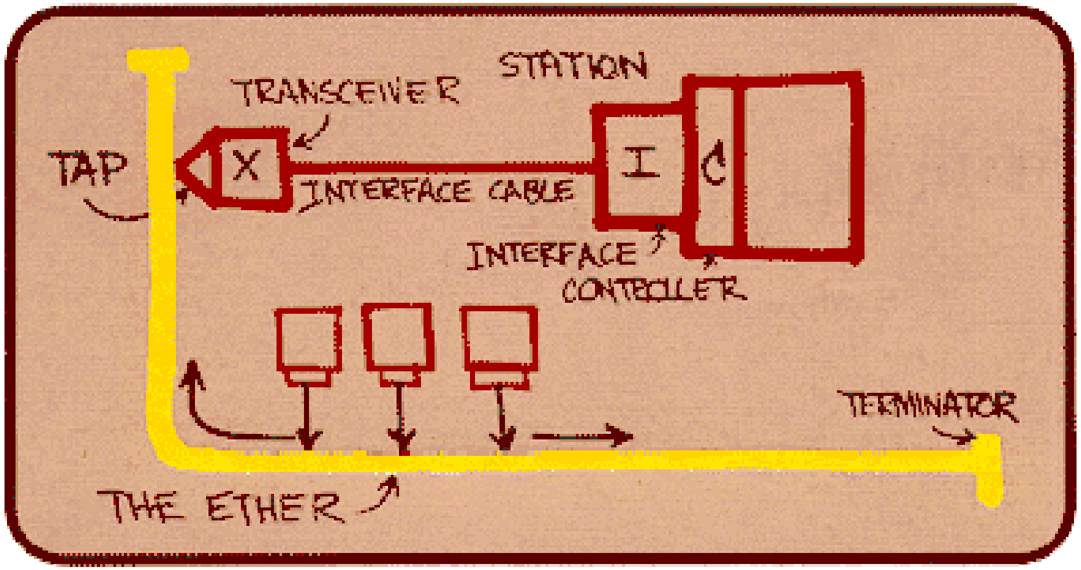
Physical Layer Issues and Methods

Content

- 802.3 Physical Layer
- Ethernet Technology
- Physical Layer Encoding

Ethernet Standard Defines Physical Layer

- 802.3 standard defines both MAC *and* physical layer details
- Even though we have worked from top down, Ethernet was about hardware first



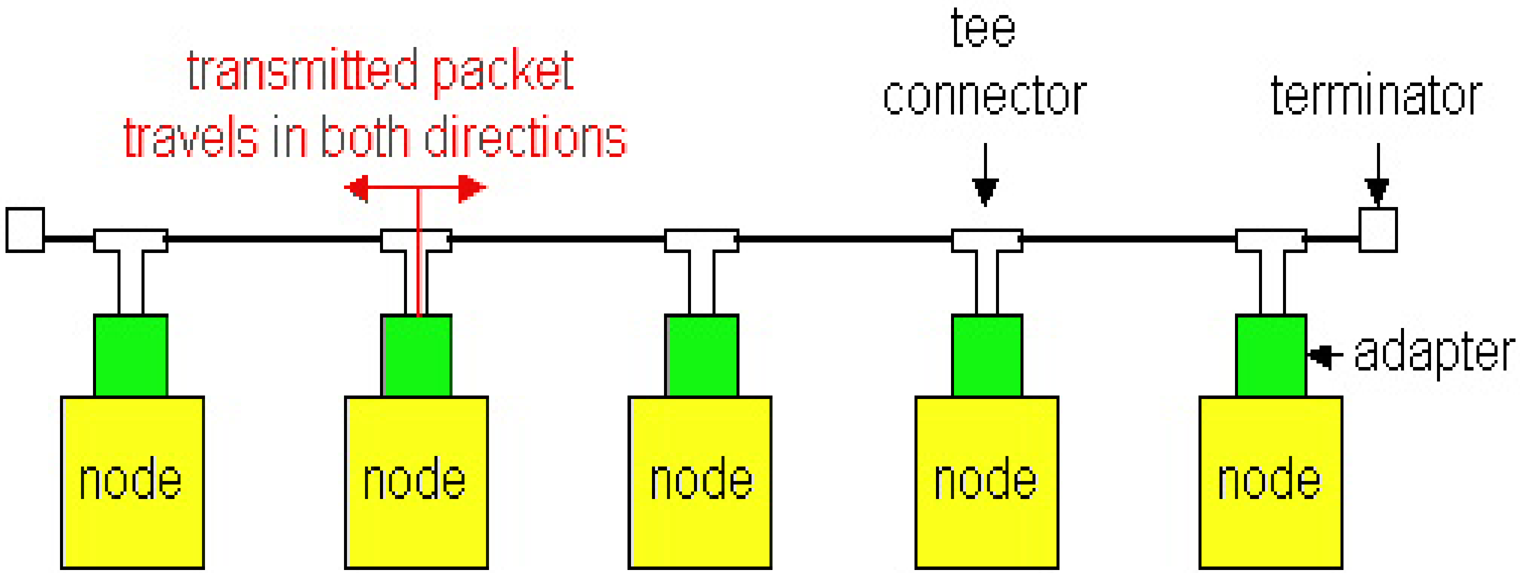
Metcalfe's original Ethernet Sketch

Physical Layer Configurations for 802.3

- Physical layer configurations are specified in three parts
- Data rate (10, 100, 1,000)
  - 10, 100, 1,000Mbps
- Signaling method (base, broad)
  - Baseband
    - Digital signaling
  - Broadband
    - Analog signaling
- Cabling (2, 5, T, F, S, L)
  - 5 - Thick coax (original Ethernet cabling)
  - F – Optical fiber
  - S – Short wave laser over multimode fiber
  - L – Long wave laser over single mode fiber

Ethernet Technologies: 10Base2

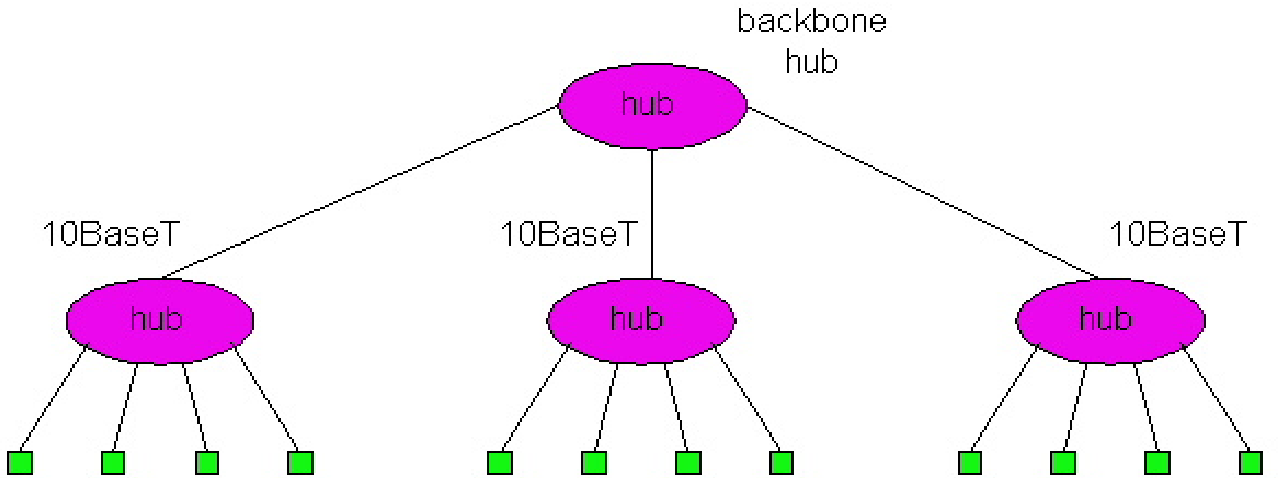
- 10: 10Mbps; 2: under 185 (~200) meters cable length
- Thin coaxial cable in a bus topology



- Repeaters used to connect multiple segments
  - Repeater repeats bits it hears on one interface to its other interfaces: physical layer device only!

10BaseT and 100BaseT

- 10/100 Mbps rate
- T stands for Twisted Pair
- Hub(s) connected by twisted pair facilitate “star topology”
  - Distance of any node to hub must be < 100M



Switched Ethernet

- Switches forward and filter frames based on LAN addresses
  - It's not a bus or a router (although simple forwarding tables are maintained)
- Very scalable
  - Options for many interfaces
  - Full duplex operation (send/receive frames simultaneously)
- Connect two or more "segments" by copying data frames between them
  - Switches only copy data when needed
    - key difference from repeaters
- Higher link bandwidth
  - Collisions are completely avoided
- Much greater aggregate bandwidth
  - Separate segments can send at once

Physical Layer Data Transfer

- Signals are placed on wire via transceivers
- Problem is how to do transmit 0's and 1's (signal encoding) in a robust fashion
  - Binary voltage encoding
    - Map 1 to high voltage
    - Map 0 to low voltage
  - How are consecutive 0's or 1's detected at node?
    - Clock synchronization problem
- Transmitted signals have a variety of problems
  - Attenuation
  - Noise
  - Dispersion

Encoding Taxonomy

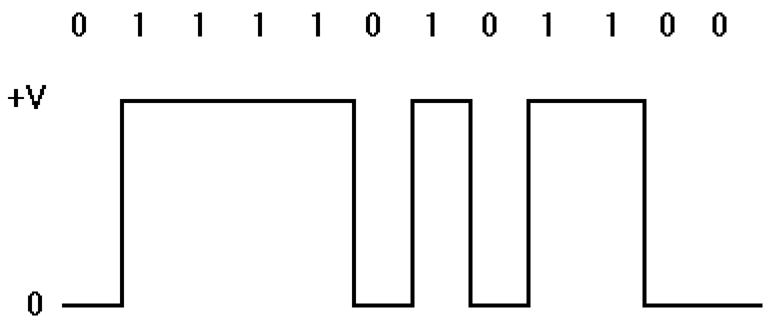
- Digital data, digital signal
  - Codes which represent bits
  - Our focus
  - Many options!
- Analog data, digital signal
  - Sampling to represent voltages
- Digital data, analog signal
  - Modulation to represent bits
- Analog data, analog signal
  - Modulation to represent voltages

Encoding Requirements

- Small bandwidth
  - Enables more efficient use of signaling capability
- Low DC level
  - Increases transmission distance
- Frequent changes in the voltage
  - Enables synchronization between the transmitter and the receiver without the addition of extra signal
- Non-polarized signal
  - Enables use of 2-wire cable to not be affected by the physical connection of the wires.

Non-Return to Zero (NRZ)

- High voltage = 1 and low voltage = 0
- Voltage does not return to 0 between bits
- Receiver keeps average of signal seen to distinguish 0 from 1

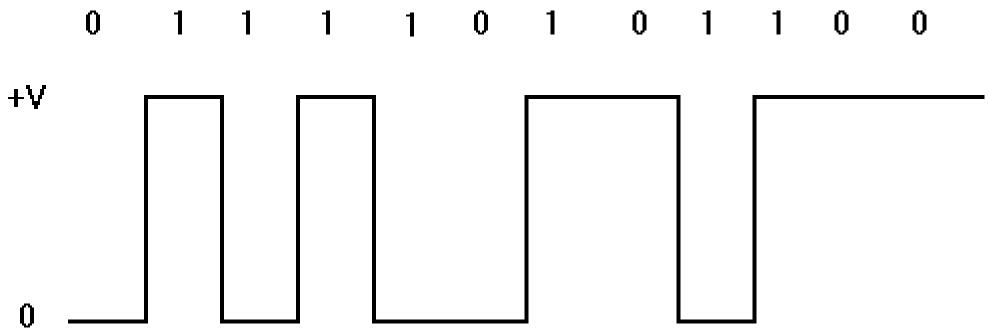


NRZ

- Benefits
  - Easy to engineer – most basic encoding
  - Efficient use of bandwidth – not many transitions
- Drawbacks
  - Long strings of 0’s can be confused with no signal
  - Long strings of 1’s can cause signal average to wander
  - Clock synchronization can be poor
  - High DC – average of ½V

NRZ-Inverted (NRZI)

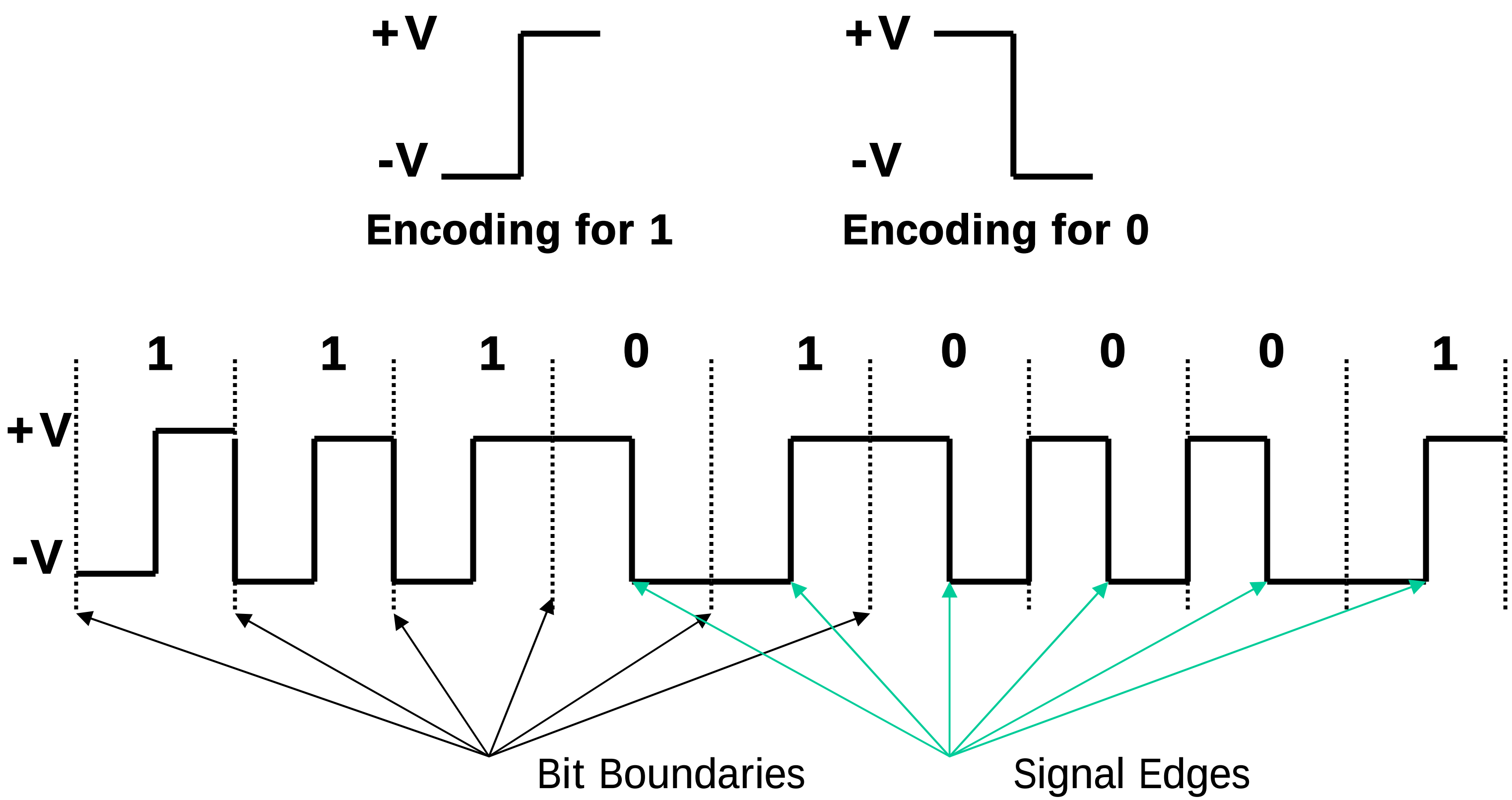
- NRZI addresses clock synchronization problem
  – Encodes 1 by transitioning from current signal
  – Encodes 0 by staying at current signal
    - So we're still out of luck on consecutive strings of 0's



Manchester Data Encoding

- Explicit merging of clock and bit stream
  - Each bit contains a transition
    - High-low = 1
    - Low-high = 0
  - Enables effective clock signal recovery at receiver
    - Clocks are still needed to differentiate between bit boundaries
- Poor bandwidth utilization
  - Effective sending rate is cut in half
- Used by 802.3 – 10Mbps Ethernet

Manchester Phase Encoding



Cable category

Type	Application	Distance	Frequency
Cat 1	Voice		
Cat 2	4 Mb/s (localtalk)		
Cat 3	10 Mb/s (ethernet)	100 m	16 MHz
Cat 4	20 Mb/s (16Mb token)		20 MHz
Cat 5	100 Mb/s (fast ethernet)	100 m	100 MHz
Cat 5e **(extended)**	1000 Mb/s (Gigabit Ethernet)	100 m	100 MHz
Cat 6			250 MHz
Cat 7			600 MHz

RJ 45 Connector Illustration

Contact	**10Base-T Signal**	**100base-TX Signal**	**1000Base-T Signal**
1	TD+ (Transmit Data)	TX+ (Transmit Data)	Bidir_D **A+** (Bidirectional Data)
2	TD- (Transmit Data)	TX- (Transmit Data)	Bidir_D **A-** (Bidirectional Data)
3	RD+ (Receive Data)	RD+ (Receive Data)	Bidir_D **B+** (Bidirectional Data)
4	Not used	Not used	Bidir_D **C+** (Bidirectional Data)
5	Not used	Not used	Bidir_D **C-** (Bidirectional Data)
6	RD- (Receive Data)	RD- (Receive Data)	Bidir_D **B-** (Bidirectional Data)
7	Not used	Not used	Bidir_D **D+** (Bidirectional Data)
8	Not used	Not used	Bidir_D **D-** (Bidirectional Data)