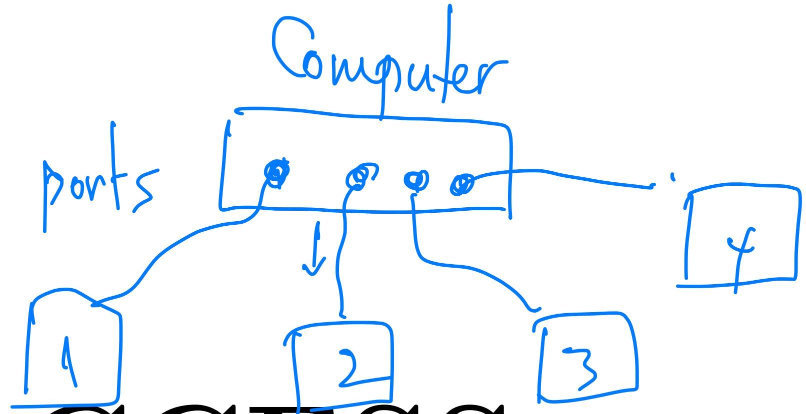
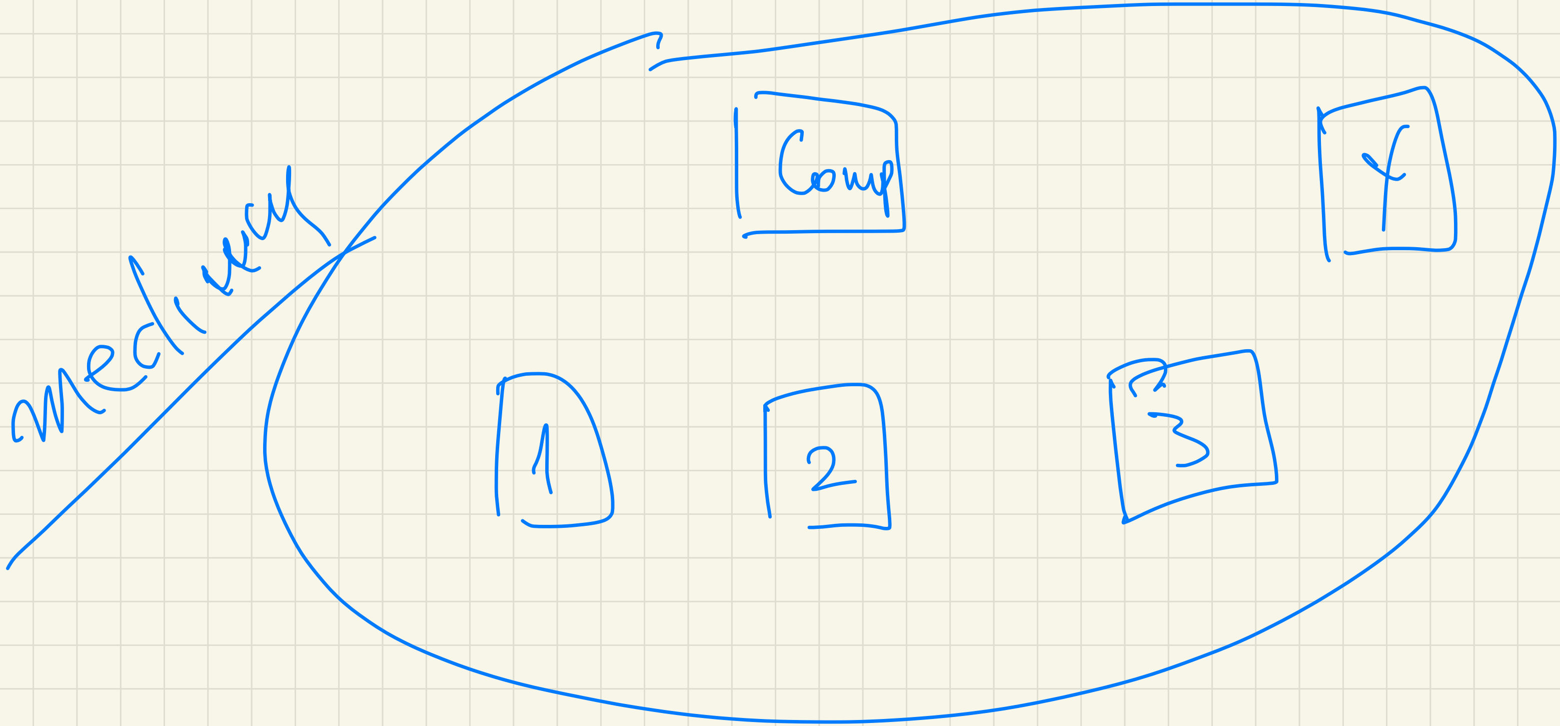


MULTIACCESS COMMUNICATION

Network Layer

October 12, 2020



medway
Comp
1
2
3
Y

LANS

Two types of networks:

S 1 2 3 R

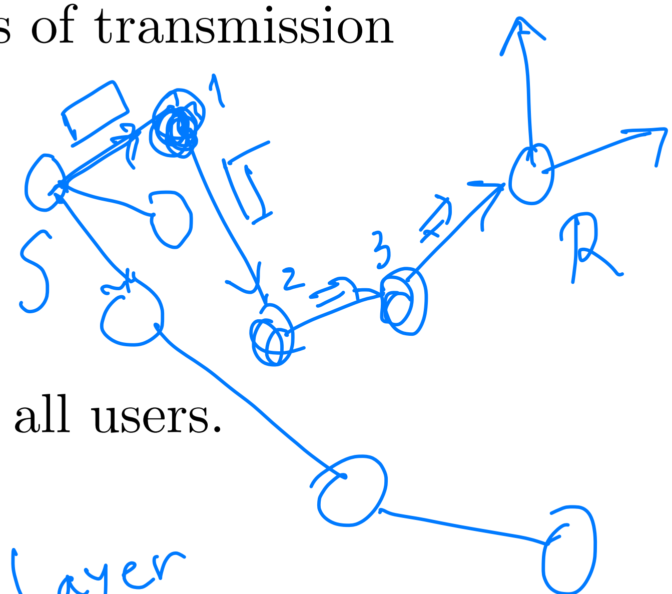
1 • **Switched:** interconnection by means of transmission

   – lines, multiplexers, switches.

   – Addressing scheme hierarchical.

   – Routing tables are required.

John



2 • **Broadcast:** information received by all users.

   – No routing is necessary.

   – Addressing scheme is flat.

   – Medium Access Control is required to orchestrate transmissions.

MAC Layer

Because of its simplicity, broadcast networks are the prefered LAN technology.

S 1 2 3 4 R

john@scs.carleton.ca

$$\text{ca} \longrightarrow \text{carleton}$$

$\downarrow$

.scs

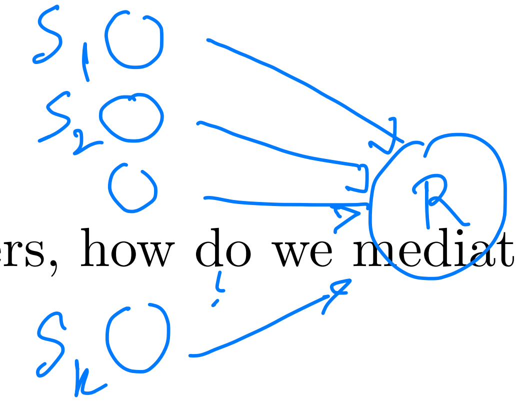
$\downarrow$

.john

Mediating Access

- In point-to-point networks received signal is a function of single transmitted signal

- In broadcast networks a single transmission medium is shared. Received signal is a function of possibly more than one transmitted signal



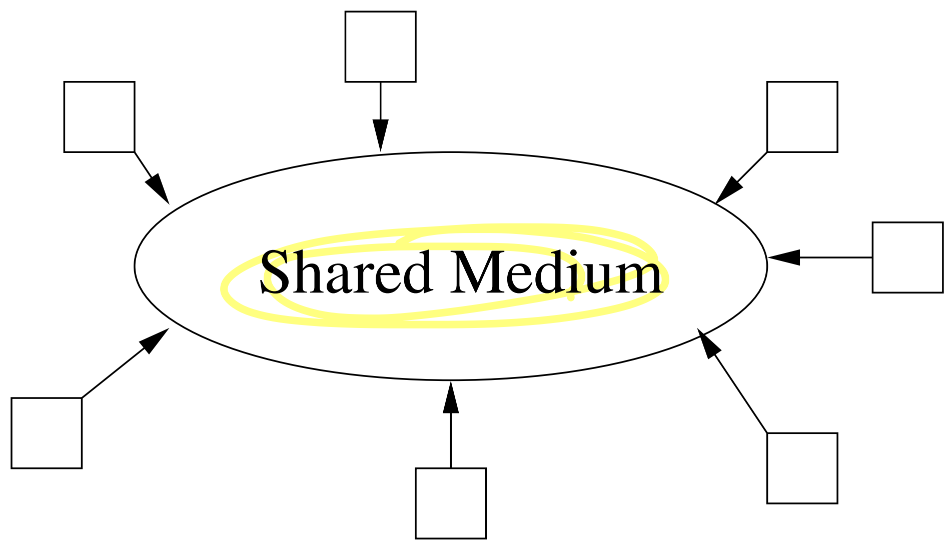
- **Problem:**

  Given that there are multiple users, how do we mediate access to a shared channel?

- Medium Access Control (MAC) sublayer between Physical and DLC (Data Link Control) is used to solve this problem

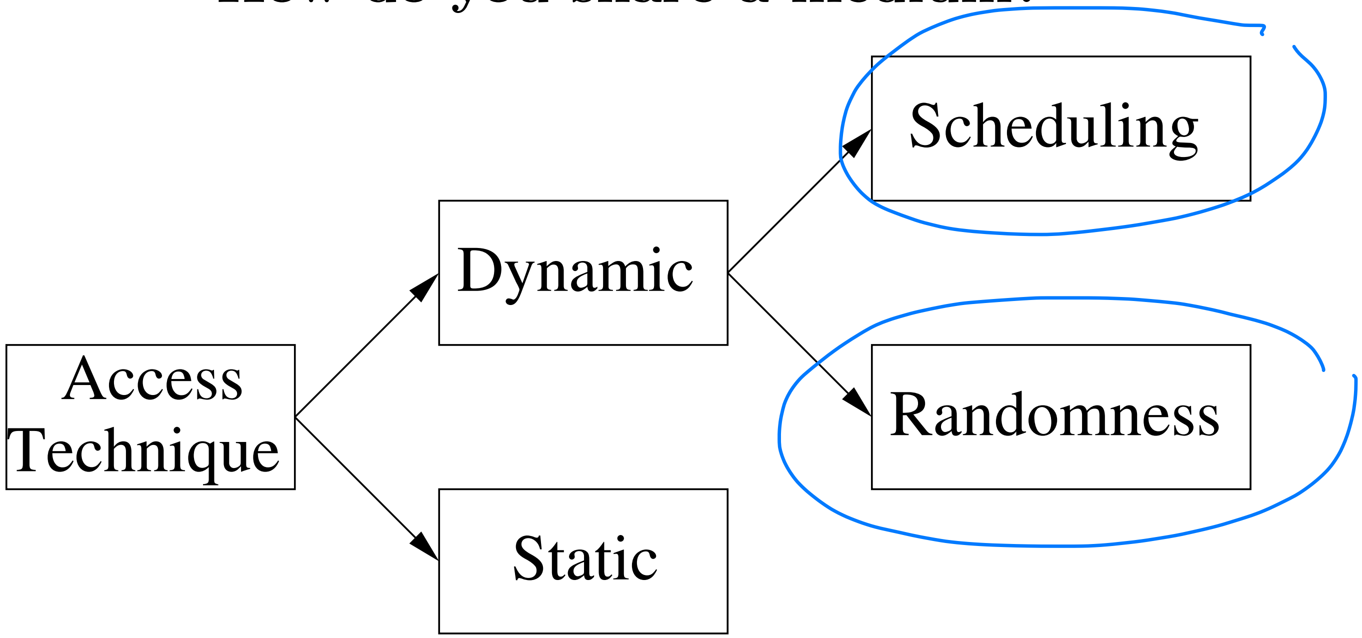
MAC Protocols

- **Centralized:** A distinguished node (master) makes access decisions for the remaining nodes (slaves).
- **Distributed:** All nodes are equivalent and the access decision is derived together in a distributed fashion.



Centralized schemes are too dependent on master failure and generally less efficient.

How do you share a medium?

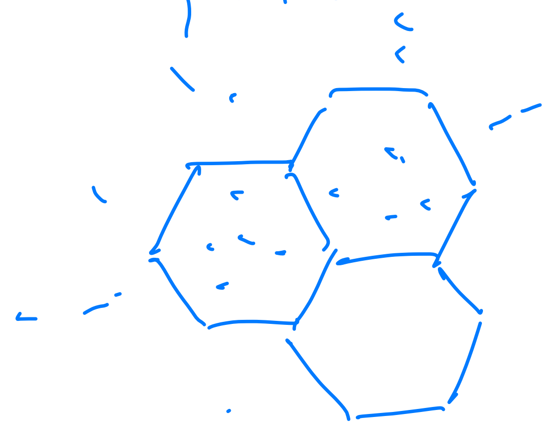


1. **Static Partitioning Schemes:** Partition transmission medium into separate dedicated channels.

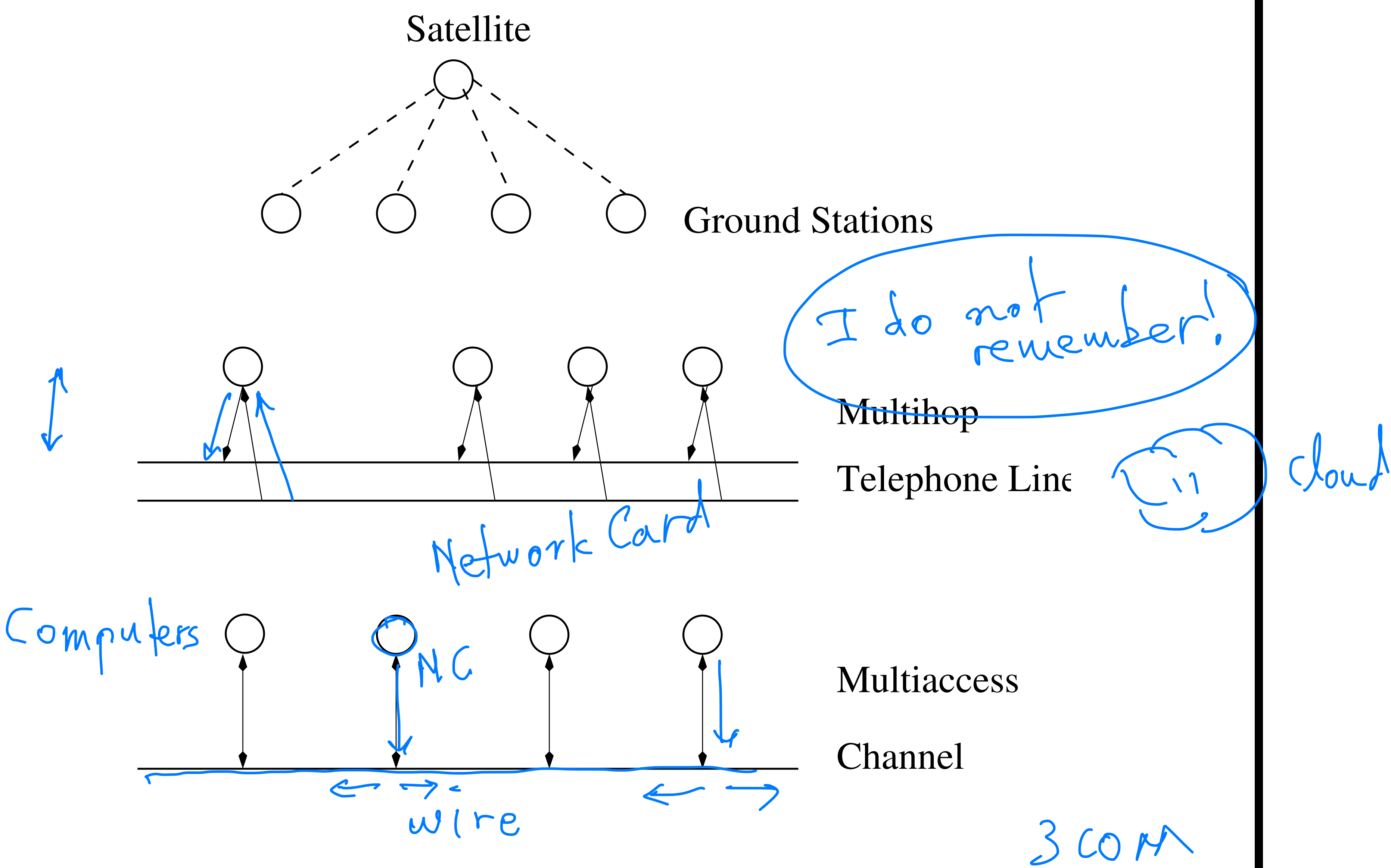
2. **MAC Schemes:** Dynamic and on-demand. However, must minimize collisions.

Some Examples: Types of Networks

- Satellite channels (wireless)
  Iridium network SpaceX, Amazon
- Multitapped bus (wired):
  Ethernet
- Star topology with hub (wired):
  Fast Ethernet
- Packet radio networks (wireless)
  Ad Hoc, Bluetooth, Piconets, Wireless networks, etc
- Cellular networks (wireless)
  Cell phones, Wireless LANs, etc



Some Examples: Network Topologies



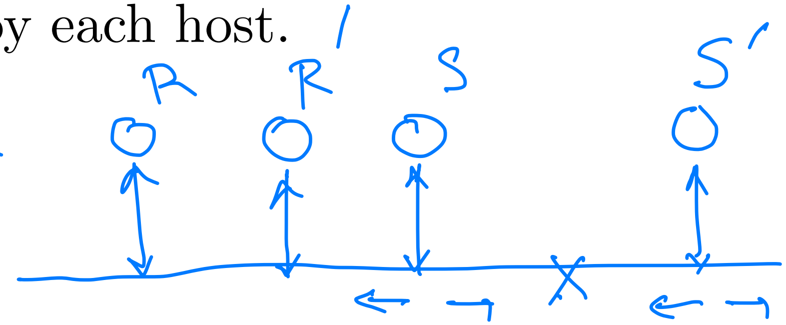
How Do You Mediate Access?

- Given that there are many users, several issues must be taken into account.
  1. Give access to each user that wants to communicate.
  2. Decide who talks first.
  3. Be fair to all.

quite complex
Some randomization is needed!

- How do you accomplish all these tasks?
- It is inevitable that we must employ some measurement on how long medium is used by each host.

Computers must tap the line



S ~ R , S' ~ R'

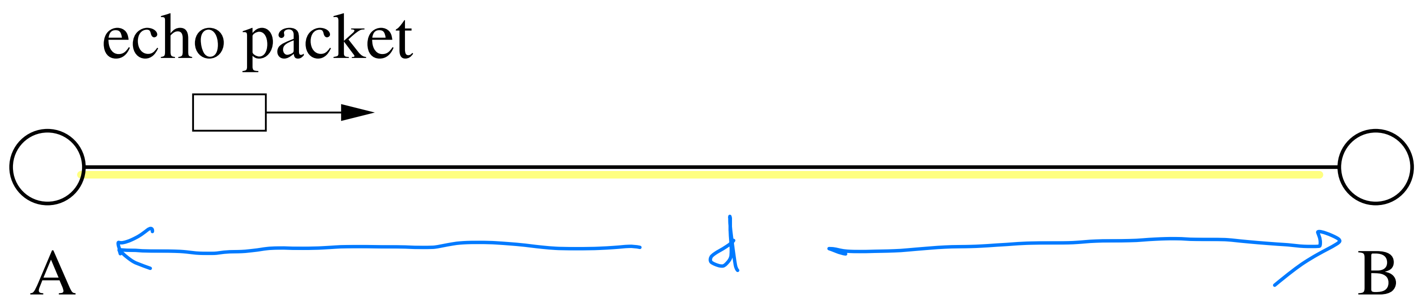
X : noise
◎ : message

The Case of Two Hosts

- Access mediation is complex even for two users.
- A lot of subtle issues arise that must be taken into account.
- Lets try to understand the problem for two hosts first!
- To be specific, we will address the following problems.
  1. Measure the Propagation Time
  2. Coordinate access.
  3. Select a winner.
- We will address the access mediation problem for many users later.

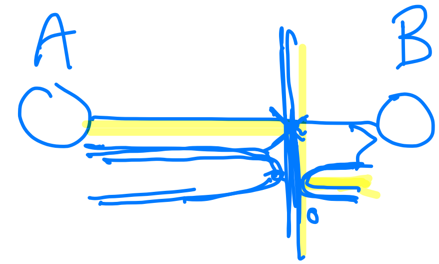
Measuring the Propagation Time

- Let T_{prop} be the bit-propagation time of a channel.
- If d = "distance between the two stations" and v = "the speed of the medium" then
$$T_{prop} = \frac{d}{v}.$$



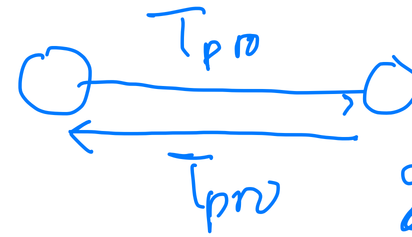
- Both stations can measure T_{prop}, e.g., can use ping.
- So we can assume they both have the same value for T_{prop}.

How do you coordinate access?



- **Access Coordination Algorithm:**

  1. A (B) listens to channel
  2. **if** channel not busy
  3.   **then** A (B) transmits packet
  4. A (B) continues to listen to channel
  5.   **if** B (A) has not began transmission "by time T_{prop}"
  6.   **then** A (B) is certain packet will reach B (A) $[0, 2T_{prop}]$
  7.   **else** A (B) detects collision and retransmits.

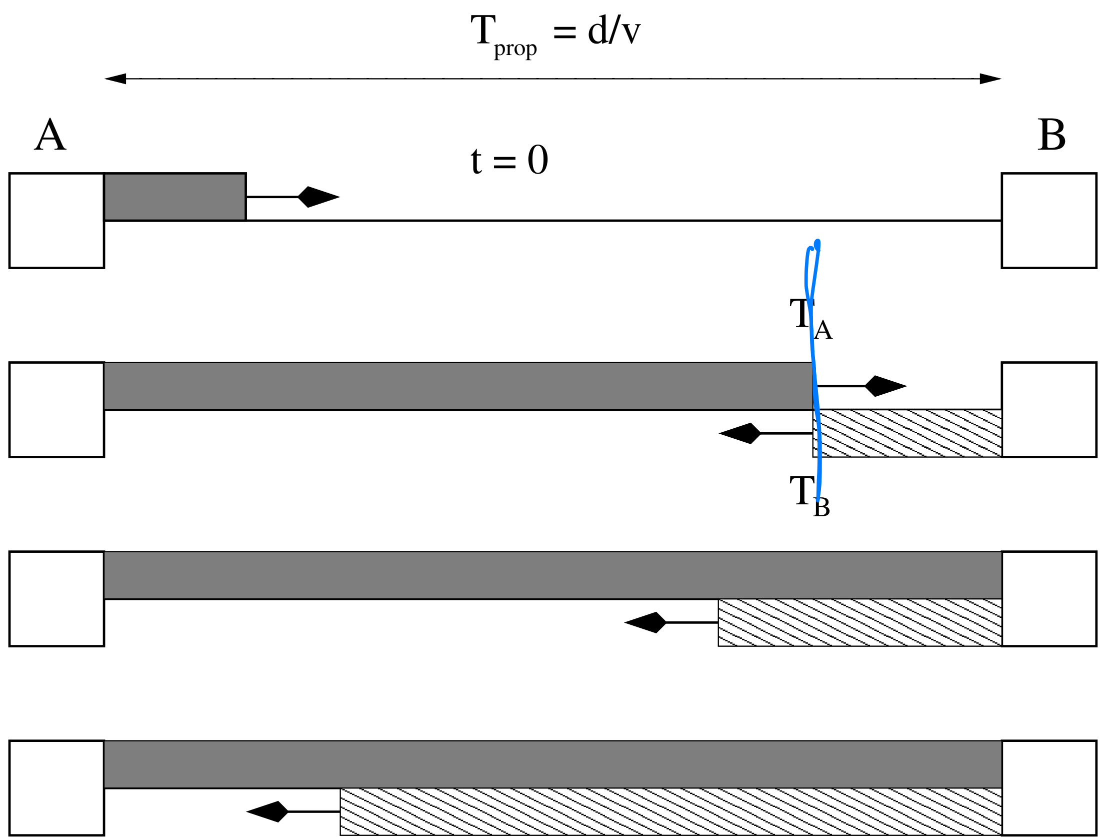


- If user A is to be able to **detect a collision** it must occupy the channel for a time period of $2T_{prop}$ time units.

- **Note:** Since both stations can measure T_{prop}, at the latest, by time $2T_{prop}$, A will know if a collision occurred.

Measuring Time

Stations measure time T_A (T_B) from the beginning of (their own) packet transmission to the time a collision occurs.



User that sends a packet occupies the channel

And the Winner Is!

- Stations A and B can compare T_A and T_B with T_{prop}.
  $T_A < T_B$ iff $T_A < T_{prop}$
  1. A wins iff $T_A < T_B$.
  2. Losing station remains quiet until winner completes transmission.
  3. For the sake of fairness, after completing transmission, the winner remains quiet for $2T_{prop}$ time units to allow the loser to capture channel.

A wins iff $2T_A < 2T_B$
iff $T_A < T_B$

Process
Very quick
μs
microsec

Efficiency!

- So for each packet sent, $2T_{prop}$ time is required to coordinate access.

- If bit rate is R and packet length is L then channel efficiency is

$$\frac{L}{L + 2T_{prop}R} = \frac{1}{1 + \frac{2T_{prop}R}{L}} = \frac{1}{1 + 2a}, \approx 1$$

$2a \approx 0$

where $a := \frac{T_{prop}R}{L}$ must be small

- The closer to 0 the number a is, the more efficient the channel.

- If $a = \frac{T_{prop}R}{L}$ (i.e., $a \sim 0$) is small then $1 + 2a \sim 1$ and therefore the efficiency is ~ 1, i.e.,

$$\frac{L}{L + 2T_{prop}R} \sim 1.$$

Measurements and LANS

- Measurements made depend on the technical specifications of the networks being used.

d, R, v, L

- Recall that

$$
\begin{aligned}
T_{prop} R &= \frac{d}{v} R \\
a &= \frac{T_{prop} R}{L} = \frac{dR}{vL},
\end{aligned}
$$

$R \uparrow \Rightarrow L \uparrow$

$v \uparrow$

where d is distance, v speed of medium, L, is the packet length, and R is the bit transmission rate.

- Clearly, these parameters depend on the network technology.

Comparing Performance of Some Networks

Use transmission speed $v = 3 \cdot 10^8$ m/s, and packet length $L = 1,500B = 12,000b$. Vary distance d and transmission rates R.

d Network	Rate $R =$ 10 Mbps	Rate $R =$ 100 Mbps	Rate $R =$ 1 Gbps	
100 m LAN	$3.33 \cdot 10^0$ $2.77 \cdot 10^{-4}$	$3.33 \cdot 10^1$ $2.77 \cdot 10^{-3}$	$3.33 \cdot 10^2$ $2.77 \cdot 10^{-2}$	$= T_{prop}R$ $= a$
10 km MAN	$3.33 \cdot 10^2$ $2.77 \cdot 10^{-2}$	$3.33 \cdot 10^3$ $2.77 \cdot 10^{-1}$	$3.33 \cdot 10^4$ $2.77 \cdot 10^0$	$= T_{prop}R$ $= a$
1000 km WAN	$3.33 \cdot 10^4$ $2.77 \cdot 10^0$	$3.33 \cdot 10^5$ $2.77 \cdot 10^1$	$3.33 \cdot 10^6$ $2.77 \cdot 10^2$	$= T_{prop}R$ $= a$

For each d and R we compute $T_{prop}R$ and $a = \frac{T_{prop}R}{L} = \frac{dR}{vL}$.

$\frac{1}{1+2a}$

What Does the Table Tell Us?

- For "large" distances a is computed to be very large and therefore the efficiency
$$\frac{1}{1+2a}$$
is very small and so unacceptable!

- The reason for this is that "one is forced to occupy the medium" so as to be sure nobody else is using it at the same time.

Scaling Ethernet

- In Ethernet, where there is broadcasting type of message passing, every node is always listening to the network and may initiate transmission only when the network is silent.
- The network is a broadcast media in which every node can hear every other node.
- In order for two nodes not to send data simultaneously in a quiet network, nodes must listen to their transmissions, and if the data a node reads from the Ethernet does not match the data it is placing on the Ethernet, it knows that a collision has occurred.
- Whenever a collision occurs, a node stops sending and waits a random time before attempting to retransmit.

Limitations of Ethernet: Distance Factor

- In a 10 Mb Ethernet, the minimum packet size is 64 bytes for a 5 km cable.
- In a 1 Gb Ethernet, the minimum packet size is about 6400 bytes.
- From an architectural perspective 6400 bytes is too large a number for the minimum packet size.

Efficiency $\frac{1}{1+2a}$

Other Issues

- Medium access protocol is very technology dependent!
- Can we be sure that measurements are accurate?
- Even "Echo" measurements nay differ for two hosts!

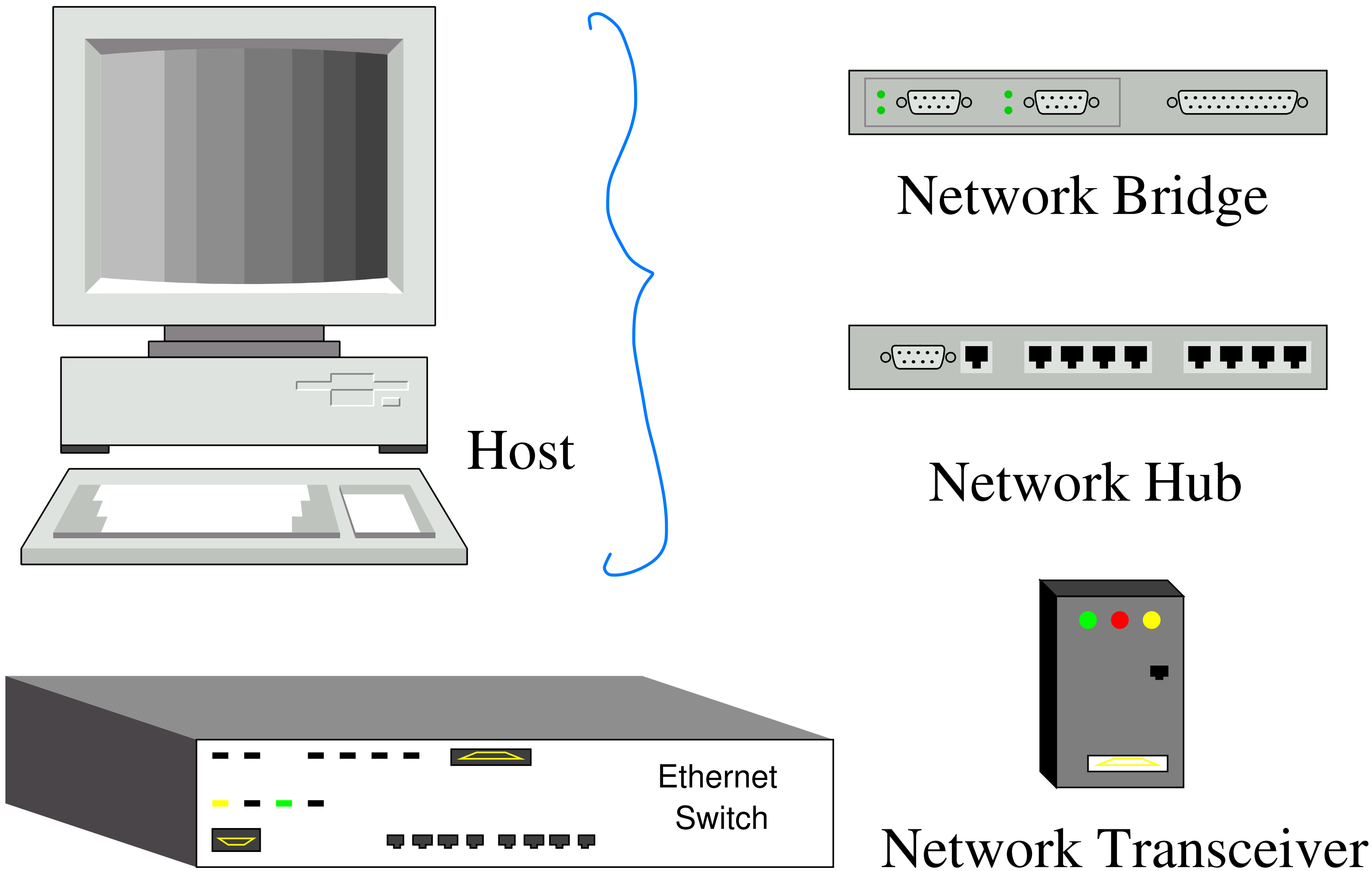
Nevertheless, resulting protocols are realistic and efficient because they are on-line.

Comparison of Peer-to-Peer and MAC Protocols

- Peer-to-Peer concern communication between two users as opposed to MAC protocols that concern many.
- A rough comparison of tradeoffs is given in the following table.

	Peer-to-Peer	MAC
# Nodes	Two	Many Two
Concern	Loss/Delay	Interference
Method	Sequencing	Randomization
Mechanism	ACK	Coordination
Performance	Delay × Bandwidth	Delay × Bandwidth
Node-Status	Independent	Coordinated

Some LAN Devices



Exercises[a]

1. Discuss advantages and disadvantages of dynamic, static access control.
2. Why does a multiaccess algorithm depend on the underlying network?
3. List three differences between switched and broadcast networks.
4. Explain why in medium access control we must obey the following design principle: the longer the distance between hosts the larger the length of the packet that must be used.
5. The distance between two hosts is 1 km and the speed of the medium is $4 \cdot 10^8$ m/s. What is the propagation time? What is the RTT?
6. Why does ethernet require that a packet must have a minimum

[a] Do not submit

length?

7. Show that if d is the distance between two hosts, v speed of medium, L, is the packet length, and R is the bit transmission rate then $\frac{T_{prop}R}{L} = \frac{dR}{vL}$.

8. The bit rate of a channel between two hosts A and B in one direction is R and in the other directions is $3R$. Assume the packet length is L. What is the channel efficiency?

9. In the previous exercise, determine the channel efficiency if in addition to propagation delays we have transmission delays, i.e., the transmission delays at hosts A and B are t_A and t_B, respectively.

10. What alternative methods could you use to decide the winner between two hosts in medium access control?