Ethernet
ARP

ITL

Ethernet

- Designed as a broadcast medium; each transmission is received by every station
- Based on a bus architecture
- Manchester Encoding
- Today, wired using 8 conductor (4-pair) wiring
- 10Mbps to 1Gbps
- All use a star topology

Fast Ethernet

- 100Base-TX
  - Two pair copper wire (Cat 5)
  - Same pin-out at 10Base-T, better wire
- 100Base-FX
  - Two fibers
- 100Base-T4
  - Rarely used; 4 pair lower quality (cat 3) wires
- 1000Base-X (4 pair Cat 5 or 5E)

Ethernet Logic

- Ethernet is a CSMA/CD network
  - Carrier Sense
    - Before sending a signal, listen to see if anyone else is transmitting
  - Multiple Access
    - ... because there can be many devices on the same wire trying to send
  - Collision Detection
    - If, while transmitting a signal, you detect another signal
    - Yours was “probably” lost
    - You should “wait a while” and then send it again

Ethernet Frames

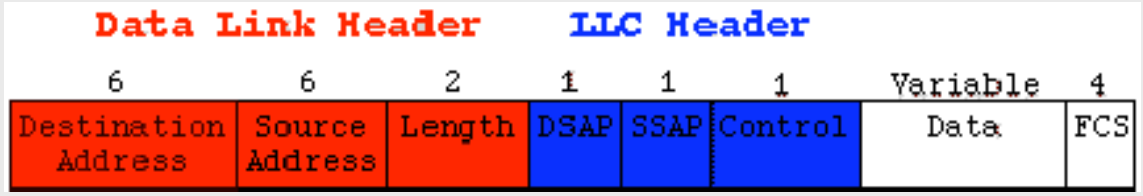
- To facilitate sharing, we bound the length of a message
  - Upper bound ensures that a single device can't use the channel for too long
    - 1514-1520 bytes maximum
  - Lower bound helps make guarantees about collision detection
    - 54 bytes minimum
  - These individual messages traveling on physical hardware are called "Frames"
  - Same term used for most network technologies

Frame Format

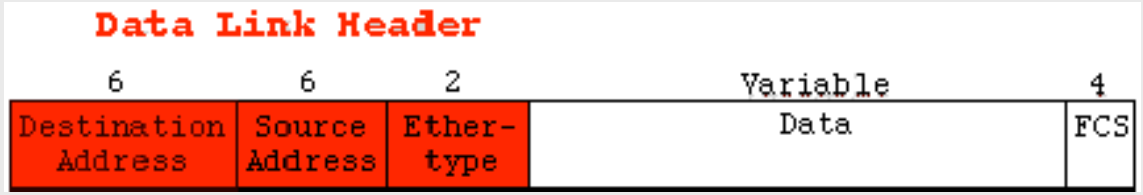
- Ethernet uses a fairly simple framing format
  - Initial pattern of bits referred to as a preamble
    - 64 bits (10101010...101011)
  - Addressing information
  - The data we're trying to send
  - Error detection data
    - 32-byte "Cyclic Redundancy Check" (CRC)
    - Also called FCS (Frame Check Sequence)

Ethernet Frame Types

802.3

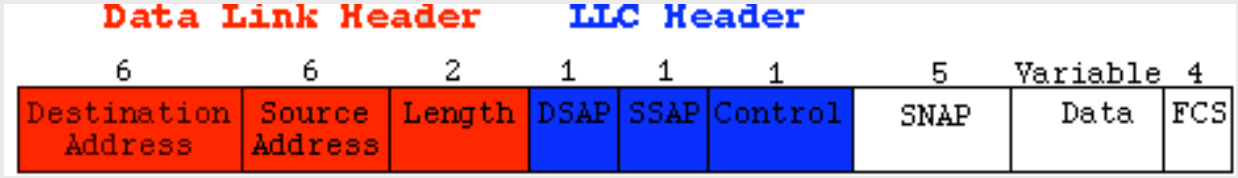


Type II



802.3 SNAP

SNAP=Sub-Network Access Protocol



"802.3 raw"

from http://www.wildpackets.com/compendium/EN/L1-Enet.html

The Ethernet II type field

- Some of the more common values (commonly written in hex)
  - Internet Protocol - 0x0800
  - Address Resolution Protocol (ARP) - 0x0806
  - Novell (IPX) - (0x8137,0x8138)
  - Appletalk - (0x809B)
  - IPv6 - (0x86DD)

Physical Address

- Each machine attached to a packet switch network is assigned a unique physical address
  - Sender must supply destination address when transmitting a packet
  - In most technologies, sender supplies source address as well
- Each technology defines its own address scheme
  - Ethernet in particular
    - 48-bit address obtained when device is manufactured
    - All 1s address reserved for broadcast
    - One-half of the addresses reserved for multicast (a restricted form of broadcast); assigned by software

Ethernet Hub aka Repeater

- Hardware device that connects two Ethernet cable segments and makes them appear to be a single cable
  - Repeats all packets from one cable to the other and vice versa
  - Performs the service one bit at a time
  - Introduces delay of 1 bit-time
  - Called “level 1” interconnect
  - Generalized to form a star rather than a bus
  - Rarely used today (but useful for troubleshooting)

Ethernet Bridge aka Switch

- Similar purpose as a repeater, but generally much smarter
  - Repeats at the packet level
    - Introduces delay of 1 packet-time
    - Does not forward collisions or noise
  - Does forward all broadcast packets
  - Adaptively "learns" source addresses and forwards only as needed
  - Called "level 2" interconnect
  - Can be very inexpensive, ≈ $40

Physical and IP Addresses

- Large Ethernets
  - Hubs/Switches can create large Ethernets
  - Addresses have no “structure”
    - No subnets or routing
- IP
  - provides subnet structure and routing
  - Independent of the physical hardware

Mapping Physical Addresses

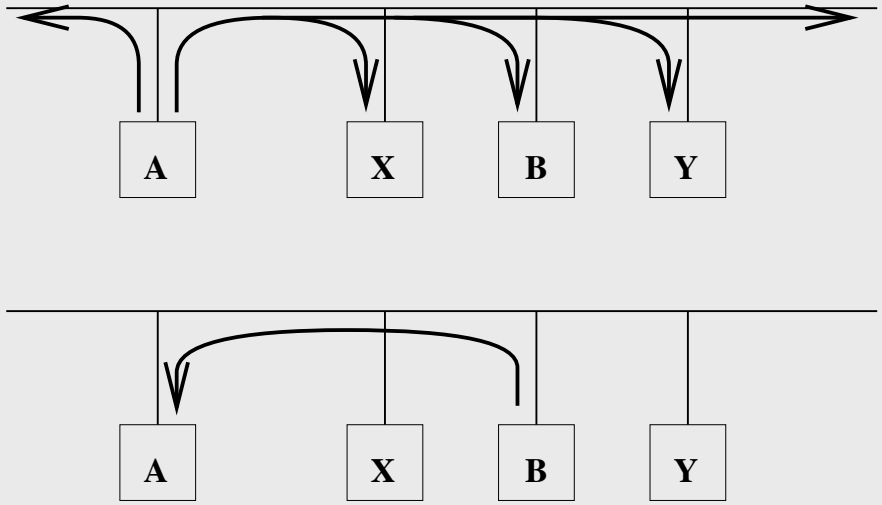
- Must use physical addresses to send and receive packets
- Therefore, must map IP addresses to physical addresses
- Particular method depends on underlying hardware technology
  - ATM, for example, is different
- Software to perform mapping built into network interface software in the Operating System
- Phone book analogy

Address Resolution Protocol (ARP)

- Internet standard for dynamic address binding
- Allows machine A to find machine B's physical address knowing only B's Internet address
- Uses hardware broadcast
- Note: ARP is only used to map addresses within a single physical network, never across multiple networks!

The ARP process

- “A” broadcasts a request containing an IP address
- “B” responds with a unicast reply



The ARP packet format

0	8	16	31
Hardware-Type		Protocol-Type	
HLEN	PLEN	Operation	
Sender HA (octets 0-3)			
Sender HA(octets 4-5)		Sender IA (octets 0-1)	
Sender IA (octets 2-3)		Target HA (octets 0-1)	
Target HA (octets 2-5)			
Target IA (octets 0-3)			

Example:

0	8	16	31
(Ethernet==1)		(IP)	
6	4	(request==1)	
8:0:2b:1b			
:b7:2c		132.235	
.1.2		xx:xx	
:xx:xx:xx:xx			
132.235.1.1			

Notes

- ARP table is merely a cache
  - Entries should time out and be invalidated
- Broadcasts are very expensive
  - Every machine on the network sees the request
  - Doesn't scale well to large networks
    - IPv6 uses multicast instead
- Other machines should update their entries, but not necessarily install them!

The “arp” command

- Unix and Windows
  - Display arp table
  - add and delete entries
  - does **not** initiate arp traffic

```
(08:51)hkruse hkruse$ arp -a
gate410.ent.ohiou.edu (132.235.16.212) at 0:14:51:ec:ee:33 on en1 [ethernet]
dhcp-018-021.cns.ohiou.edu (132.235.18.21) at 0:11:24:a7:67:47 on en1 [ethernet]
wireless7b.cns.ohiou.edu (132.235.19.200) at 0:3:47:dd:69:3a on en1 [ethernet]
sn19gwv.cns.ohiou.edu (132.235.19.254) at 0:3:47:dd:69:3a on en1 [ethernet]
```

A Quick Example

- Note: “tcpdump” is a command line packet capture program available on all unix systems

```
(09:27)hkruse hkruse$ sudo tcpdump -n -e -vv -i en1 arp
tcpdump: listening on en1, link-type EN10MB (Ethernet), capture size 96 bytes

09:28:48.541711 00:16:cb:08:2a:ee > ff:ff:ff:ff:ff:ff, ethertype ARP (0x0806),
length 42: arp who-has 132.235.19.254 tell 132.235.18.68

09:28:48.944210 00:03:47:dd:69:3a > 00:16:cb:08:2a:ee, ethertype ARP (0x0806),
length 60: arp reply 132.235.19.254 is-at 00:03:47:dd:69:3a
```

Resources

- On proquest.safaribooksonline.com
  - Ethernet: The Definitive Guide by Charles E. Spurgeon
    - O'Reilly, February 01, 2000,ISBN-10: 1-565-92660-9,ISBN-13: 978-1-56-592660-8
  - Network Performance Baselining by Daniel Nassar, Section 8.6
    - Sams, May 09, 2000, ISBN-10: 1-57870-240-2, ISBN-13: 978-1-57870-240-4