LOCAL AND LONG-DISTANCE DATA COMMUNICATION

Signaling method: defines the way information is encoded for transmission and the frequency spectrum of the media. All networking communications are performed serially.

Two primary methods:
1. Baseband (digital) - uses entire bandwidth of the medium for a single channel.
2. Broadband (analog) - subdivides the bandwidth of the medium by frequency to form two or more subchannels, enabling multiple data transfer paths.

<table>
<thead>
<tr>
<th>Type</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseband</td>
<td>• simpler data encoding/decoding</td>
<td>• susceptible to distortion</td>
</tr>
<tr>
<td></td>
<td>• uses only a single channel</td>
<td>• signal reconstruction more difficult</td>
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<tr>
<td></td>
<td>• good for high speed</td>
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<tr>
<td>Broadband</td>
<td>• less susceptible to distortion</td>
<td>• requires more than 1 channel</td>
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<td></td>
<td>• good for long distances</td>
<td>• requires modems</td>
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<td></td>
<td></td>
<td>• lower speeds</td>
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</tbody>
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Local communications: typically done with a simple digital, asynchronous, bit-serial scheme as defined in the RS-232C spec. over short distances.

RS-232C:
- standardized by EIA years ago
- uses voltage levels to represent bits on a wire (+12V=0, -12V=1), “NRZ” signaling
- uses ASCII coding to send 8-bit values framed with start/stop bits
- baud: number of signal changes per second on the wire (also = BPS for RS-232)
  ex: 2400, 9600, 19200, 56000 baud
- may add optional parity bit for simple error-checking
- provides half- and full-duplex for 2-way communication
- attached devices are considered either DTE or DCE, use of “null modem” cables

limitation of baseband signaling: signal loss of cable
- bandwidth: a measure of amount of the EM spectrum supported by a transmission system in Hertz (Hz); ex: FM is 88-108 MHz, TV channels are 6 MHz ea.
  Nyquist’s theorem: theoretical max data rate (in bps) = \(2 \times \) bandwidth
- signal-to-noise ratio (S/N): addition of noise in a communication link limits actual bandwidth below the theoretical maximum
  Shannon’s theorem: practical max data rate considering noise
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Long-distance communications: must switch from digital to analog signaling to circumvent limitations of digital signaling.

Modulation: technique of encoding data on a communication link by modifying a carrier signal; results in signal propagation over much greater distances.

Demodulation: what a receiver does to extract data from a modulated signal, discarding the carrier in the process; similar to “tuning” in a radio or TV.

- more complex than baseband since transmission requires modulation and demodulation of a carrier signal (thus: modems)
- sinusoidal waveform usually used for carrier (AC)
- modulation methods: amplitude (AM), frequency (FM/FSK), phase shift (PSK)
  - constellation diagrams: used to map phase shift values to bits
- modulation methods may be combined to increase data bits per baud
  - Quadrature Amplitude Modulation (QAM): combines amplitude & phase shifting
- is unidirectional, use dual cable or two channels for bi-directional

Modem types:
1. dialup – uses carrier signals suitable for use on phone systems
2. cable/DSL – similar to dialup but with higher frequencies
3. RF – used in a WAP to implement wireless networking

Multiplexing: mixing of multiple data paths on a single communications link; the opposite process is known as demultiplexing.

- ex: multiple channels on cable TV

Multiplexing methods:
1. frequency division multiplexing (FDM) – divides a link’s bandwidth into multiple channels, each having a different carrier frequency
2. wavelength division multiplexing (WDM) – use of different wavelengths of light (colors) in a single optical fiber for multiple channels
3. time division multiplexing (TDM) – allocation of fixed time slots for multiple data streams over a single link, typically over the phone system
4. spread spectrum – use of multiple carrier frequencies for a single data stream, to improve reliability