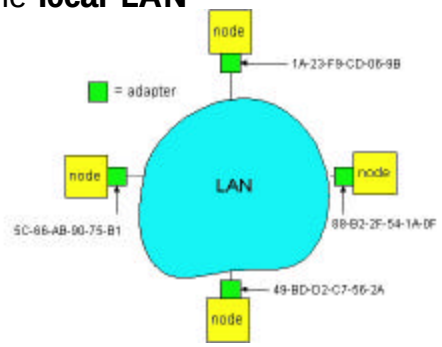
LAN Addresses and ARP

- **IP address**: drives the packet to destination **network**
- **LAN** (or MAC or Physical) **address**: drives the packet to the destination node's LAN interface card (adapter card) on the **local LAN**
- **48 bit MAC address** (for most LANs); burned in the adapter ROM



Summary of MAC protocols

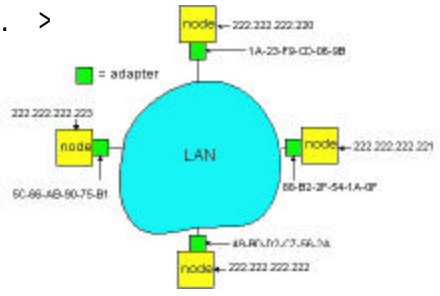
- What do you do with a shared media?
  - Channel Partitioning, by time or frequency
    - Code Division MA, Wave Division MA
  - Random partitioning (dynamic),
    - ALOHA, S-ALOHA, CSMA, CSMA/CD
  - Taking Turns
    - polling from a central cite, token passing
- For satellites, sensing if the channel is busy (if the channel is carrying a signal) is hard: ALOHA
- For LANs, carrier sensing is easier, but no perfect): CSMA
- Improve things is Collision Detection exists (CSMA/CD)
- 802.3 (ethernet) is CSMA/CD

LAN Address (more)

- MAC address allocation administered by IEEE
- A manufacturer buys a portion of the address space (to assure uniqueness)
- Analogy:
  - (a) MAC address: like Social Security Number
  - (b) IP address: like postal address
- MAC flat address => portability
- IP hierarchical address NOT portable (need mobile IP)
- Broadcast LAN address: 1111… … … … .1111

ARP: Address Resolution Protocol

- Each IP node (Host, Router) on the LAN has **ARP** module and Table
- ARP Table: IP/MAC address mappings for **some** LAN nodes
  - < IP address; MAC address; TTL>
  - < … … … … … … … … … … … … >
- TTL (Time To Live): timer, typically 20 min



ARP (more)

- Host A wants to send packet to destination IP addr XYZ on same LAN
- Source Host first checks own ARP Table for IP addr XYZ
- If XYZ **not** in the ARP Table, ARP module **broadcasts** ARP pkt:

  < XYZ, MAC (?) >
- ALL nodes on the LAN accept and inspect the ARP pkt
- Node XYZ responds with **unicast** ARP pkt carrying own MAC addr:

  < XYZ, MAC (XYZ) >
- MAC address **cached** in ARP Table

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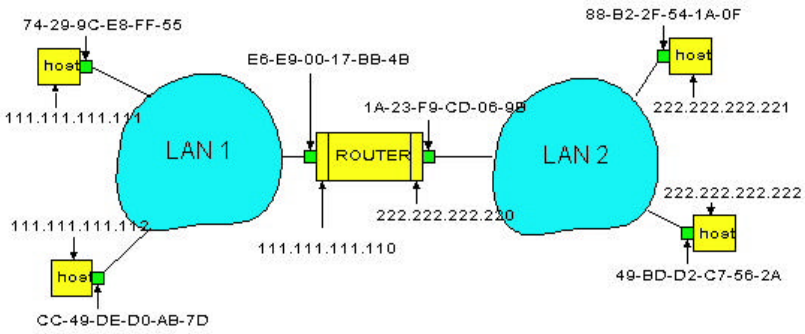
Routing pkt to another LAN

- Say, route packet from source IP addr <111.111.111.111> to destination addr <222.222.222.222>



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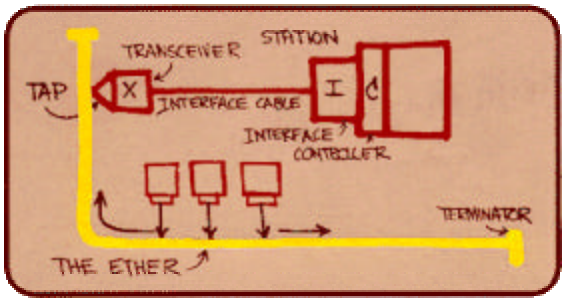
Ethernet

- Widely deployed because:
  - Cheap as dirt! $20 for 100Mbs!
  - First LAN technology
  - Simpler and less expensive than token LANs and ATM
  - Kept up with the speed race: 10, 100, 1000 Mbps
  - Many E-net technologies (cable, fiber etc). But they all share common characteristics



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Ethernet Frame Structure

- Sending adapter encapsulates an IP datagram (or other network layer protocol packet) in **Ethernet Frame** which contains a Preamble, a Header, Data, and CRC fields
- **Preamble**: 7 bytes with the pattern 10101010 followed by one byte with the pattern 10101011; used for synchronizing receiver to sender clock (clocks are never exact, some drift is highly likely)

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Ethernet Frame Structure (more)

- Header contains Destination and Source Addresses and a Type field
- **Addresses**: 6 bytes, frame is received by all adapters on a LAN and dropped if address does not match
- **Type**: indicates the higher layer protocol, mostly IP but others may be supported such as Novell IPX and AppleTalk)
- **CRC**: checked at receiver, if error is detected, the frame is simply dropped

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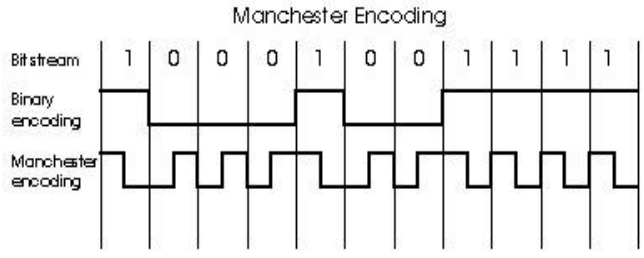
Baseband Manchester Encoding

- Baseband here means that no carrier is modulated; instead bits are encoded using Manchester encoding and transmitted directly by modified voltage of a DC signal
- Manchester encoding ensures that a voltage transition occurs in each bit time which helps with receiver and sender clock synchronization



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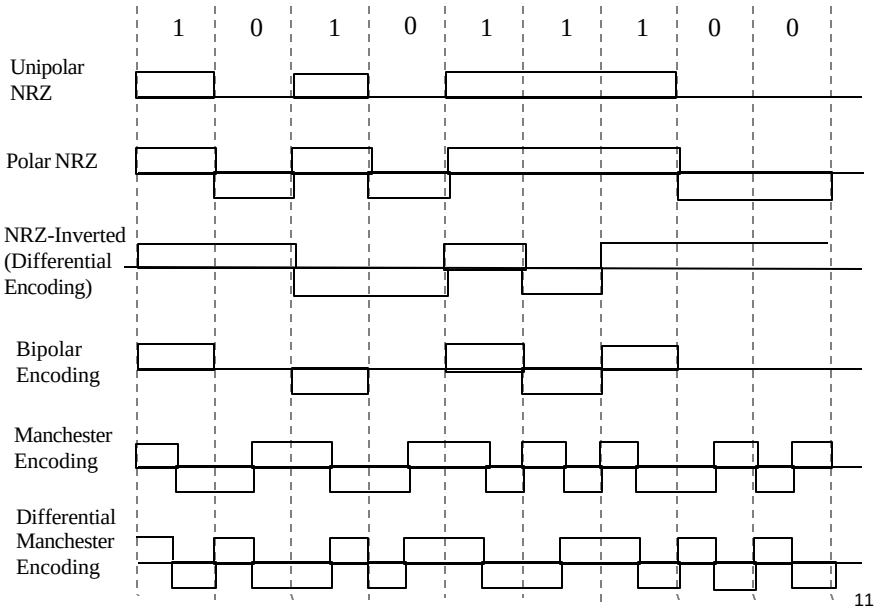
More Baseband Encoding



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4B/5B Encoding

- Manchester only has 50% efficiency.
- Insert extra bits into the bit stream to break up long sequence of 0s and 1s.
- 4-bit data are encoded in a 5-bit code.
- No more than one leading 0 and no more than two trailing 0s.
- Use NRZI (non-return to zero inverted) to transmit.
- 4B/5B: 80% efficiency.
- Used in 100Mbit Ethernet.

4-Bit Data Symbol	5-Bit Code
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1110	11100
1111	11101

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CSMA/CD

```
A: sense channel, if idle
    then {
            transmit and monitor the channel;
            If detect another transmission
              then {
                 abort and send jam signal;
                 update # collisions;
                 delay as required by exponential backoff algorithm;
                 goto A
                 }
             else {done with the frame; set collisions to zero}
        }
    else {wait until ongoing transmission is over and goto A}
```


CSMA/CD (more)

- **Jam Signal**: to make sure all other transmitters are aware of the collision; 48 bits;
- **Exponential Backoff**:
  - Goal is too adapt the offered rate by transmitters to the estimated current load (ie backoff when load is heavy)
  - After the first collision Choose K from {0,1}; delay is K x 512 bit transmission times
  - After second collision choose K from {0,1,2,3}…
  - After ten or more collisions, choose K from {0,1,2,3,4,… ,1023}

CSMA/CD (more)

- Note that under this scheme a new frame has a chance of sneaking in in the first attempt, even in heavy traffic
- **Ethernet Efficiency**: under heavy traffic and large number of nodes:

$$Efficiency = \frac{1}{1 + (5 * \frac{t_{prop}}{t_{trans}})}$$

- (Does this help you at all?)

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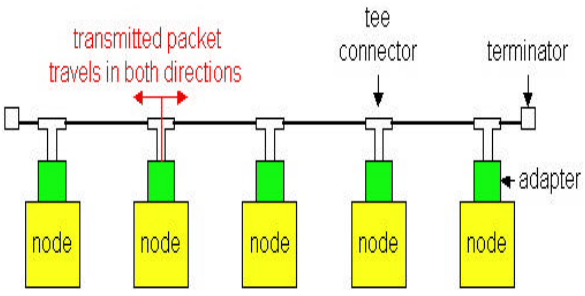
Ethernet Technologies: 10Base2

- 10==10Mbps; 2==under 200 meters maximum length of a cable segment; also referred to as "Cheapnet"
- Uses thin coaxial cable in a bus topology
- Repeaters are used to connect multiple segments (up to 5); a repeater repeats the bits it hears on one interface to its other interfaces, ie a physical layer device only!



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10BaseT and 100BaseT

- 10/100 Mbps rate; latter called “fast ethernet”
- T stands for Twisted Pair
- Hub to which nodes are connected by twisted pair, thus “star topology”
- CSMA/CD implemented at the Hub

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10BaseT and 100BaseT (more)

- Max distance from node to Hub is 100 meters
- Hub can disconnect a “jabbering adapter”; 10base2 would not work if an adapter does not stop transmitting on the cable
- Hub can gather monitoring information and statistics for display to LAN administrators
- 100BaseT does not use Manchester encoding; it uses 4B/5B for better coding efficiency

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Gbit Ethernet

- Use standard Ethernet frame format
- Allows for Point-to-point links and shared broadcast channels
- In shared mode, CSMA/CD is used; short distances between nodes to be efficient
- Uses Hubs called here “Buffered Distributors”
- Full-Duplex at 1 Gbps for point-to-point links