Objectives for this lecture

- Goal of (digital) communication systems
  - data transmission from source to sink (A → B)
  - over a given communication channel
  - avoid transmission errors

- Objectives: Digital communication systems
  - typical blocks
  - mathematical modeling of these blocks and of the communication signals
  - goal: optimization of blocks (system optimization)

Outline: Introduction

- What is digital communications?
- Block diagram
- Why digital?
- Introductory example

Reference: [Sklar, Section 1.1; Proakis, Ch. 1]
  - for (most) figures see [Sklar]
This lecture: Digital modulation and channel

011011

bit stream

baseband
modulation

baseband signal (analog)

carrier mod
ulation

(bandpass)

RF-channel
digital modulation

transmission channel

This lecture: Digital Demodulator

(matched) carrier filter

baseband signal (analog)

digital demodulation

 carrier de-
modulation

010011

bit stream

sampling (detection)

baseband signal (analog)
Goals (refined)

- Derive:
  - Optimum signaling waveforms
  - Optimum receiving filter
  - Optimum detection methods
  For a variety of signaling (modulation) schemes and different channel conditions

- This implies/requires:
  - Derivation of mathematical models of digital communication systems
  - Analysis of performance metrics; e.g. the error rate performance

Outlook

- Mathematical background
  - Signal representations (time/frequency domain; signal space)
  - Linear systems
  - Stochastic processes and noise

- Modulation
  - Baseband and bandpass (passband; carrier modulated)

- Additive white Gaussian noise (AWGN) channel
  - and linear filter channel

- Optimum detection
  - Matched filter and sampling
  - Fundamentals of detection theory
  - Performance analysis (and limits): bit error rate (BER)
  - Equalization (linear filter channels), OFDM, and MIMO channels
Books – Digital Communications

- J. G. Proakis, *Digital Communications*, 3rd edition, McGraw-Hill, 1995 (Ch. 1, 2, 4, 5) (classical text)
- M. Werner, *Nachrichtentechnik*. 4. Auflage, Vieweg Verlag, 2003 (Kapitel 1-4) (very basic text; doesn’t cover all aspects of the course)

Block Diagram of a Typical DCS (extended)

- Block diagram of a typical digital communication system [for RF channels] [Sklar: Figure 1.2]
  - Signal processing steps (signal transformations)

- Essential blocks:
  - Formatting (source coding)
  - Modulation (generate waveforms compatible with channel)
  - Demodulation/detection
  - Synchronization

- Essential in practice:
  - Channel coding (for ARQ or FEC)

Other processing steps

- Encryption: provide privacy
- Multiplexing: combine several data streams
- Multiple access: allow several users on medium
- Frequency spreading:
  - Enhance robustness against interference (natural and man-made)
  - Code division multiple access
  - Reduction of fading

[Sklar] Figure 1.2 Block diagram of a typical digital communication system.