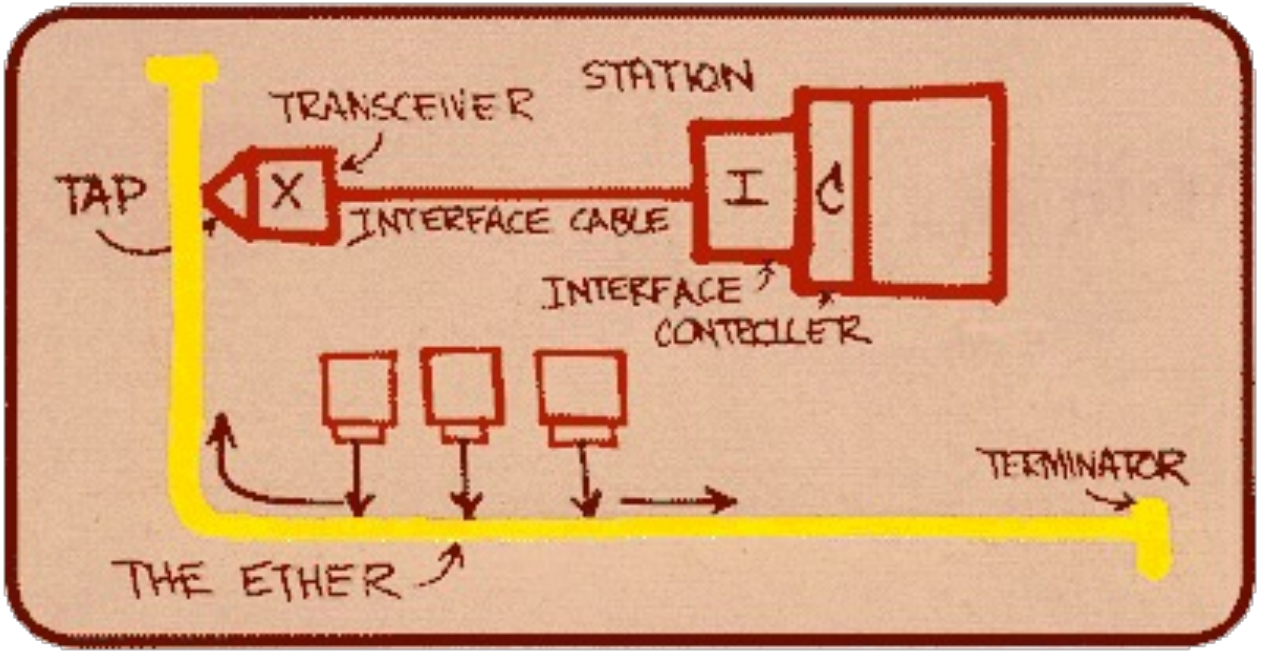
Ethernet, intro

- 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)

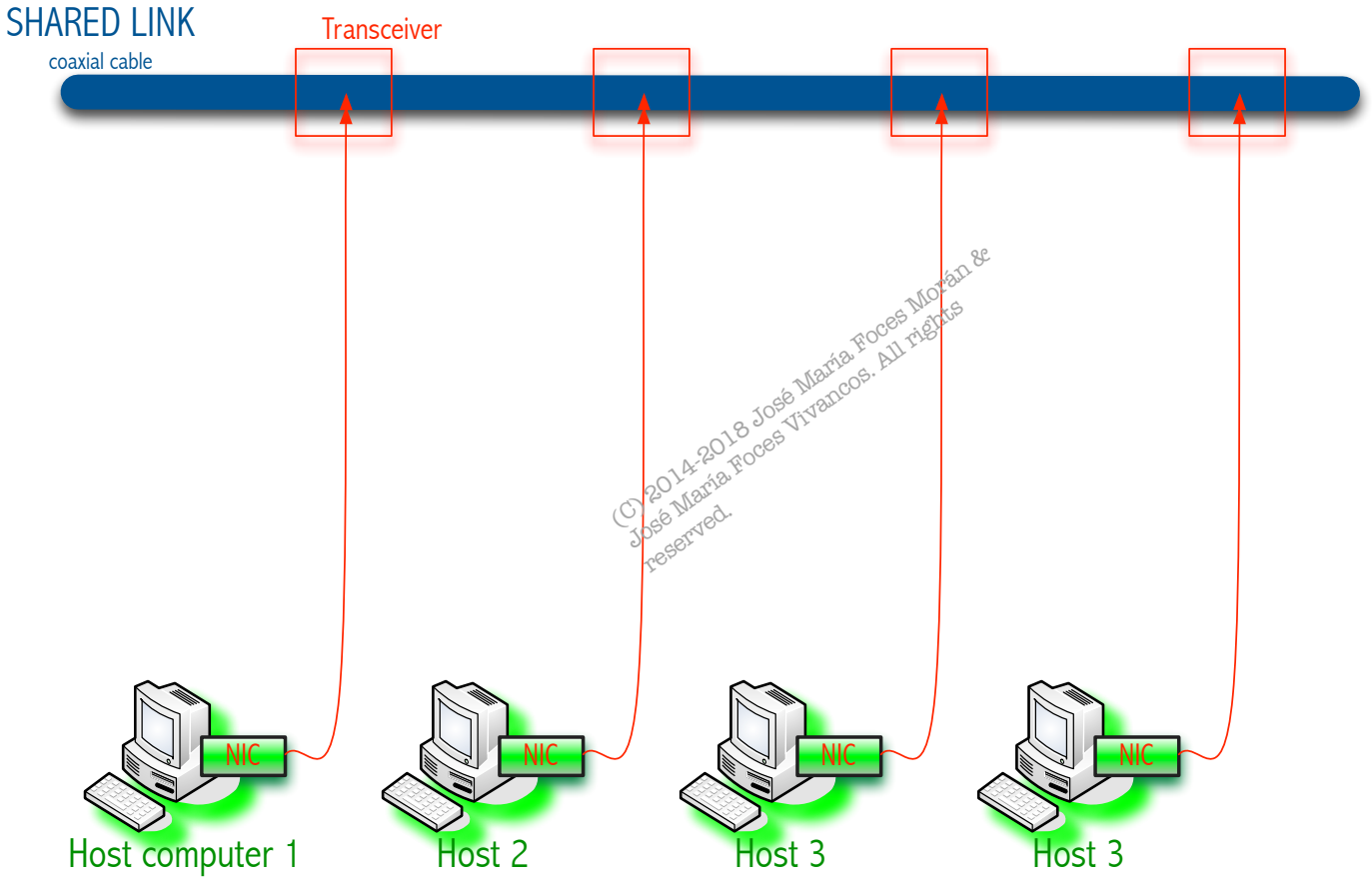
Ethernet (≈ IEEE 802.3)

- 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+**

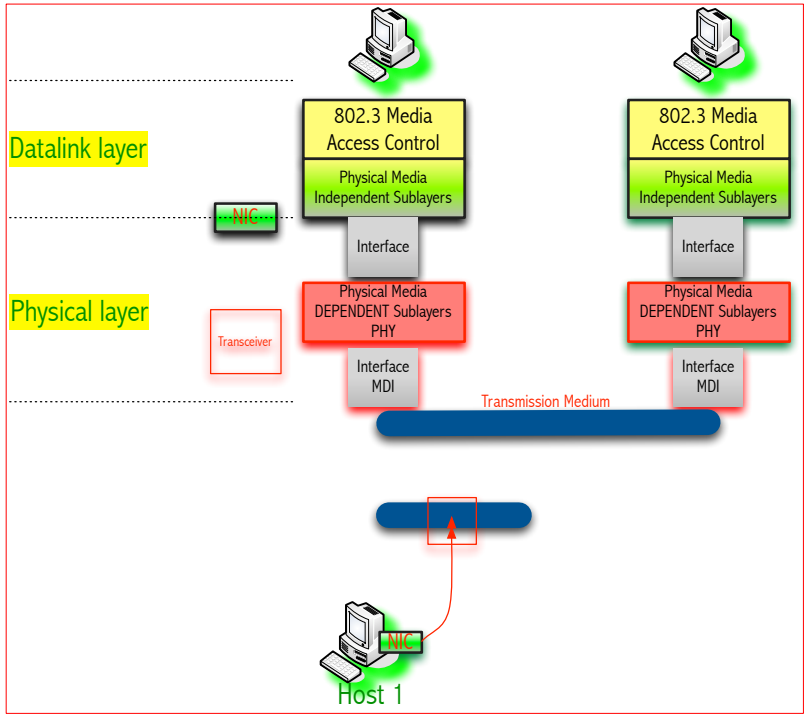
Ethernet

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



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

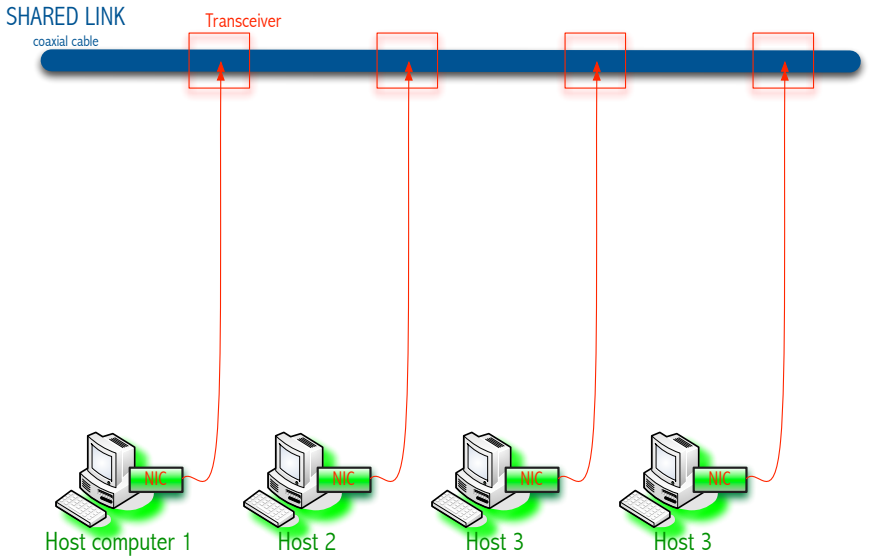
- **CS: Carrier Sense**

  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

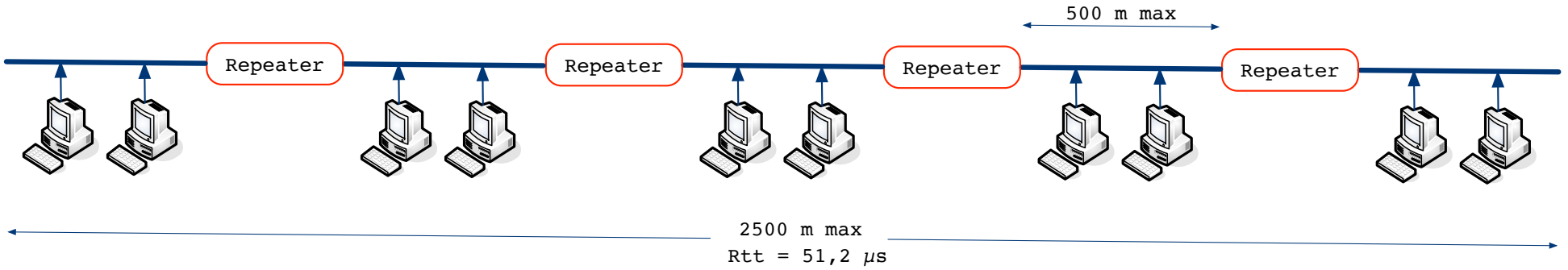
- **CD: Collision Detection**
  - As the transceiver transmits a frame, it also receives each of its bits
  - In consequence, it can detect when one of its transmissions is colliding with another frame being transmitted by another node



IEEE 10-BASE-5

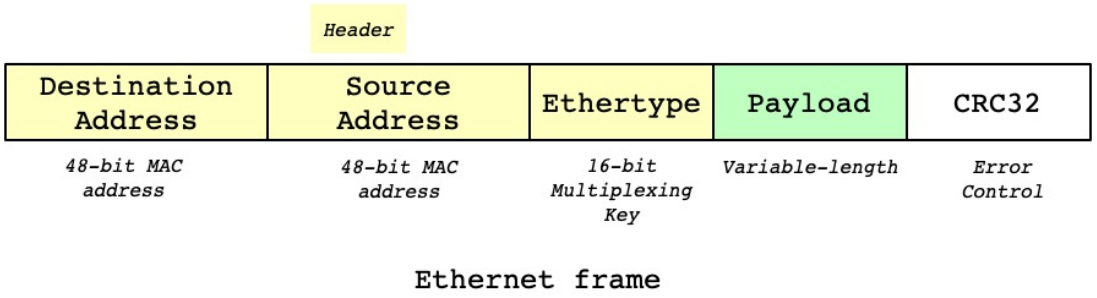
Multiple Ethernet segments can be joined together by using ***repeaters***.

- 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



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**



- **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 unicast addresses, an Ethernet address consisting of all 1s is treated as a broadcast 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 multicast 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

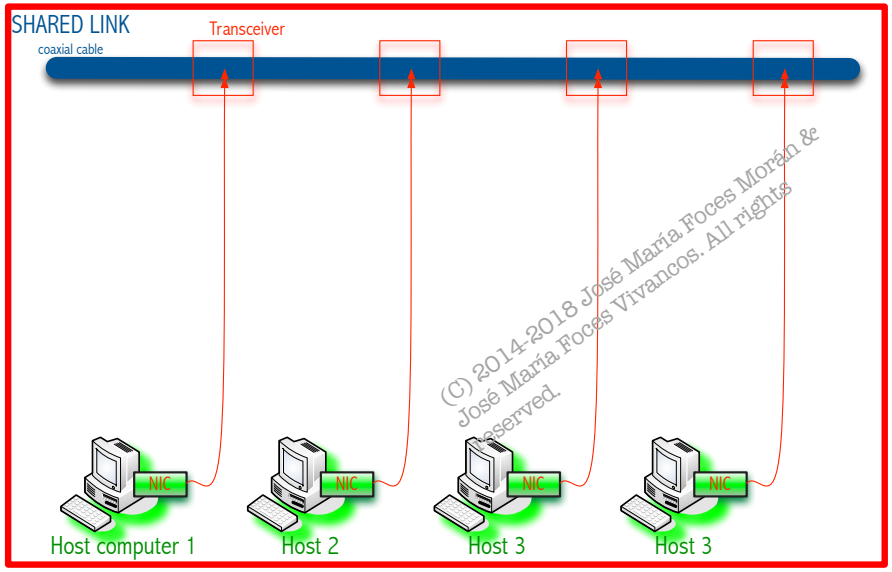
- In addition, it is possible to set the NIC in a mode that accepts all the incoming traffic regardless of its destination MAC
  - The promiscuous mode

Other IEEE 802.3 Technologies

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**

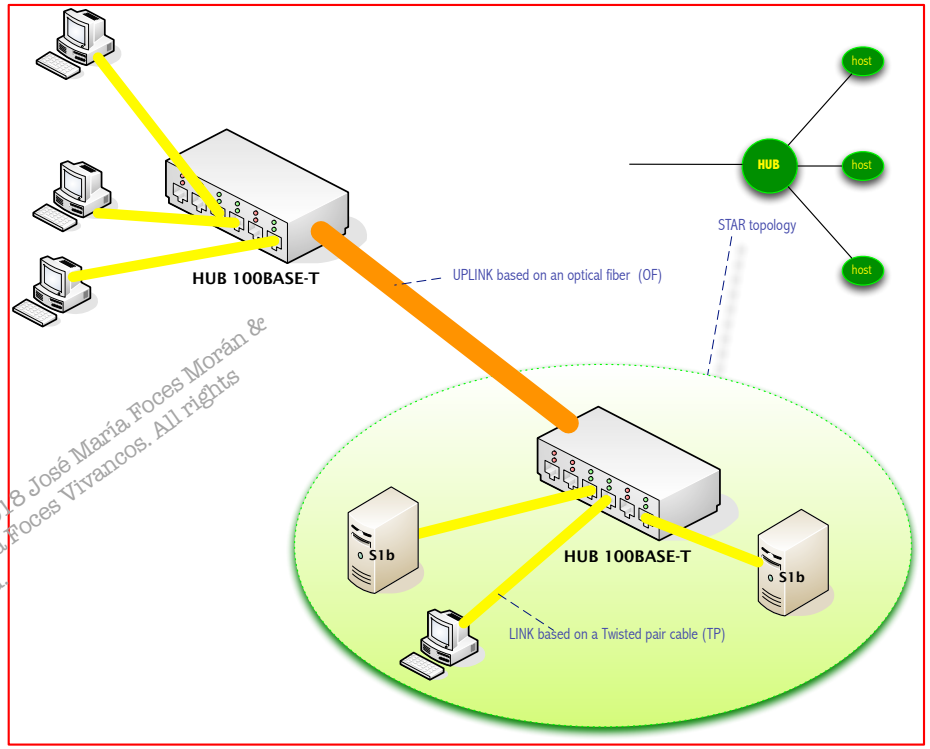


More modern Ethernet technologies

- 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**



10-BASE-T Hubs extending an Ethernet with 10BASE-FL (Fiber optic link)