Chapter 6
Long-Distance Communication

The Problem

- Last chapter looked at point-to-point connections spanning short distances
- In this chapter we will look at techniques for building long distance point-to-point links

Long-distance communication

- Encoding used by RS-232 cannot work in all situations
  - Over long distances
  - Using existing systems like telephone
- Different encoding strategies needed
Sending signals long distances

- Electric current becomes weaker as it travels on wire
- Resulting signal loss may prevent accurate decoding of data
- Signal loss prevents use of RS-232 over long distances

Oscillating signals

- Continuous, oscillating signal will propagate farther than electric current
- Long distance communication uses such a signal, called a carrier
- Waveform for carrier looks like:
Carrier can be detected over much longer distances than RS-232 signal
**Encoding data with a carrier**

- Modifications to basic carrier encode data for transmission
- Technique called modulation
- Same idea as in radio, television transmission
- Carrier modulation used with all types of media - copper, fiber, radio, infrared, laser

**Types of modulation**

- **Amplitude modulation** - strength, or amplitude of carrier is modulated to encode data
- **Frequency modulation** - frequency of carrier is modulated to encode data
- **Phase shift modulation** - changes in timing, or phase shifts encode data
Examples of modulation techniques

- Amplitude modulation:

![Diagram of Amplitude Modulation]

- Diagram showing the process of amplitude modulation with a data signal modulating an carrier wave.
Phase shift modulation:

![Diagram showing phase shift modulation]
Encoding data with phase shift modulation

- **Amount** of phase shift can be precisely measured
  - Measures how much of sine wave is "skipped"
  - Example shows 1/2 and 3/4 cycle

![Diagram showing phase shift on a sine wave]

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Encoding data with phase shift modulation: (continued)

- Each phase shift can be used to carry more than one bit; in example, four possible phase shifts encode 2 bits:
  - 00 - no shift
  - 01 - 1/4 phase
  - 10 - 1/2 phase
  - 11 - 3/4 phase
- Thus, each phase shift carries 2 bits
- Data rate is twice the baud rate

**Hardware for Modulated Data Transmission**

- **Modulator** encodes data bits as modulated carrier
- **Demodulator** decodes bits from carrier
- Data transmission requires modulator at source and demodulator at destination
Full Duplex Communication

- Most systems provide for simultaneous bidirectional, or full duplex, transmission
- Requires modulator and demodulator at both endpoints:
• Modulator and demodulator typically in single device called a modem (modulator/demodulator)
If external to computer, RS-232 can be used between modem and computer
• If internal, direct bus connection used
Dialup modems

Diagram showing the connection between a modem and a computer at site 1. RS-232 can be used.
• Circuitry for sending data
• Circuitry to mimic telephone operation
  – Lifting handset, Dialing, Replacing handset (hanging up), Detect
dial tone
• Full duplex on one voice channel
  – Different carrier frequencies for each direction
  – Filters eliminate interference

Carrier frequencies and multiplexing

• Multiple signals with data can be carried on same medium without
  interference
  – Allows multiple simultaneous data streams
  – Dialup modems can carry full-duplex data on one voice channel
• Example - multiple TV stations in air medium
• Each separate signal is called a channel
Multiplexing

- Carrying multiple signals on one medium is called **multiplexing**
Frequency division multiplexing (FDM) achieves multiplexing by using different carrier frequencies. Receiver can "tune" to specific frequency and extract modulation for that one channel.
- Frequencies must be separated to avoid interference
- Only useful in media that can carry multiple signals with different frequencies - high-bandwidth required

**Spread spectrum multiplexing**
- Spread spectrum uses multiple carriers
- Single data stream divided up and sent across different carriers
- Can be used to bypass interference or avoid wiretapping
**Time division multiplexing**

- Time division multiplexing uses a single carrier and sends data streams sequentially
- Transmitter/receiver pairs share single channel
- Basis for most computer networks used shared media - will give details in later chapters