
Introduction to Networks, Links

26 October 2025
Lecture 1

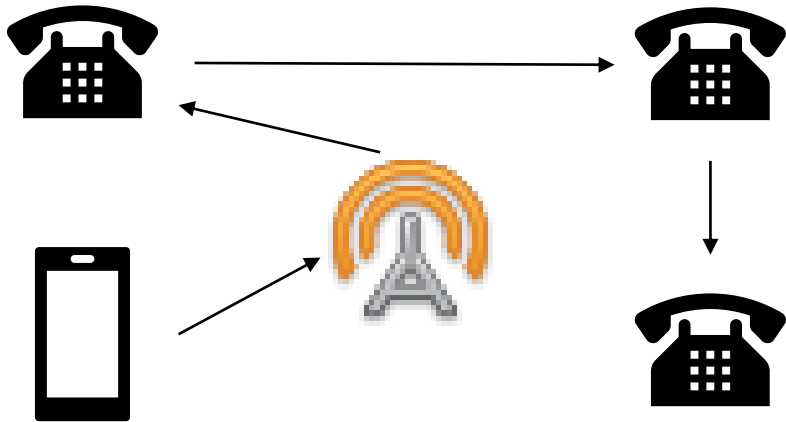
Slides Credits: Steve Zdancewic (UPenn)

Topics for Today

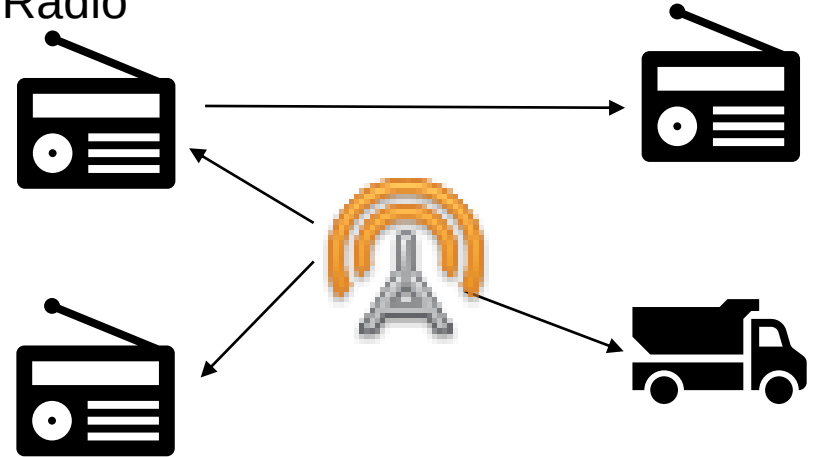
- What is a network?
 - Connectivity
 - Efficient Resource Sharing
 - Functionality
 - Performance

Four Networks

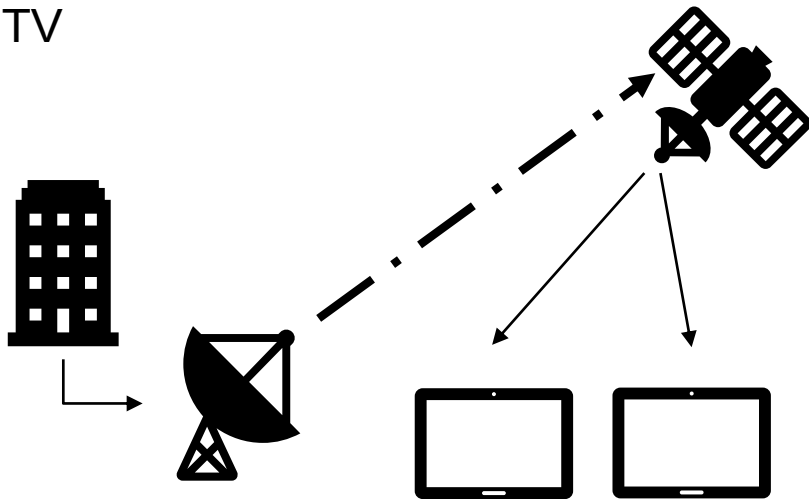
Telephone



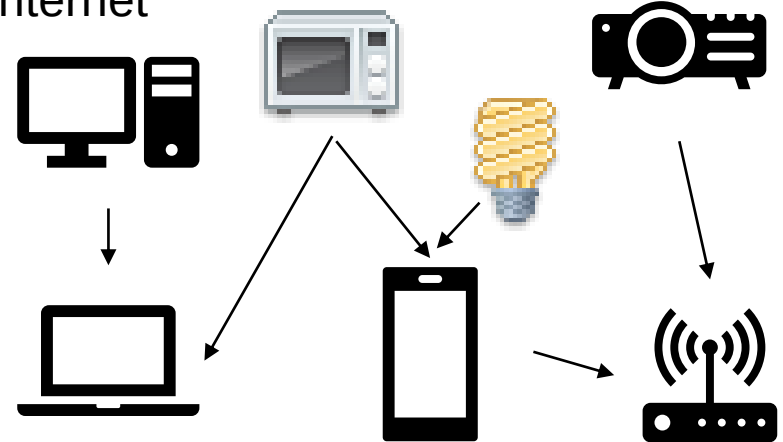
Radio



TV

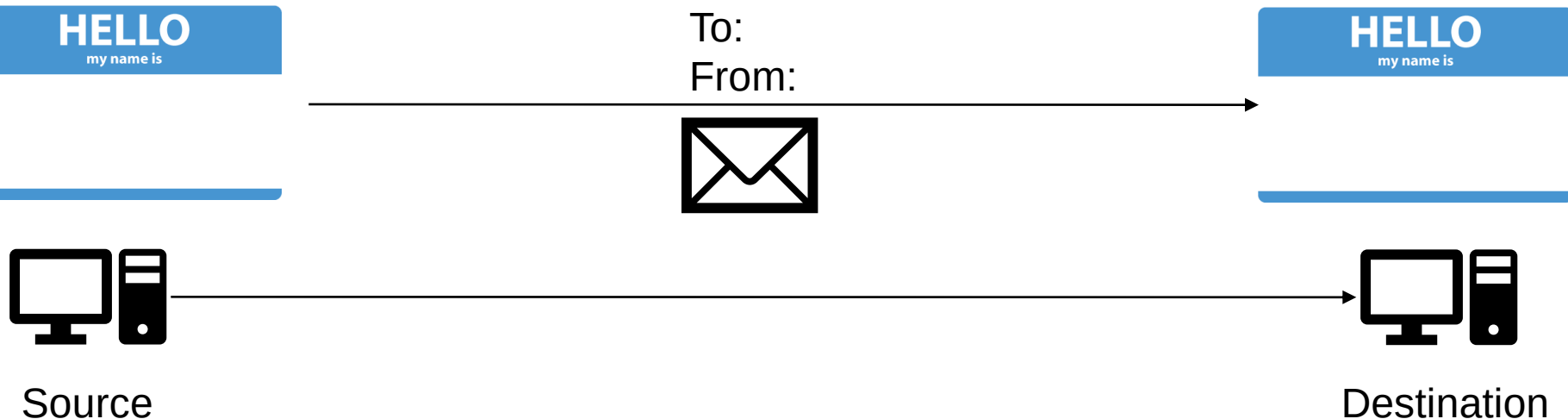


Internet



Requirement: Connectivity

- Goal of a network is to get information from one place to another
 - Source
 - Destination
 - *Nodes or Hosts*
- } Specified by an *address*

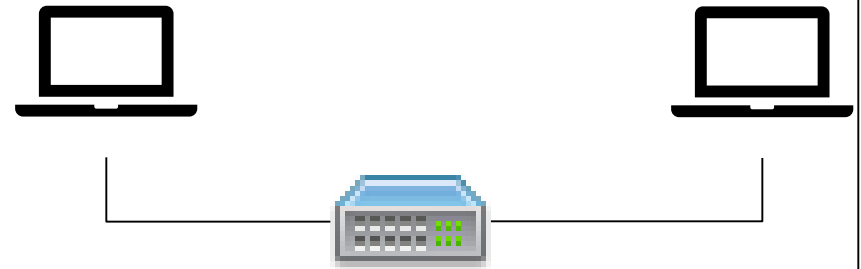


Network paths

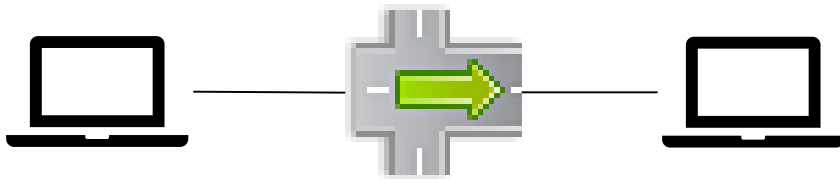
Direct



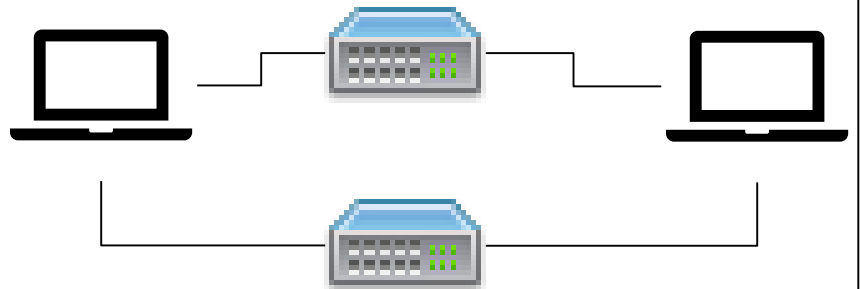
Indirect (Hops)



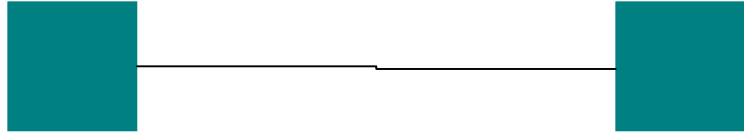
Static



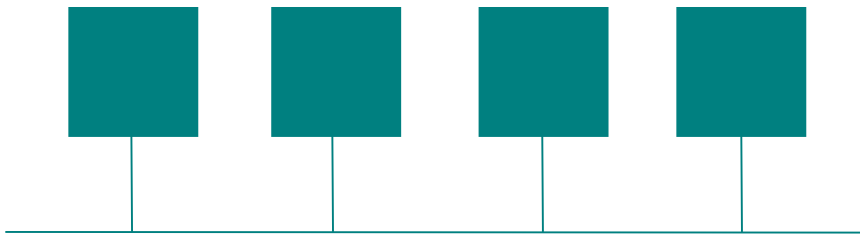
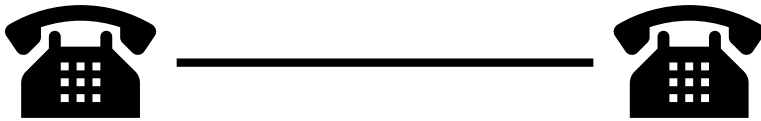
Dynamic (Dis/Appear)



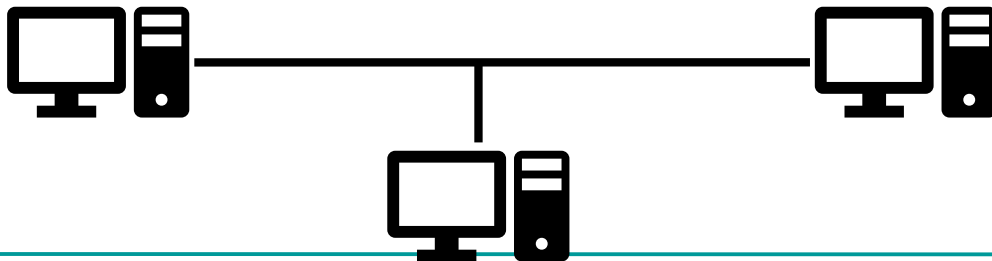
Connectivity: Direct Links



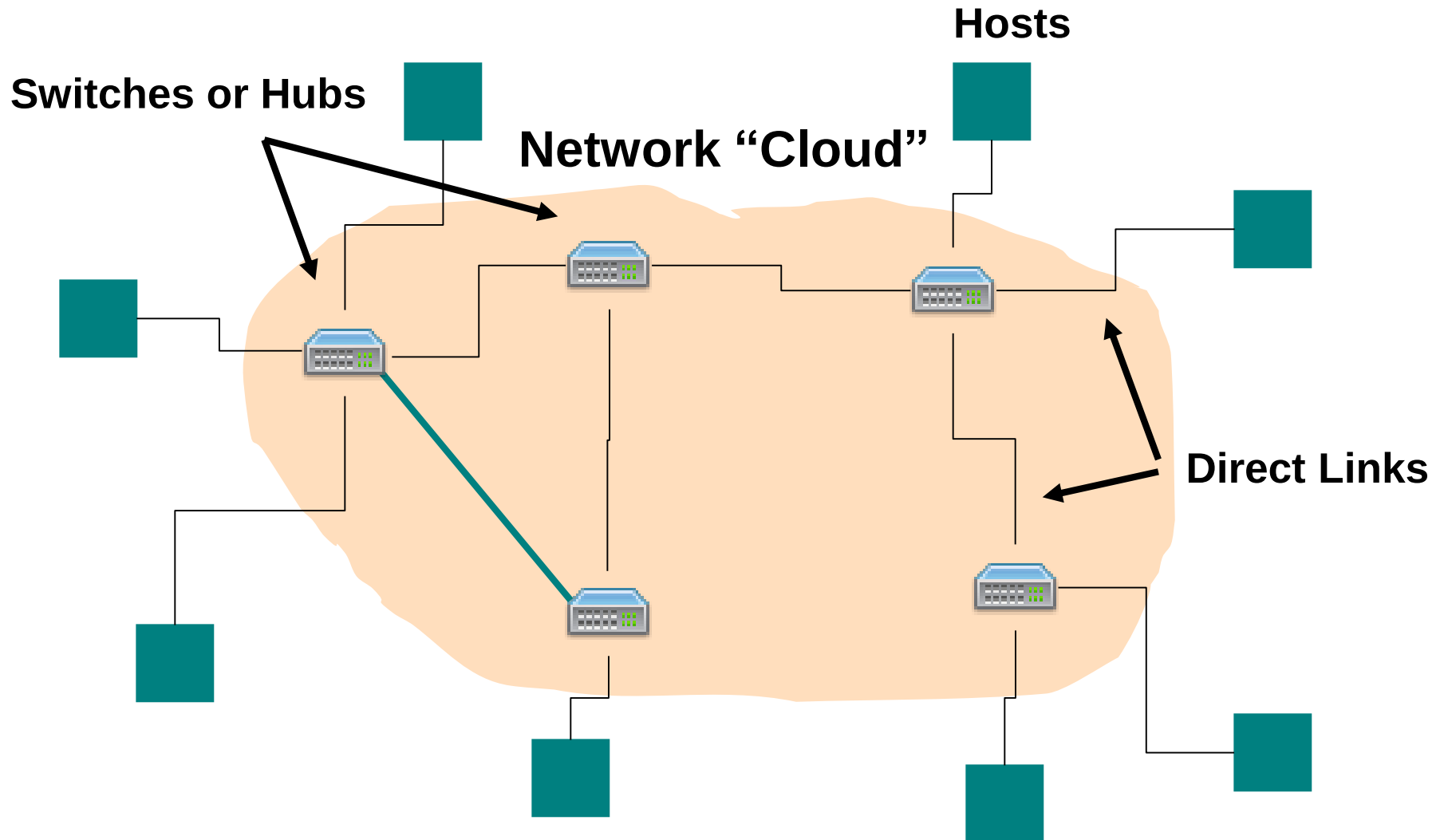
Point to Point
e.g. telephone



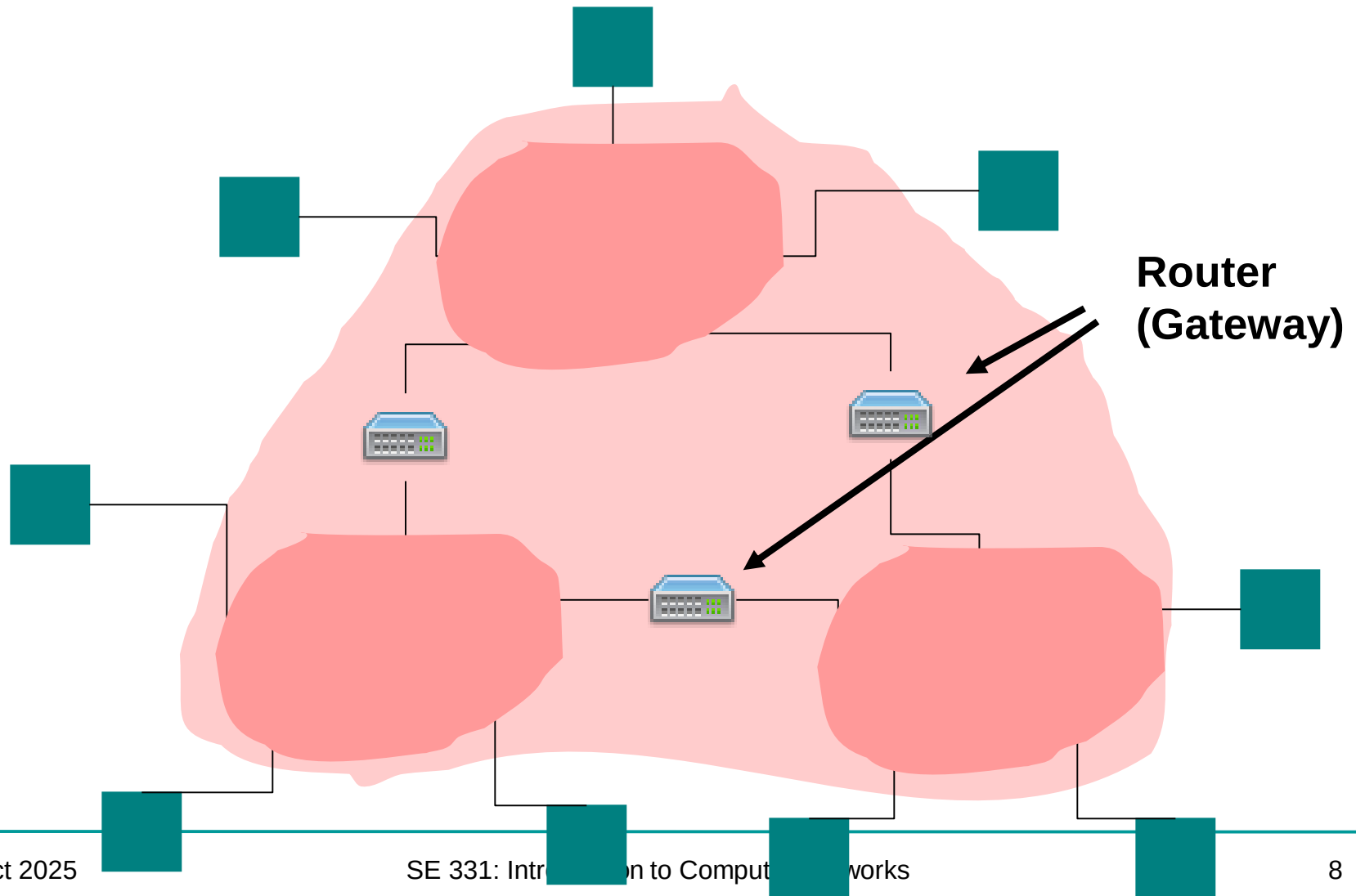
Multiple Access
e.g. Ethernet, Wi-Fi



Connectivity: Switched Networks



Connectivity: Internetworks

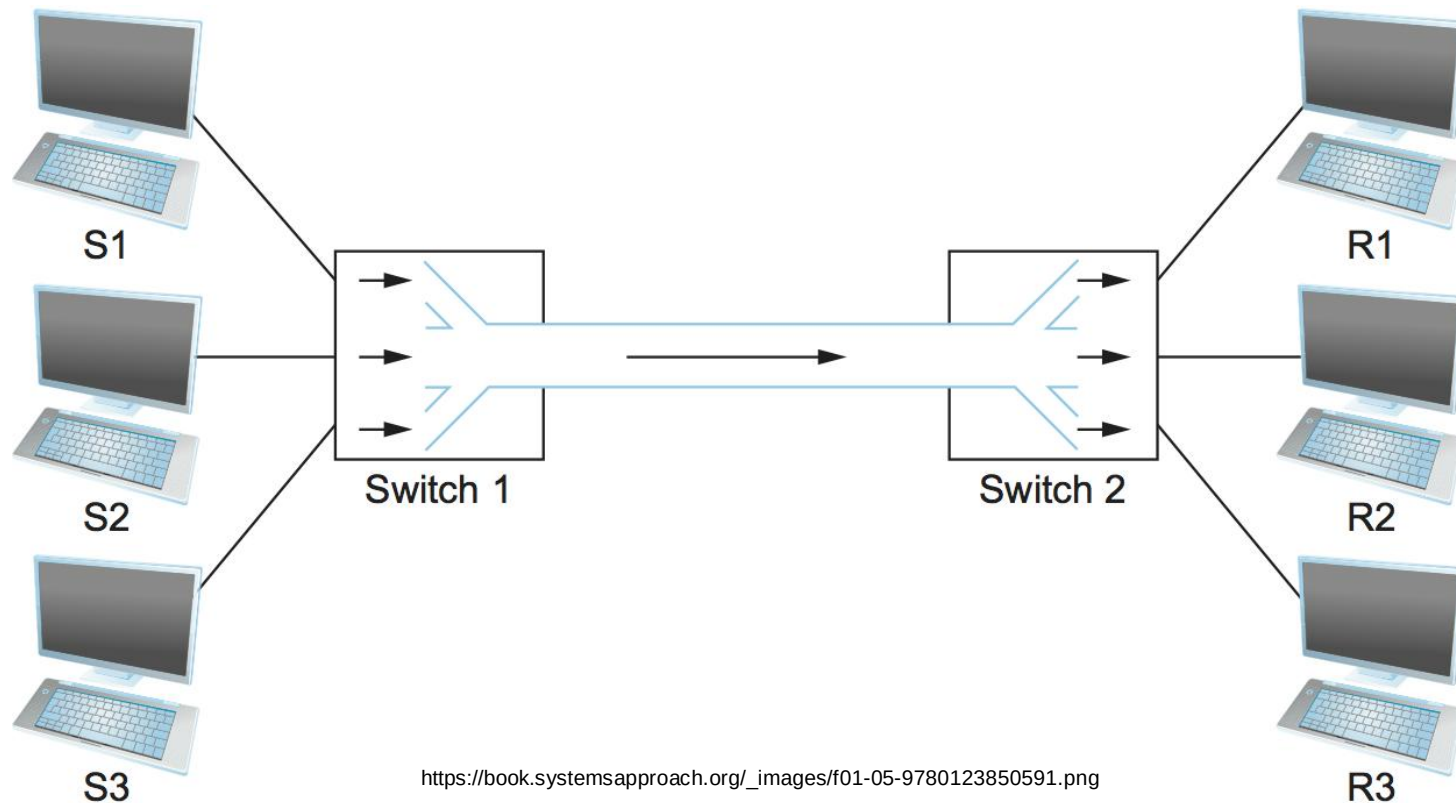


So Far

- What is a network?
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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

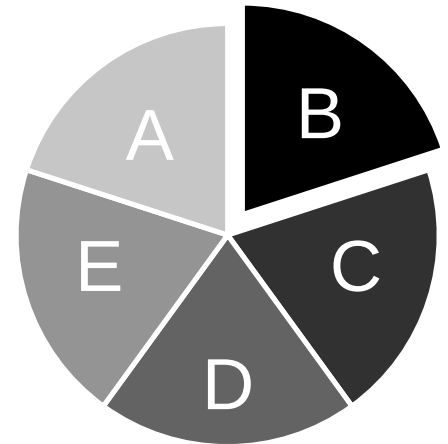


I'm not worried. My time will come.

Freddy Adu

Limitations:

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



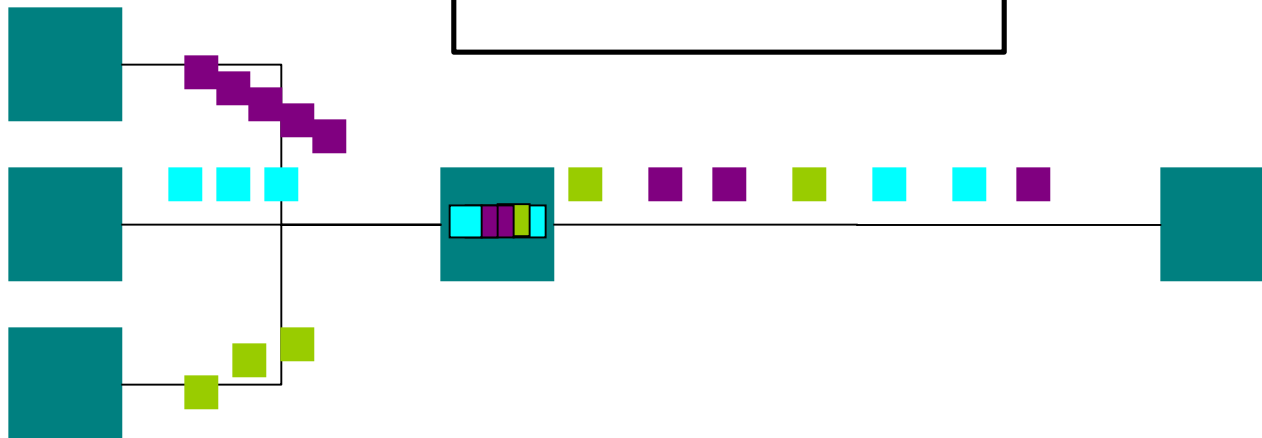
Statistical Multiplexing

Data
partitioned into
packets

Routing
decision made
per packet

Better **resource**
usage than
STDM

Fairness?
Congestion?

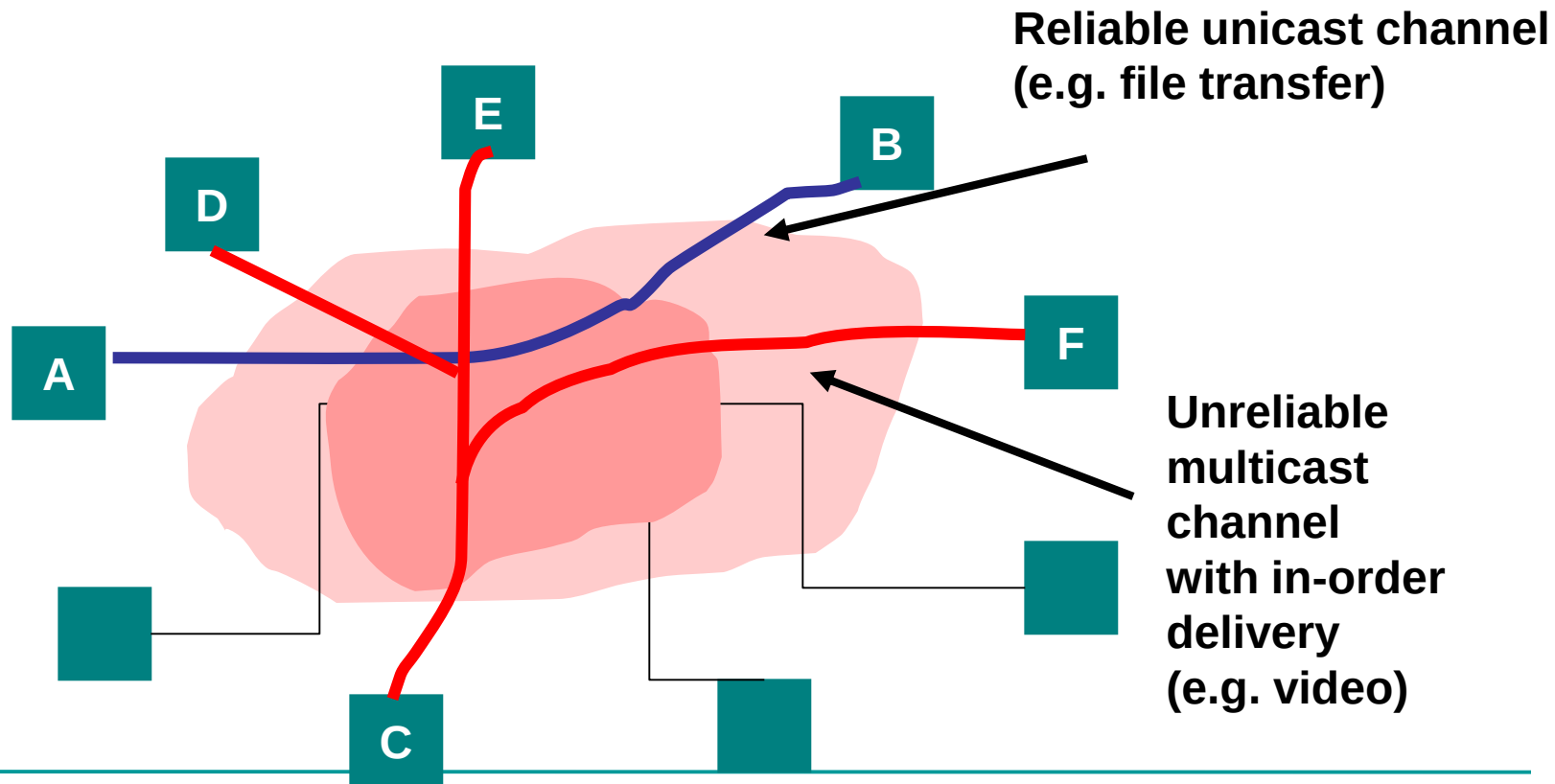


So Far

- What is a network?
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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

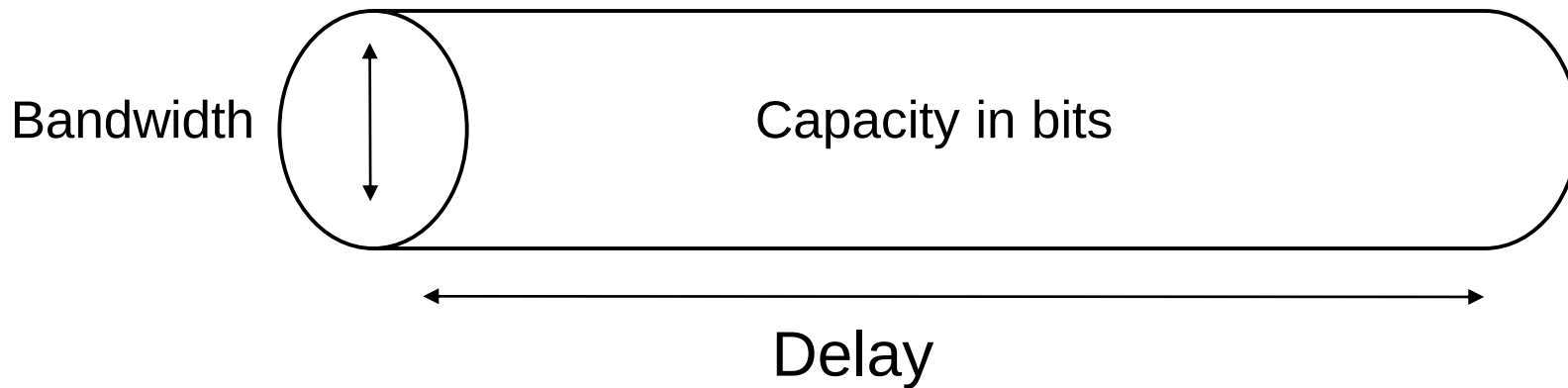
Latency (delay)

- 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)

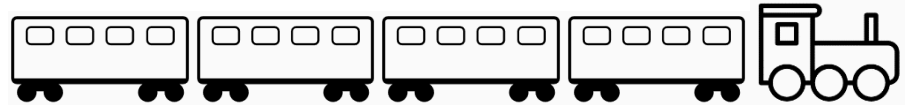
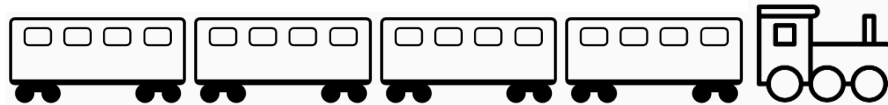
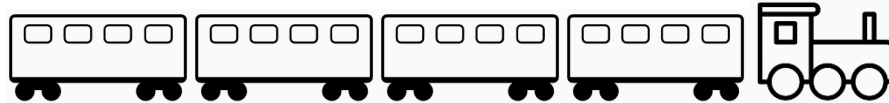
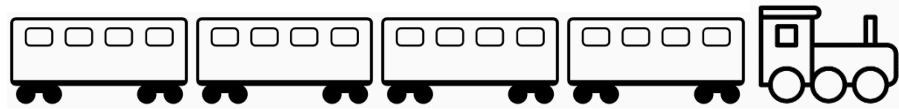


Image Credits: By Misbahul Munir, ID, In the Kids and Toys (line) Collection and By Elizabeth Trejo, In the Public Transit Collection from The Noun Project

Large Packets (Arriving while Sending)

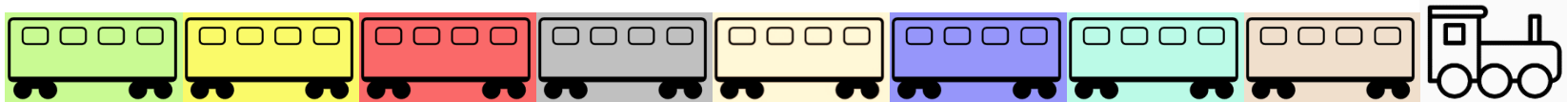
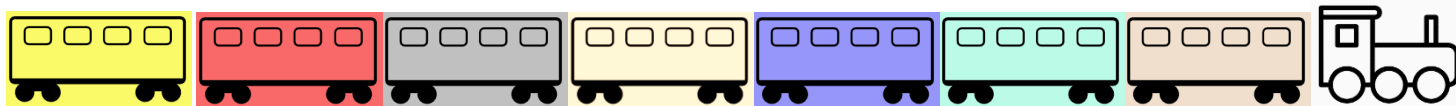
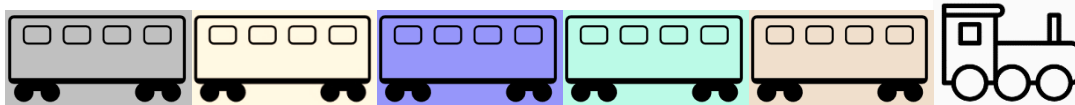
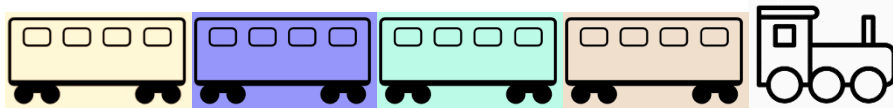
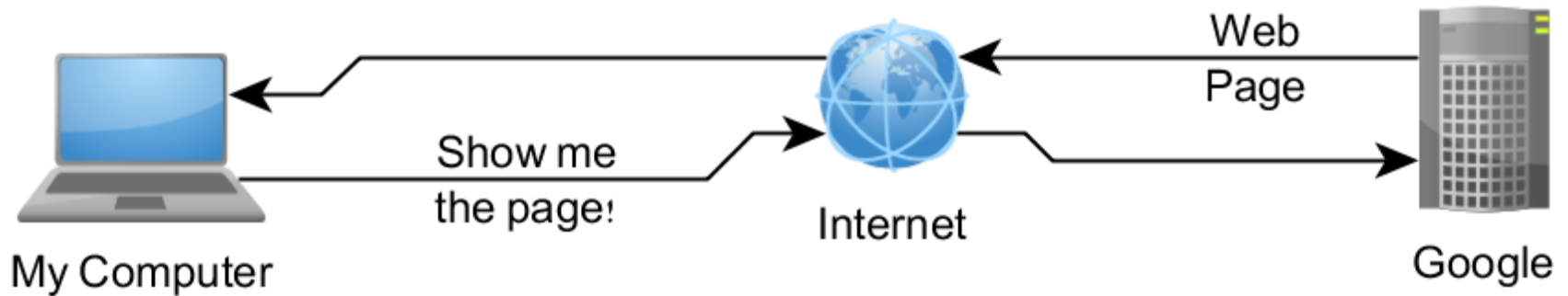


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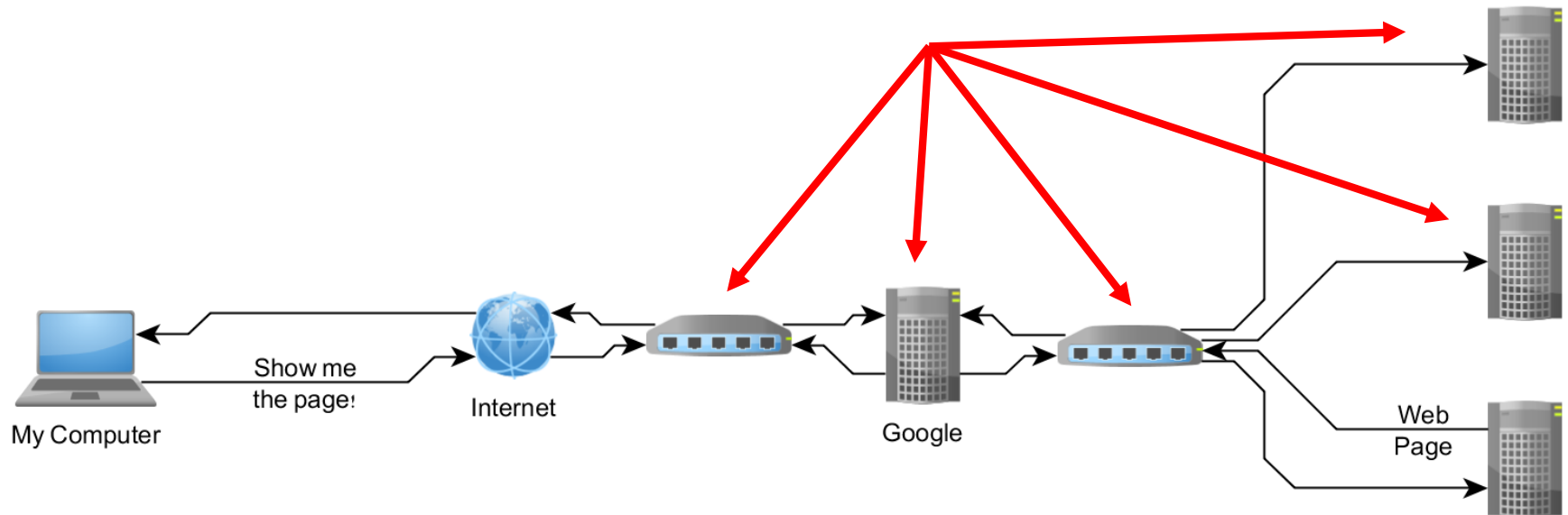
Conclusion

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

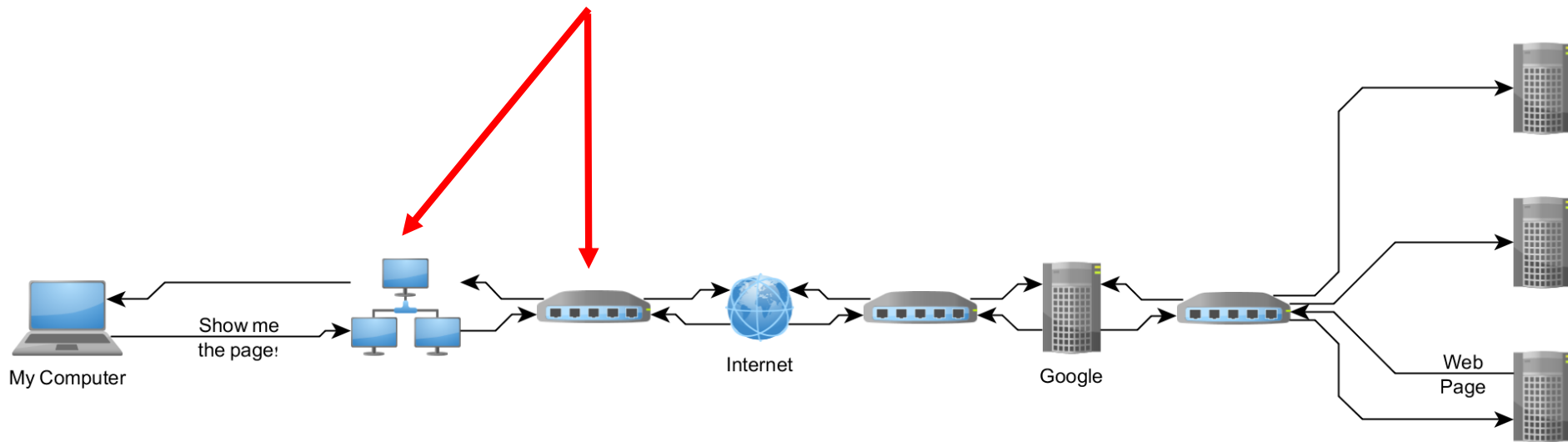
The Big Picture



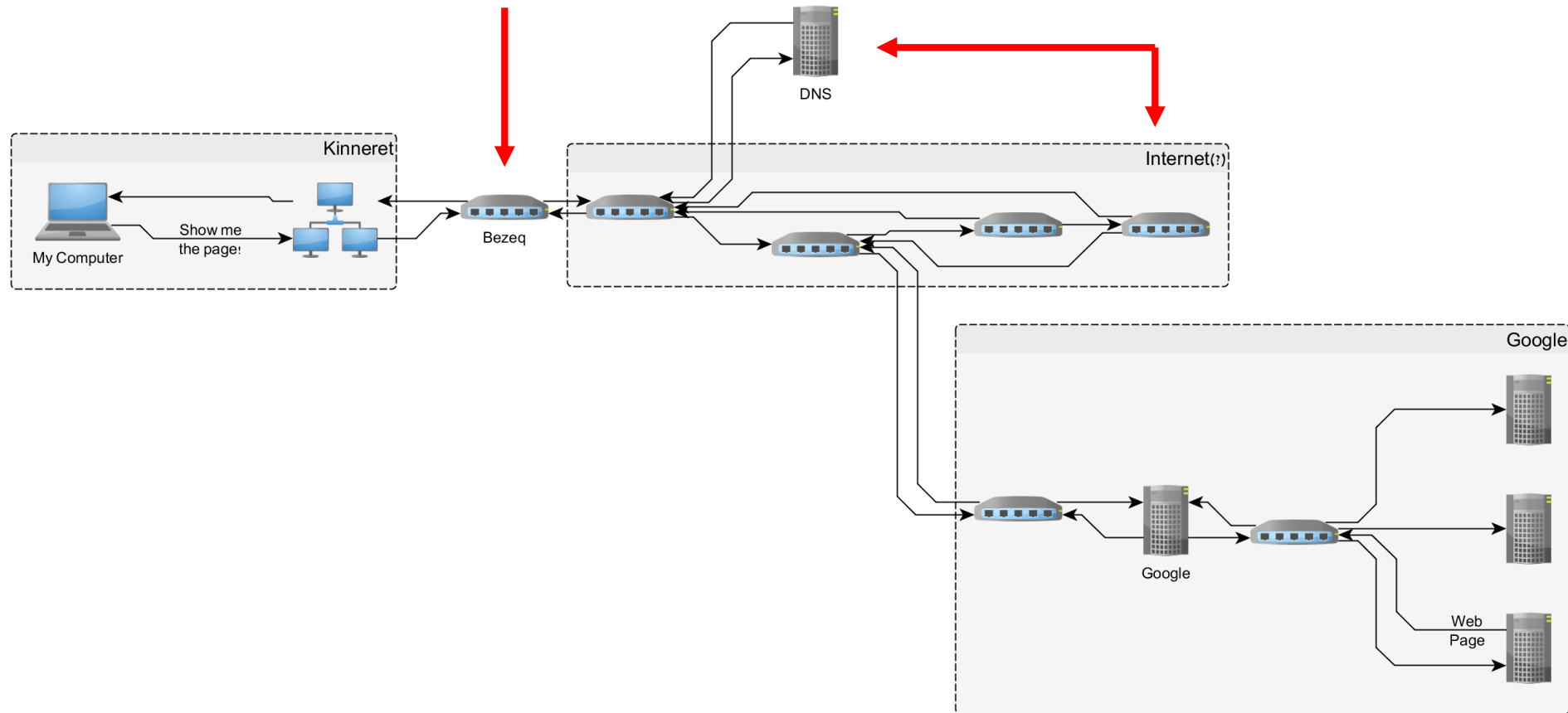
2nd Level



3rd Level



4th Level



5th Level

