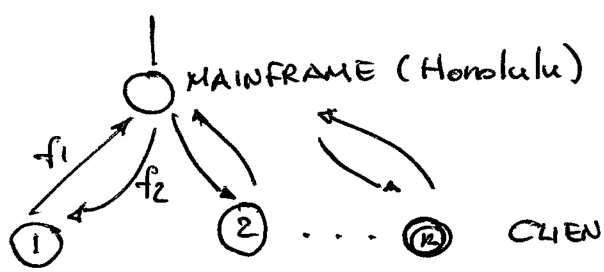
ETHERNET

Ethernet is an example of Link Layer Technology. It is used to create local area networks (LANS) that interconnect to form INTERNET. These networks have ≈ 100's devices or less. Most hosts on Internet have ethernet connection (or Wi-Fi that is wireless counterpart).
Remember it operates at physical level & link level (no routing, no transport, no application).

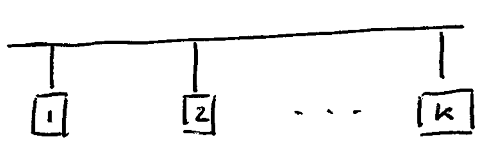
Origin of Ethernet is Wireless (Aloha Network) 1970
Aloha is based on RANDOMIZED MULTIPLE ACCESS using Two freq. one for data & one for acks.



- Transmit
- Wait for ack
- If not ack, wait random delay & retransmit immediately

] ALOHA randomized protocol. Exploits statistical multiplexing.

Cable Ethernet is based on same idea ~1975
Multiple devices share same cable. But with one improvement:
CARRIER SENSING & COLLISION DETECTION
That reduce time wasted due to collisions



- Sense channel, wait until idle.
- If idle wait random delay
- Transmit
- If collision detected repeat

] ETHERNET collision detection protocol.

Collision detection requires the possibility of listening while transmitting. This is difficult in wireless because of self-interference: one only hears itself transmitting. Also it requires more than one antenna.

How is random delay chosen?
In ethernet this is done through <u>EXPONENTIAL BACKOFF</u>.
Choose a random X

$X \sim \text{Unif}\{0, 1, 2, 3, 4, \ldots 2^N - 1\}$ where $N = \min\{m, 10\}$

m # of collisions for that packet

wait for X time slots where a time slot is some specified constant that describes the typical time required to send a packet.

<u>EXAMPLE</u>

1 collision $\Rightarrow$ pick $X \in \{0, 1\}$ where $P(X=0) = 1/2$, $P(X=1) = 1/2$

2 collision $\Rightarrow$ pick $X \in \{0, 1, 2, 3\}$ each with prob $1/4$

3 collision $\Rightarrow$ pick $X \in \{0, 1, 2, 3, 4, 5, 6, 7\}$ each w/p $1/8$

Suppose there are two stations colliding:

After 1 collision $P(\text{new collision}) = P(X=1, Y=1) + P(X=0, Y=0) =$

$$= \frac{1}{2} \cdot \frac{1}{2} + \frac{1}{2} \cdot \frac{1}{2} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$$

After 2 collisions $P(\text{new collision}) = \frac{1}{4} \cdot \frac{1}{4} + \frac{1}{4} \cdot \frac{1}{4} + \frac{1}{4} \cdot \frac{1}{4} + \frac{1}{4} \cdot \frac{1}{4} = \frac{1}{4}$

After 3 collisions $P(\text{new collision}) = \underbrace{\frac{1}{8} \cdot \frac{1}{8} + \cdots}_{} = \frac{1}{8}$

$$P(\text{two stations collide } k \text{ times}) = \frac{1}{2} \cdot \frac{1}{4} \cdot \frac{1}{8} \cdots \frac{1}{2^{k-1}} \xrightarrow{\text{as } k \to \infty} 0$$

Tends to zero very fast!

There is a potential problem:

"Winner Takes All"

A picks $X=0$ => [A Transmits
B picks $X=1$ => [B waits

If they still have data to send they will collide again.

A will pick $X \in \{0,1\}$

B will pick $X \in \{0,1,2,3\}$

It is more likely $X_A < X_B$ => A Transmits again

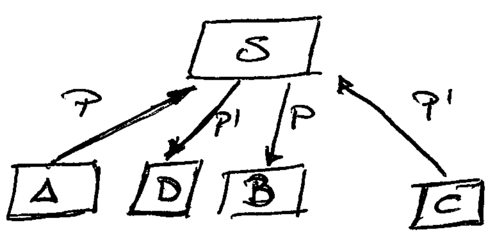
Suppose A still has data to send, they will collide again

A $X \in \{0,1\}$

B $X \in \{0,1,2,3,4,5,6,7\}$

and so on...

The problem is solved introducing SWITCH in 1989 that sends packet only output port where it is needed avoiding sharing of the same cable and eliminating collisions.



Nowdays all ethernets use intelligent switches while collision avoidance remains a problem for wireless connections.

Switch relies on MAC address (48 bits unique identifier) To decide where To relay The packet.