CSC4200/5200 – COMPUTER NETWORKING

FINAL REVIEW - 1

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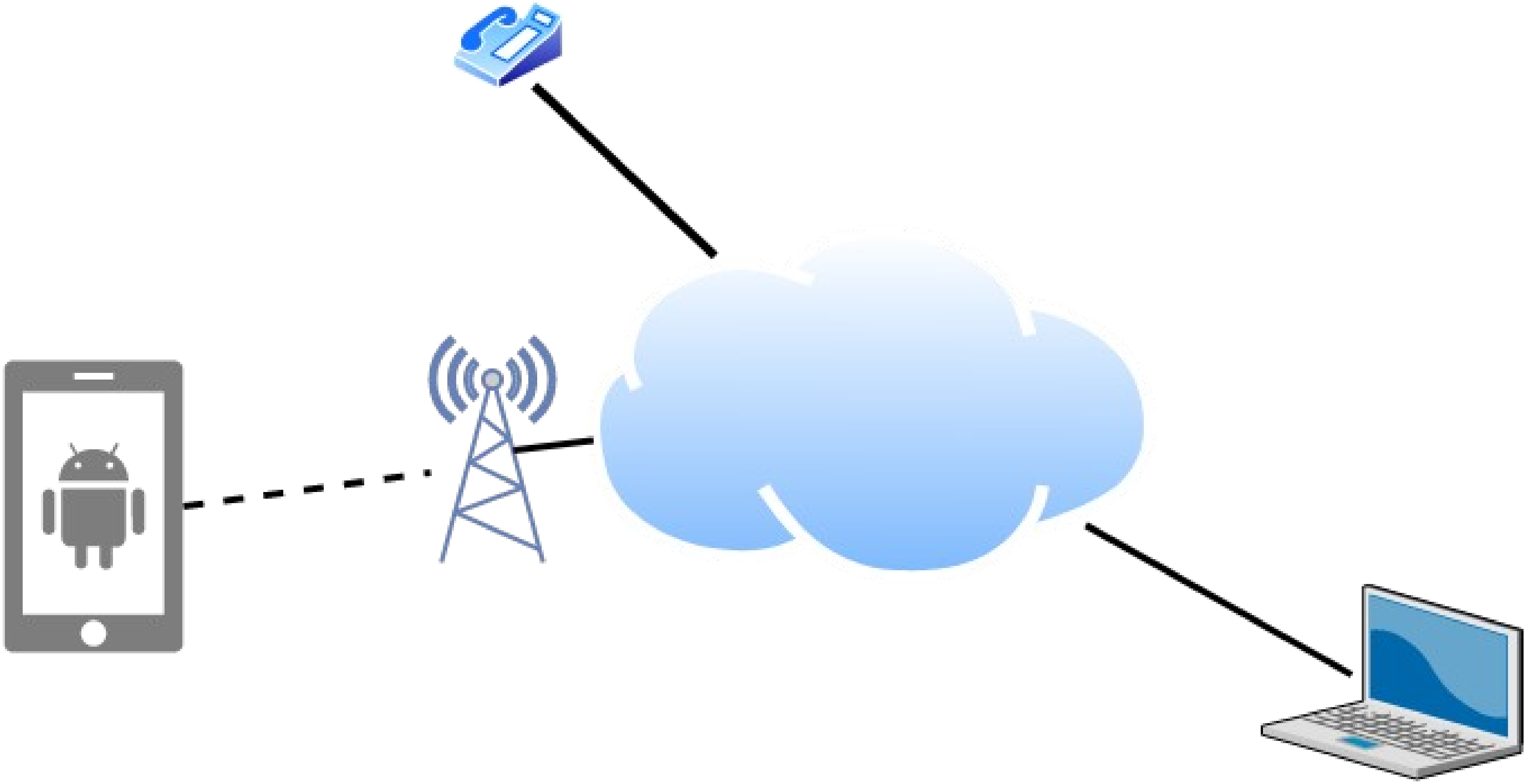
TECH

Chapter 1: Fundamentals

- Networking is ubiquitous
  - What did you use it for today?

- First things first:
  - Terminology
  - Basic tools
  - What does it take to build an Internet?

Links, Nodes, Cloud, Routers, Switches



Client and Server

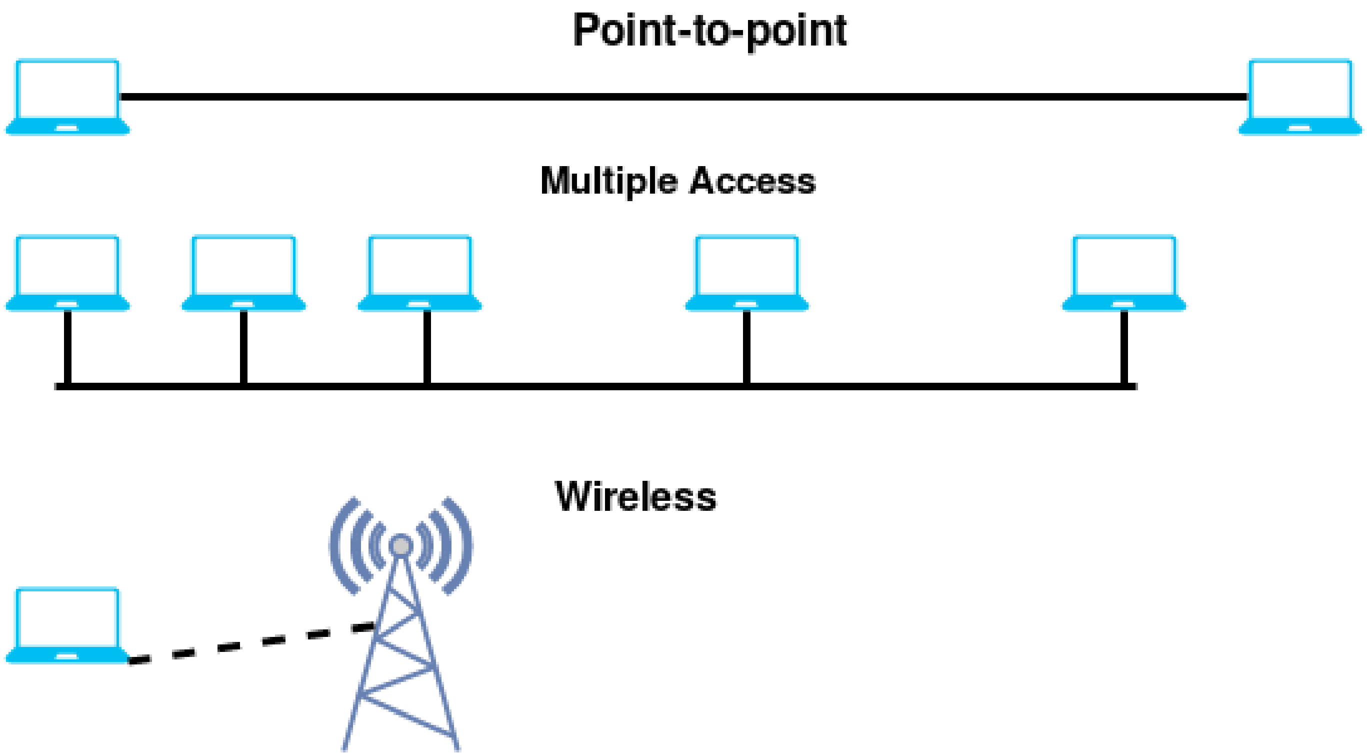
- My laptop with a browser = client
  - It requests a service
  - Email, chat, video, youtube

- A node running a program that serves the requests = server
  - Runs a service
  - Chat, video, messaging

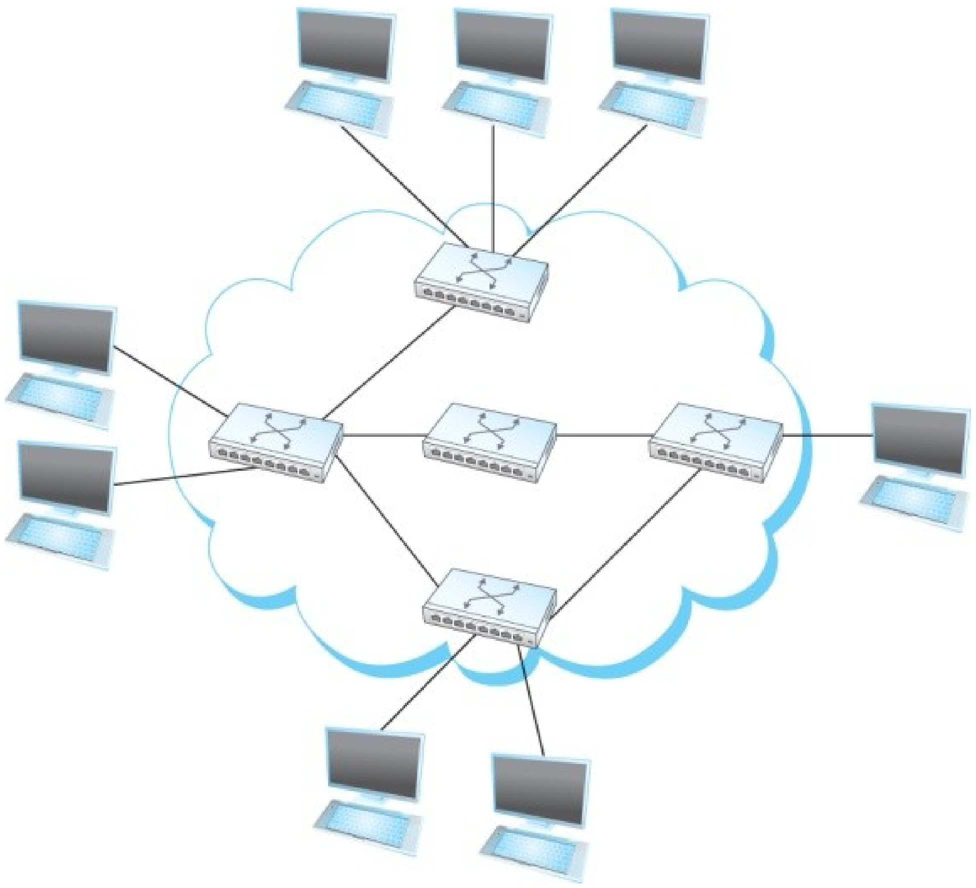
- A node can both be a client and a server

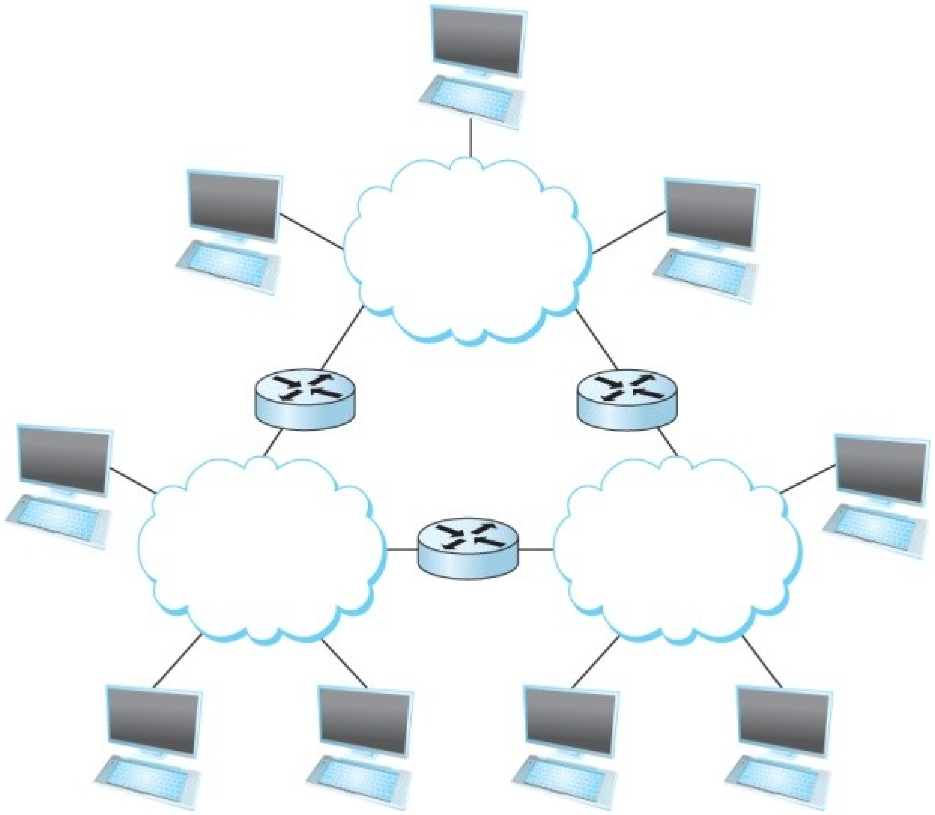
Connectivity

- Point to Point
- Multiple access
- Wireless

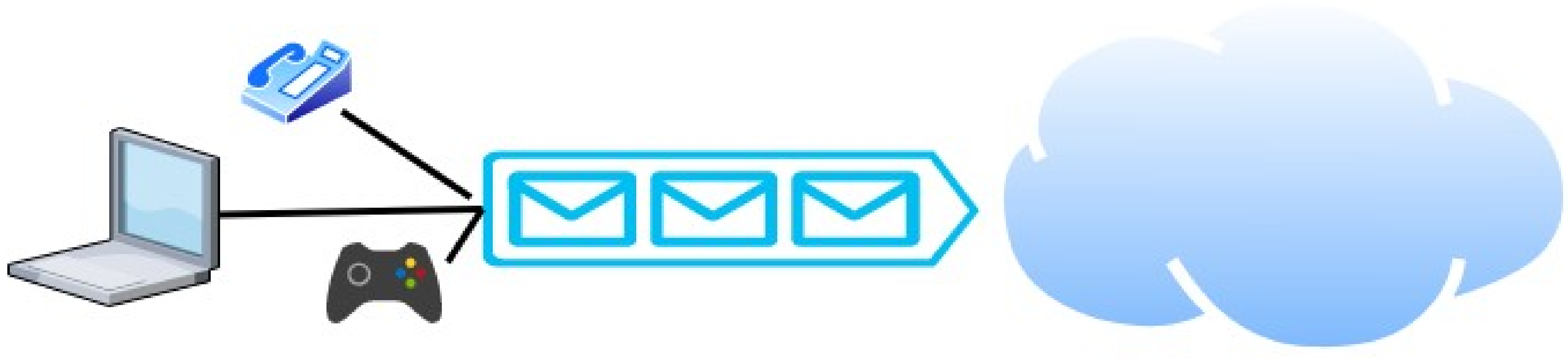


A Network and the Internet



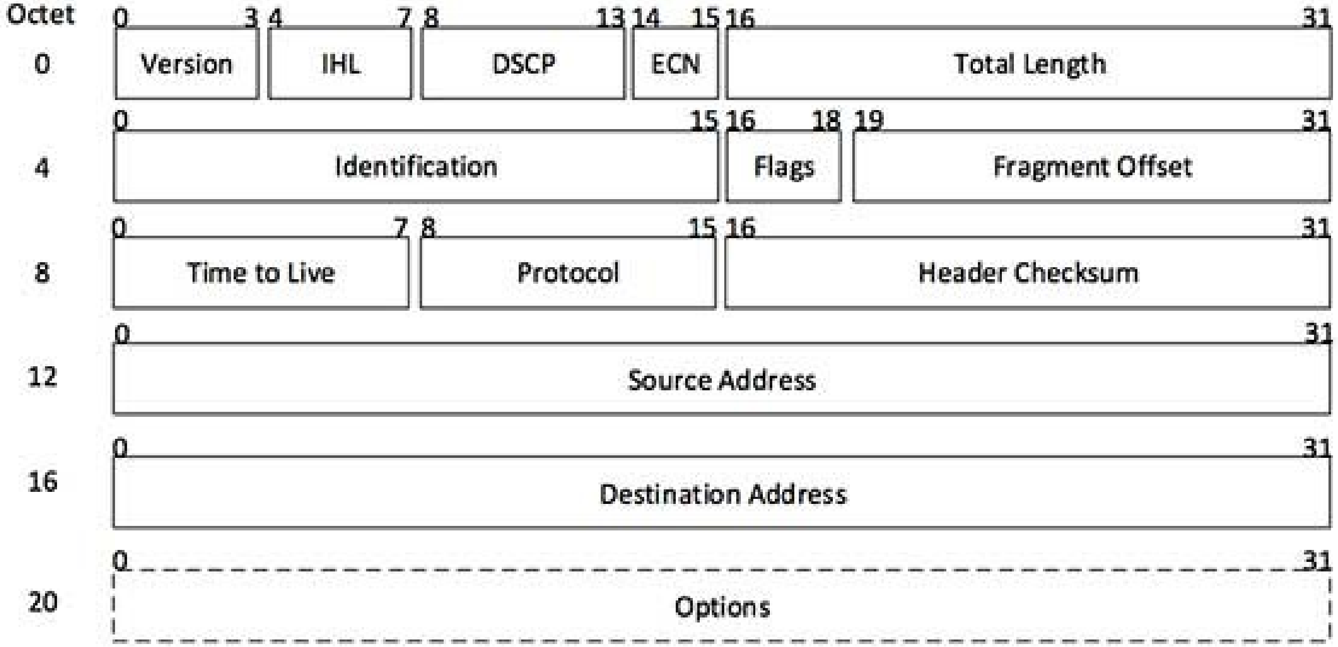


Packet Switching



- Packets are low level components
- Multiple kind of traffic with different requirements
  - Gaming vs Phone
- Dumb network – How do you ensure quality of service?
- End points must be smart

But What is a Packet?

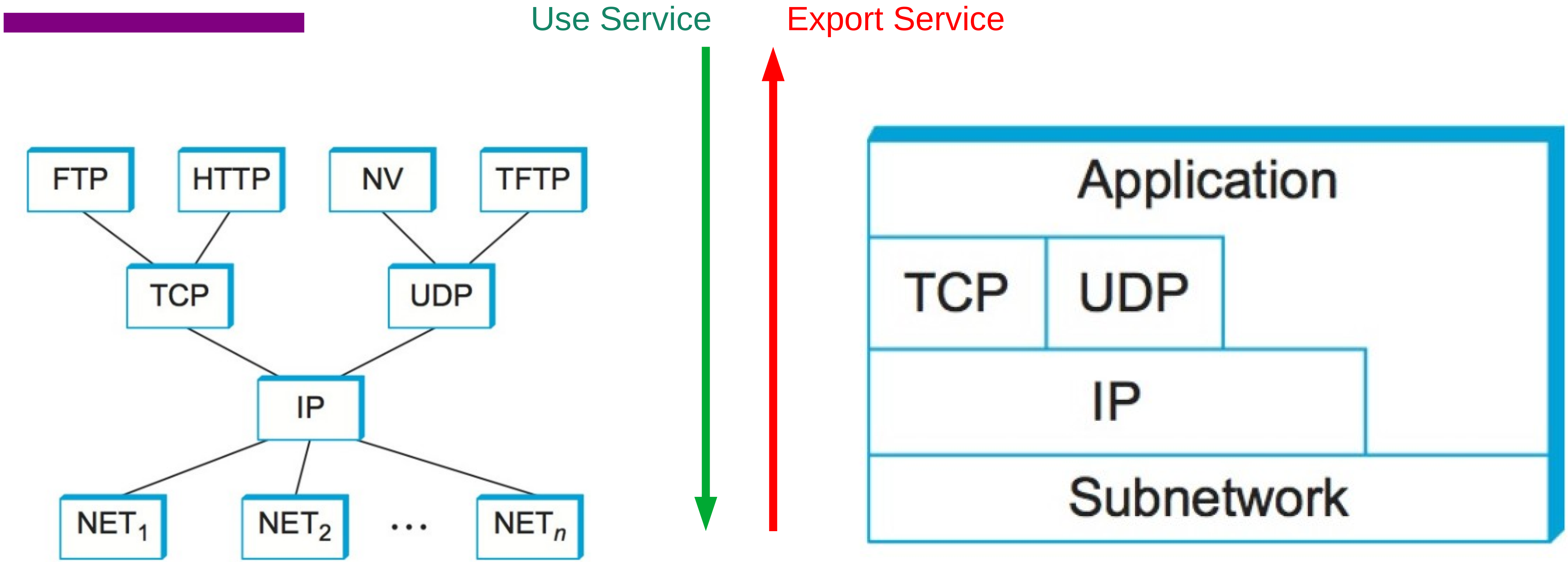


Octet					
	0 3	4 7	8 13	14 15	16 31
0	Version	IHL	DSCP	ECN	Total Length
	0 15	16 18	19 31		
4	Identification	Flags	Fragment Offset		
	0 7	8 15	16 31		
8	Time to Live	Protocol	Header Checksum		
	0 31				
12	Source Address				
	0 31				
16	Destination Address				
	0 31				
20	Options				

[Image: IP Header]

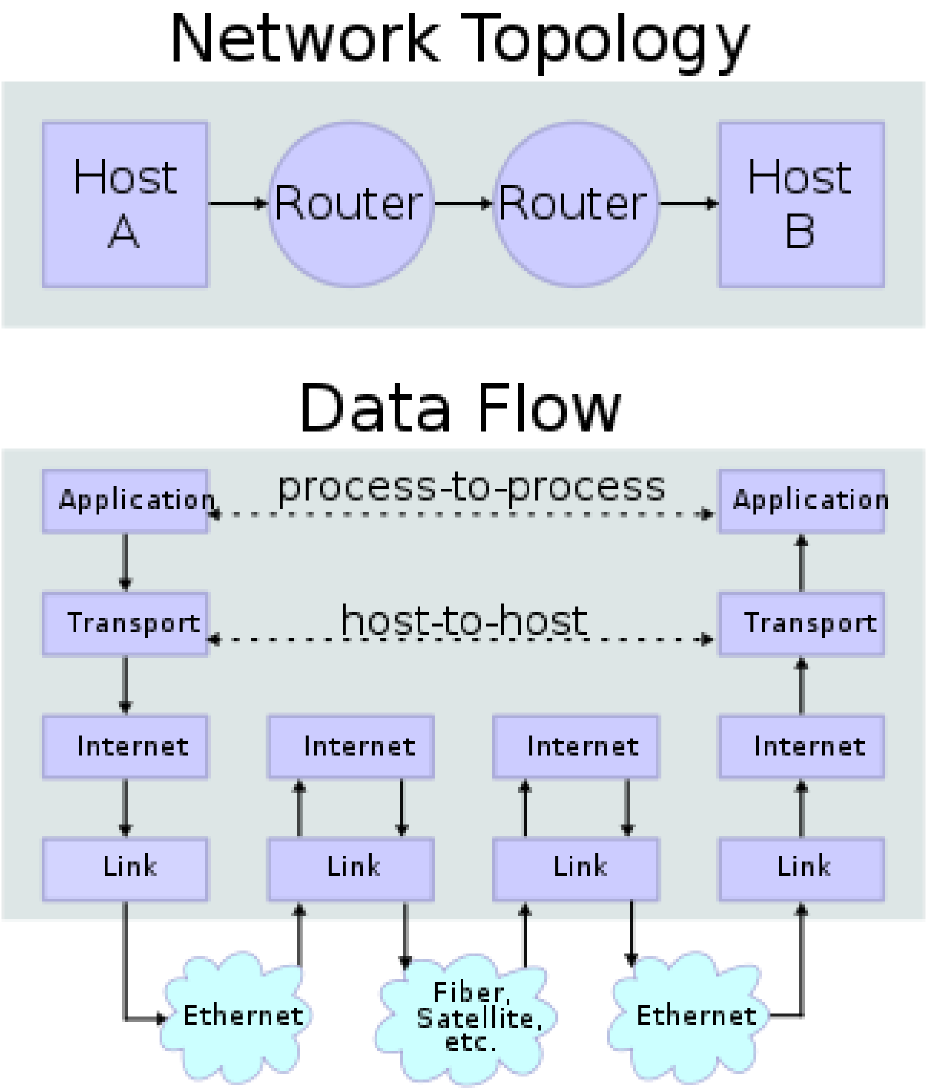
- Self-contained data unit
- Has two parts (generally)
  - Control information
  - Payload
- How do we transmit a dictionary?

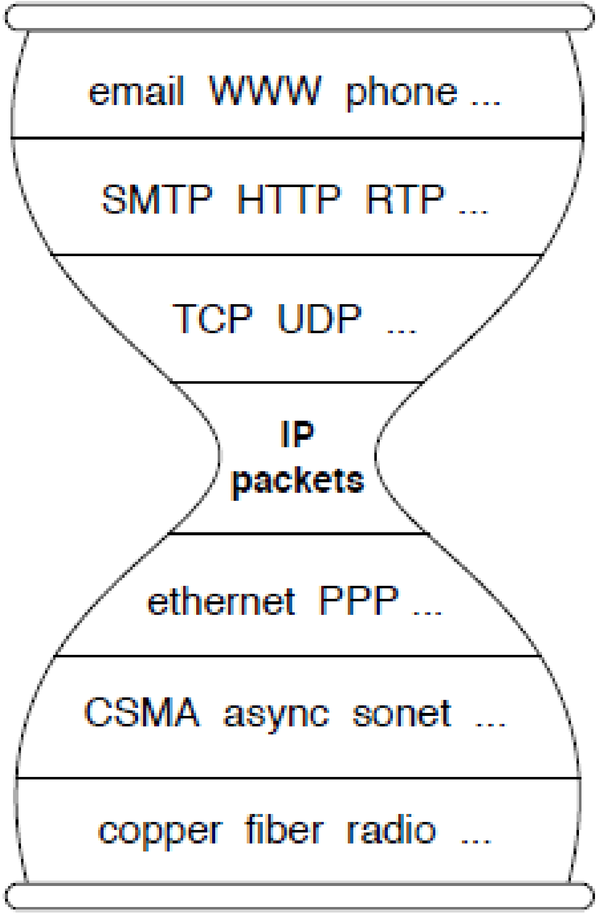
Network Layers



- Makes it easier to divide functionality
- Hides implementation details
- What else?

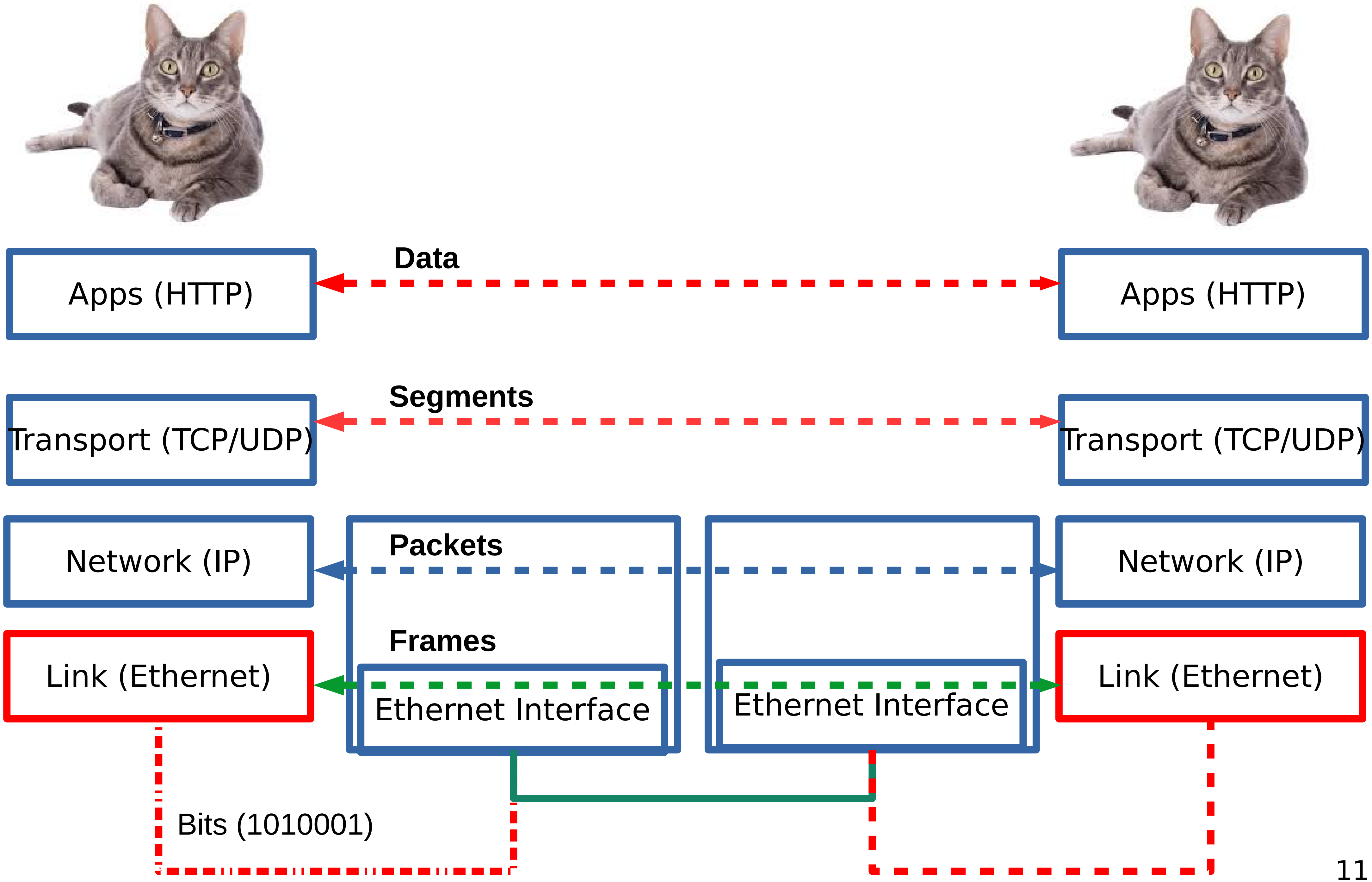
IP Suite





wikipedia

We reject kings, presidents, and voting. We believe in rough consensus and running code. (David Clark, IETF, July 1992)



Data

Apps (HTTP)

Apps (HTTP)

Segments

Transport (TCP/UDP)

Transport (TCP/UDP)

Packets

Network (IP)

Network (IP)

Frames

Link (Ethernet)

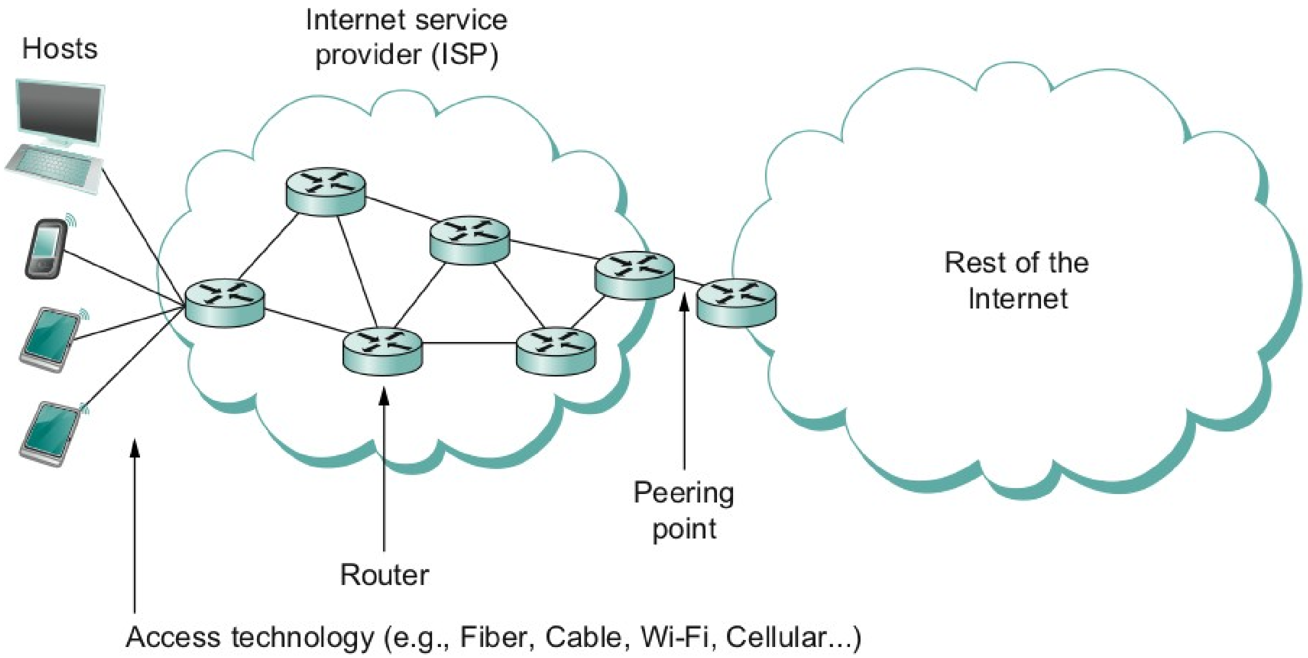
Ethernet Interface

Ethernet Interface

Link (Ethernet)

Bits (1010001)

What does it take to create a link?

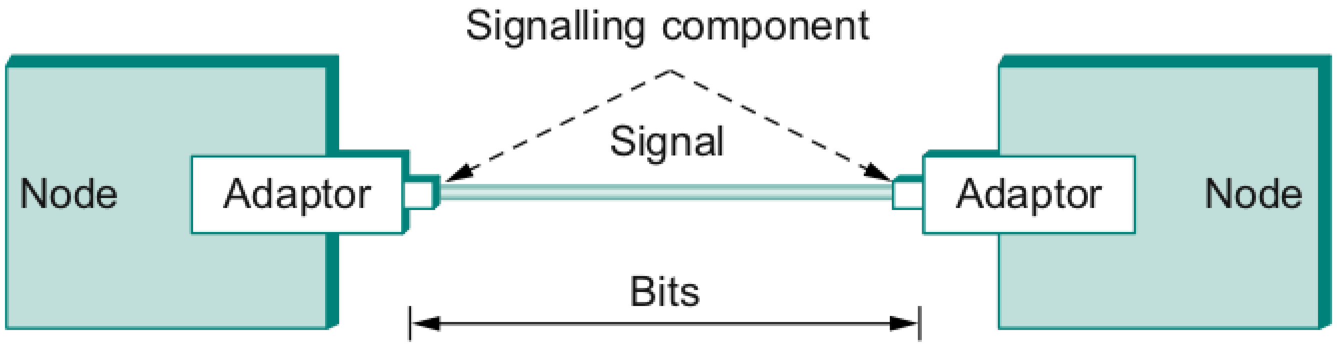


Hosts
Internet service provider (ISP)
Rest of the Internet
Peering point
Router
Access technology (e.g., Fiber, Cable, Wi-Fi, Cellular...)

- Common abstractions
  - Why?

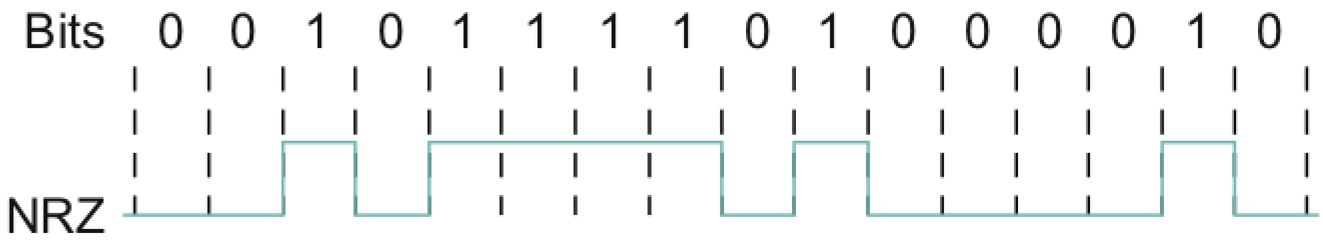
Packet to Low level Signals

- Bit pattern - 0101001
  - Must encode it into electrical signals and then decode it on the other end!



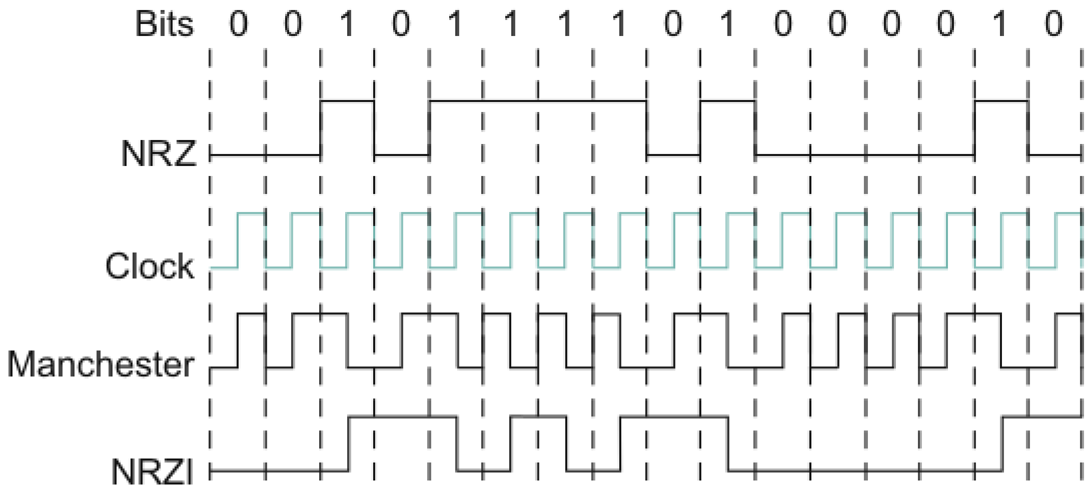
One easy way - NRZ

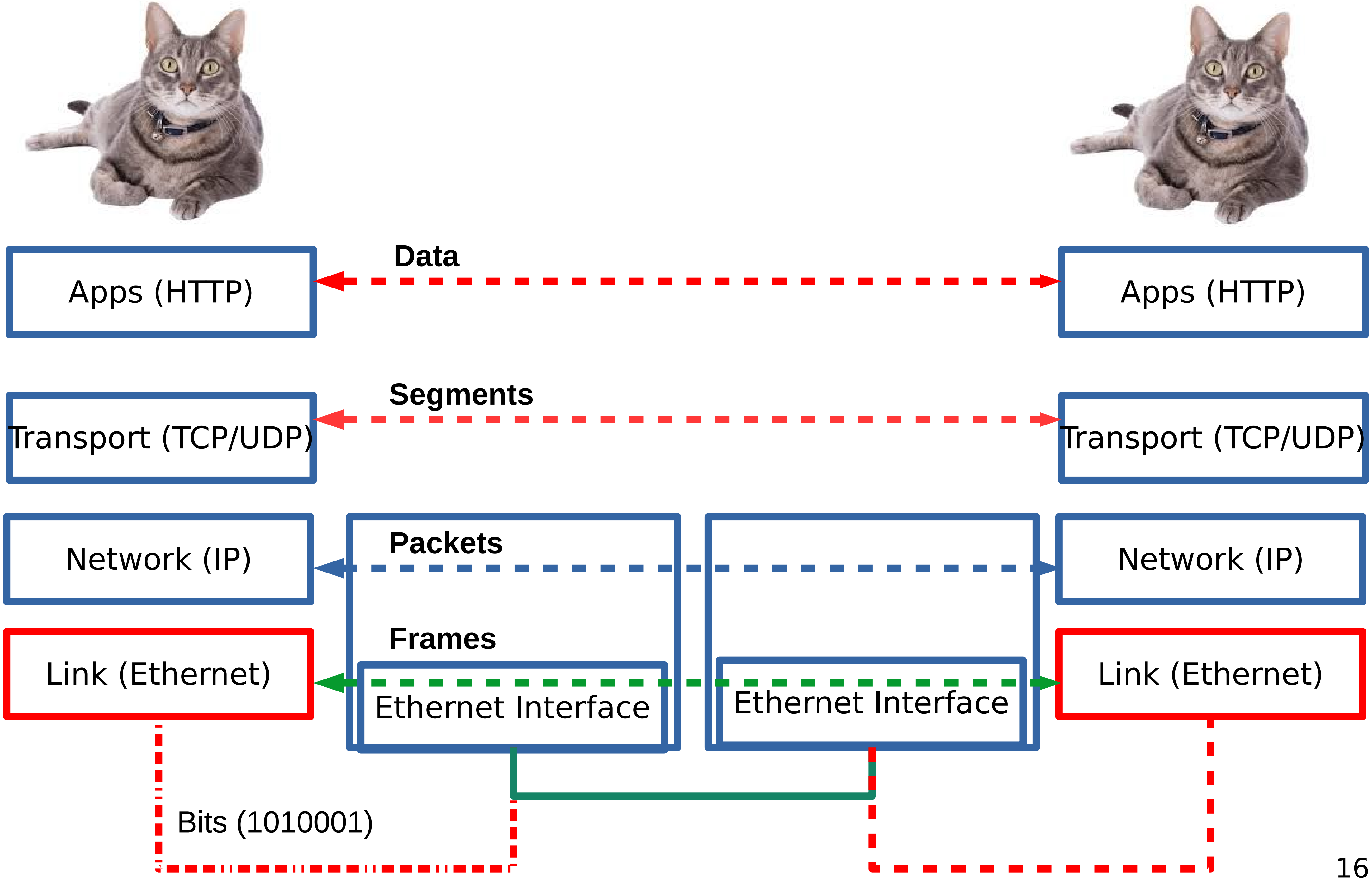
- 0 = low, 1= low
- Problem if you have too many 0s or 1s in a row
  - Baseline wander (read it in the book)



Other ways – NRZI/ Manchester Encoding

- NRZI – 1=transition, 0= Don’t
- Machester encoding – XOR of clock + NRZ data





Apps (HTTP)

Data

Apps (HTTP)

Transport (TCP/UDP)

Segments

Transport (TCP/UDP)

Network (IP)

Packets

Network (IP)

Link (Ethernet)

Frames

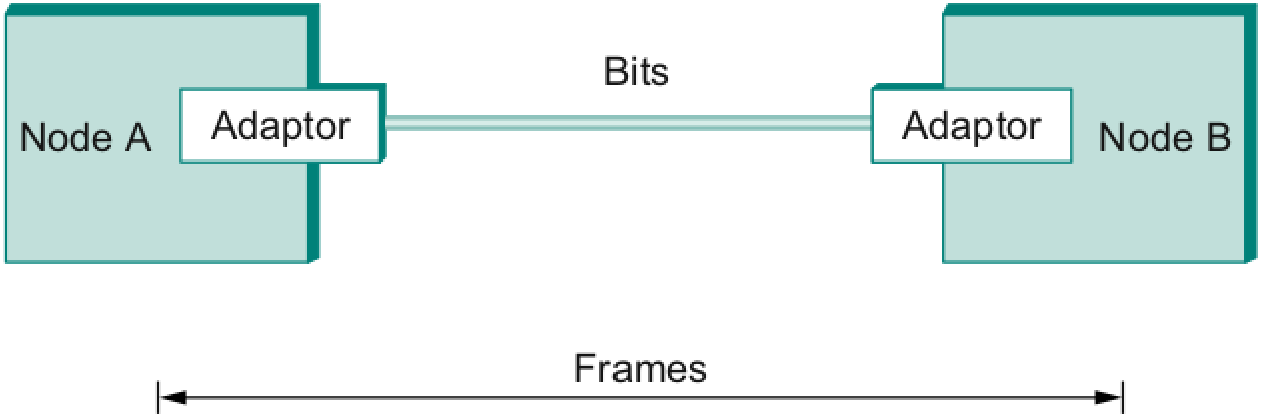
Ethernet Interface

Ethernet Interface

Link (Ethernet)

Bits (1010001)

Frames – bag of bits



- Bits - between adaptors
- Frames – between hosts (two computers)
  - The job of adaptors is to find frames in a bit sequence

- Frames are link layer protocols

Error Detection

- Basic Idea of Error Detection
  - To add redundant information to a frame that can be used to determine if errors have been introduced

0	1	0	1	0	**0**

0	1	0	1	1	**1**

Number of 1s

- Odd 1s = Parity bit 0
- Even 1s = Parity bit 1

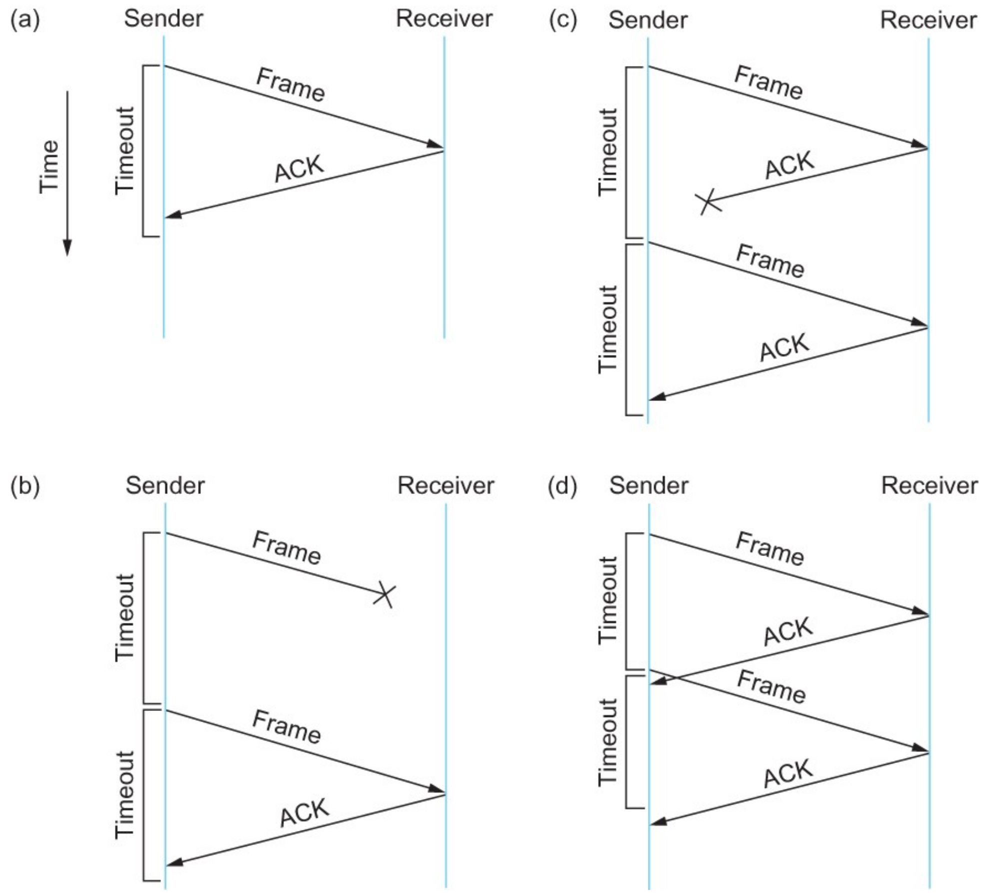
Reliable Delivery

- Frames might get lost
  - Too many bits lost
  - Clock did not sync properly
  - Error detected but the report got lost

- Can we build links that does not have errors?
  - Not possible

- How about all those error correction stuff we learned?
  - Can we add them to frames?
  - We could, but think of the overhead
  - What happens when the entire frame is lost?

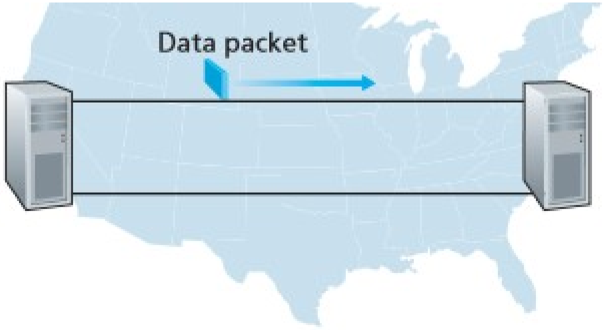
Stop and Wait



- Sender sends a frame, sets a timeout (e.g., 1 sec)
- Receiver receives the frame, sends an ACK
- Sender
  - sends the next frame on ACK
  - retransmits the same frame if timeout happens
- **Spot the bugs in the protocol**

Stop and Wait – How does it perform?

- Bandwidth (R)= 1Gbps
- Packet size (L) = 1000 bytes
- RTT = 30ms
- T_{trans} = L/R = 8000bits/10^9bits/sec = 8microsecond
- T_{prop} = 15ms
- Total Delay = 15.008 ms

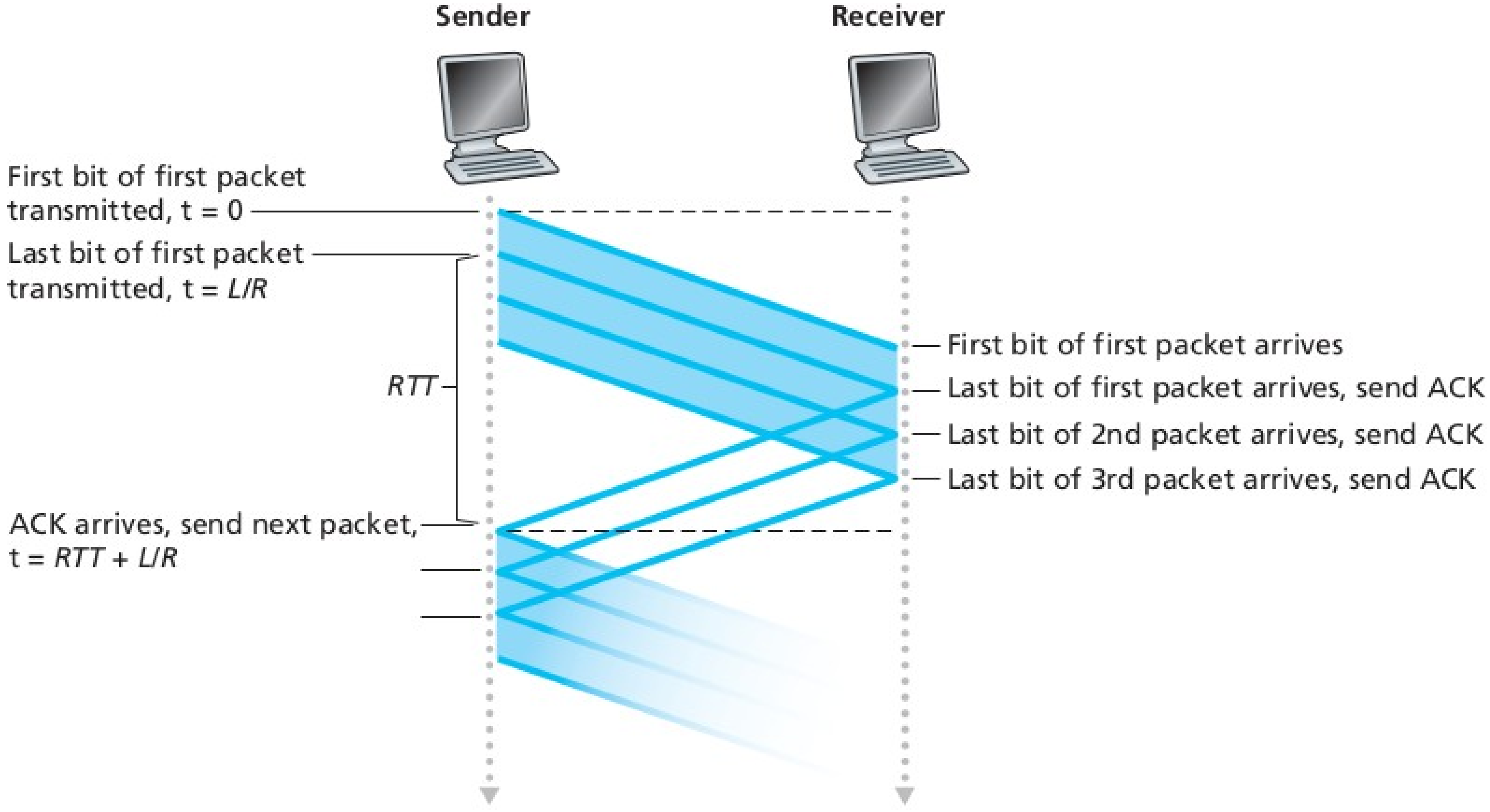


a. A stop-and-wait protocol in operation

Kurose/Ross

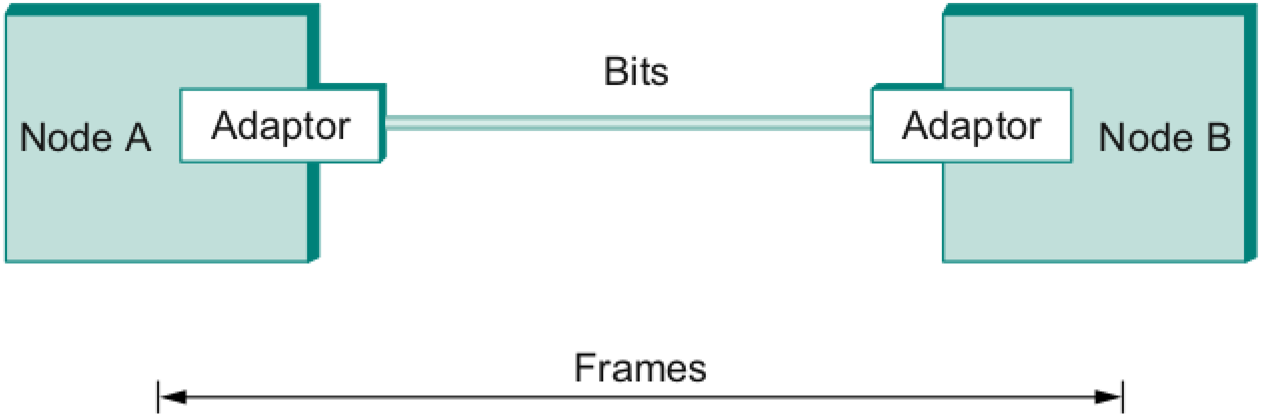
Sliding window to the rescue!

Utilization = 0.008*3/30.008 = 0.00079 (3 times increase)


Sender
Receiver
First bit of first packet transmitted, t = 0
Last bit of first packet transmitted, t = L/R
RTT
ACK arrives, send next packet, t = RTT + L/R
First bit of first packet arrives
Last bit of first packet arrives, send ACK
Last bit of 2nd packet arrives, send ACK
Last bit of 3rd packet arrives, send ACK

b. Pipelined operation

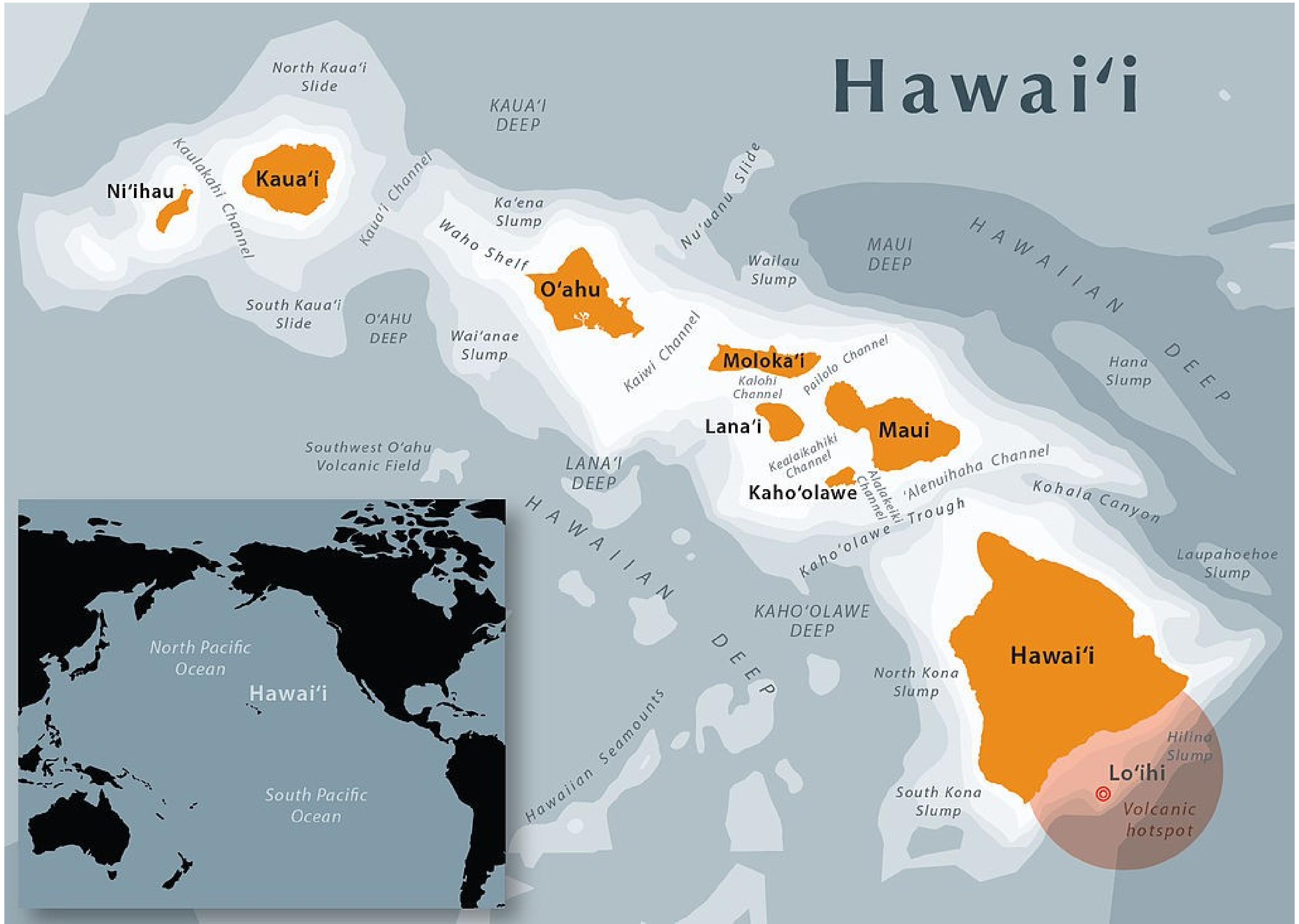
So far..



- We have connected two machines using point to point wires
  - Encoded bits
  - Sent bits as Frames
  - Caught and corrected errors
  - Tuned efficiency and reliability using sliding window

- What happens when there are more than two machines?

AlohaNET



wikipedia

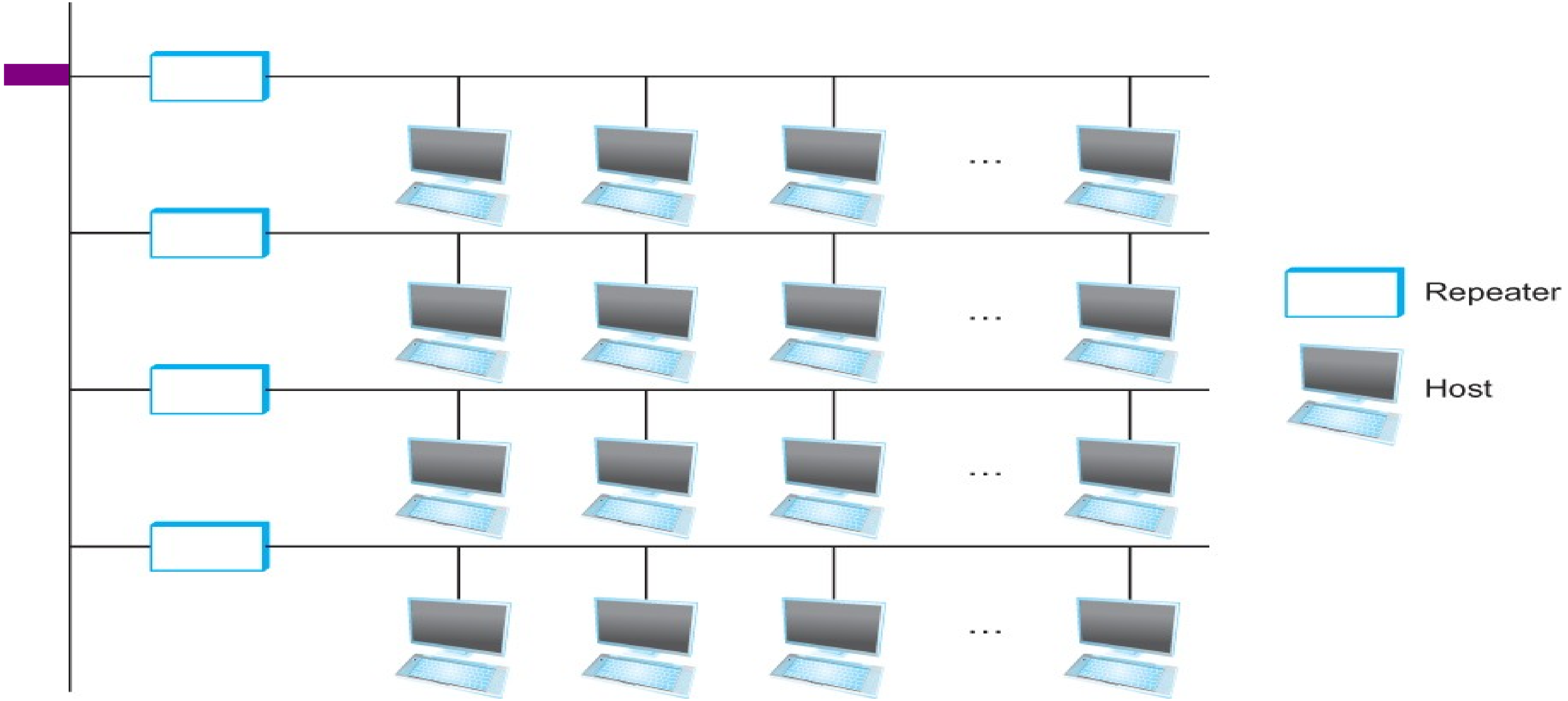
Ethernet – Random Access

- How to allow many adaptors to send frames over the wire?
  - **Random access**

  - When you have data – send at Full channel rate!
  - No coordination needed.

- If collision happens
  - Detect
  - Recover
  - Retransmit

Ethernet

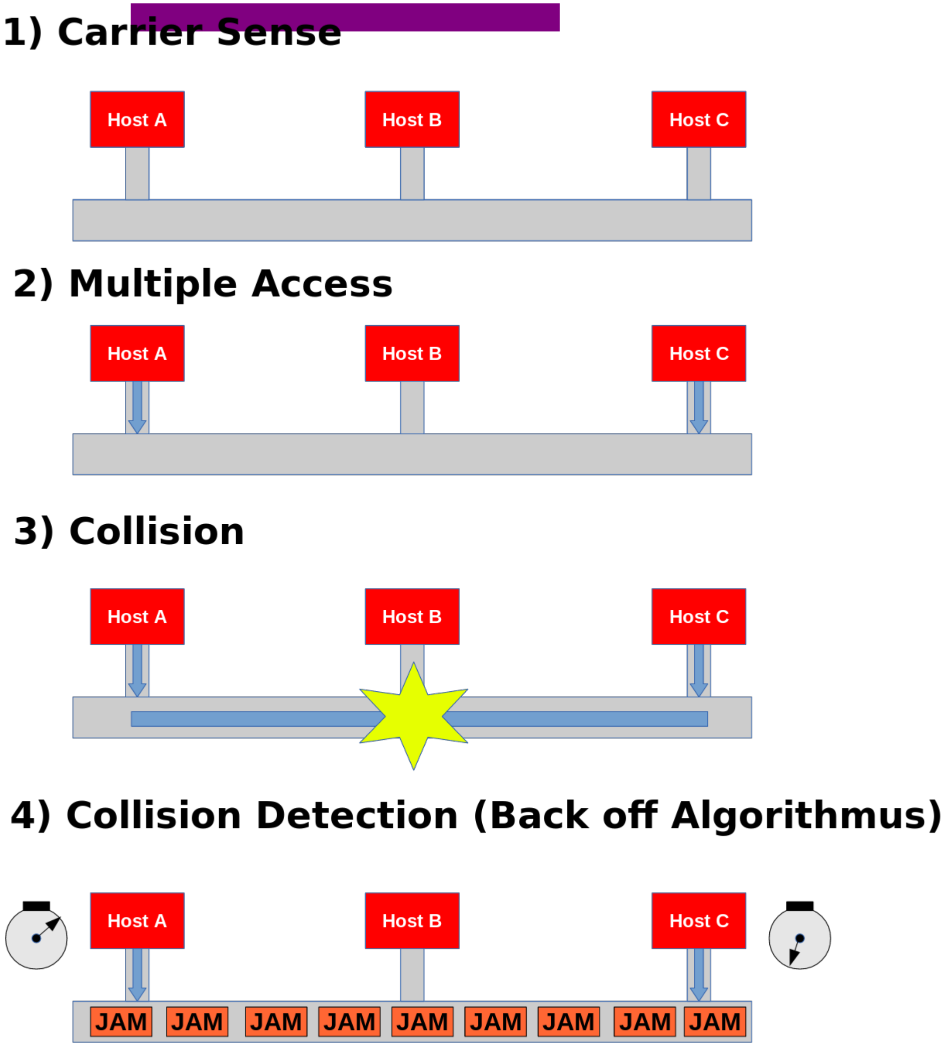


Ethernet repeater

CSMA/CD – Listen first, talk later!

- CSMA – Carrier sense Multiple access
  - Listen if anyone is transmitting
  - Wait until carrier is free, do not interrupt others
  - **What is the carrier here?**
- CD – Collision Detection
  - If you hear anyone while talking, **collision, stop!**
  - Monitor signal strength at the adapter
  - Higher than normal = collision
- Random wait before retransmitting
  - **Why?**

CSMA/CD – Ethernet

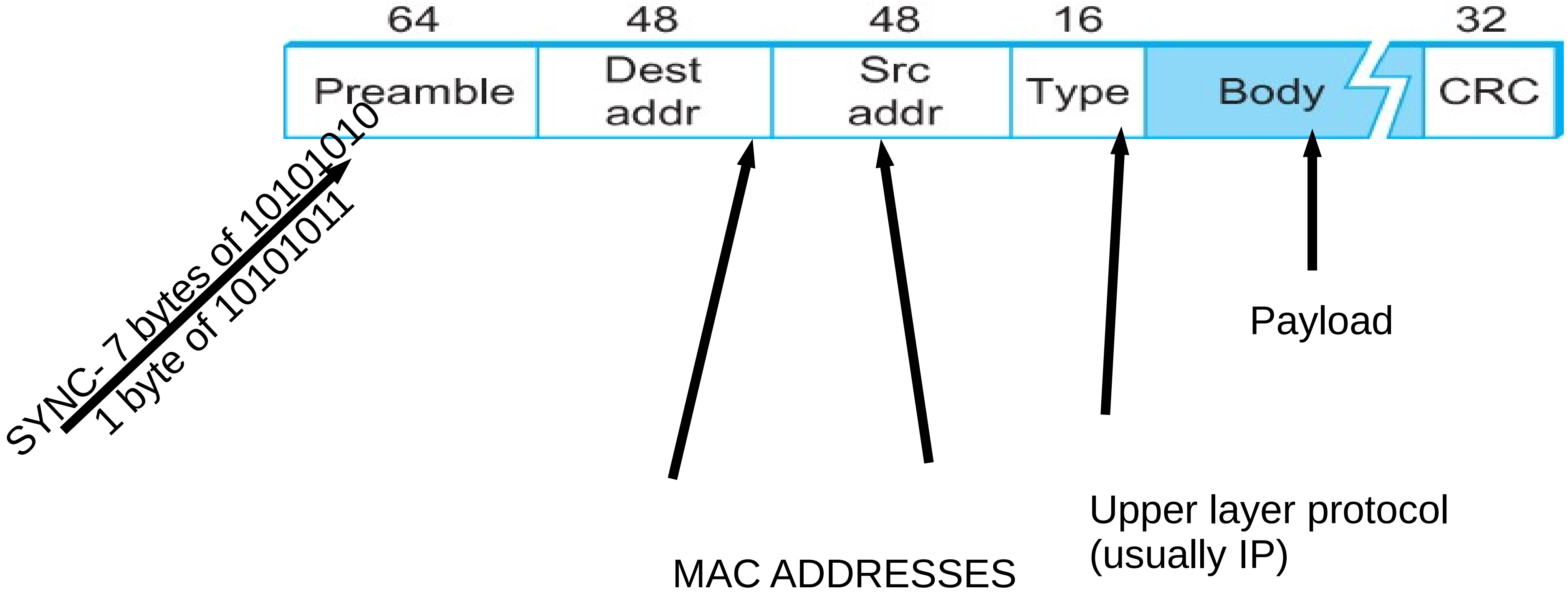


- CS – wait until idle
  - Channel idle – trasmit
  - Channel busy – wait

- CD – listen while transmitting
  - No collision: transmission successful
  - Collission: abort, send jam signal (32bit special sequence)

- Wait random time
  - Try again
  - After m^th collision, t = random(0,$2^{m\,-}$ 1),
  - Wait t*512 bit times before retry

Ethernet Frame



SYNC- 7 bytes of 10101010
1 byte of 10101011

MAC ADDRESSES

Upper layer protocol
(usually IP)

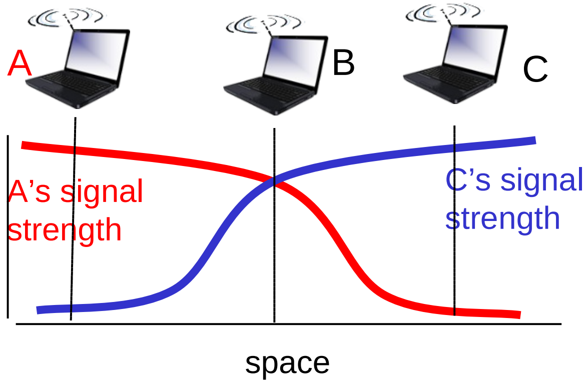
Payload

Wireless

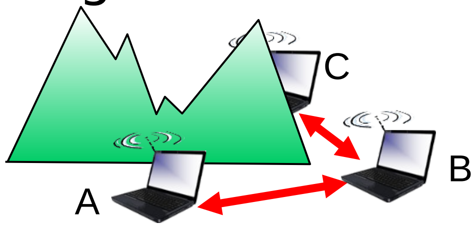
- Wireless links transmit electromagnetic signals
  - Radio, microwave, infrared
- Wireless links all share the same “wire” (so to speak)
  - The challenge is to share it efficiently without unduly interfering with each other
  - Most of this sharing is accomplished by dividing the “wire” along the dimensions of frequency and space
- Exclusive use of a particular frequency in a particular geographic area may be allocated to an individual entity such as a corporation

IEEE 802.11: Multiple Access

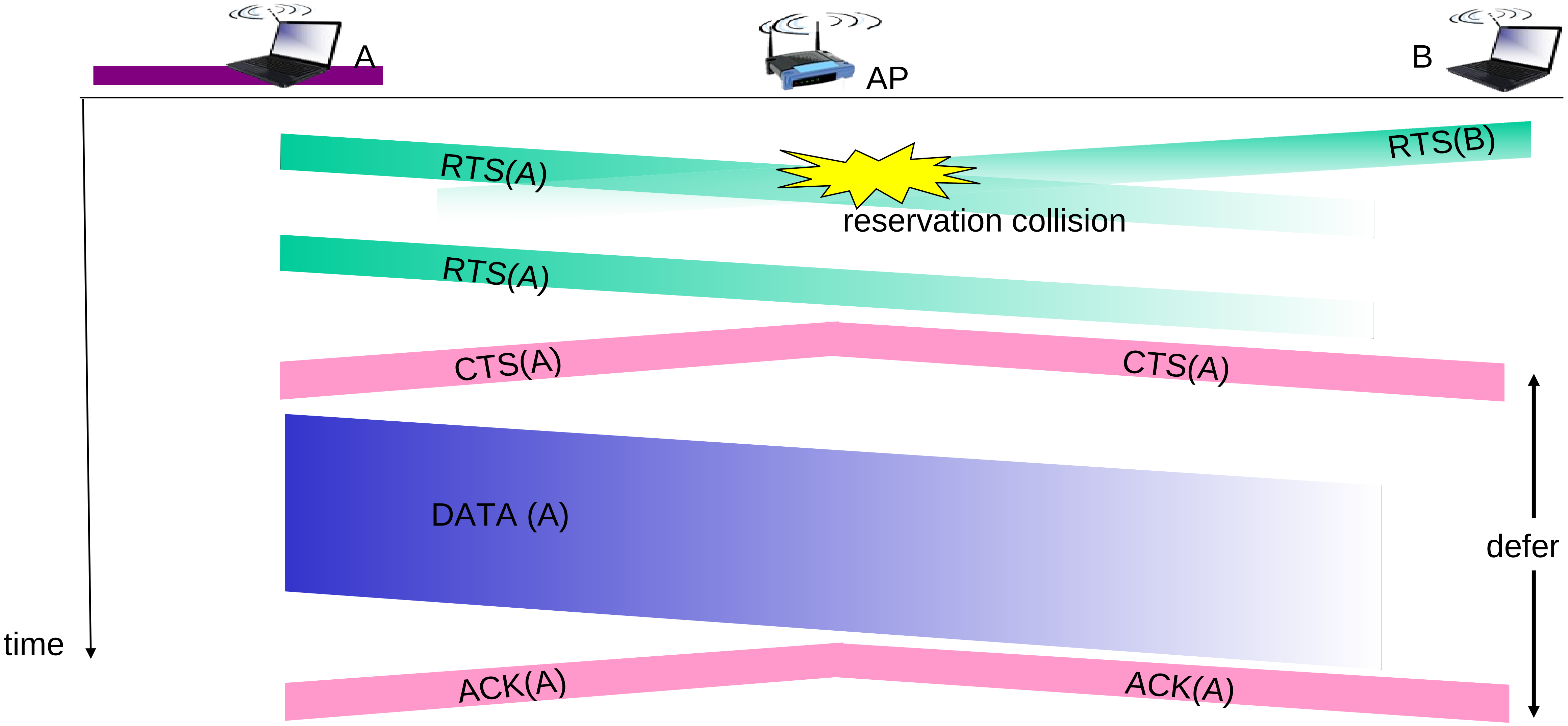
- Avoid collisions: 2+ nodes transmitting at same time



- 802.11: CSMA - sense before transmitting
  - don't collide with ongoing transmission by other node
- 802.11: *no* collision detection!
  - difficult to receive (sense collisions) when transmitting due to weak received signals (fading)
  - can't sense all collisions in any case: hidden terminal, fading
  - goal: *avoid collisions:* CSMA/C(ollision)A(voidance)



Collision Avoidance: RTS-CTS exchange



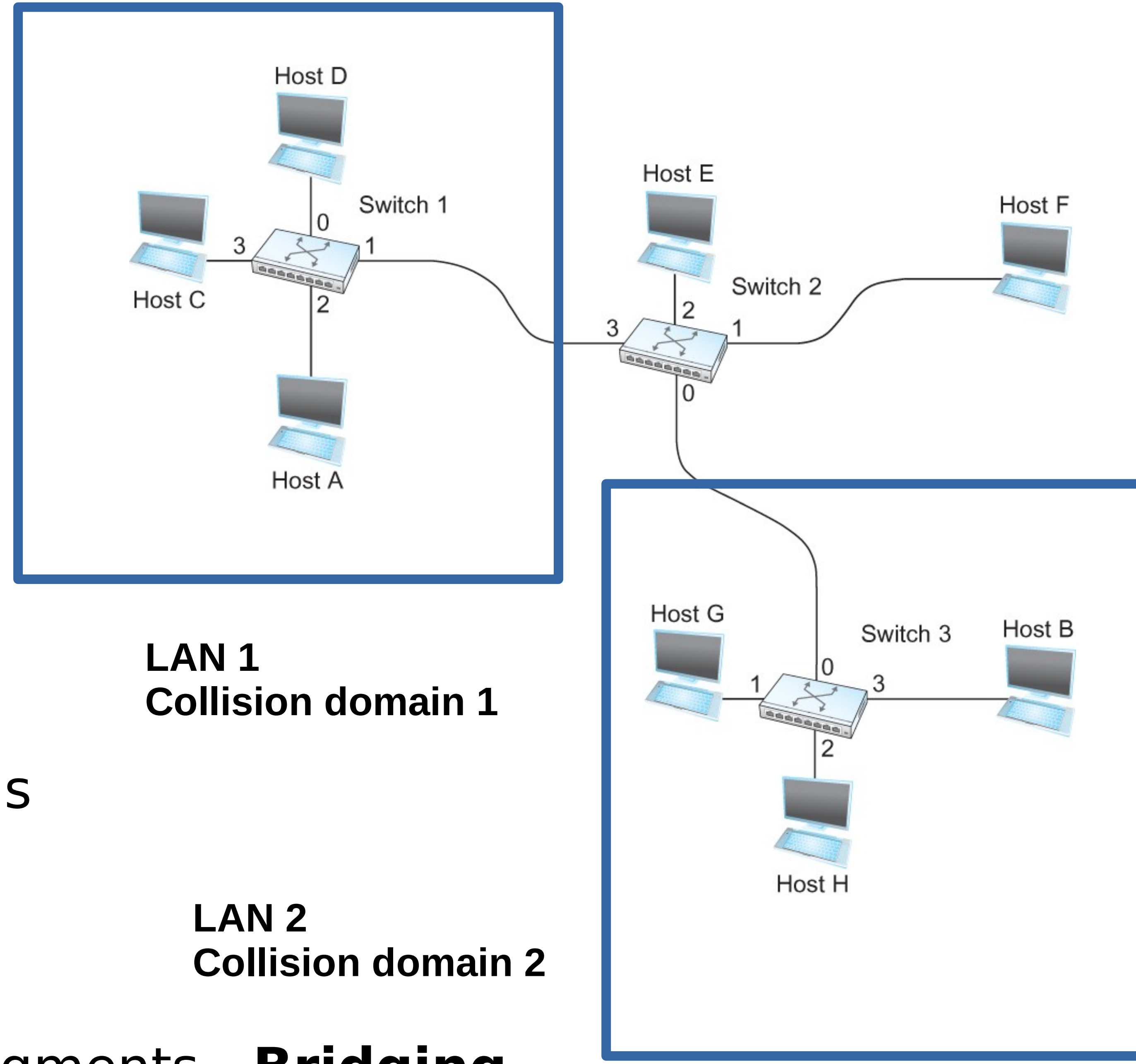
So far...

- we saw how to build a local network

- How do we interconnect different types of networks to build a large network?

Switching

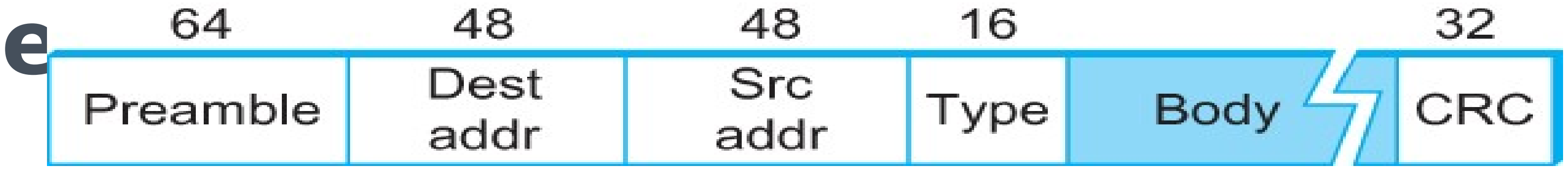
- Switch
  - A mechanism to interconnect links to form a large network
  - Forward **frames**
  - Separate the collision domains
  - Filter packets between LANs
  - Connects two or more LAN segments - **Bridging**



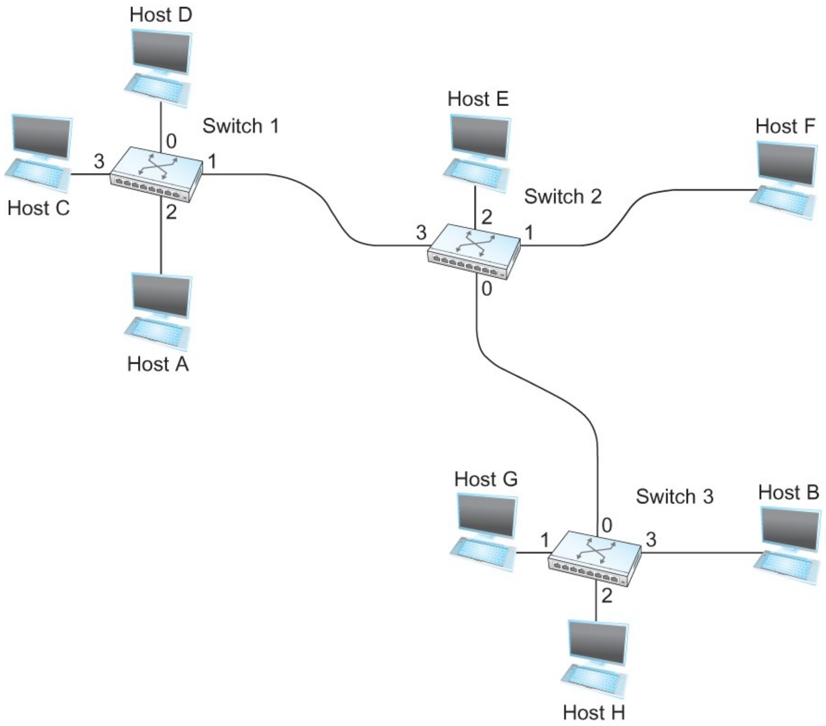
LAN 1
Collision domain 1

LAN 2
Collision domain 2

Switching Table



- To decide how to forward a packet, a switch consults a *forwarding table*



Destination, Port

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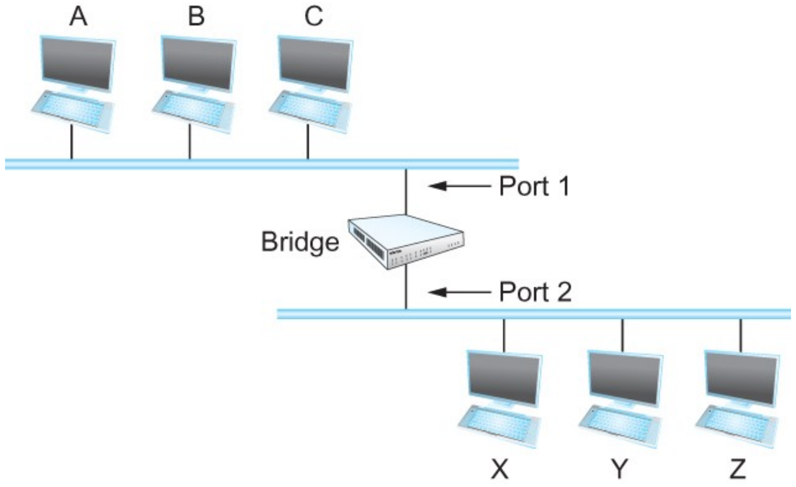
A	3
B	0
C	3
D	3
E	2
F	1
G	0
H	0

Forwarding Table for Switch 2

Bridges

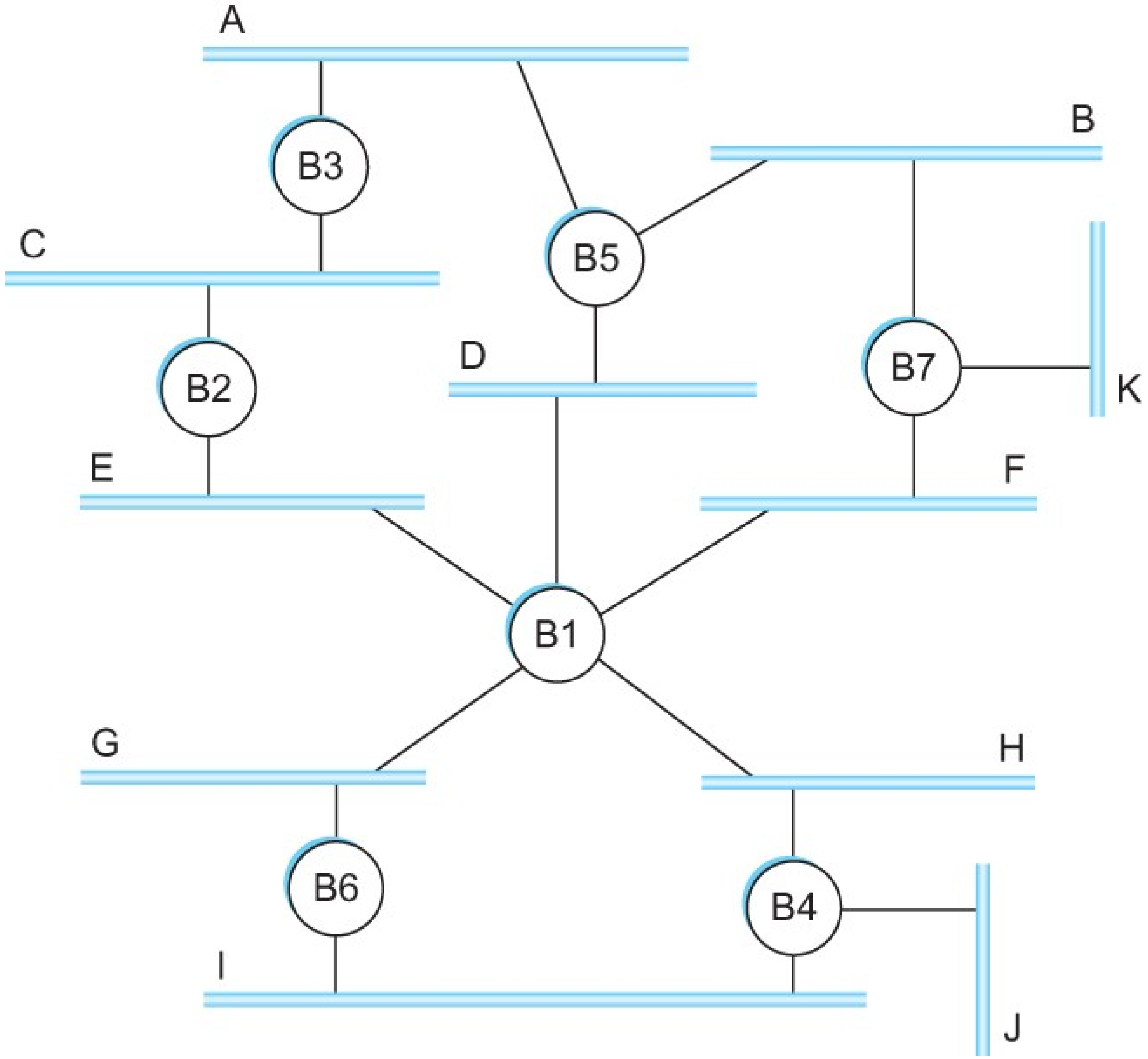


- Bridges and LAN Switches
  - Class of switches that is used to forward packets between shared-media LANs such as Ethernets
  - Known as LAN switches
  - Referred to as Bridges

- Suppose you have a pair of Ethernets that you want to interconnect
  - One approach is put a repeater in between them, physical limitations

- An alternative would be to put a node between the two Ethernets and have the node forward frames from one Ethernet to the other
  - This node is called a **Bridge**
  - A collection of LANs connected by one or more bridges is usually said to form an **Extended LAN**

Flooding over bridges causes forwarding loops – Spanning tree



Spot the loop
Why?