Direct Link Communication II: Wired Media

Multi-Access Communication

Two classes:

- contention-based

  → e.g., CSMA/CD, CSMA/CA

  → used in Ethernet, WLAN

- contention-free

  → e.g., TDM, FDM, TDMA, CDMA, token ring

  → used in telephony and broadband data networks

One more. . .

$\longrightarrow$ also called MAC (medium access control)

- broadband: FDM, TDMA, CDMA
- baseband: TDM, multiple access

Contention-based MAC for baseband:

- Time slots are available for grab

  $\rightarrow$ "on-demand" TDM
- Can listen to channel activity...
- To grab channel slot is to send

  $\rightarrow$ shoot-first-ask-later (e.g., TV talk shows)
- If ≥ 2 users grab at the same time, slot becomes junk

  $\rightarrow$ collision

Why not just used TDM?

Benefits of contention-based MAC:

- when not too many users, faster response time
  - → don't need to go through registration & reservation phase (TDM)
  - → avoids admission control overhead
- decentralized
  - → no central coordinator
  - → simple; "self-organization"

Drawbacks of contention-based MAC:

- when many users, degraded response & throughput
  - → collision wastes slots, i.e., bandwidth
- lack of QoS (quality of service) assurances
  - → "you get is what you get"; best effort
  - → problematic for real-time traffic, e.g., telephony

Thus when to use what?

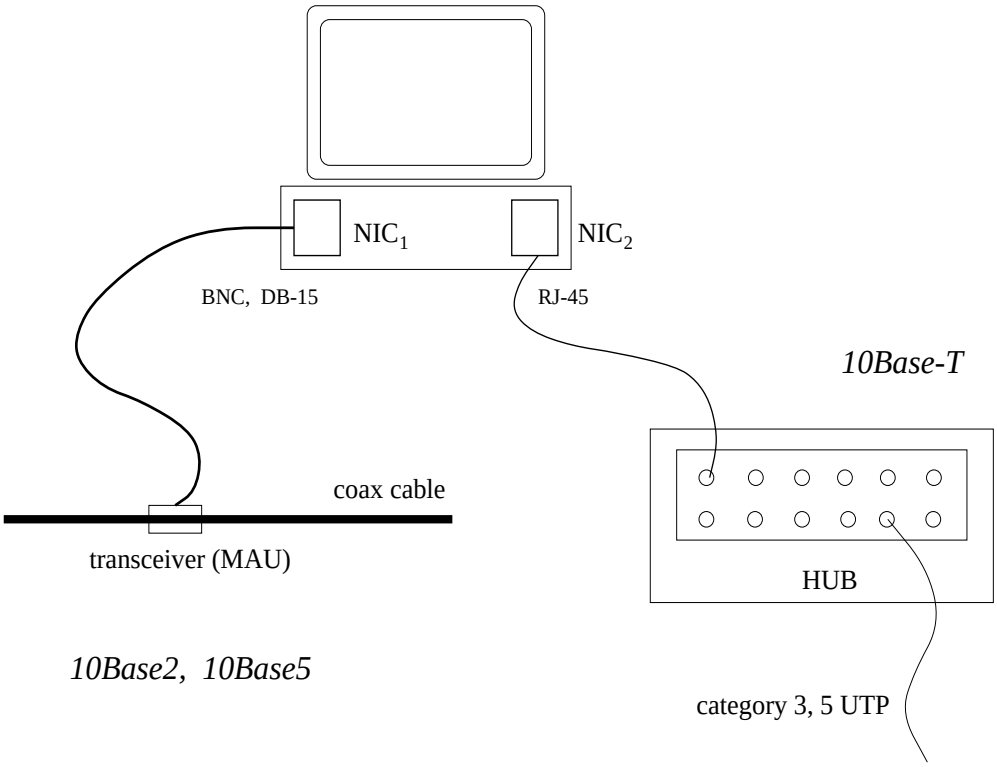
Ethernet and CSMA/CD

$\longrightarrow$ copper, fiber

Types:

- 10Base2 (ThinNet): coax, segment length 200 m, 30 nodes/segment
- 10Base5 (ThickNet): coax, segment length 500 m, 100 nodes/segment
- 10Base-T: twisted pair, segment length 100 m, 1024 nodes/segment
- 100Base-T (Fast Ethernet): category 5 UTP, fiber (also 100VG-AnyLAN)
- Gigabit & 10 Gbps Ethernet: fiber, category 5 UTP

Connectivity example:



- single-homed vs. multi-homed
- unique Ethernet address per NIC
- physical network: bus vs. hub vs. switch

  → very old vs. old vs. not-so-old

$\longrightarrow$ hub: multi-tap junction

$\longrightarrow$ bus and hub: logically equivalent

Wire segments can be hooked up by repeaters, bridges, hubs or switches.

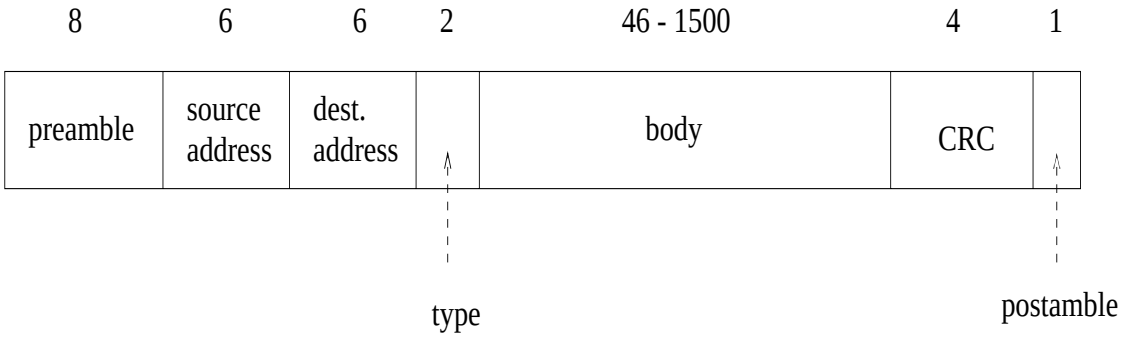
- maximum of 2 (4 for IEEE 802.3) repeaters between two hosts; 1500 m
- for Fast Ethernet, 2 repeater hops

High-speed Ethernets have shorter network diameter

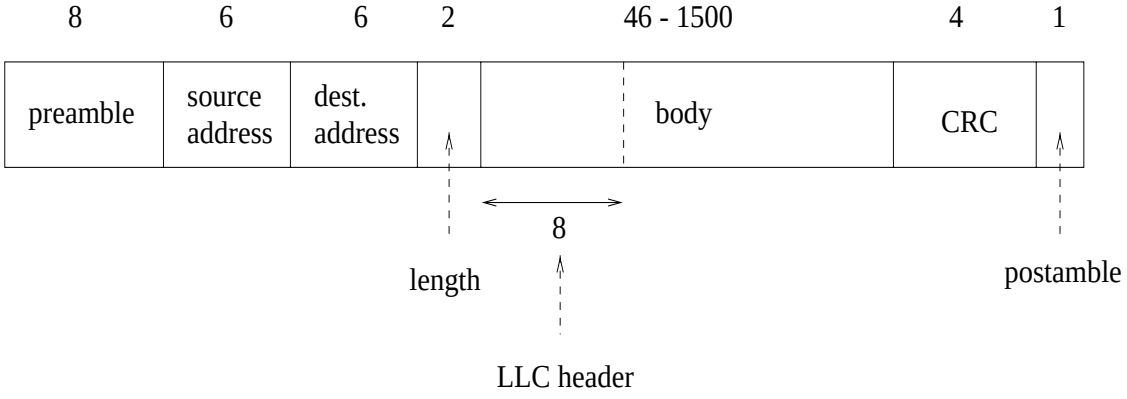
- about 2500 m for 10 Mbps Ethernet
- about 200 m for 100 Mbps Ethernet
- even shorter for 1 Gbps Ethernet

  $\rightarrow$ additional complications for medium-haul

DIX Ethernet frame:



IEEE 802.3 Ethernet frame:



$\longrightarrow$ IEEE 802.2 LLC (Logical Link Control)

$\longrightarrow$ common interface to different link protocols

Encoding: Manchester

$\longrightarrow$ recall: Ethernet is baseband

Addressing:

- 48 bit unique address
- point-to-point
- broadcast (all 1's)

Receiver: Ethernet adaptor accepts frames with "relevant" address.

- accepts only own frame address
- accepts all frames: promiscuous mode

  $\rightarrow$ NIC feature

  $\rightarrow$ sniffing

CSMA/CD MAC:

- CS (Carrier Sense): can detect if some other node is using the link

  → rule: if busy, abstein

- MA (Multiple Access): multiple nodes are allowed simultaneous access

  → rule: if channel seems silent, send

- CD (Collision Detection): can detect if collision due to simultaneous access has occured

  → rule: if collision, retry later

Wired vs. wireless media:

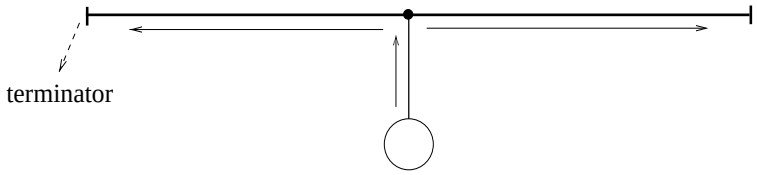
⟶ CD is key difference

⟶ diffcult to detect collision while transmitting

Signal propagation and collision:

Bi-directional propagation

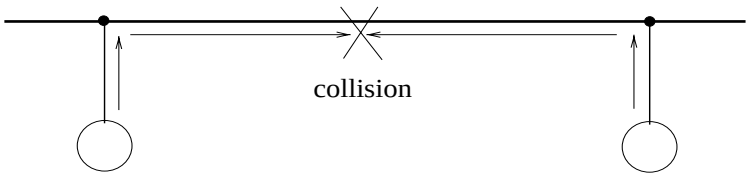
$\longrightarrow$ terminator absorbs signal: prevent bounce back



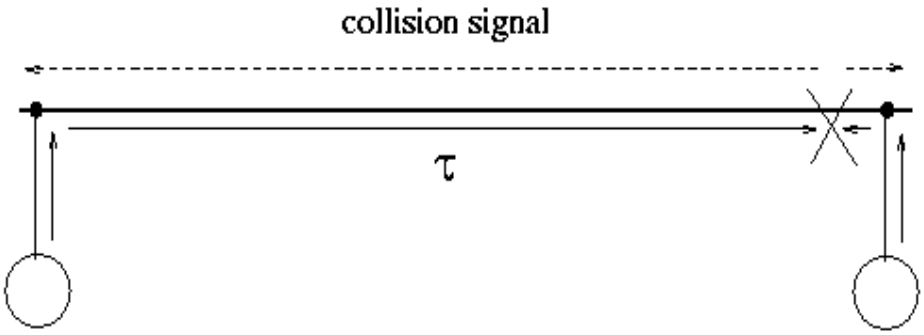
Best-case collision: 2 stations

$\longrightarrow$ meet in the middle

$\longrightarrow$ worst-case?



Worst-case collision scenario:



$\longrightarrow$ τ: one-way propagation delay

- sender needs to wait 2τ sec before detecting collision
- for 2500 m length, 51.2 μs round-trip time (2τ)

  $\rightarrow$ fact
- enforce 51.2 μs slot time
- at 10 Mbps, 512 bits; i.e., minimum frame size

  $\rightarrow$ assures collision detection

Transmit at least 512 bits

$\longrightarrow$ $6 + 6 + 2 + 46 + 4 = 64$ B $= 512$ bits

$\longrightarrow$ note: delay-bandwidth product

Retry upon collision: exponential backoff

1. Wait for random $0 \leq X \leq 51.2$ μs before first retry
2. On i'th collision, wait for $0 \leq X \leq 2^{i-1}\,51.2$ μs before next attempt
3. Give up if $i > 16$

$\longrightarrow$ a form of stop-and-wait

$\longrightarrow$ what's the ACK?

$\longrightarrow$ guaranteed reliability?

$\longrightarrow$ pretty drastic measure: necessary?