CS698T

Wireless Networks: Principles and Practice

Topic 06
Modulation

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Modulation

- **Modulation**: the process of converting a digital signal to “appropriate” signals on wire or on air (wireless)

- **Wireless**:
  - **Digital modulation**: converting the digital signal to an analog signal
  - This results in a signal with bandwidth proportional to $B$ Hz, if the digital signal is $B$ bits/sec
The Need for Analog Modulation

• Cannot send a signal of frequency $B$ Hz directly:
  – Antenna size may be inappropriate
  – Propagation characteristics may not be desirable
  – Frequency Division Multiplexing (FDM) not possible

• Hence **analog modulation**:
  – Convert one frequency range to another
  – Using a **carrier frequency**
Modulation at the Transmitter

Source: Mobile Communications, Jochen Schiller

Also known as keying
Demodulation at the Receiver

Source: Mobile Communications, Jochen Schiller
An RF Signal

\[ g_t = A_t \sin (2 \times \pi \times f_t \times t + \phi_t) \]

- Has **three** components: amplitude, frequency, and phase
- Modulation/keying can be based on any of these three (or a combination)
Amplitude Shift Keying

Source: Mobile Communications, Jochen Schiller
Frequency Shift Keying

Source: Mobile Communications, Jochen Schiller
Phase Shift Keying

Source: Mobile Communications, Jochen Schiller
Some Remarks

- Phase Shift Keying: binary, quadrature, etc.
  - 802.11b uses BPSK, QPSK, CCK
- **Metrics in modulation:**
  - Spectral efficiency: bits/sec/Hz
  - Power efficiency
  - Robustness to noise
BER vs. SNR

- For a given modulation:
  - Bit-Error-Rate (BER) is a function of the Signal-to-Noise-Ratio (SNR)

- Thermal noise: $k \times T \times B$
  - $k$: Boltzmann’s constant $= 1.38 \times 10^{-23}$
  - $T$: temperature in Kelvin
  - $B$: bandwidth in Hz

- Strictly, Signal-to-Interference-and-Noise-Ratio (SINR) must be used
Spread Spectrum

- Spreading a signal over a wider frequency range
  - Avoids narrow-band interference
  - E.g. 802.11b Barker code: 10110111000

- Two techniques for spread-spectrum
  - Direct Sequence, Frequency Hopping

Source: Mobile Communications, Jochen Schiller