The Link Layer – Wireless and Switches

COMP 30650: Networks and Internet Systems

Dr. Gavin McArdle
Email: gavin.mcardle@ucd.ie
Office: A1.09 Computer Science

MULTIPLEXING

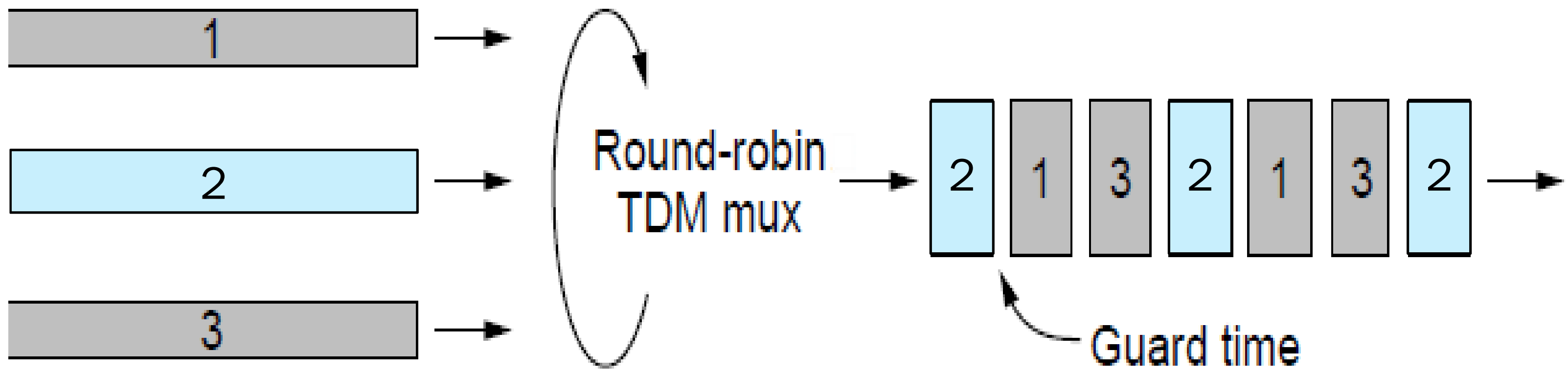
Multiplexing is the network word for the sharing of a resource

E.g. Sharing a link or channel among different users

- Time Division Multiplexing (TDM)
- Frequency Division Multiplexing (FDM)

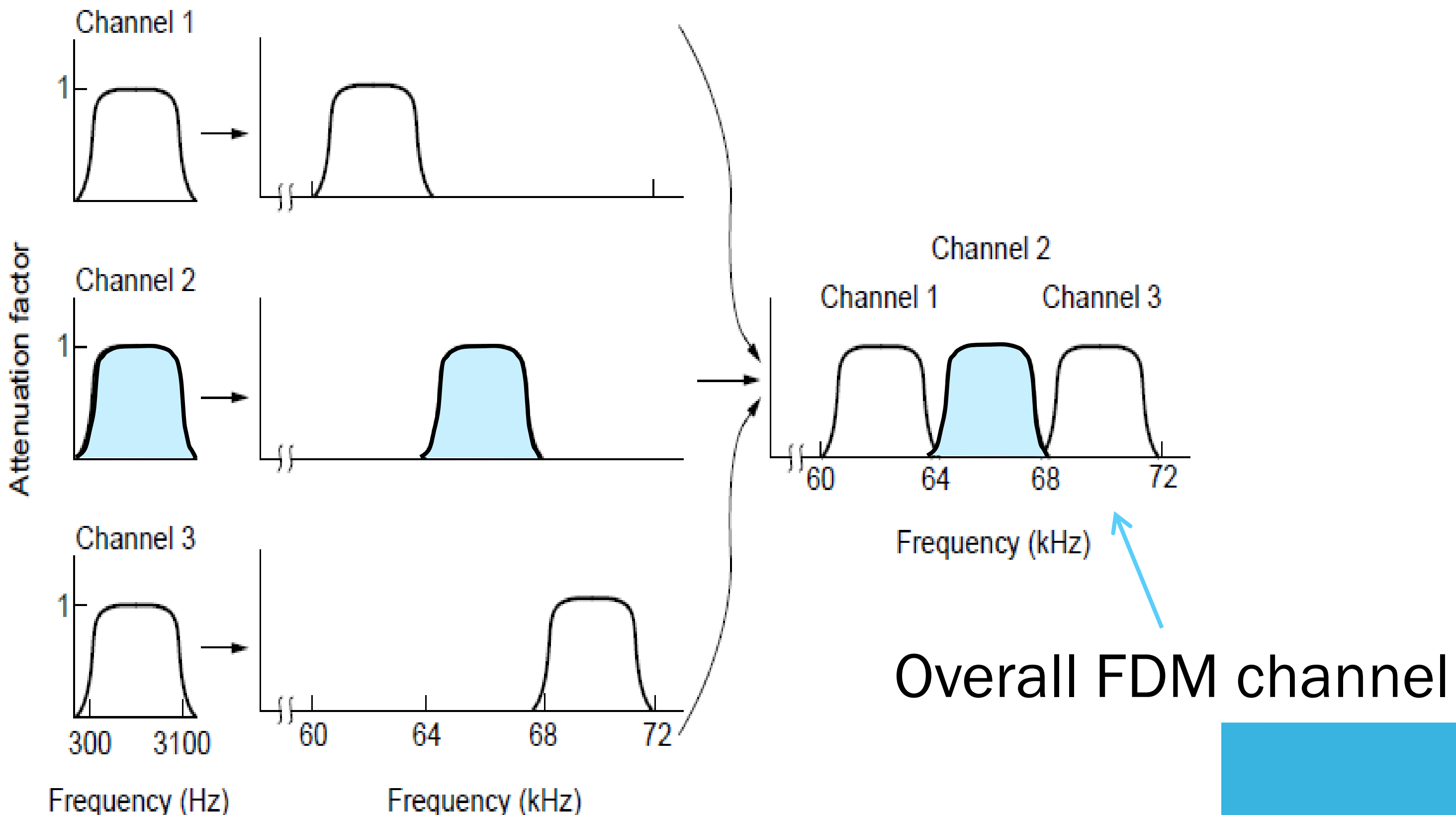
TIME DIVISION MULTIPLEXING (TDM)

Users take turns on a fixed schedule



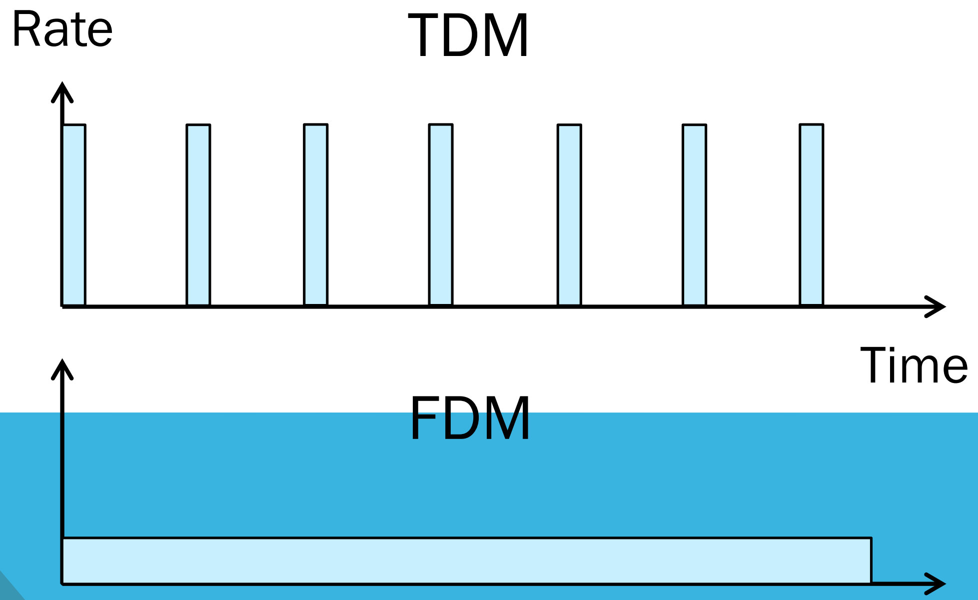
FREQUENCY DIVISION MULTIPLEXING (FDM)

Put different users on different frequency bands



TDM VERSUS FDM

- TDM: a user sends at a high rate a fraction of the time
- FDM: a user sends at a low rate all the time



TDM/FDM USAGE

Statically divide a resource

- Suited for continuous traffic, fixed number of users

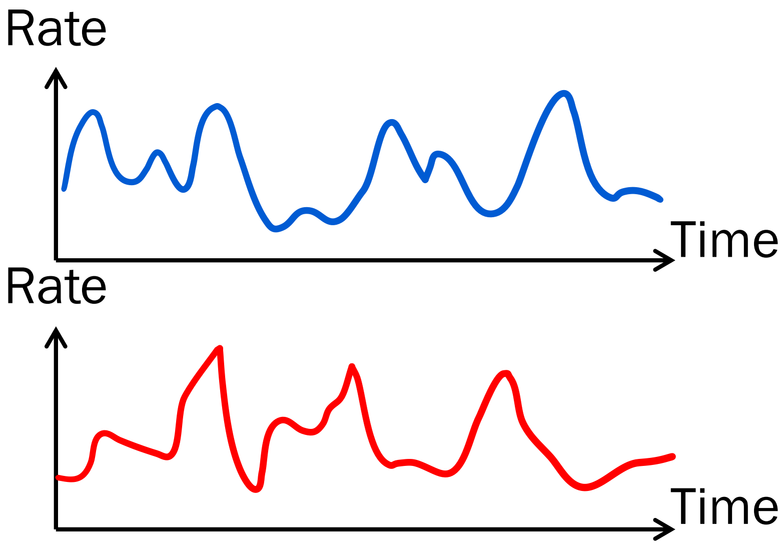
Widely used in telecommunications

- TV and radio stations (FDM)
- 2G/3G allocates calls using TDM within FDM

MULTIPLEXING NETWORK TRAFFIC

Network traffic is bursty

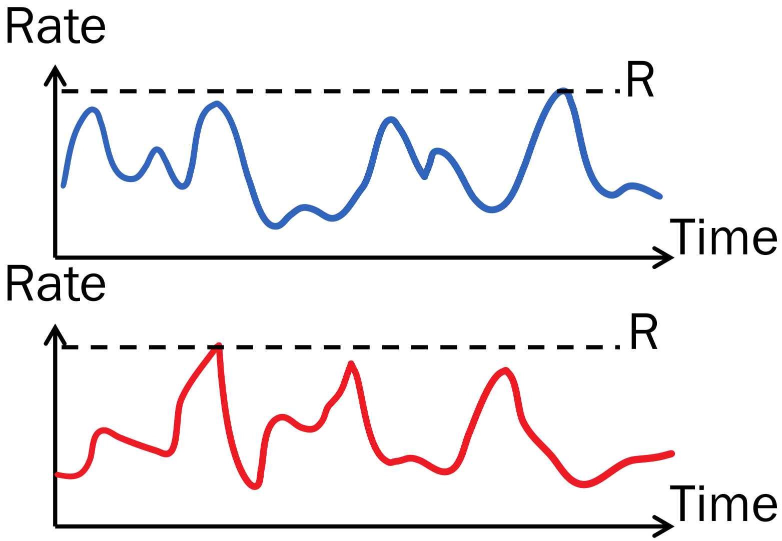
- ON/OFF sources
- Load varies greatly over time



MULTIPLEXING NETWORK TRAFFIC

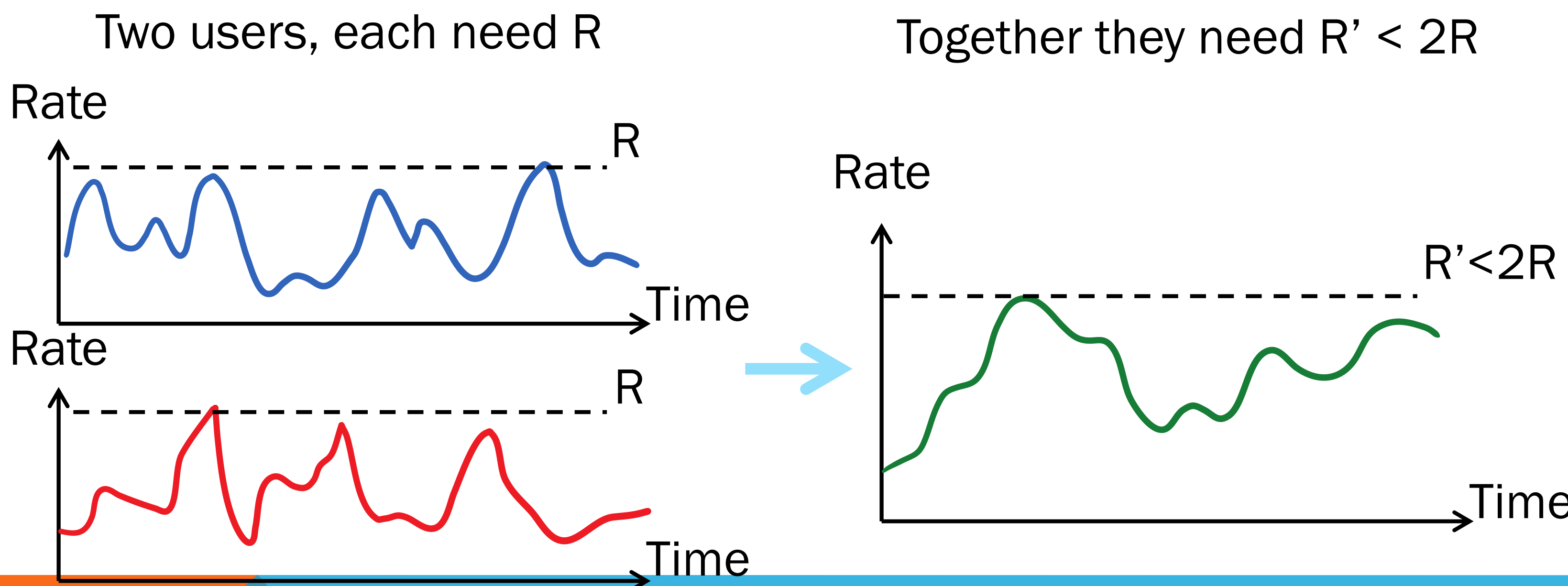
Network traffic is <u>bursty</u>

- Inefficient to always allocate user their ON needs with TDM/FDM



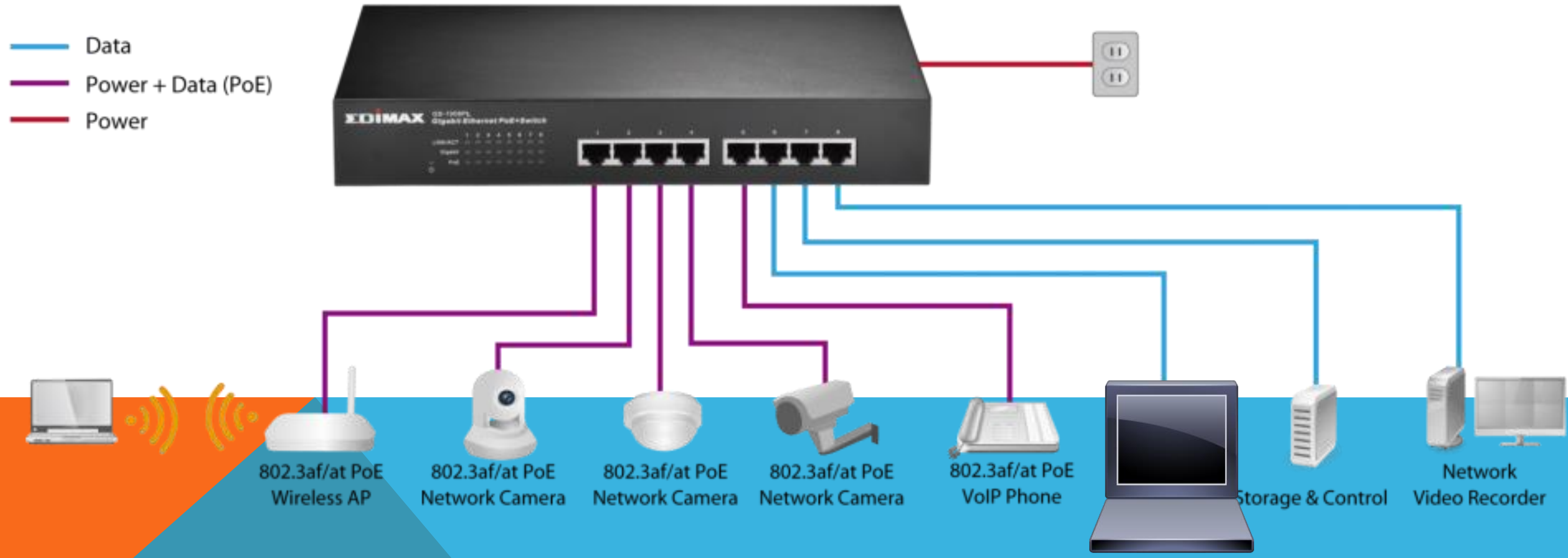
MULTIPLEXING NETWORK TRAFFIC

Multiple access schemes multiplex users according to their demands – for gains of statistical multiplexing



MODERN ETHERNET

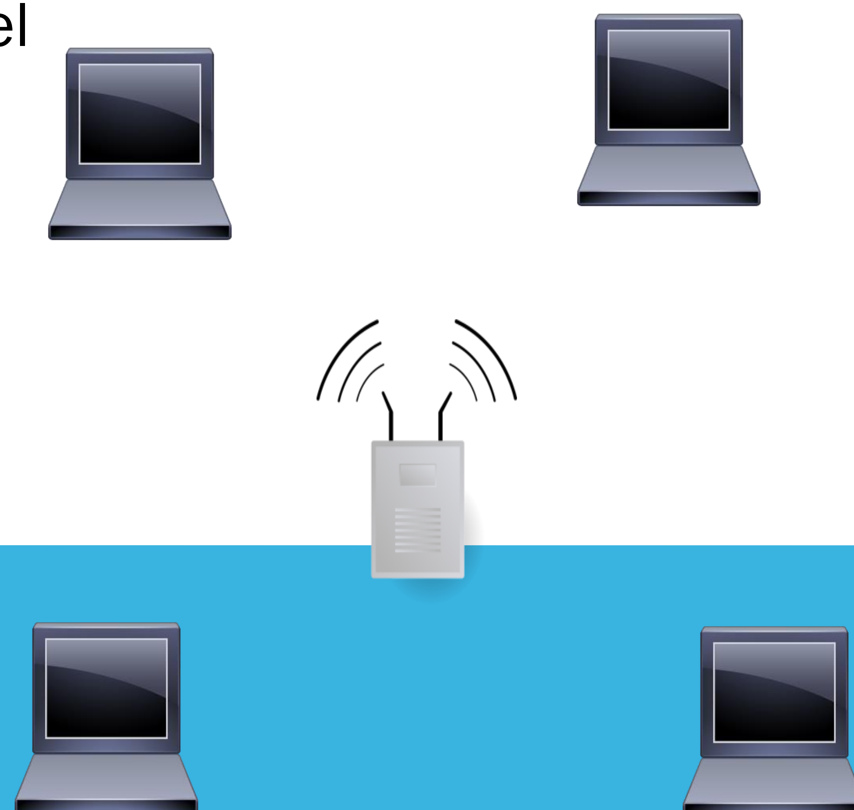
Based on switches, not multiple access



WIRELESS - WIFI

How do wireless nodes share a single link?

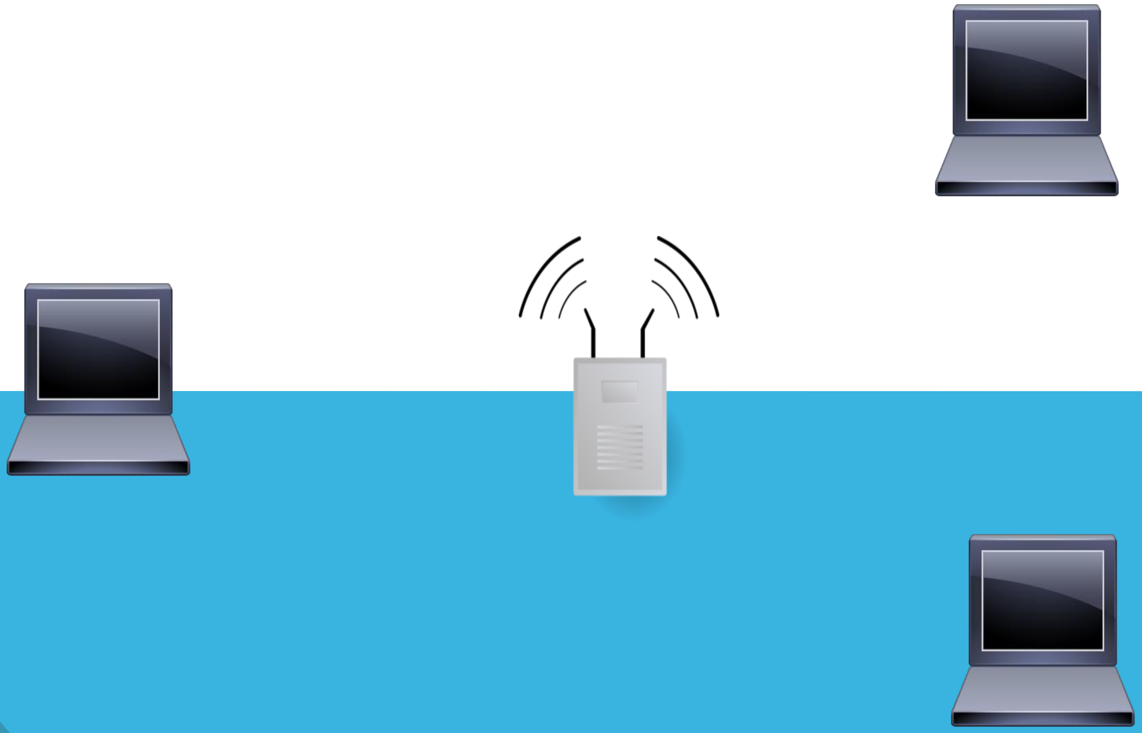
- Build on our simple, wired model
- Wifi



WIRELESS COMPLICATIONS

Wireless is more complicated than the wired case

- Nodes may have different areas of coverage
- Nodes can’t hear while sending – can’t Collision Detect
- A Collision occurs when messages collide, this produces *noise* and garbage data.



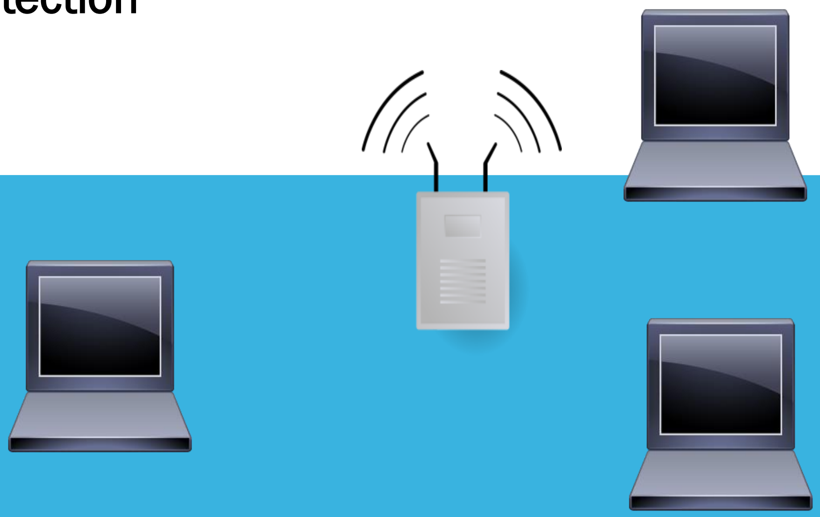
CARRIER SENSE MULTIPLE ACCESS/COLLISION AVOIDANCE

Carrier Sense Multiple Access

- A transmitting nodes listens to see if another node is transmitting and if the channel is free will transmit its frame

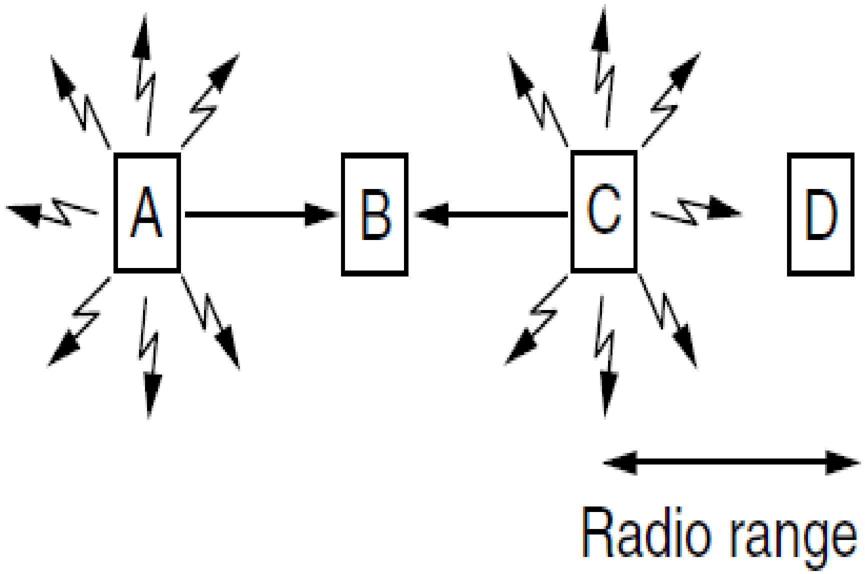
Collision Avoidance

- If there is another node transmitting, wait a random amount of time and listen again.
- Can use Binary Exponential Backoff instead of a random wait time.
- BEB doubles interval for each successive detection
  - Quickly gets large enough to work
  - Very efficient in practice



DIFFERENT COVERAGE AREAS

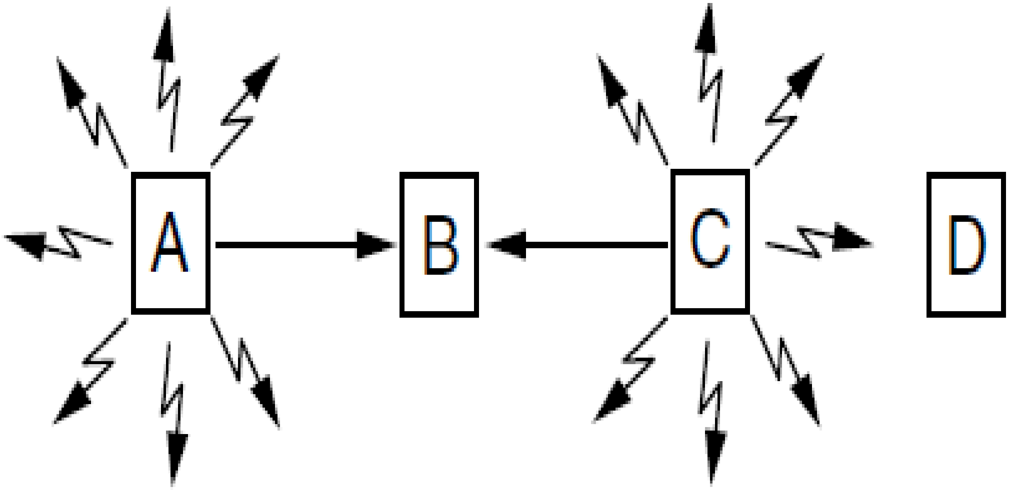
Wireless signal is broadcast and received nearby, where there is sufficient SNR



HIDDEN TERMINALS

Nodes A and C are <u>hidden terminals</u> when sending to B

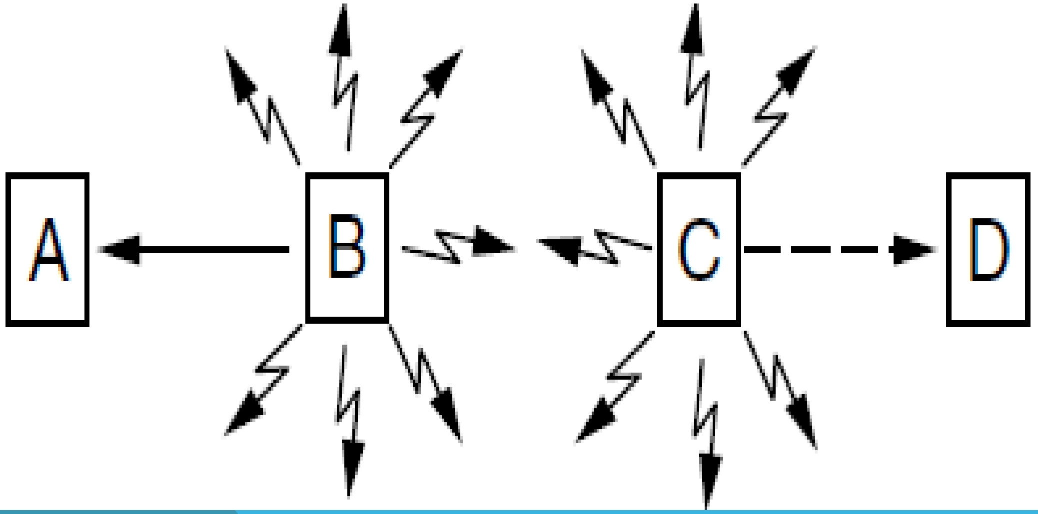
- Can't hear each other (to coordinate) yet collide at B
- We want to avoid the inefficiency of collisions



EXPOSED TERMINALS

B and C are <u>exposed terminals</u> when sending to A and D

- Can hear each other yet don't collide at receivers A and D
- We want to send concurrently to increase performance



POSSIBLE SOLUTION: NEGOTIATE

Multiple Access Collision Avoidance (MACA)

MACA uses a short handshake to negotiate when sending messages is possible.

Protocol rules:

1. A sender node transmits a RTS (Request-To-Send, with frame length)
2. The receiver replies with a CTS (Clear-To-Send, with frame length)
3. Sender transmits the frame while nodes hearing the CTS stay silent
   - Collisions on the RTS/CTS are still possible, but less likely

MACA – HIDDEN TERMINALS

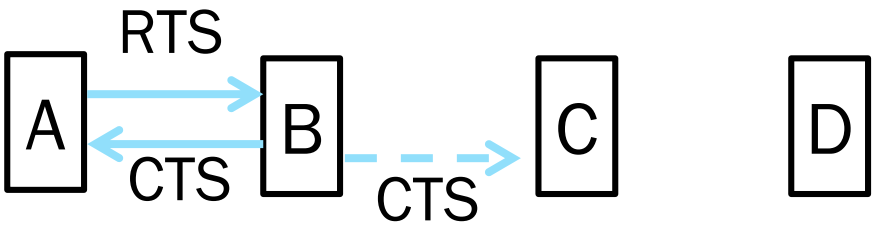
A→B with hidden terminal C

1. A sends RTS, to B

MACA – HIDDEN TERMINALS

A→B with hidden terminal C

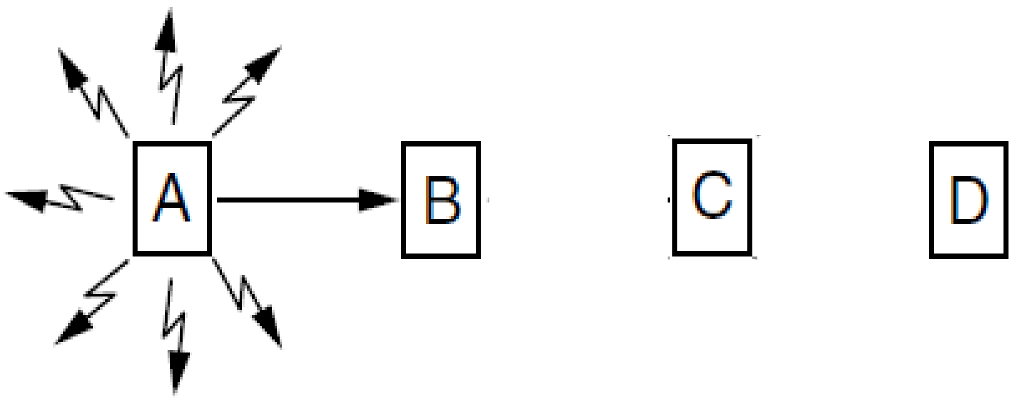
1. A sends RTS, to B
2. B sends CTS, to A, and C too



MACA – HIDDEN TERMINALS

A→B with hidden terminal C

1. A sends RTS, to B
2. B sends CTS, to A, and C too
3. A sends frame while C defers



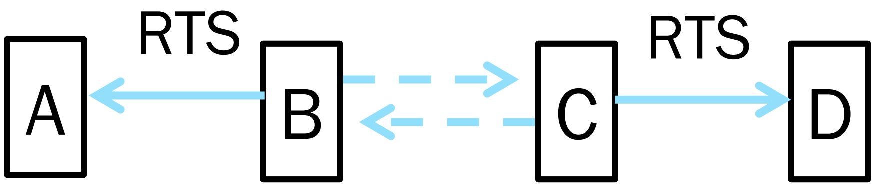
MACA – EXPOSED TERMINALS

B→A, C→D as exposed terminals

MACA – EXPOSED TERMINALS

B→A, C→D as exposed terminals

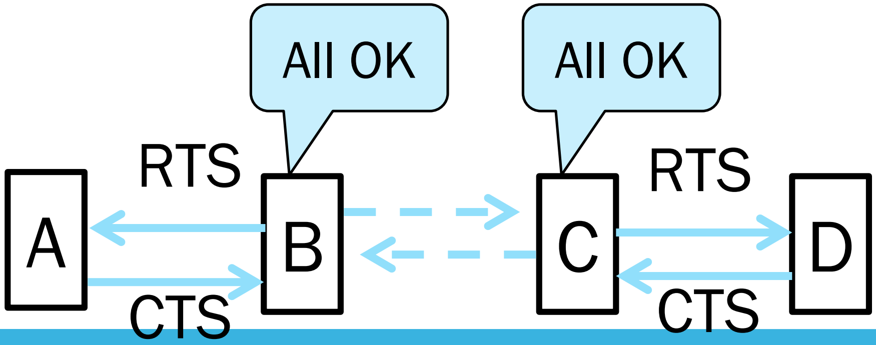
1. B and C send RTS to A and D



MACA – EXPOSED TERMINALS (3)

B→A, C→D as exposed terminals

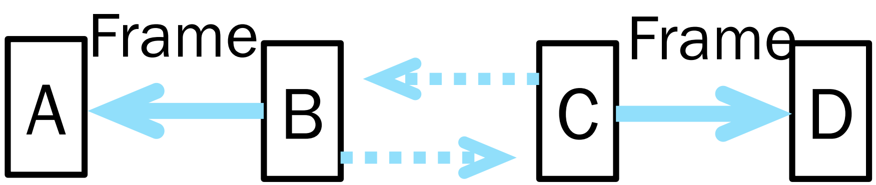
1. B and C send RTS to A and D
2. A and D send CTS to B and C



MACA – EXPOSED TERMINALS

B→A, C→D as exposed terminals

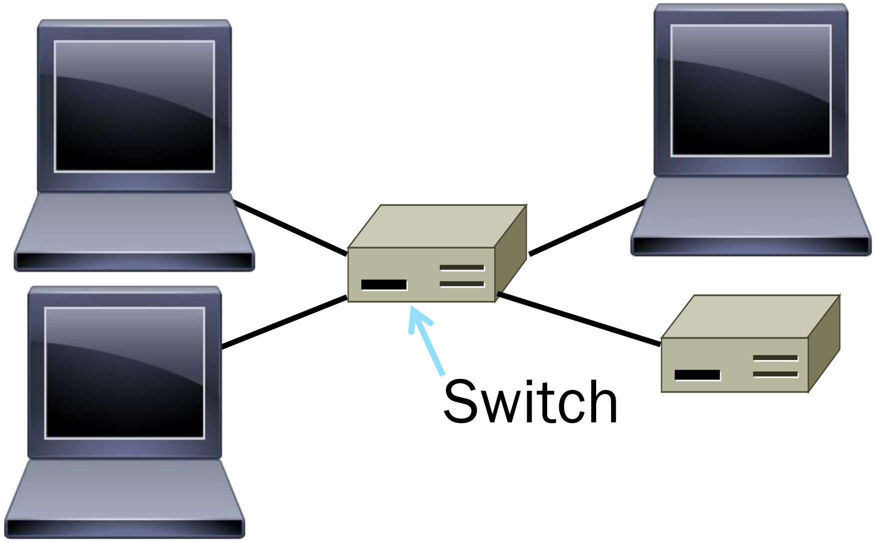
1. B and C send RTS to A and D
2. A and D send CTS to B and C
3. B sends frame to A and C sends frame to D



802.11 WIFI AT THE LINK LAYER

- Multiple access uses Carrier Sense Multiple Access/Collision Avoidance
    - RTS/CTS optional to help hidden node problem
- Frames are ACKed and retransmitted with ARQ
- Errors are detected with a 32-bit CRC
- Many, many features (e.g., encryption, power save)

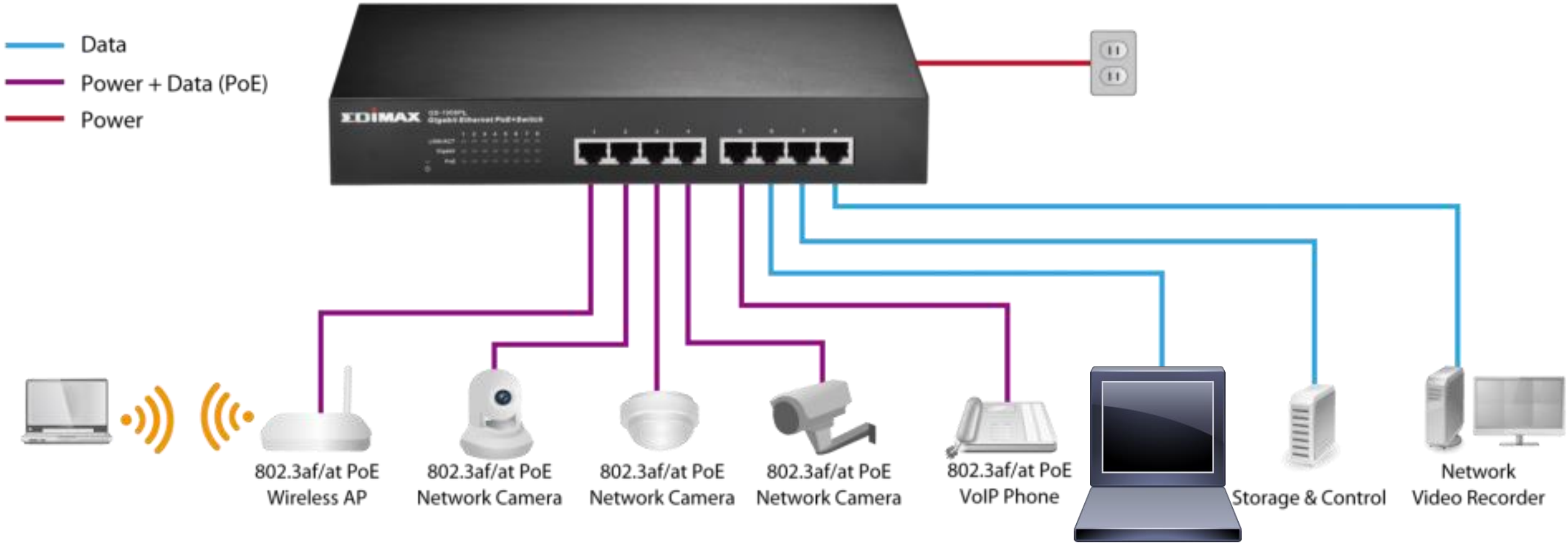
SWITCHED ETHERNET



SWITCHED ETHERNET

Hosts are wired to Ethernet switches with twisted pair

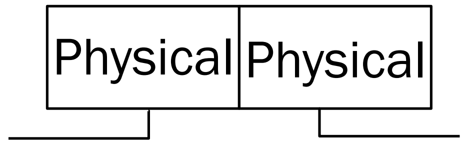
- Switch serves to connect the hosts



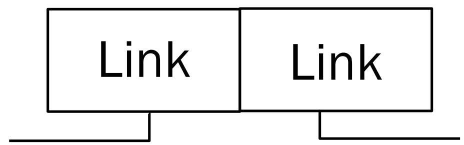
WHAT'S IN THE BOX?

Remember from protocol layers:

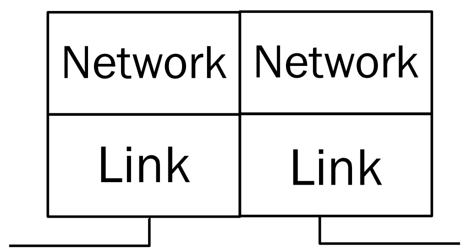
Hub, or repeater



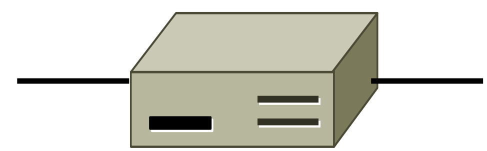
Switch



Router

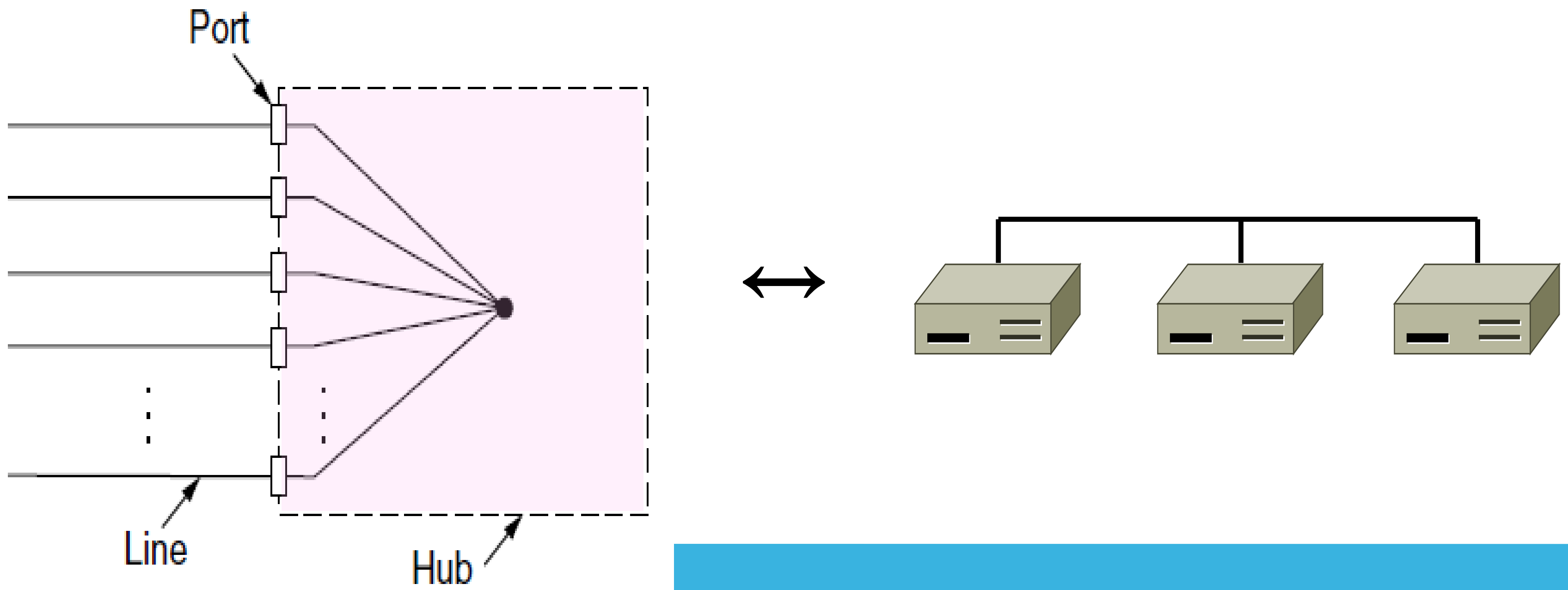


All look like this:



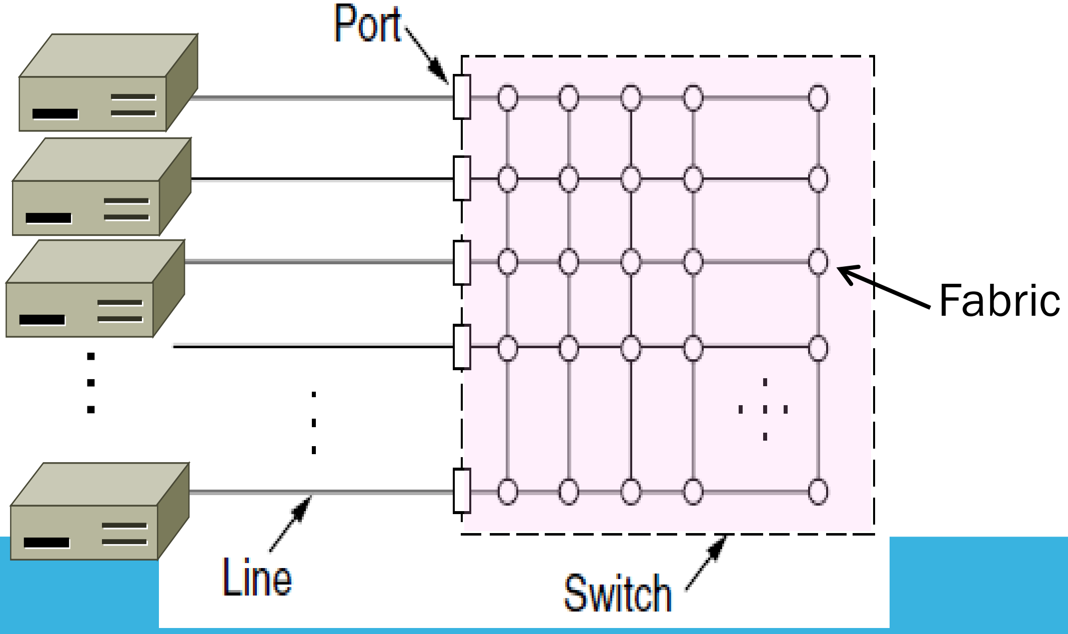
INSIDE A HUB

All ports are wired together; more convenient and reliable than a single shared wire



INSIDE A SWITCH

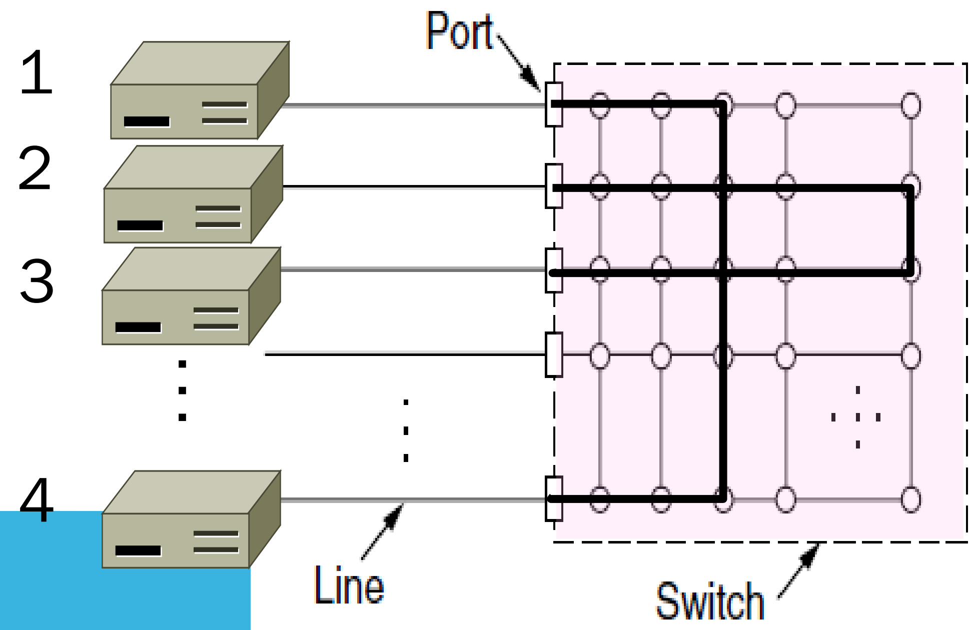
Uses frame addresses to connect input port to the right output port; multiple frames may be switched in parallel



INSIDE A SWITCH

Port may be used for both input and output (full-duplex)

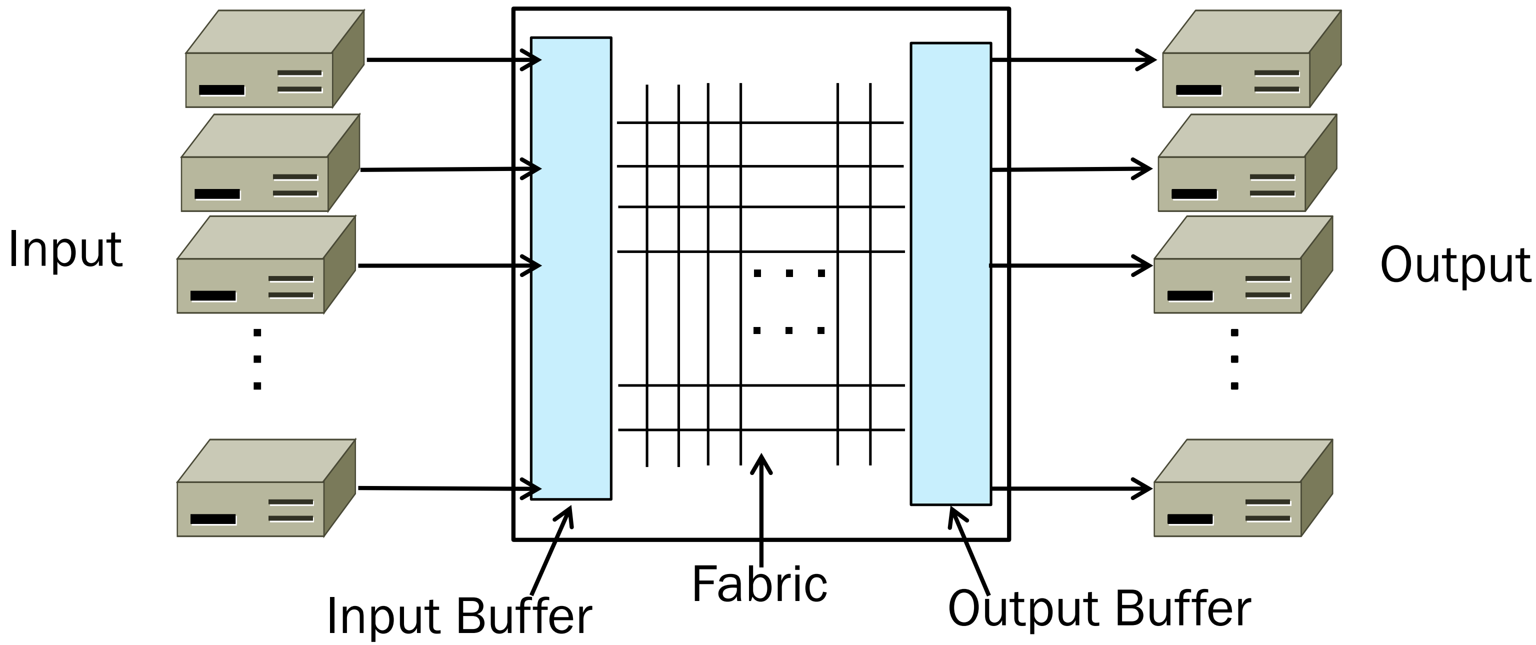
- Just send, no multiple access protocol



1 → 4
and
2 → 3

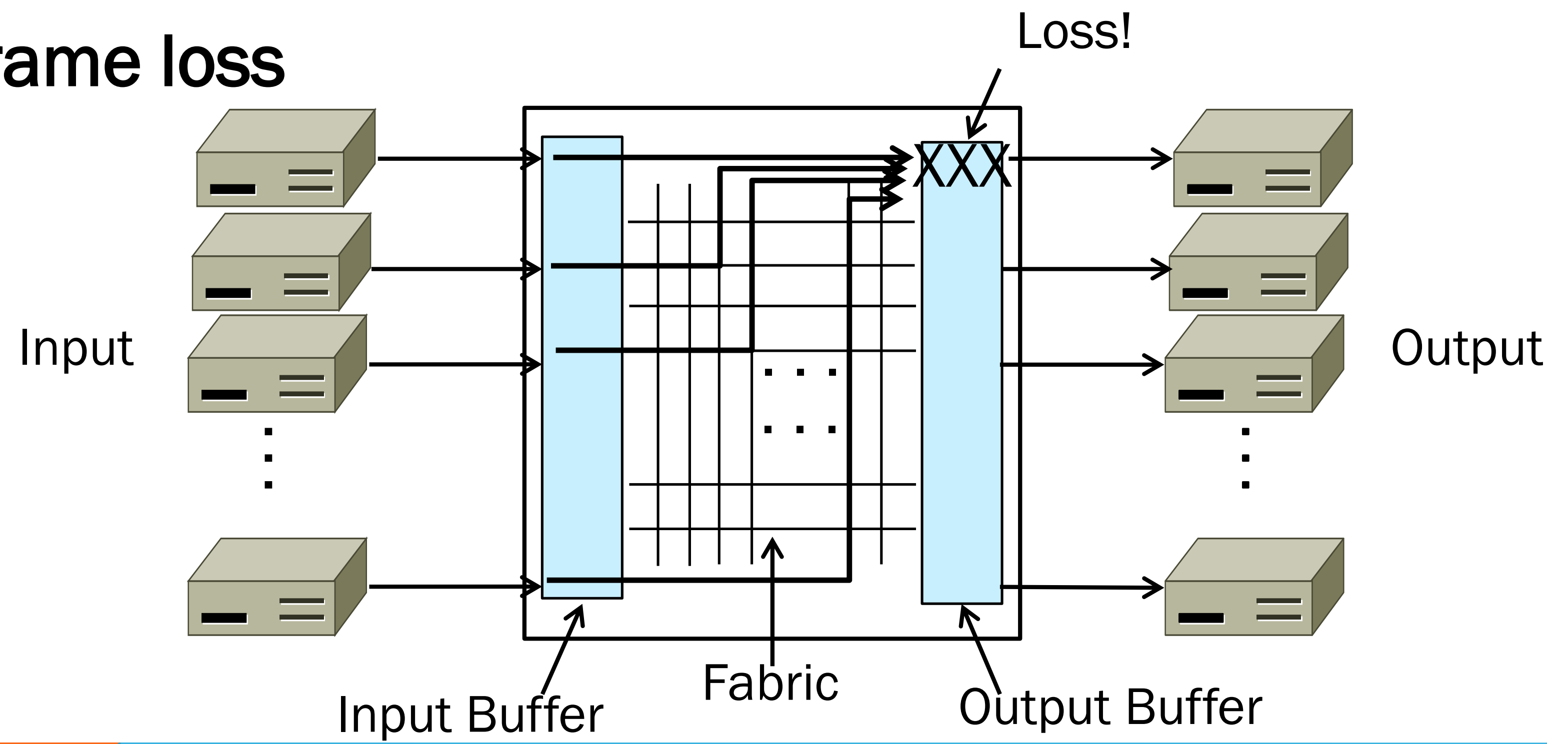
INSIDE A SWITCH

Need buffers for multiple inputs to send to one output



INSIDE A SWITCH

Sustained overload will fill buffer and lead to frame loss



ADVANTAGES OF SWITCHES

Switches and hubs have replaced the shared cable of *classic Ethernet*

- Convenient to run wires to one location
- More reliable; wire cut is not a single point of failure that is hard to find

Switches offer scalable performance

- E.g., 100 Mbps per port instead of 100 Mbps for all nodes of shared cable / hub