BROADCAST, MULTIPLE ACCESS ETHERNET
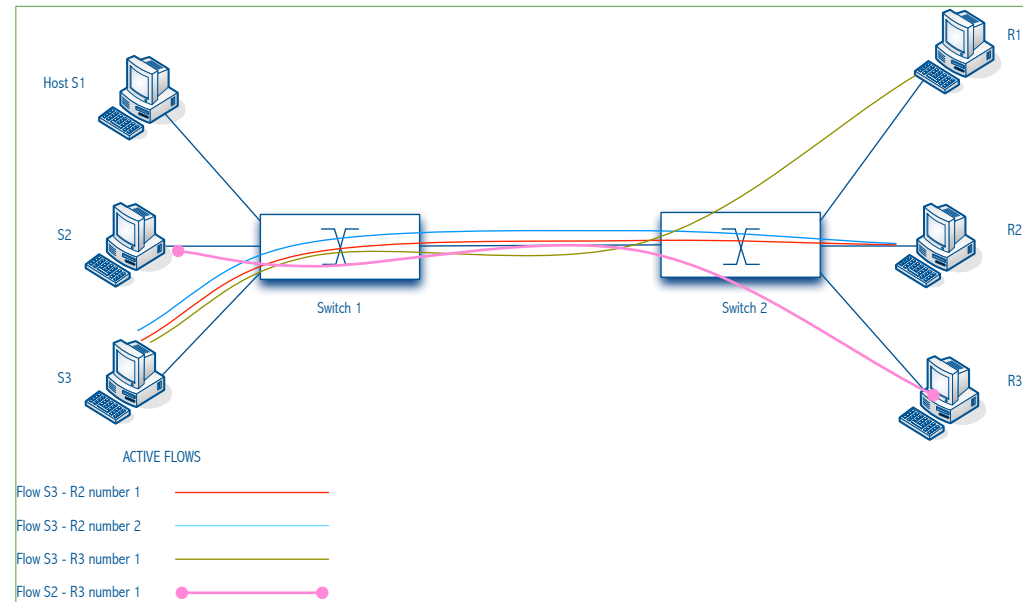
v 5.0 27th/April/2022

The scenario for Chapter 2

- **Statistical multiplexing**
  - Switching according to distribution of demand across all connected nodes

- **Directly connected nodes**
  - Host – Switch
  - Host – Host

- PDU of Ethernet is Frame

Host S1

S2

S3

Switch 1

Switch 2

R1

R2

R3

ACTIVE FLOWS

Flow S3 - R2 number 1

Flow S3 - R2 number 2

Flow S3 - R3 number 1

Flow S2 - R3 number 1

Ethernet, intro

- A brief introduction to the original Ethernet, a shared medium local network technology with an access arbitration known as CSMA/CD

- Today the most prevalent form of Ethernet is the switched Ethernet which we will take up in chapter 3

Ethernet

- Most **successful** local area networking technology
- Developed in the mid-1970s by researchers at the Xerox Palo Alto Research Centers (PARC).
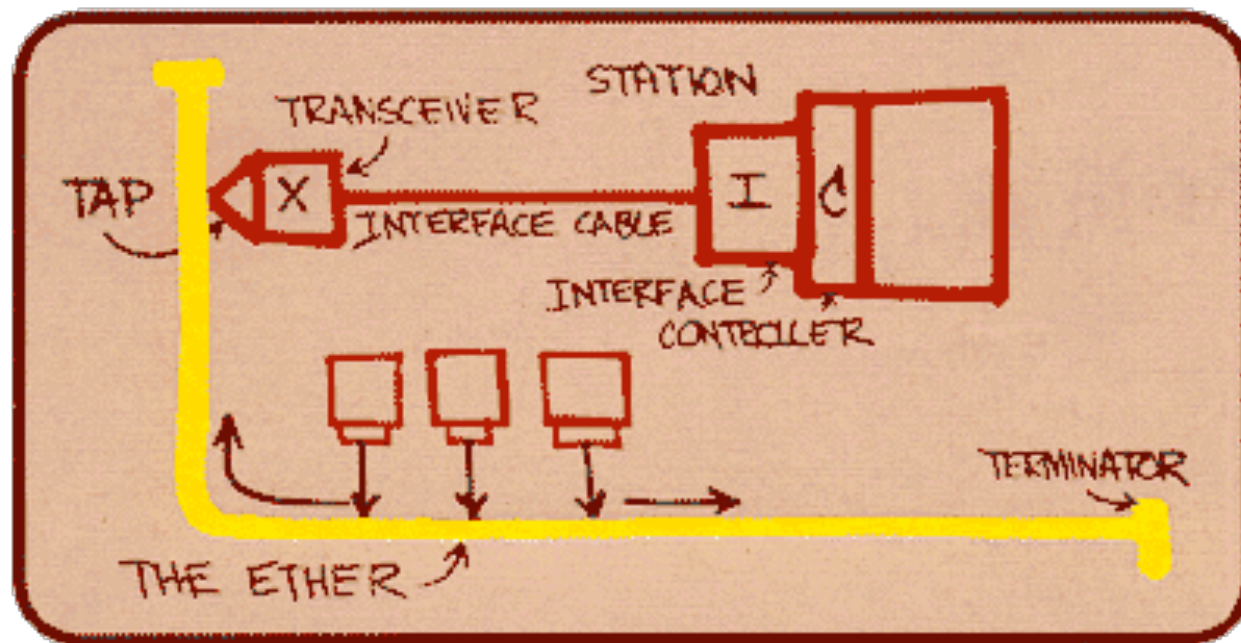
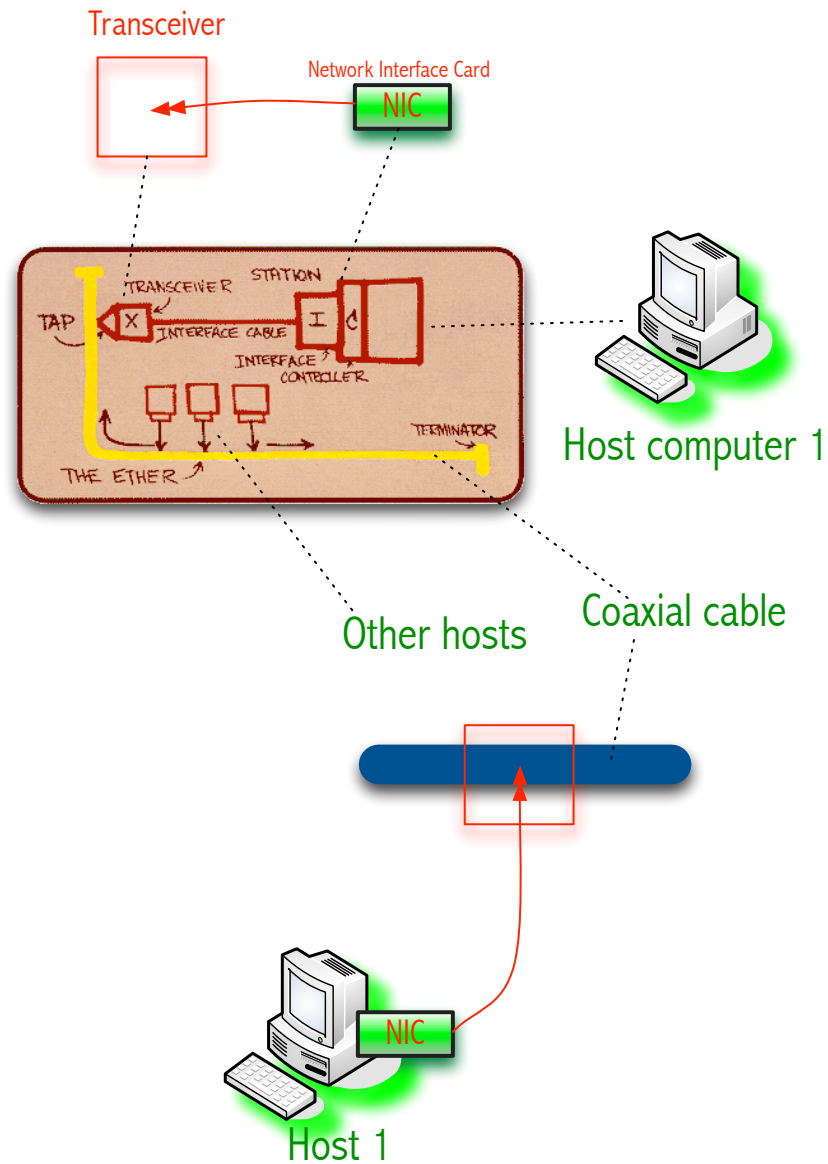Original Ethernet drawing (© Bob Metcalfe)

Ethernet (≈ IEEE 802.3)

- Based on ALOHA (A packet radio network)
  - Developed at the University of Hawaii to support communication across the Hawaiian Islands
  - For ALOHA, the medium was open space, for Ethernet the medium is a coaxial cable
  - Today's 802.11(WiFi) protocols are based on the ideas developed in the Aloha network
- DEC and Intel joined Xerox to define a **10-Mbps Ethernet** standard in 1978
- Ethernet became the basis for **IEEE standard 802.3 LAN technology**

- More recently **802.3** has been extended:
  - 100-Mbps
    - Fast Ethernet
  - 1000-Mbps
    - Gigabit Ethernet
  - 10G+

Our Ethernet diagrams vs. Metcalf's

Transceiver

Network Interface Card

NIC

TRANSCEIVER   STATION
TAP   X
INTERFACE CABLE   I   C
INTERFACE
CONTROLLER
TERMINATOR
THE ETHER
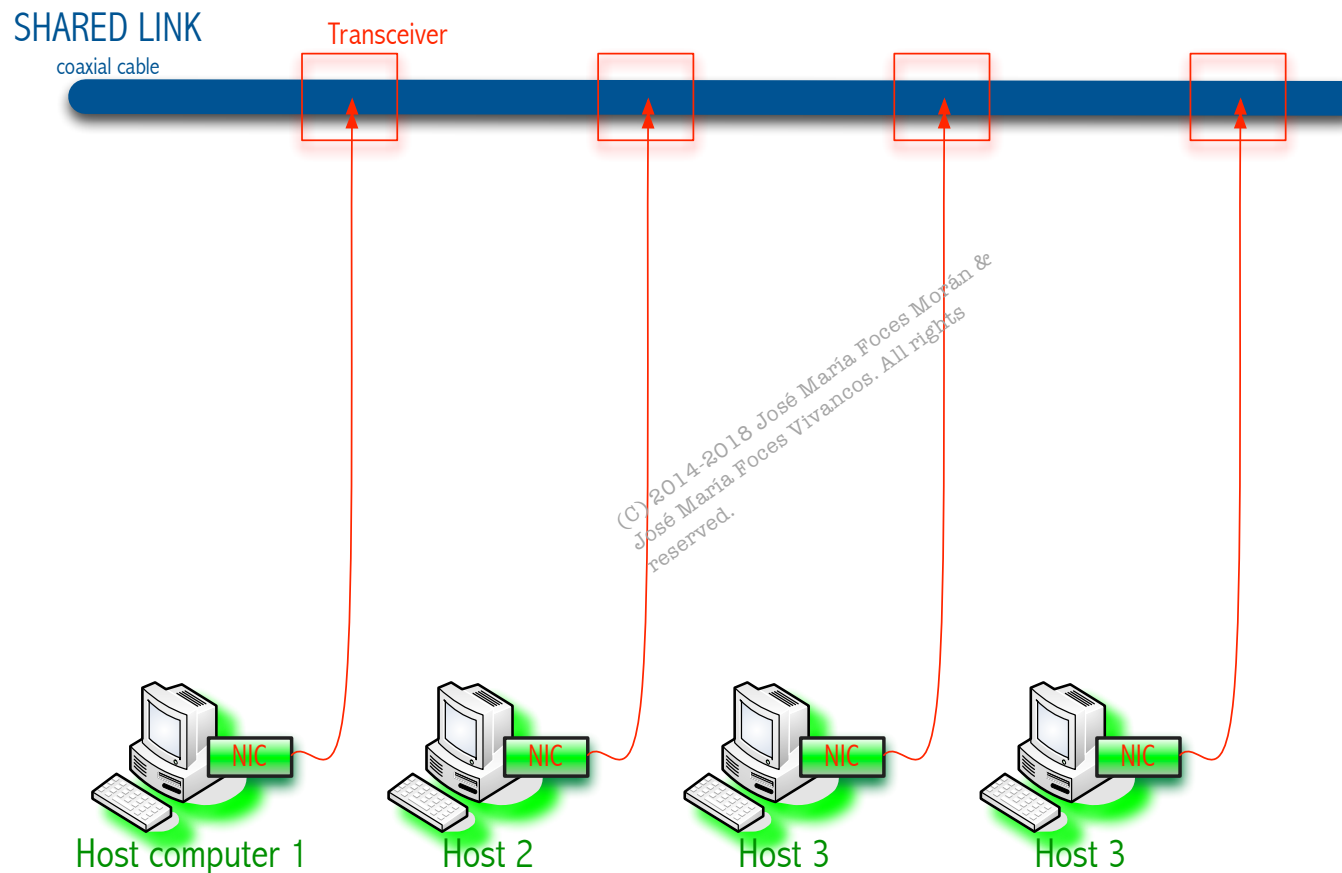
Host computer 1

Other hosts

Coaxial cable

NIC

Host 1

Ethernet

- An *Ethernet segment* is implemented on a coaxial cable
- *Host* connects to an Ethernet segment by means of a NIC (Network Interface Card)

SHARED LINK   Transceiver

coaxial cable

Host computer 1   Host 2   Host 3   Host 3

NIC   NIC   NIC   NIC

Ethernet

- **NIC** (Network Interface Adaptor)

  - Datalink protocol is implemented on NIC

  - NIC taps into the coaxial cable by means of a transceiver

- **Transceiver** (a small device directly attached to the tap)

  - Detects when the line is idle by applying Carrier Sense = CS

  - Drives signal when the host is transmitting

  - Receives incoming signal

  - Connected to an Ethernet adaptor which is plugged into the host.

  - Right after a bit is transmitted (Tx), its signal is received (Rx) and checked for equality
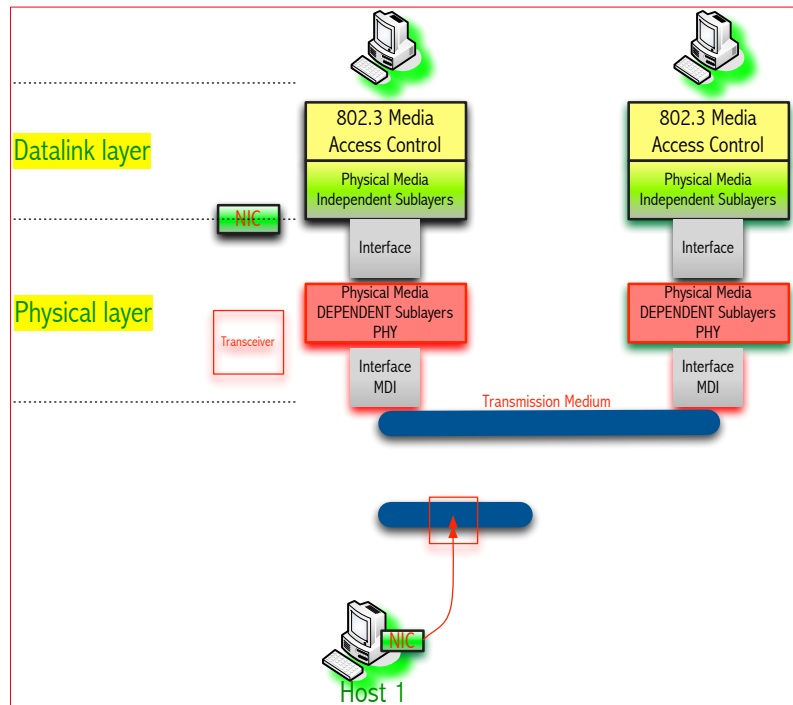
    - ```
      if (Tx != Rx){
          A collision took place;
          Do backoff;
      }
      ```

CSMA/CD distributed access scheme

☐ **CS: Carrier Sense**

   A computer can distinguish when the link is being used and when it is not (Idle)

☐ **MA: Multiple Access**

   The link is shared among all the computers connected to it

☐ **CD: Collision Detection**

   ▫ <u>As the transceiver transmits a frame, it also receives each of its bits</u>

   ▫ In consequence, it can detect when one of its transmissions is colliding with another frame being transmitted by another node

IEEE 10-BASE-5

Multiple Ethernet **segments** can be joined together by using *repeaters*.

□ A *repeater* is a device that *forwards digital signals*.

□ No more than four repeaters may be positioned between any pair of hosts.

▪ An Ethernet can have a max distance of only **2500 m, RTT = 51,2 µs**

```
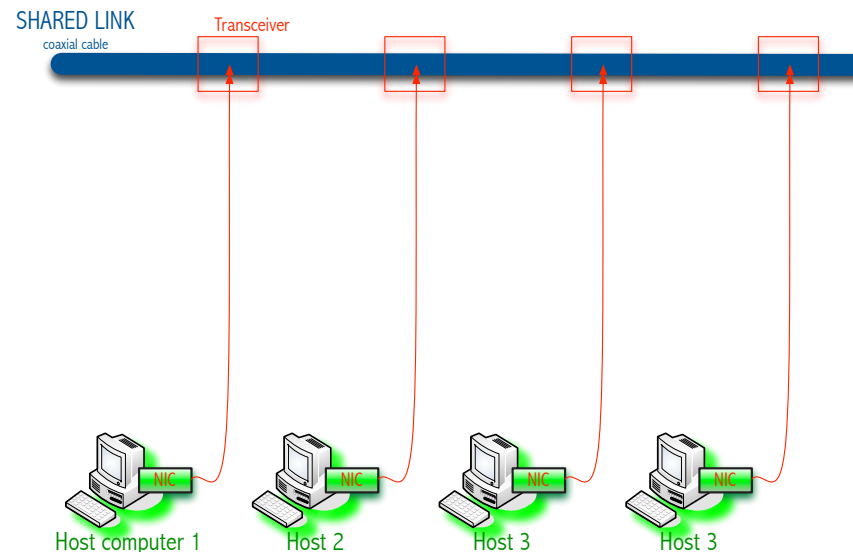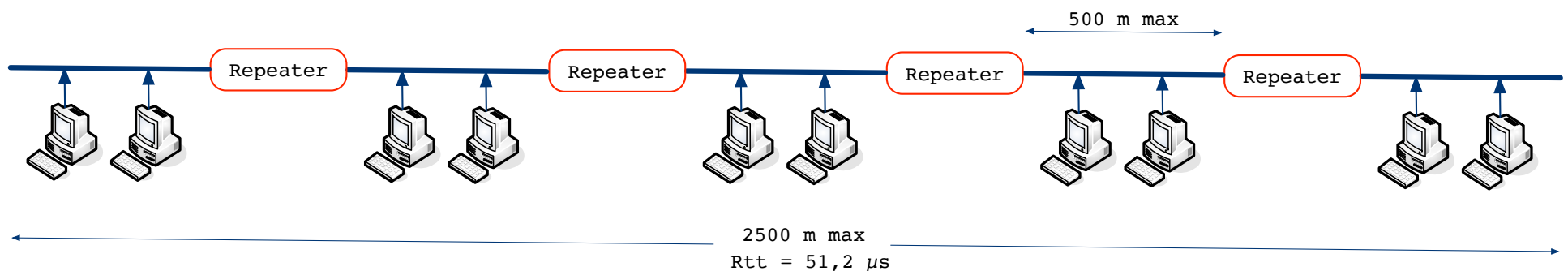                                                    500 m max
                                                  ←──────────→
───┬───┬──[Repeater]───┬───┬──[Repeater]───┬───┬──[Repeater]───┬───┬──[Repeater]───┬───┬──
   ↑   ↑               ↑   ↑               ↑   ↑               ↑   ↑               ↑   ↑
```

```
←──────────────────────────── 2500 m max ────────────────────────────→
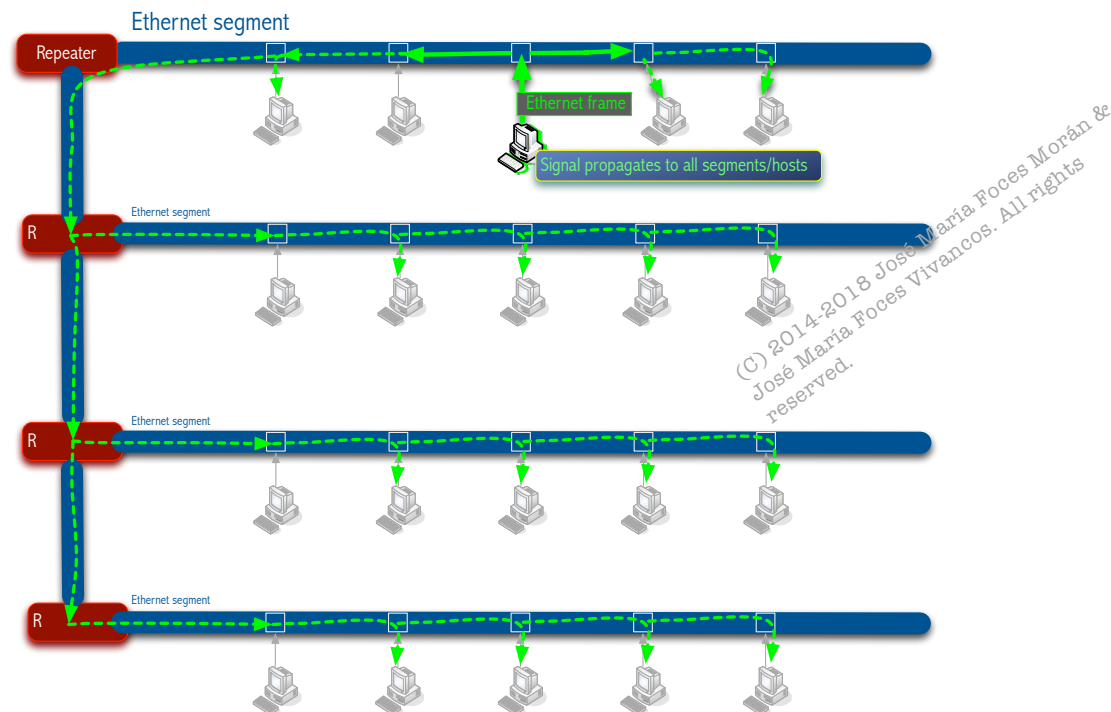                              Rtt = 51,2 µs
```

Ethernet

Any **signal** placed on the Ethernet by a host is *inherently* __broadcast__ over the entire cable (Network)

- Signal propagates in *both directions*
- Repeaters forward the signal on all outgoing segments

◻ Ethernet uses **Manchester** encoding scheme

Access Protocol for Ethernet

□ Access protocol is called Ethernet's Media Access Control (MAC)

- Remains CSMA/CD

- It is implemented in Hardware on the **network adaptor**

Header

Destination Address	Source Address	Ethertype	Payload	CRC32
48-bit MAC address	48-bit MAC address	16-bit Multiplexing Key	Variable-length	Error Control

Ethernet frame

□ **Frame format**

- Preamble (64bit): allows the receiver to synchronize with the signal (sequence of alternating 64 0s and 1s ending in 11)

- Host and Destination Address (48bit each)

- Packet type (16bit): acts as multiplexing key to identify the higher level protocol

- Data (MTU is 1500)

  - A frame must contain at least 46 bytes of data (Padding if necessary)

  - Frame must be long enough to allow collision detection

- CRC (32bit)
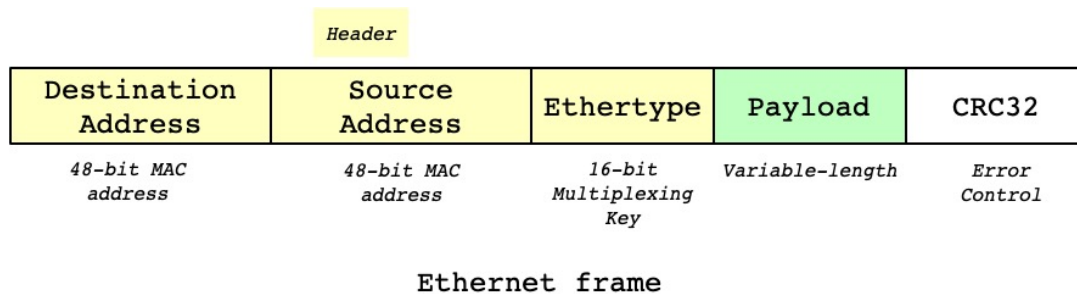
Ethernet Addresses

- Every Ethernet NIC in the world has a **unique** Ethernet Address.

- The address belongs to the **NIC**

  - Usually kept in stable storage (NVRAM, Flash), EEPROM)

- Ethernet addresses are typically printed in a human readable format

  - As a sequence of six hex numbers separated by colons

    - Check out ifconfig command and the exercises in the PF_PACKET practices

  - Each number corresponds to 1 byte of the 6 byte address and is given by a pair of hexadecimal digits, one for each of the 4-bit nibbles in the byte

  - Leading 0s are dropped

  - For example, 8:0:2b:e4:b1:2 is

    - 00001000 00000000 00101011 11100100 10110001 00000010

Ethernet Addresses

- To ensure that every adaptor gets a **unique address**, each manufacturer of Ethernet devices is allocated a different prefix that must be prepended to the address on every adaptor they build
    - AMD has been assigned the 24bit prefix 8:0:20

- Modern NICs and operating systems allow allocating several MAC addresses to a single NIC

Ethernet Addresses

- Each adaptor recognizes the frames addressed to its own address
- In addition to <u>unicast</u> addresses, an Ethernet address consisting of all 1s is treated as a <u>broadcast</u> address.
  - Adaptors pass frames addressed to its own MAC address or to the broadcast address upward the host's protocol stack
- Similarly, an address that has the first bit set to 1 but is not the broadcast address is called a multicast address
  - A given host can program its adaptor to accept some set of <u>multicast</u> addresses

Ethernet Addresses

- An Ethernet adaptor accepts:
  - Frames addressed to its own MAC address
  - Frames addressed to the broadcast MAC address
  - Frames addressed to a multicast addressed if it has been instructed

- In addition, it is possible to set the NIC in a mode that accepts all the incoming traffic regardless of its destination MAC
  - The promiscuous mode

Other IEEE 802.3 Technologies

3

IEEE 802.3 technologies

☐ Instead of using the thick coax cable, an Ethernet can be constructed from a **thinner cable:**

- ◘ 10Base2 (Thinlan)
- ◘ The original was 10Base5
  - **10** means the network operates at *10 Mbps*
  - **Base** means signals are pulses (Baseband transmission), no modulation (Broadband), encoding only
  - *2* means that a given *segment* can be no longer than *200 m* (Thinlan)
  - *5* means that a given *segment* can be no longer than *500 m (ThickLan)*

☐ Network topology implemented by 10BASE5 and 10BASE2

- ◘ Bus Topology
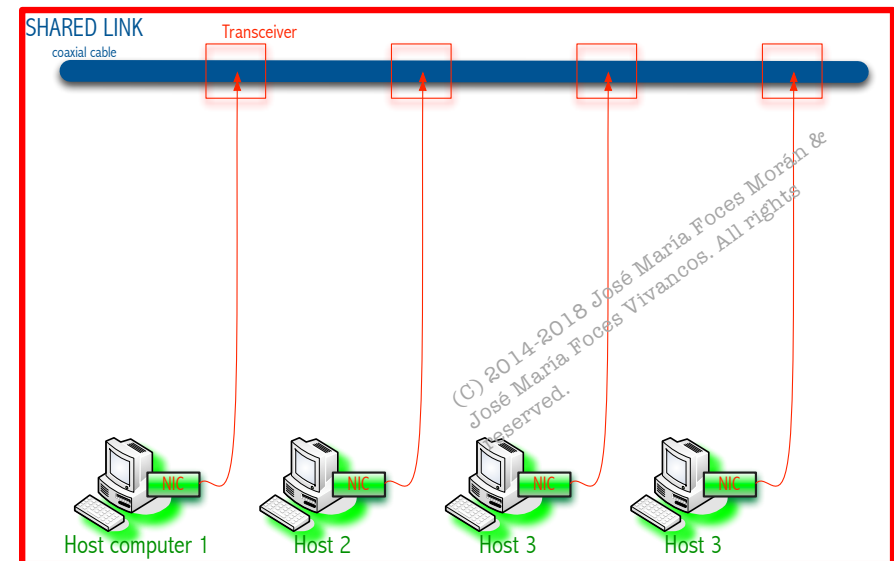
More modern Ethernet technologies

- Another cable technology is 10Base-T
  - T stands for **twisted** pair cable
  - Limited to **100 m** in length

- With 10Base-T, the common configuration is to have several point to point segments coming out of a multiway repeater, called Hub
  - Concentrator
  - 10 Mbps
  - Baseband transmission
  - T = Twisted pair cables

- Network topology in 10BASE-T is
  - Star Topology

HUB 100BASE-T
UPLINK based on an optical fiber (OF)
STAR topology
HUB
host
host
host
S1b
HUB 100BASE-T
S1b
LINK based on a Twisted pair cable (TP)

HUB 100BASE-T

UPLINK based on an optical fiber (OF)
10BASE-FL (Fiber link)
2000 m max length

STAR topology

host
host
HUB
host
host

HUB 100BASE-T

S1b

S1b

LINK based on a Twisted pair cable (TP)