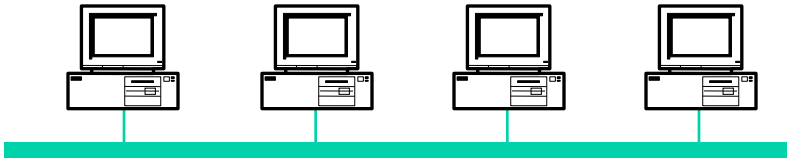
COMP/ELEC 429/556
Introduction to Computer Networks

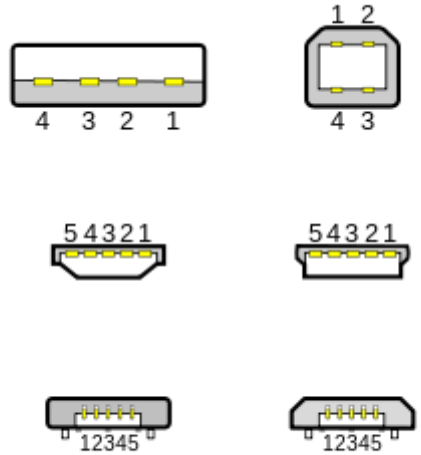
Encoding and Framing

Some slides used with permissions from Edward W. Knightly, T. S. Eugene Ng, Ion Stoica, Hui Zhang

Let's Begin with the Most Primitive Network



A Real Data Link Example



USB 1.x/2.0 standard pinout

Pin	Name	Wire color	Description
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3	D+	Green	Data+
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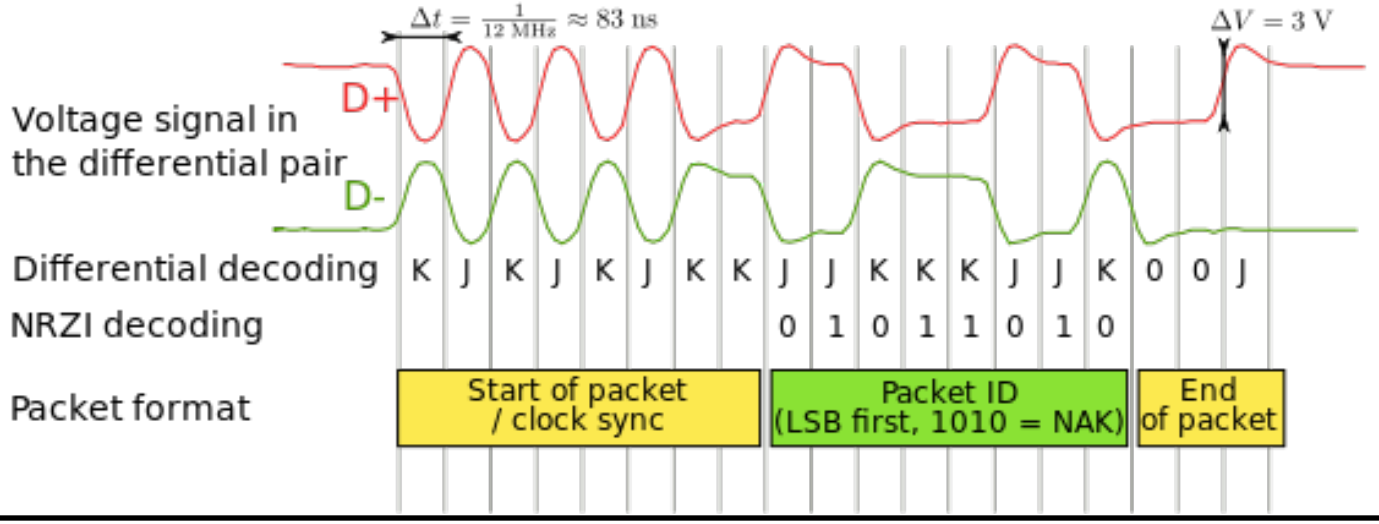
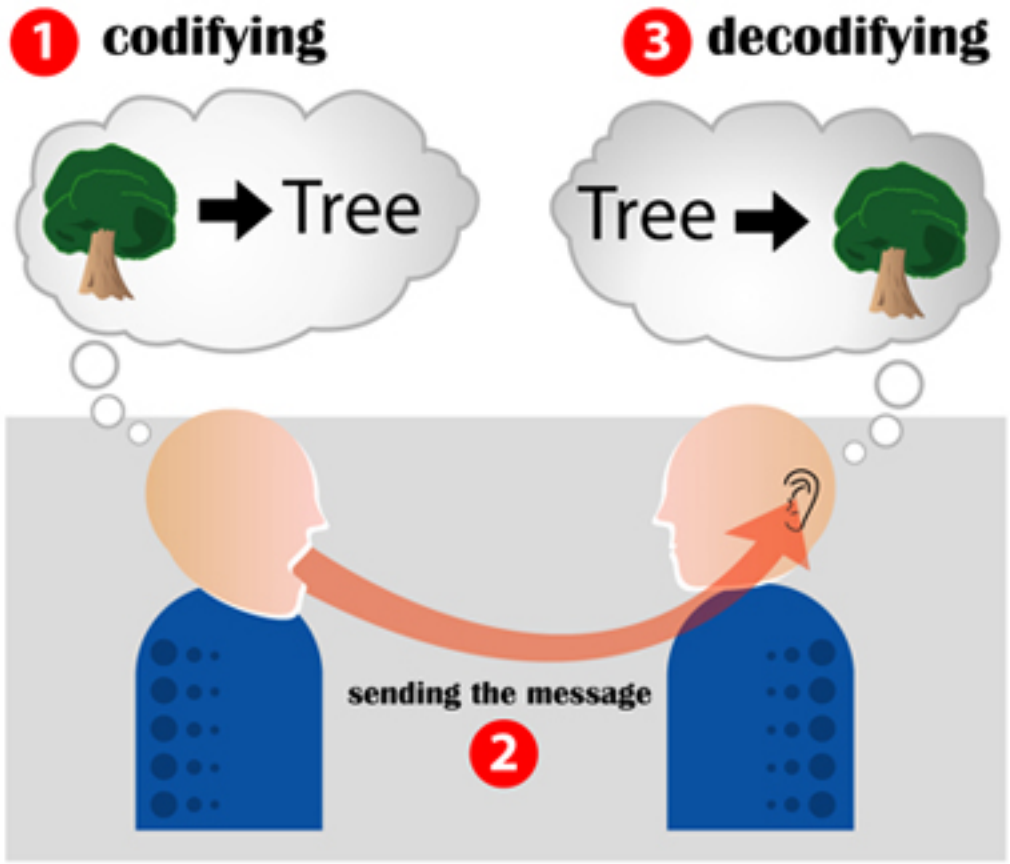
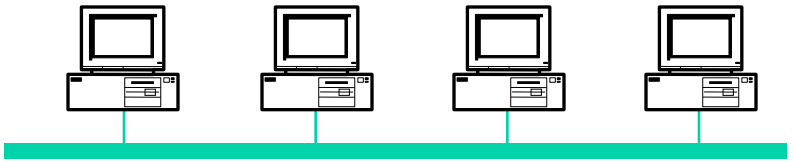


Encoding



Framing

Typical Services for Point-to-Point Communications



- Encoding
  - How to encode 1's and 0's?
- Framing
  - How to create frames/packets that have explicit beginning and end?
- Addressing
  - How to identify the communication parties?
- Access control
  - How to coordinate multiple senders who share one data link?
- Error detection
  - How to detect if bits have been flipped accidentally?
- Error recovery
  - How to correct detected errors?
- Flow control
  - How to ensure sender doesn't send faster than the receiver can handle?

Bit Stream Encoding

- Specify how bits are represented in the analog signal
- Challenges:
  - Efficiency: ideally, bit rate is maximized
  - Robustness: minimize the chance of mis-interpreting received signal

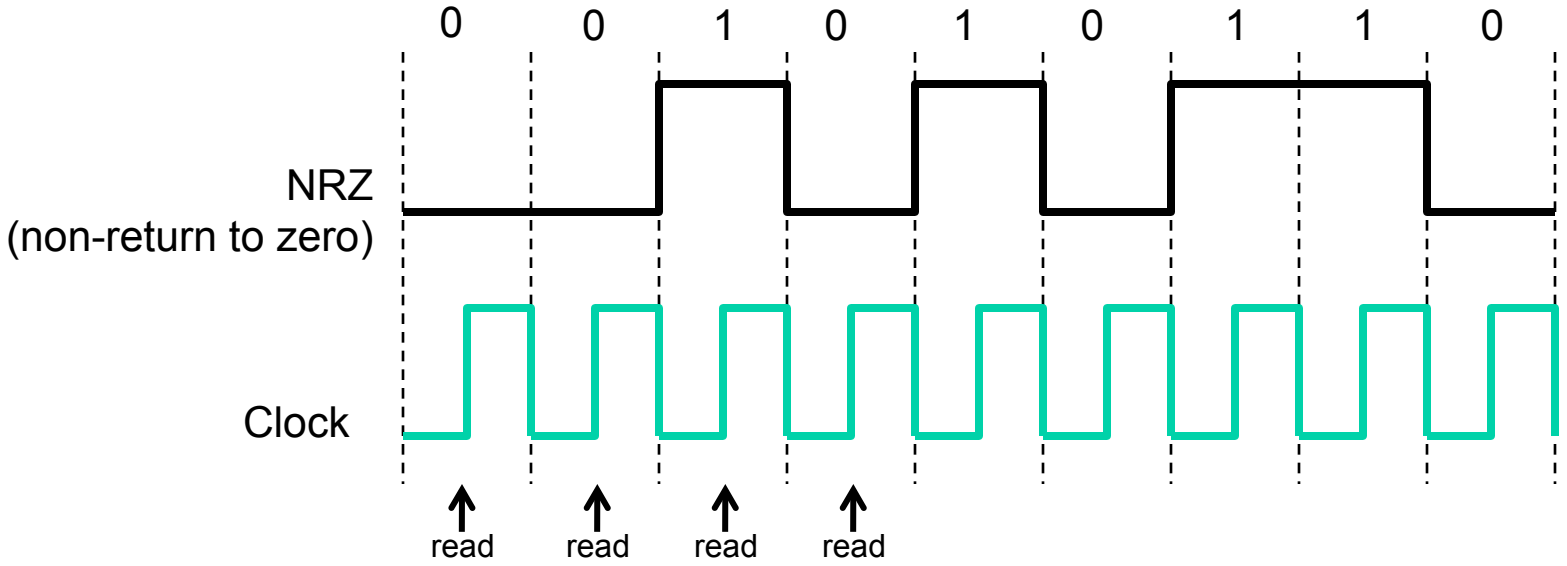
Assumptions

- We use two discrete signals, high and low, to encode 1 and 0
- There is a clock used to pace transmission; there is a clock used to sample the received signal
- Sender and receiver do not have perfect clocks
  - i.e. clocks can drift!

Non-Return to Zero (NRZ)

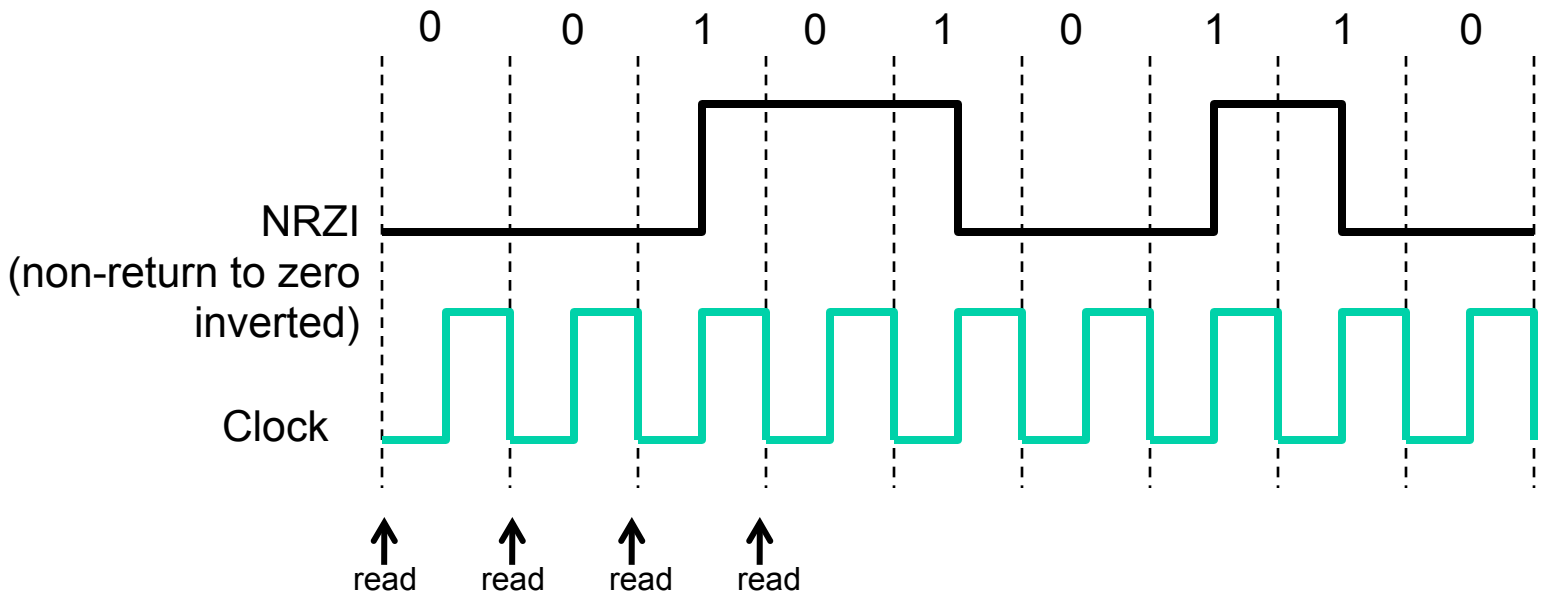
- 1 → high signal; 0 → low signal
- Efficiency?
  - Assumption: 1 bit of information conveyed per sampling period is considered 100% efficient
- Robustness?
  - When there is a long sequence of 1's or 0's

    Sensitive to clock skew, i.e., difficult to do clock recovery



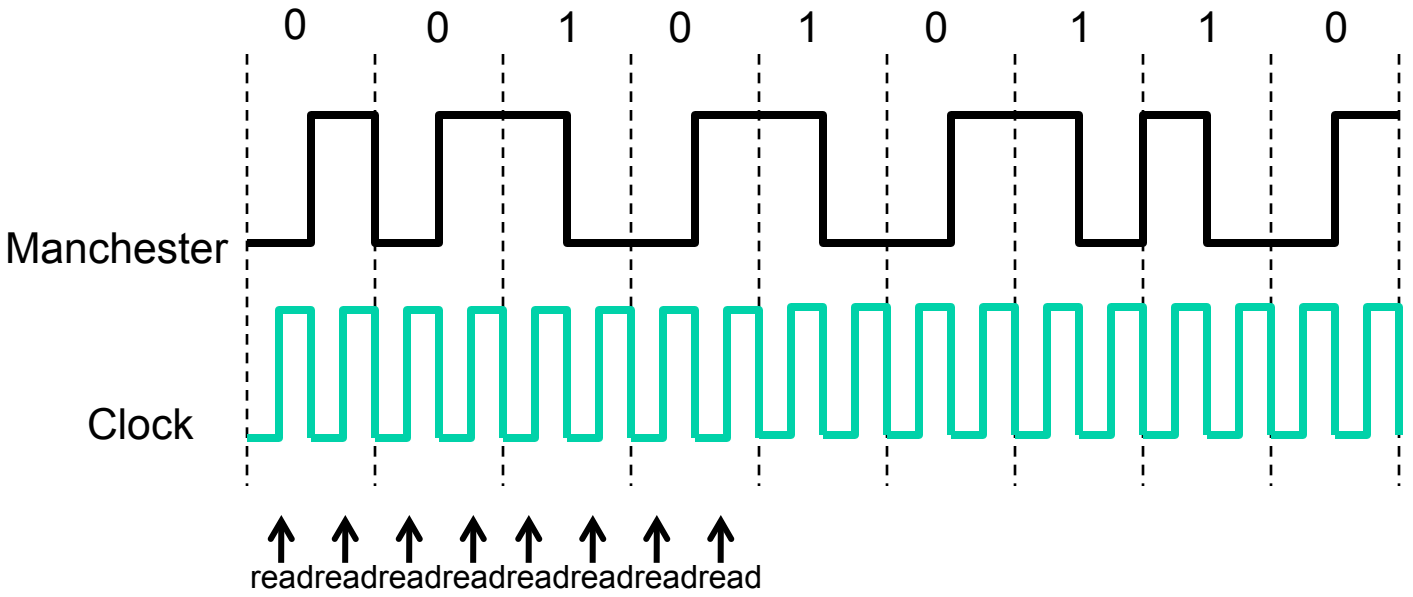
Non-Return to Zero Inverted (NRZI)

- 1 → make transition; 0 → stay at the same level
- Solve problem of long sequences of 1's, but not long sequences of 0's



Manchester

- 1 → high-to-low transition; 0 → low-to-high transition
- Addresses clock recovery problems
- Disadvantage: signal transition rate doubled
  - I.e. useful data rate on same physical medium halved
  - Efficiency of 50%



4-bit/5-bit (100Mb/s Ethernet)

- Goal: address inefficiency of Manchester encoding, while avoiding long periods of low signals
- Solution:
  - Use 5 bits to encode every sequence of 4 bits such that no string of encoded bits will have more than 3 consecutive 0's
  - Use NRZI to transmit the encoded bits
  - Efficiency is 80%

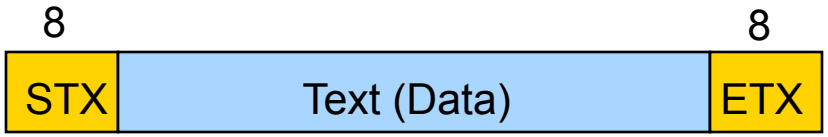
4-bit	5-bit
0000	
0001	
0010	
0011	
0100	
0101	
0110	
0111	

4-bit	5-bit
1000	
1001	
1010	
1011	
1100	
1101	
1110	
1111	

Framing

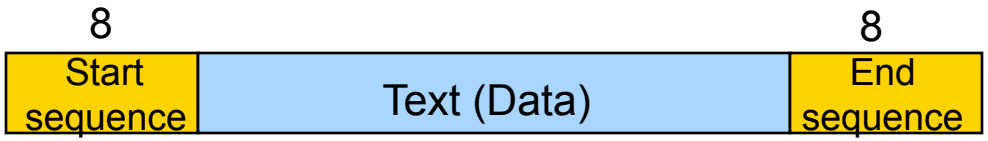
- Specify how blocks of data are transmitted between two nodes connected on the same physical media
- Decide when a frame starts/ends

Byte-Oriented Protocol: Sentinel Approach (e.g. PPP)



- STX – start of text
- ETX – end of text
  - STX and ETX can be the same
- Problem: what if ETX appears in the data portion of the frame?
- Solution
  - If ETX appears in the data, introduce a special character DLE (Data Link Escape) before it
  - If DLE appears in the text, introduce another DLE character before it
  - Like in C programming, “Say \”Hello\””, (\ is the escape character)

Bit-Oriented Protocol (HDLC)

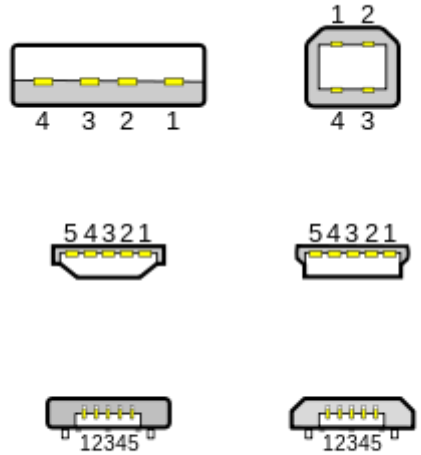


- Both start and end sequence can be the same
  - E.g., 01111110 in HDLC (High-level Data Link Protocol)
- Sender: in data portion inserts a 0 after five consecutive 1s
  - "Bit stuffing"
- Receiver: when it sees five 1s makes decision on the next two bits
  - If next bit 0 (this is a stuffed bit), remove it
  - If next bit 1, look at the next bit
    - If 0 this is end-of-frame (receiver has seen 01111110)
    - If 1 this is an error, discard the frame (receiver has seen 01111111)

Byte Counting Approach

- Instead of using an end of frame sequence...
- Sender: insert the length of the data (in bytes) at the beginning of the frame, i.e., in the frame header
- Receiver: extract this length and decrement it every time a byte is read. When this counter becomes zero, we are done

A Real Data Link Example



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