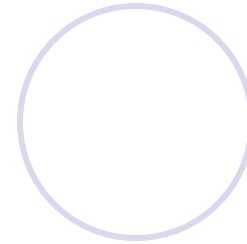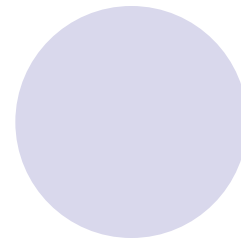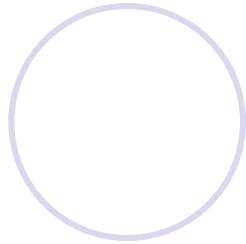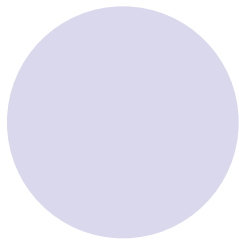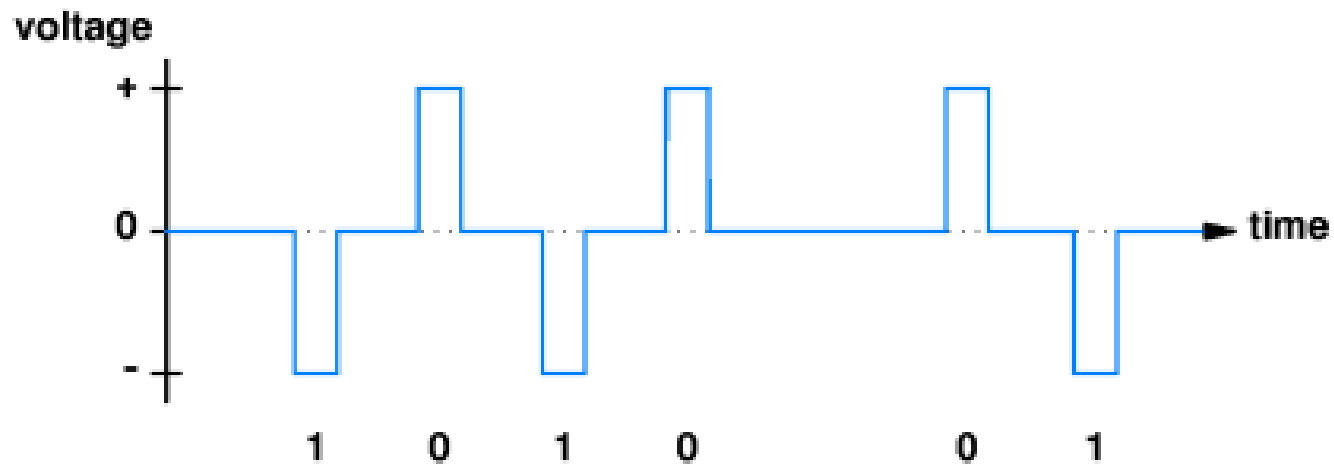# Introduction to Computer Networks

Lecture 3

Local Asynchronous Communication

- Signals are sent out from one node to another in the physical layer
- Binary bits are sent over data link layers
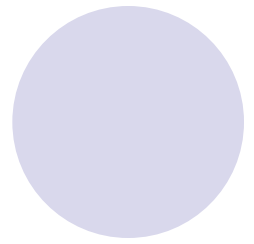
# Bits can be sent by varying the voltage

Local Asynchronous Communication

- asynchronous communications
  - a sender and receiver do not need to coordinate before data can be transmitted
  - Do not know the time the next byte will be sent
  - wait arbitrarily long between transmissions
- synchronous communications
  - each bit is sent at a specified time after the previous bit
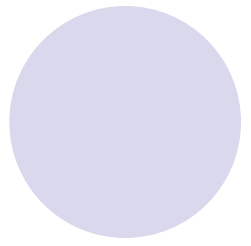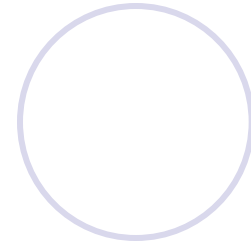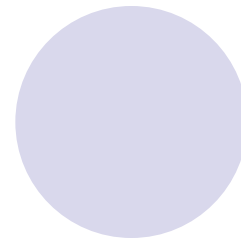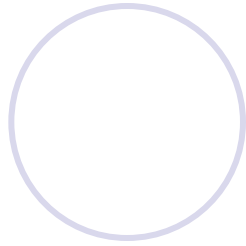- Bits and Bytes

RS-232

- byte-wise asynchronous, bit-wise synchronous communication

- RS-232 represents a 1 as -15 volts and 0 as +15 volts.

- The signal is always +15 or -15 without returning to 0 between bits

- there is nothing to send, the line is kept at the -15 volt state

- Why not 0?

RS-232
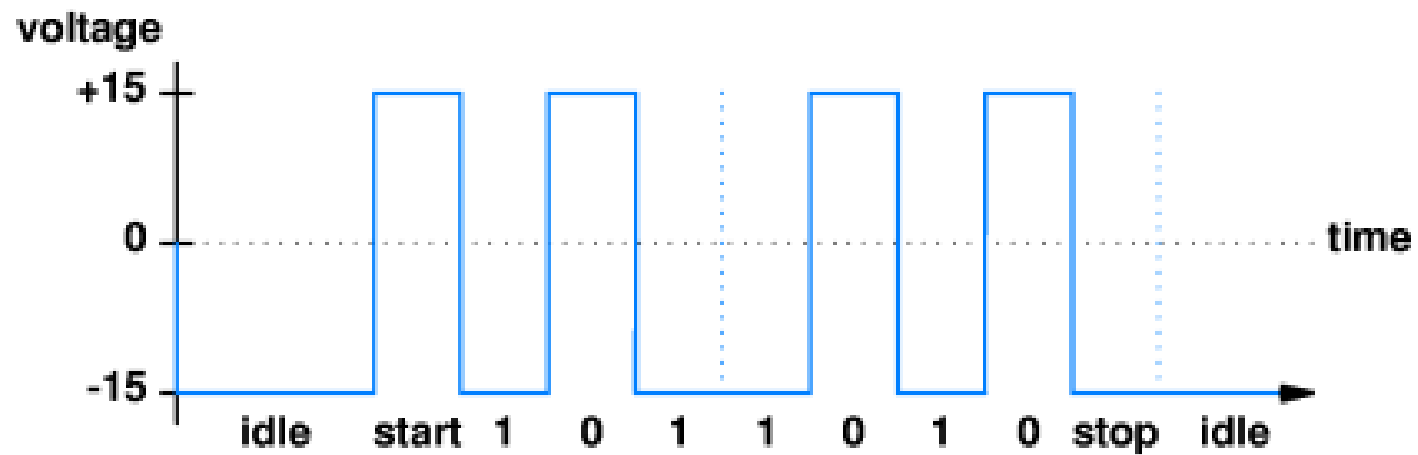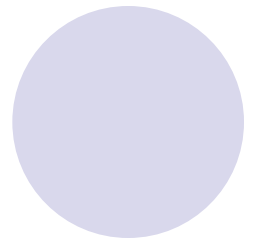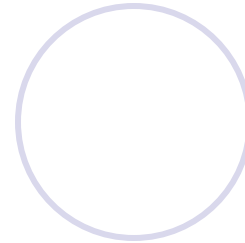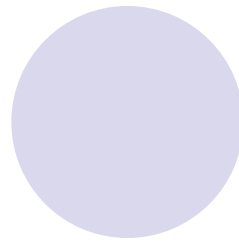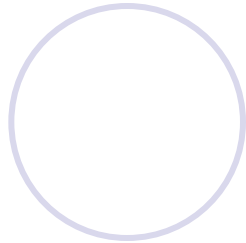
RS-232

- Start bit
  - Extra 0 before sending
- Stop bit
  - Return to 0 at the end of sending
  - leave the line idle for a minimum time
- **Framing error**
- Sending not fit this pattern (start bit, data, stop bit)
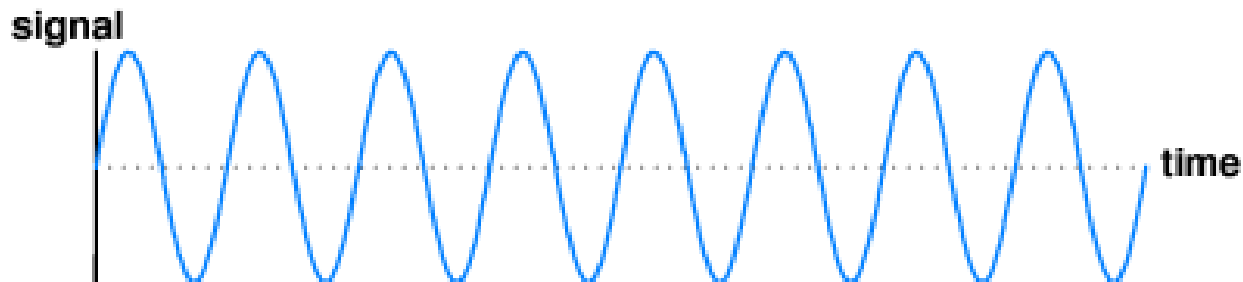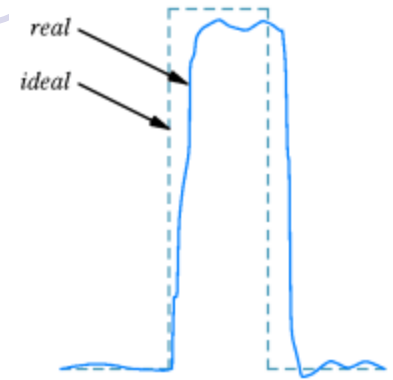
Baud rate

- number which signal values can change per second

- 1200 baud means the signal can change its value 1200 times in a second.

- Transmission rate
  - the number of bits per second

- Same?

Long-Distance Communication

- Signal los

- Sine waves propagate better than square waves

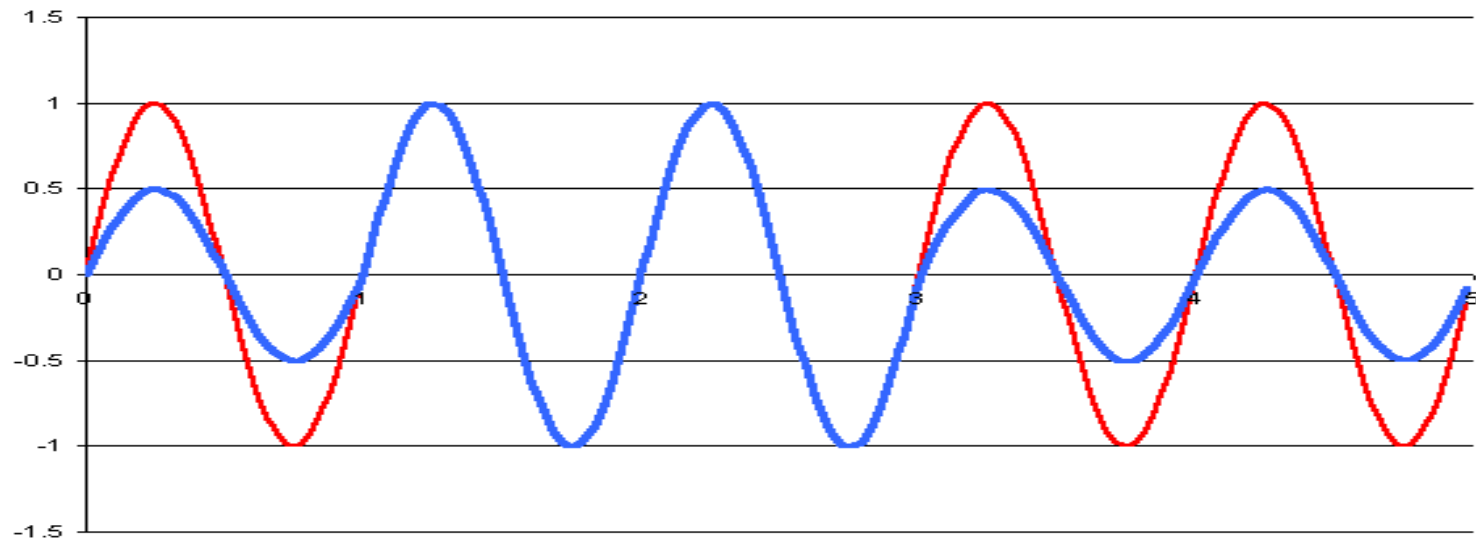- how to use the carrier (sine wave) to represent the digital bits

Modulation Techniques

- *modulation*
  - transmitter needs to modify the carrier slightly
  - Modem
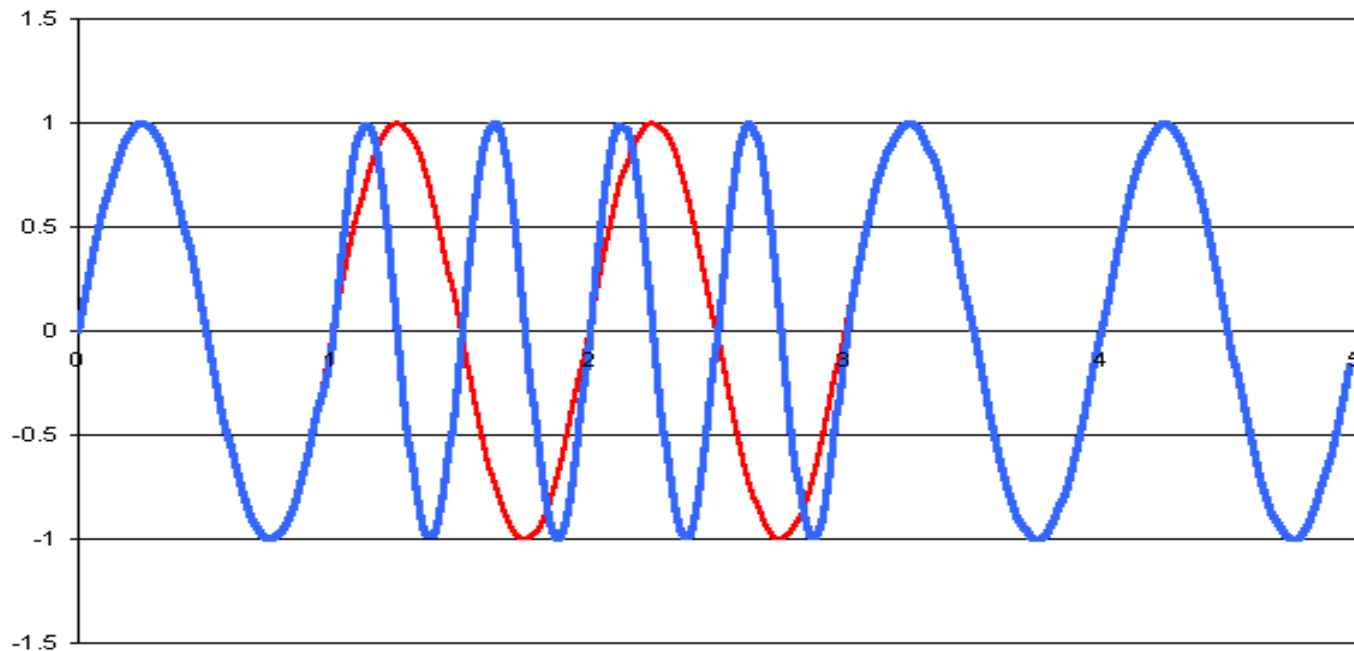- Amplitude
- Frequency
- Phase shift

Amplitude

- A 0 bit might be represented by a wave that has half the energy or height in the graph. A 1 bit might be represented by a full sized wave. E.g.,01100
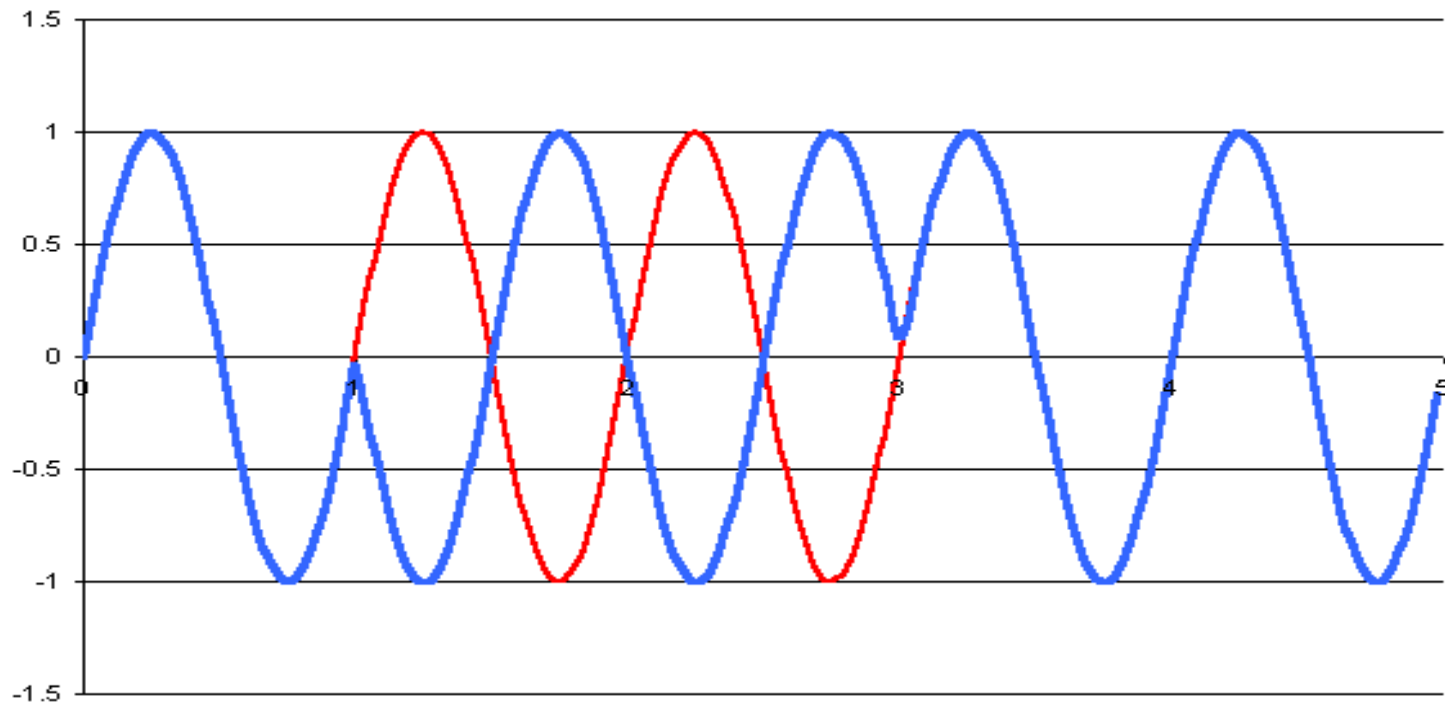
Frequency

- A 0 bit might be represented by a low frequency wave. A 1 bit might be represented by a high frequency wave. E.g., 01100

Phase shift

- A 0 bit might be represented by an unchanged wave. A 1 bit might be represented by a wave shifted by 180°. E.g., 01100
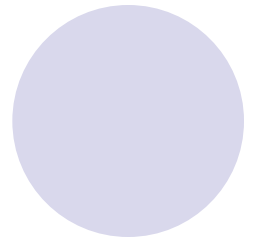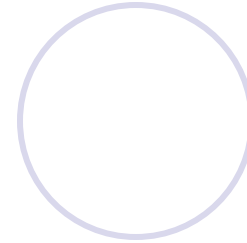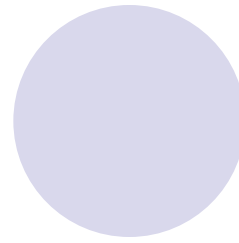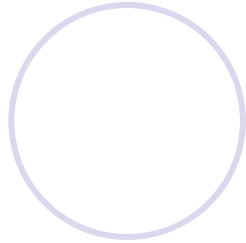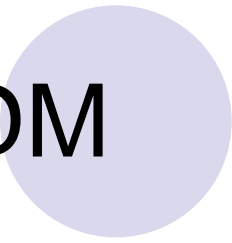
Multiplexing

- FDM
  - Frequency-Division Multiplexing
  - WDM: Wavelength Division Multiplexing

- TDM
  - Time-Division Multiplexing

FDM

- allows multiple pairs of senders and receivers to communicate over a shared medium simultaneously. The carrier used by each pair operates at a unique frequency that does not interfere with the others.

- when the concept of FDM is applied to optical transmission systems