The Physical Layer

- Exchange messages across a link with specific properties regarding the media, the electrical properties and the signal type.
- Physical layer types can be broadly defined as:
  - LAN (Local Area Network) - small, dense networks with demands for low cost and high per user speed.
  - WAN (Wide Area Network) - long distance, low density with high total data throughput demands.
  - MAN (Metropolitan Area Network) - everything else; medium size, medium density.

An Example Network

Physical Layer Properties of Interest

- Signaling method - digital or analog, encoding method, data rates, ...
- Physical organization - topology, media type, size, connection methods
- Access method - how does a node get access to the media
- Frame format - what data is passed in the message and how it is organized.
- Error control - how errors are handled

The Data Link Layer, and the Medium Access Control Layer.
Protocol Data Units (PDU's) and Service Data Units (SDU's)

Framing

- Needed for synchronization between the sender and receiver and to prevent/detect errors.
- Sentinel framing
  Byte stuffing
  <STX>ABC<ETX>DEF<ETX> becomes
  <STX>ABC<DLE><ETX>DEF<ETX>
  <STX>ABC<ETX>D<DLE><ETX>EF<ETX> becomes
  <STX>ABC<DLE><ETX>D<DLE><DLE><DLE><ETX>EF<ETX>
- Byte/Bit counts
- Synchronous framing

Error Checking

Types of errors:

- Bit errors in messages (Physical/Data Link).
- Packets out of order or missing (Transport).
- Packets not part of the message stream are delivered (Transport).

Bit Errors

- Simple parity bit.
- Multidimensional parity bit
- Cyclical redundancy check (CRC)
  - The Generating Polynomial
  - $G_n = d_{n-1}x^{n-1} + d_{n-2}x^{n-2} + ... + d_0x^0$
  - Use One's complement arithmetic
  - $R_x = M_x + E_x$

Example CRC Calculation

$G_4 = 10011$

$M_x = 100101001$

$\frac{M_x}{G_4} = \frac{100101001,0000}{10011} => Q = 100011011, R = 1111$

$T_X = 100101001,0000 + 1111 = 1001010011111$

If $R_x = 1001010\underline{1}01111$, then

$\frac{R_x}{G_4} = \frac{1001010101111}{10011} => Q = 100011000, R = 0111$

which indicates a failure.