Modulation and Encoding

• Modulation
  – Amplitude
    • Two amplitudes to represent a 0 and 1
  – phase
    • Two phases to represent a 0 and 1
  – Frequency
    • Two frequencies to represent a 0 and 1
amplitude modulation

frequency modulation

phase modulation
Modulation and Encoding

• Encoding
  – Required for clock recovery
  – A long sequence of 1s/0s can lead to clock wander
  – Receiver should be able synchronise
    • NRZ, NRZI, Manchester Encoding, Differential Manchester Encoding
Modulation and Encoding

- Conversion of bits into signals

**Signaling component**

```
node <--- Adapter -----> node

bits

signal
```
NRZ

0 0 1 0 1 1 1 1 0 1

NRZI

0 0 1 0 1 1 1 0 0 0

middle high to low
低 to 高

low to high
Manchester coding: Used in Ethernet

EXOR of clock and NRZ

0 0 1 0 1 1 1 0 0 0

clock
clock
Manchester
Physical Layer

- Xmitter/Rcvr – Transmitter/receiver
- Amp/rep – amplifier/repeater
Physical Layer

• **Mechanical:**
  – connectors, cable

• **Functions:**
  – assign meaning to circuits

• **Procedures:**
  – establish / tear down connection, hand shaking
  – guided / unguided (TP / coaxial cable / fibre / radio)
Data Rate

• Baud Rate
  – Number of times the signal changes/second

• Bit Rate
  – Baud Rate * number of bits represented by sample
Data Rate

- Example: Signal takes one of 0, 1, ..., 15 volts
  - BaudRate – b/s
  - Each signal value represents 4 bits
  - Data Rate = b*4 bits/s
  - Greater the baudrate, greater the bandwidth required to transmit the signal
    - Shannon’s theorem
Data Rate

• **Nyquist rate:**
  – signal passed through a low pass filter of bandwidth H recover from 2H samples.

• **Clean Channel:**
  – Maximum Data Rate = $2H \log_2 V$ bits/s
    • $V$ – number of discrete lines

• **Noisy channel:**
  – Maximum Data Rate = $H \log_2 (1+S/N)$ bits/s
    • $S/N$ – signal to noise ratio