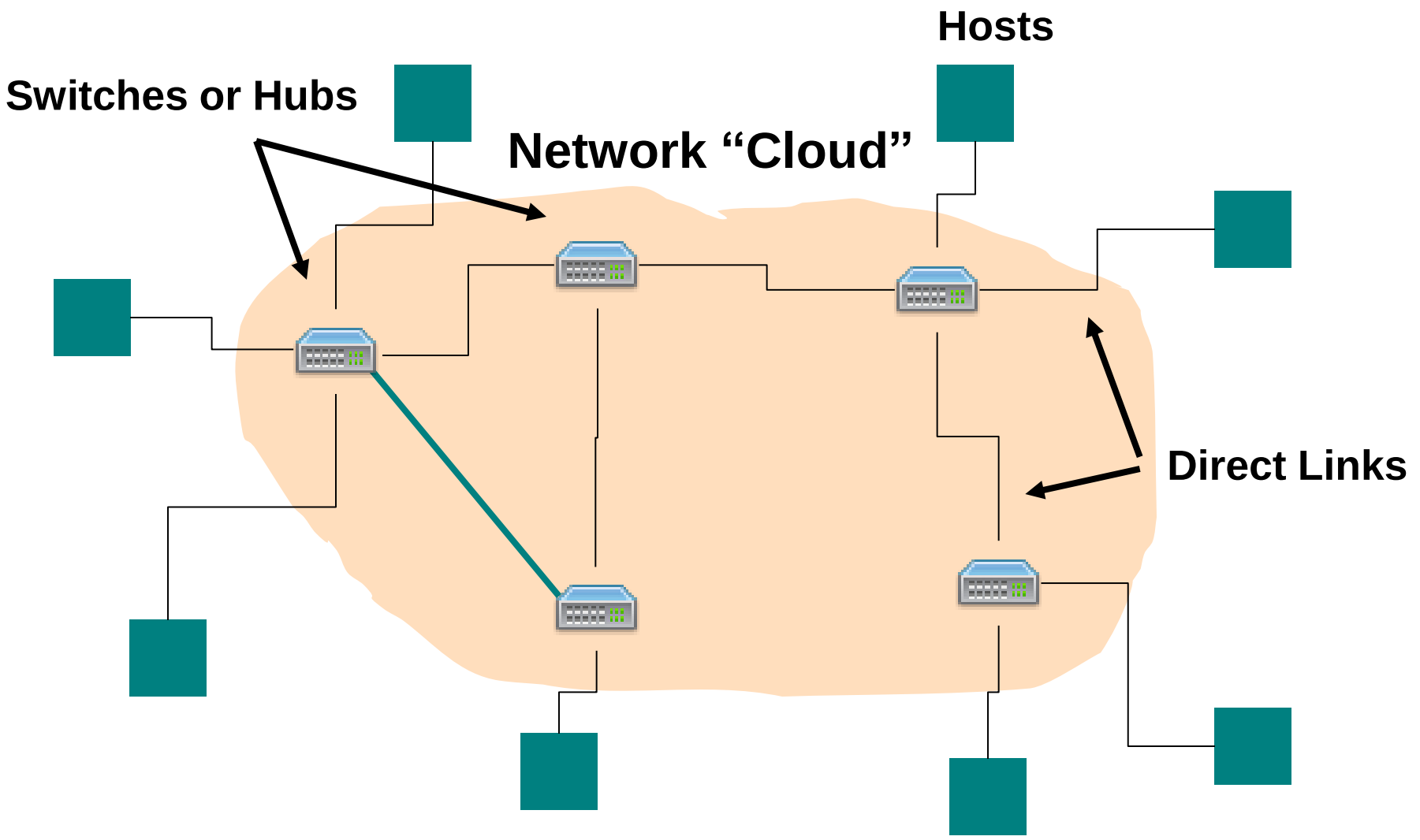


Multiple Access

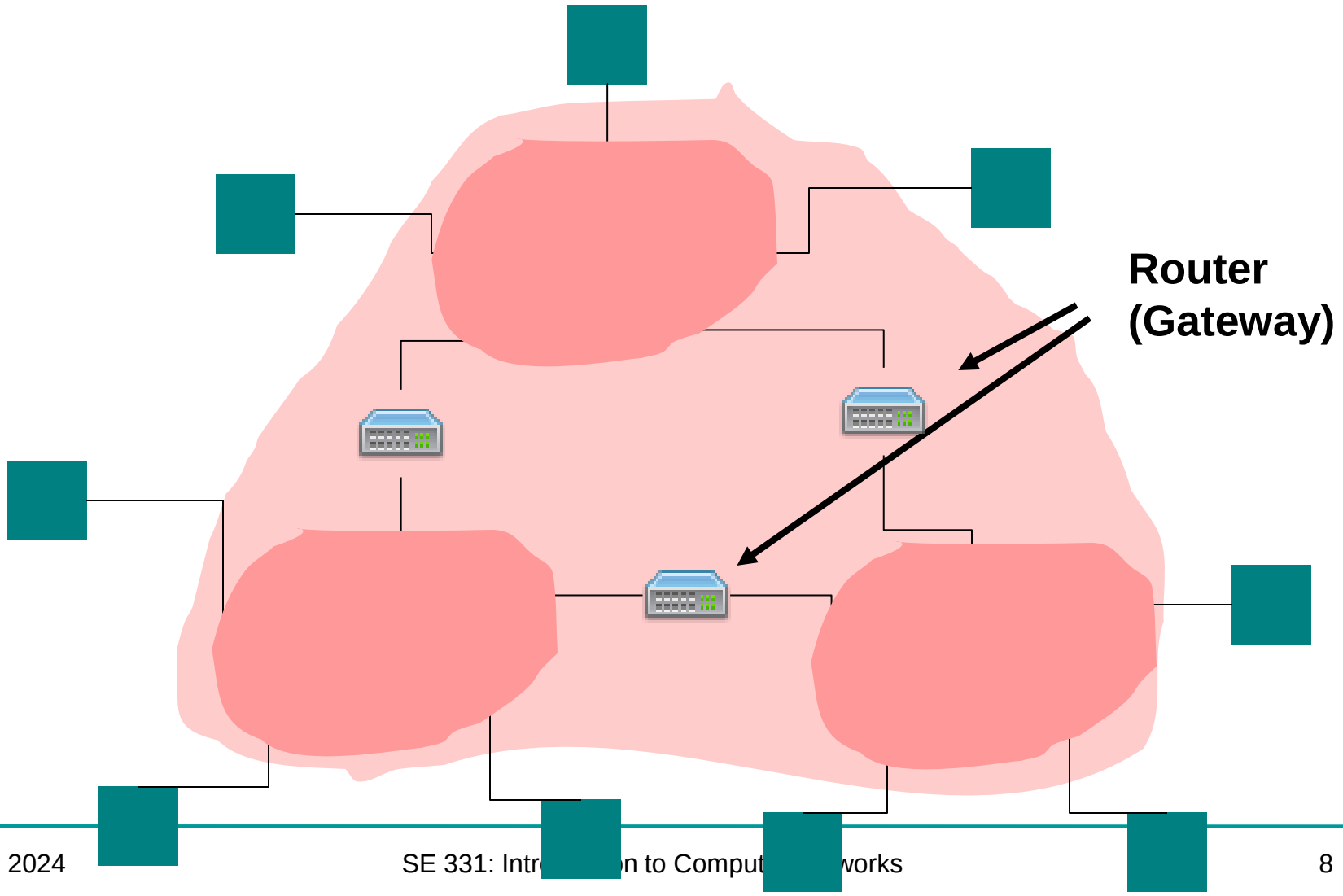
e.g. Ethernet, Wi-Fi



Connectivity: Switched Networks



Connectivity: Internetworks

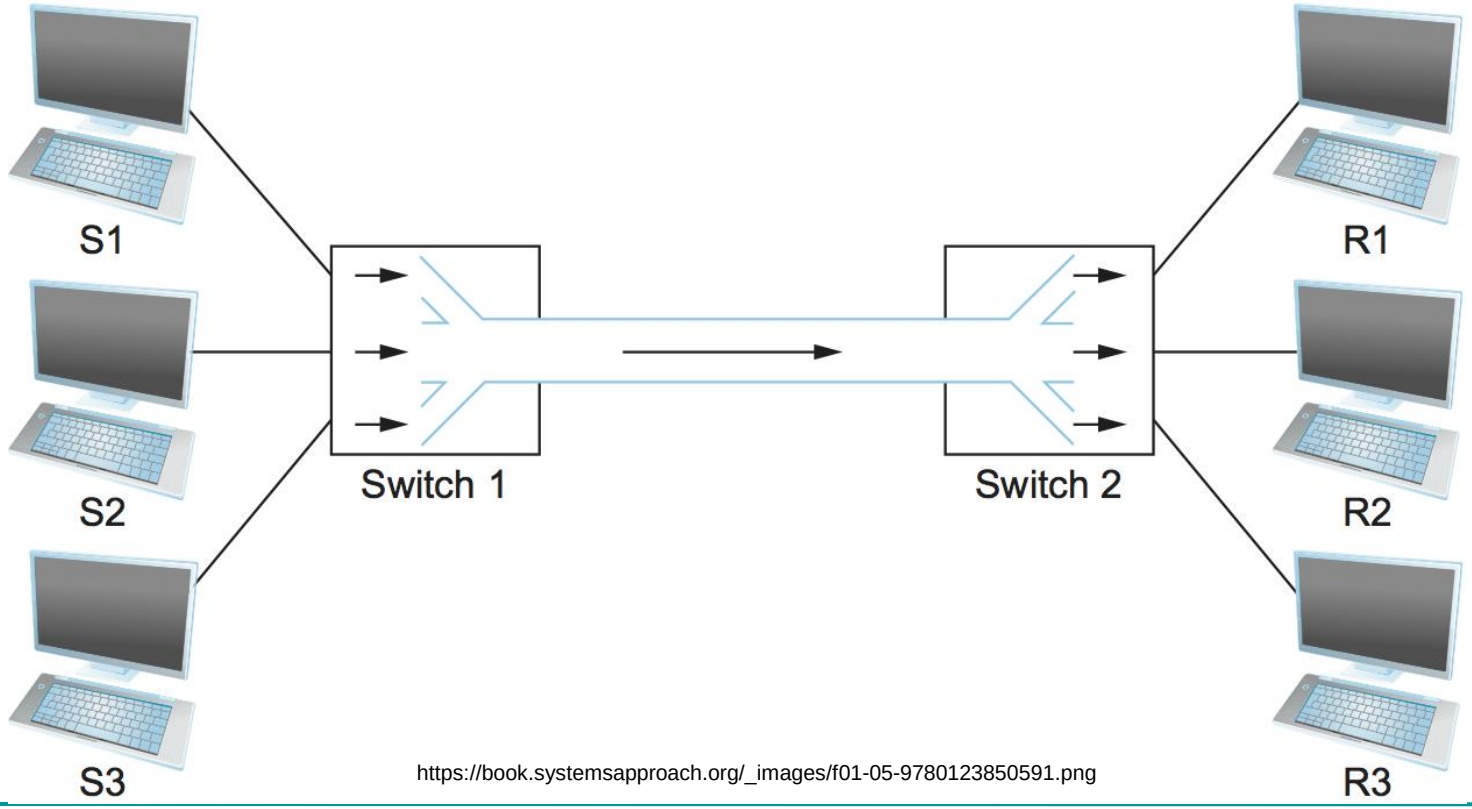


So Far

- What is a network?
  - Connectivity
  - Efficient Resource Sharing
  - Functionality
  - Performance

Resource Sharing: Multiplexing

- How can multiple hosts share the network if they want to use it at the same time?
  - Sharing links
  - Sharing switches



https://book.systemsapproach.org/_images/f01-05-9780123850591.png

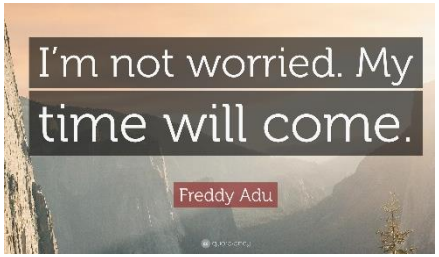
Multiplexing: STDM & FDM

Synchronous Time-division Multiplexing (STDM)

- “Time sharing”
- Divide time into equal sized quanta
- Round-robin

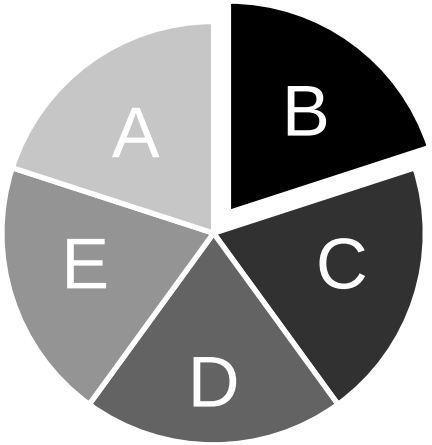
Frequency-division Multiplexing (FDM)

- Transmit all flows at different frequencies
- Radio or Television



Limitations:

- Wasted resources
- Maximum # flows can’t be changed



Icon from https://freesvg.org, Batman image TM and © DC Comics

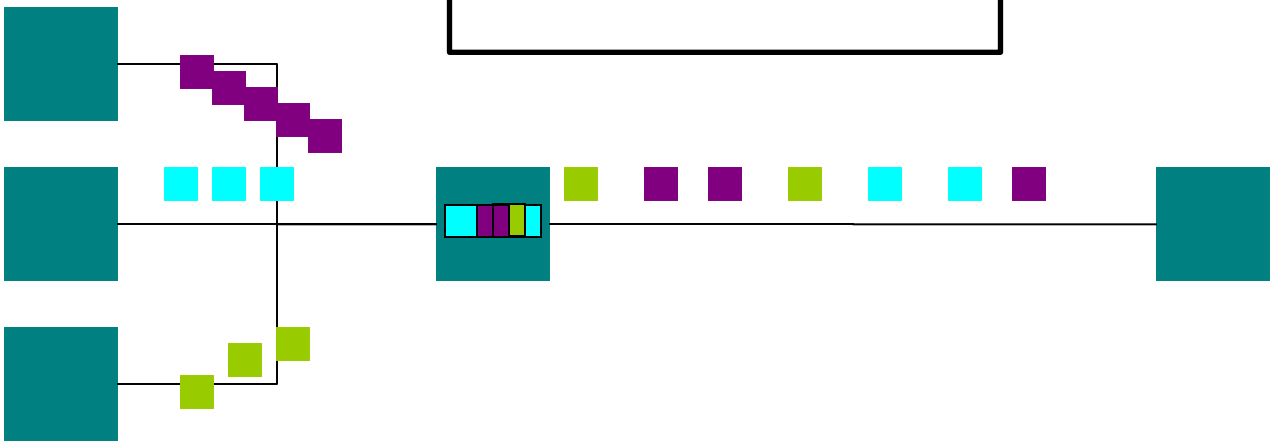
Statistical Multiplexing

Data partitioned into packets

Routing decision made per packet

Better resource usage than STDM

Fairness? Congestion?



So Far

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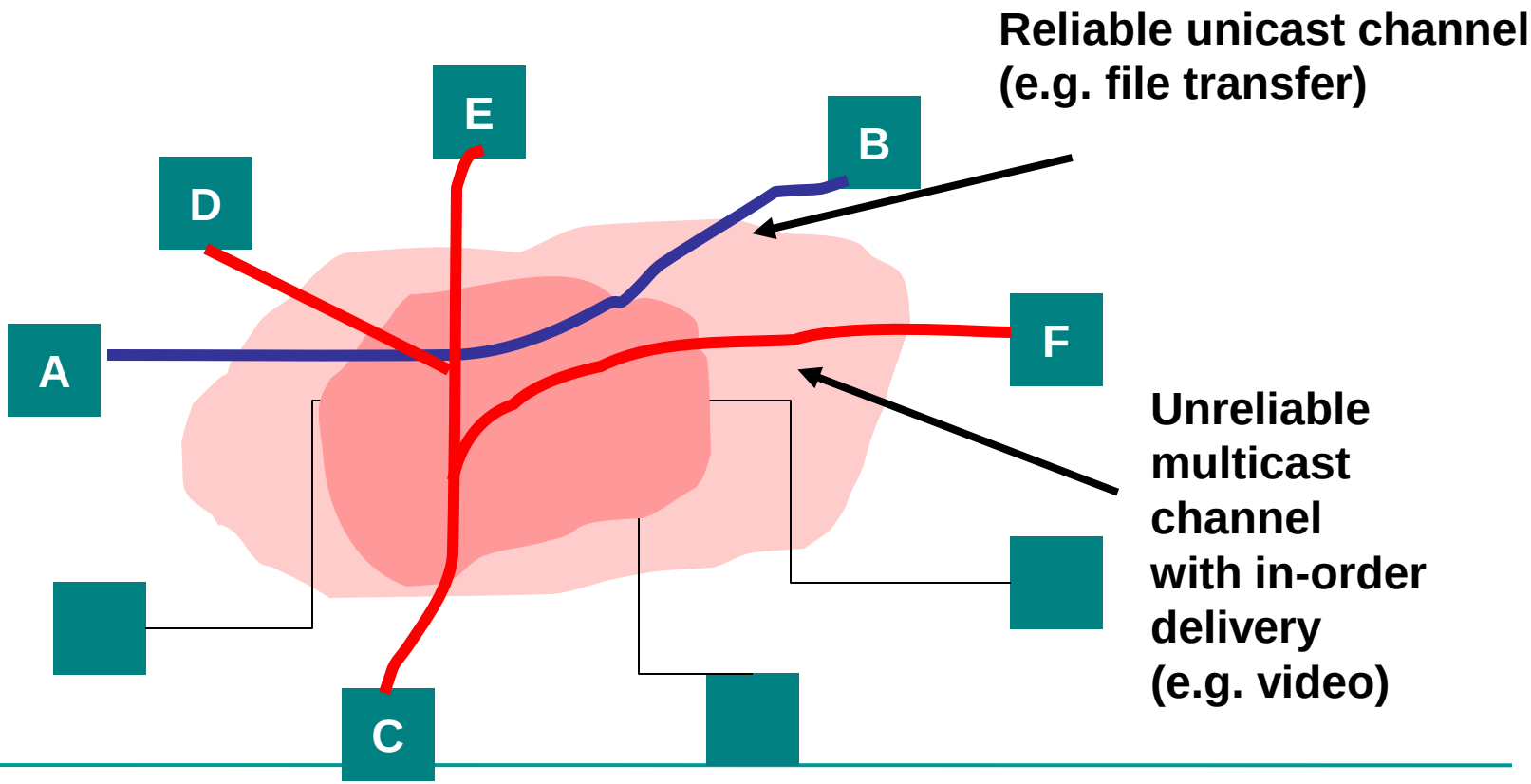
Functionality

- Different applications require different services
- Principle: The end-to-end argument



Functionality & Dealing with Failure

Fairness

Congestion

Quality of Service

Bit or burst errors

Link or node outages

Performance Metrics

Bandwidth (throughput)

- Number of bits that can be transmitted over the network in a period of time.
- Measured in bits/sec
- Pedantically, this is bit rate
- Bandwidth is in Hz

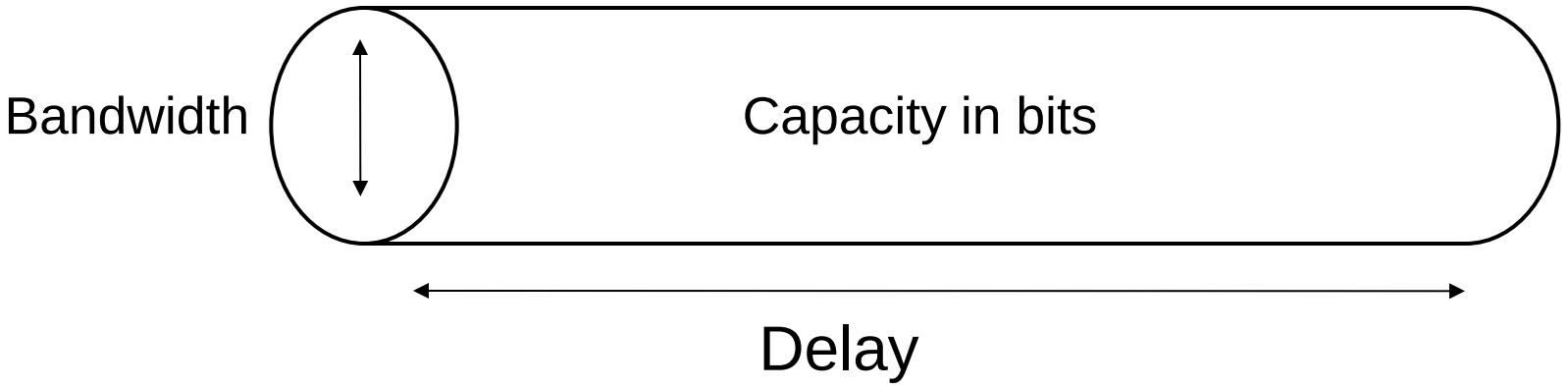
Latency (delay)

- How long it takes 1 bit to propagate from one end of the network to the other.
- Measured in seconds

Round Trip Time (RTT)

- How long it takes for 1 bit to get from one end of the network to the other and back

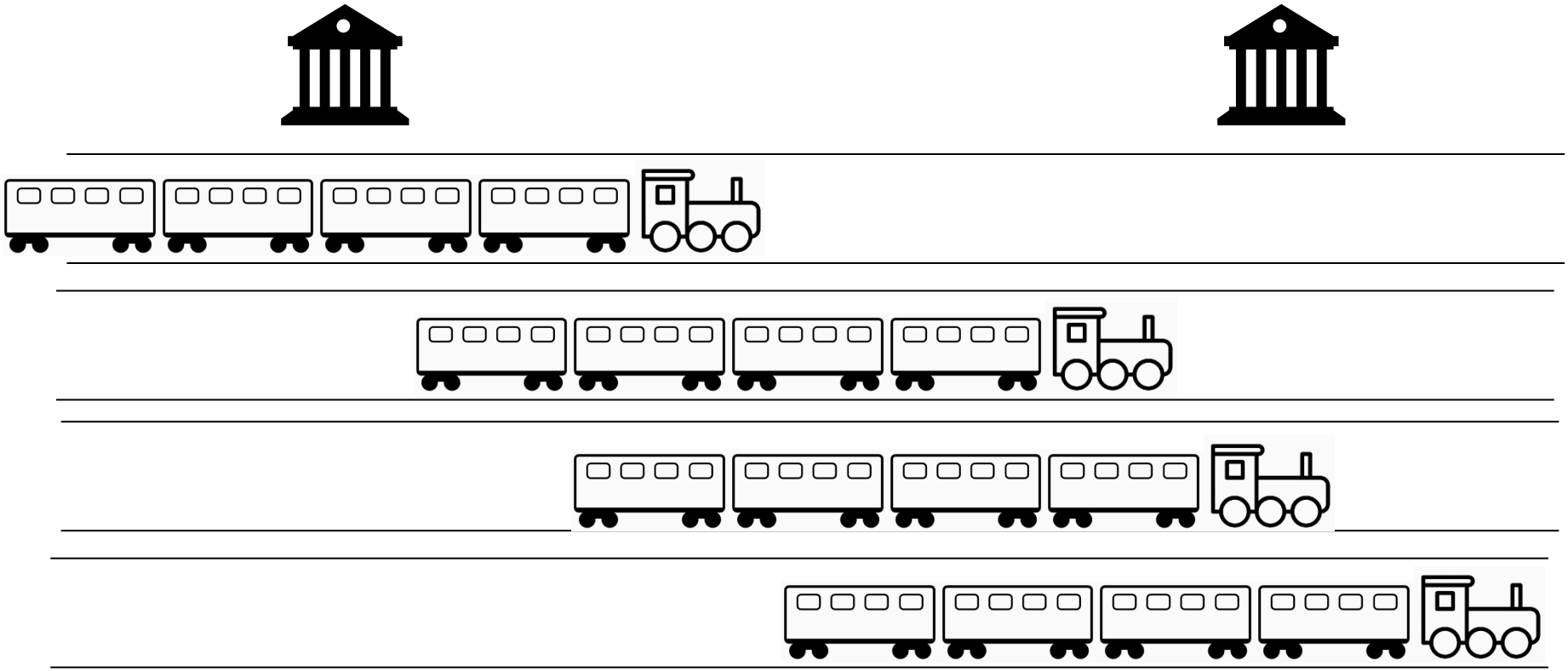
Performance: Delay x Bandwidth



- Delay x Bandwidth determines the number of bits that can be “in flight”.

- For efficient resource usage: keep the pipe full.

Short Packets (All in Flight)



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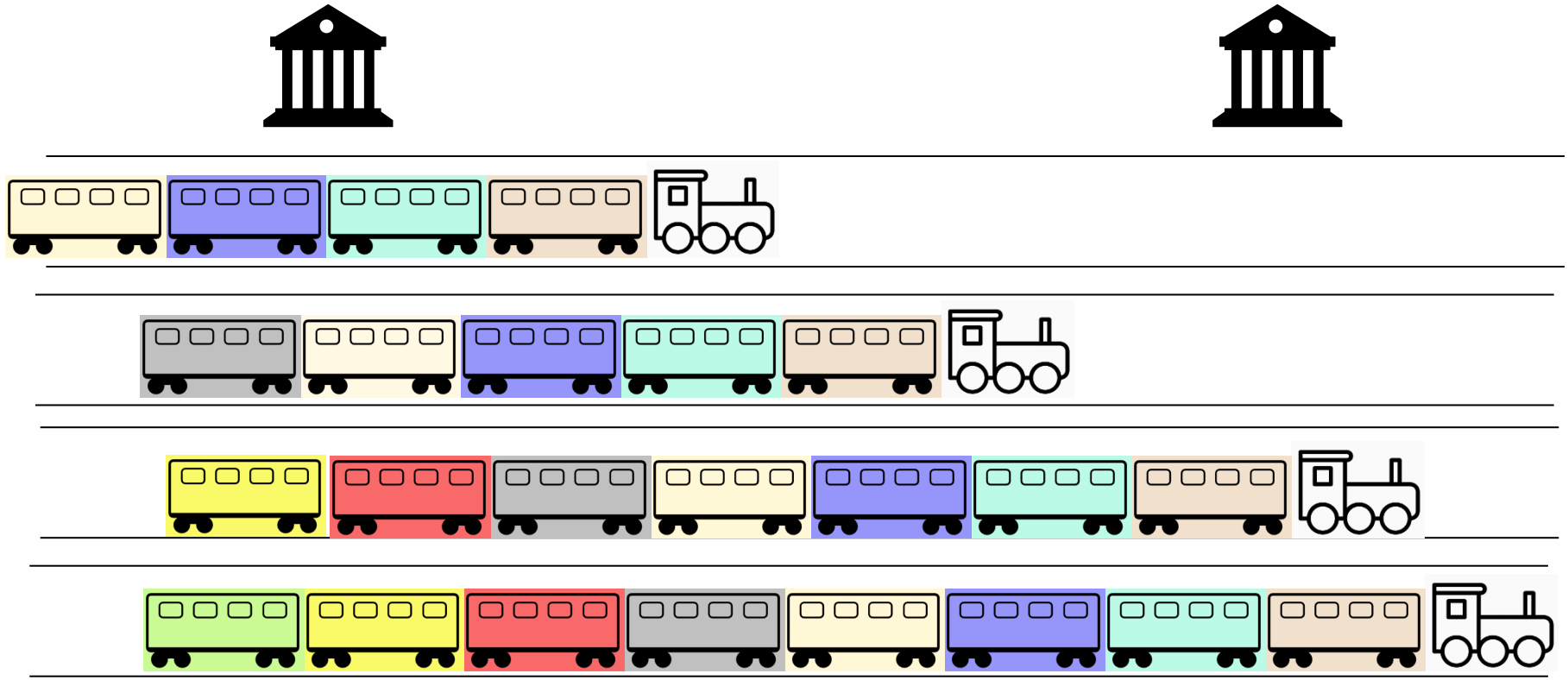
Large Packets (Arriving while Sending)



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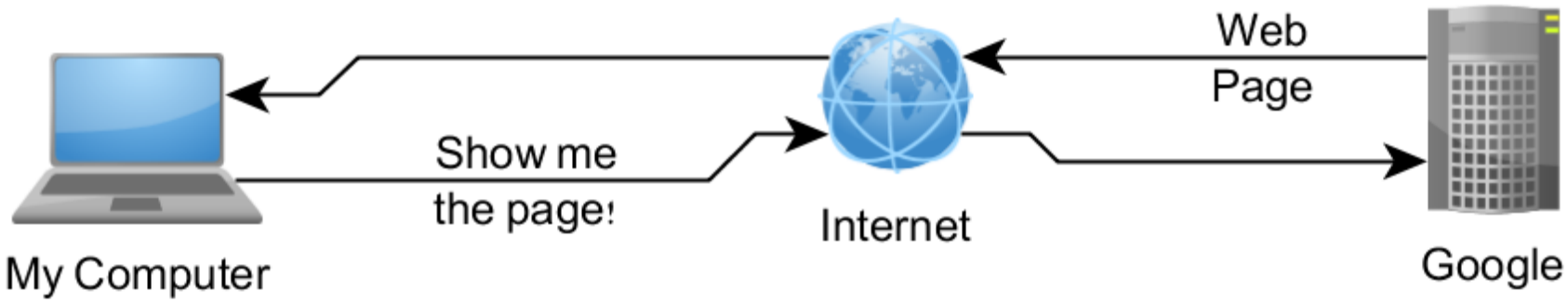
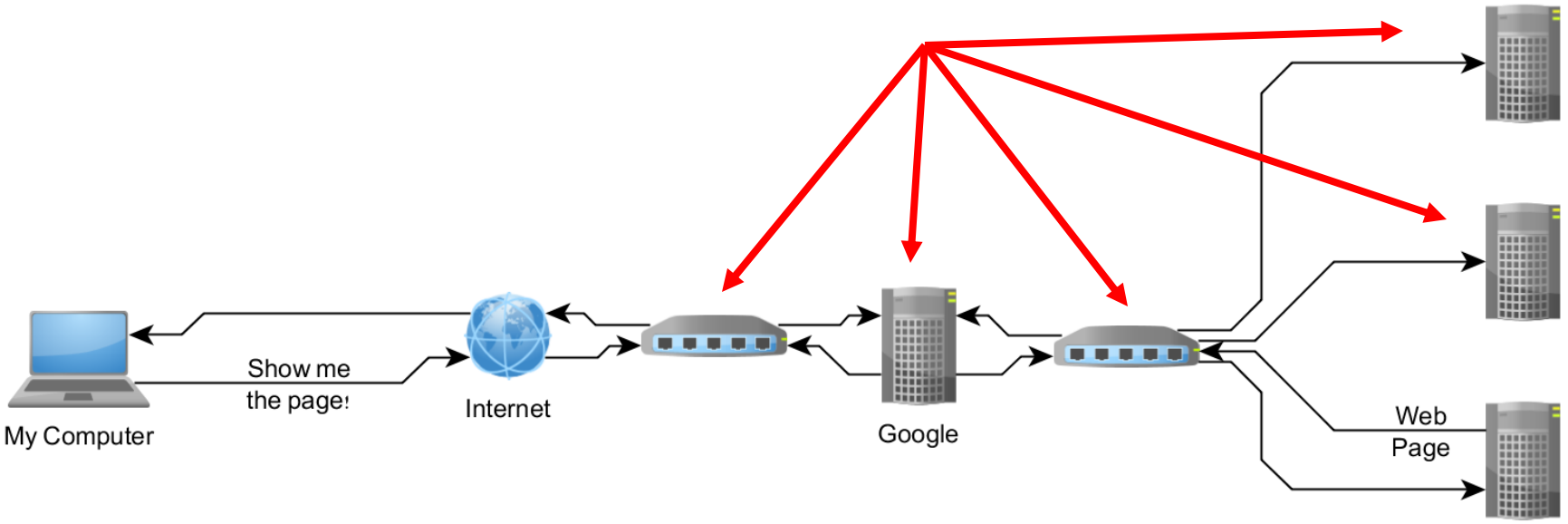
Conclusion

- What is a network?
  - Connectivity
  - Efficient Resource Sharing
  - Functionality
  - Performance

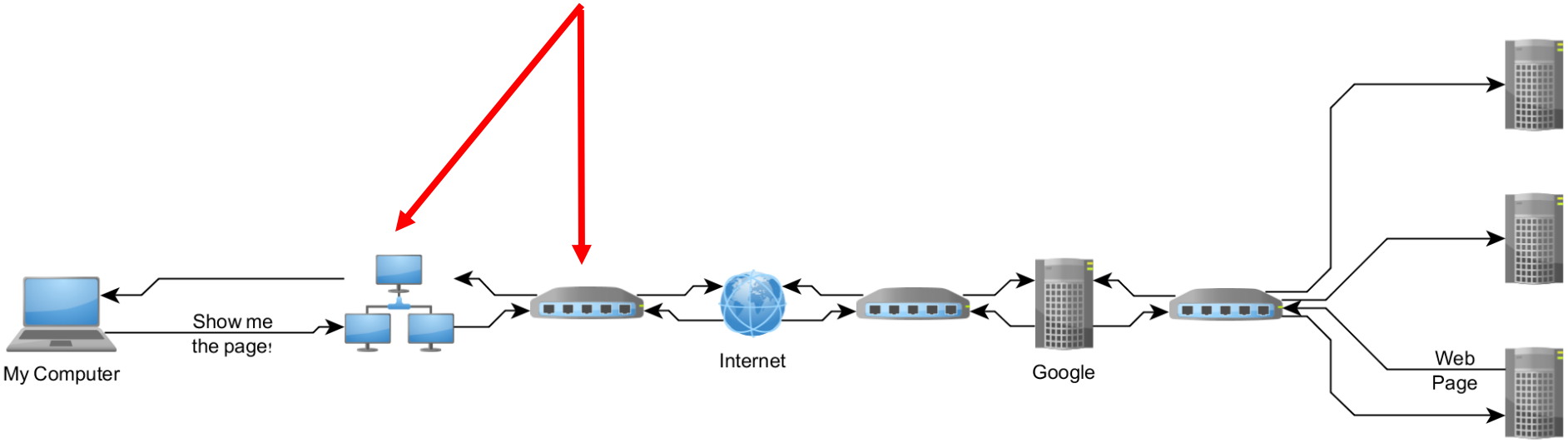
The Big Picture



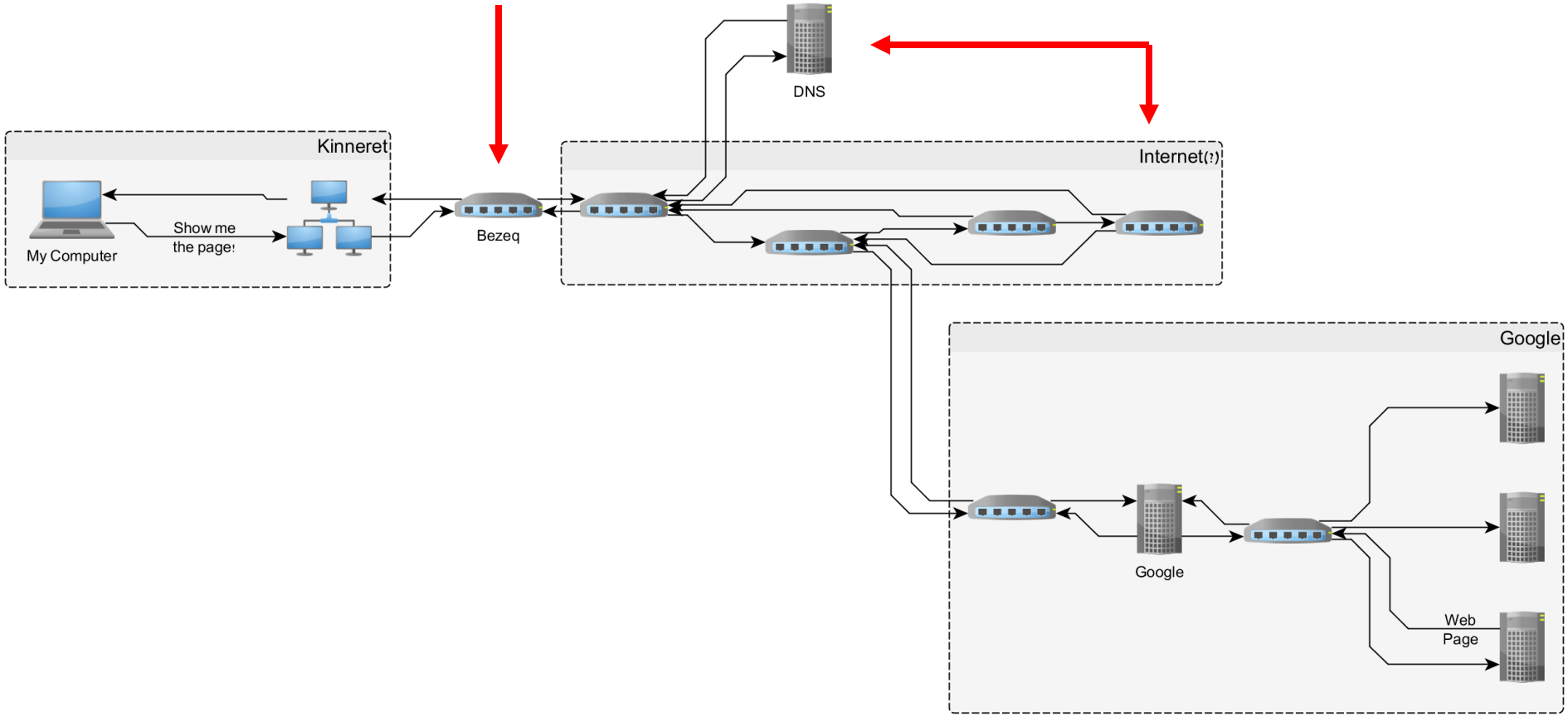
2nd Level



3rd Level



4th Level


DNS
Kinneret
Internet(?)
My Computer
Show me
the page
Bezeq
Google
Google
Web
Page

5th Level