Lecture 11
Signals and
Communications

November 11, 2009
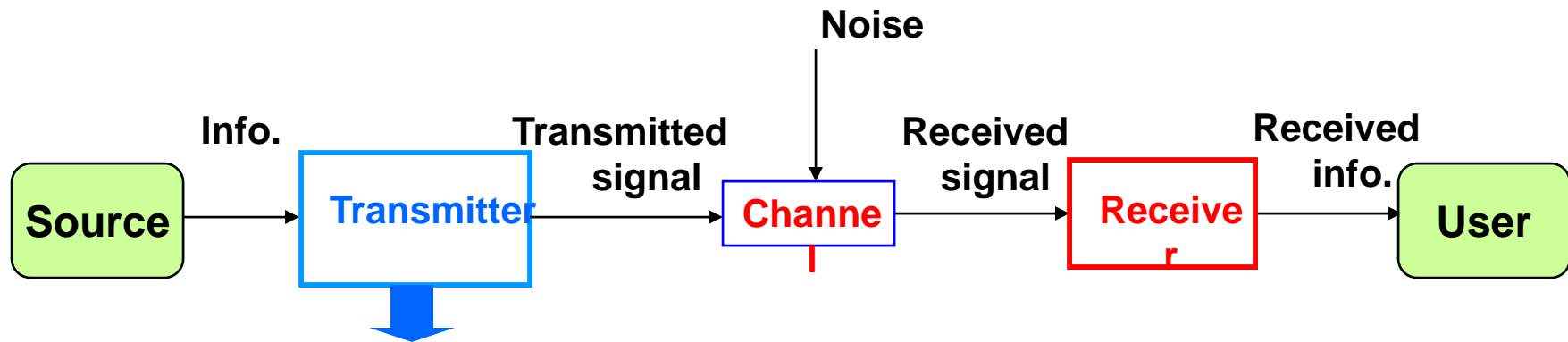
Today, we are going to talk about

- What are the features of a Digital communication system (DCS)?
- Why "digital" instead of "analog"?
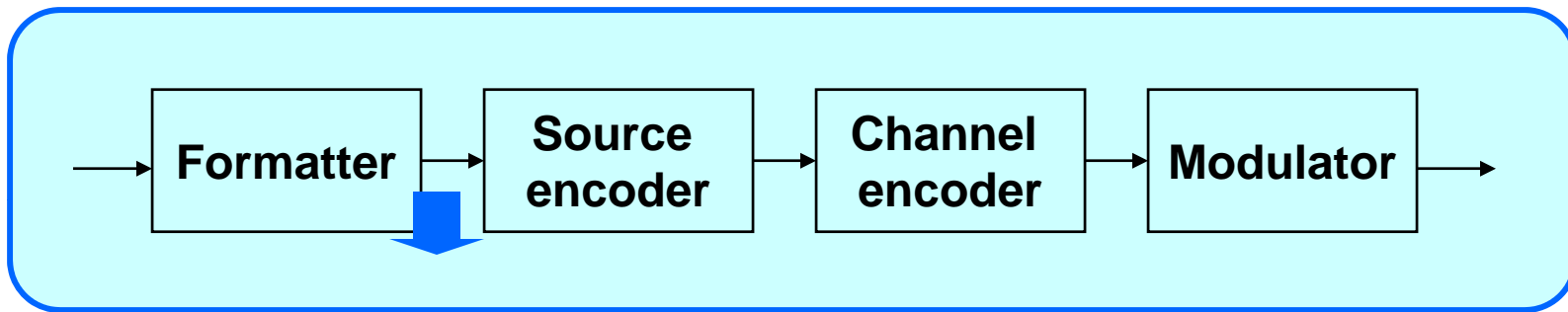- Reduction of Bit Error Rate
- Classification of signals

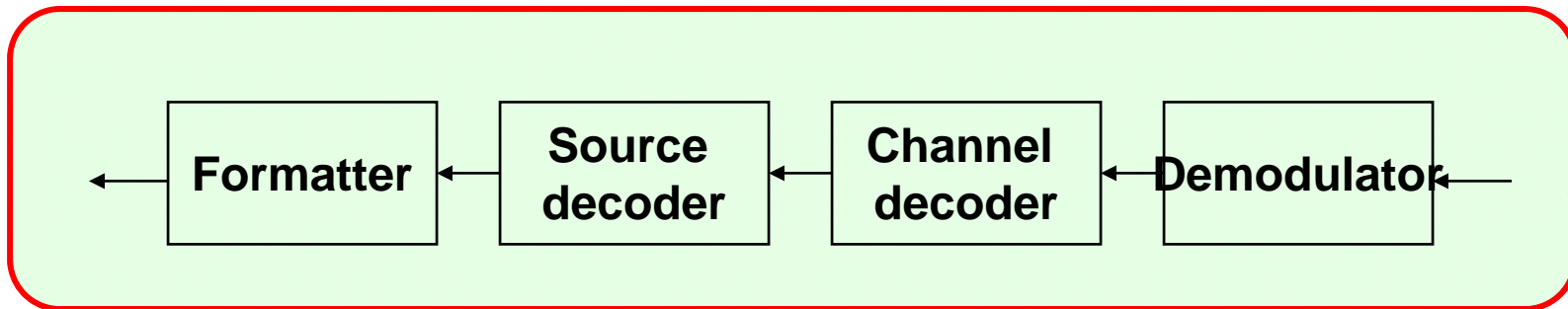# Block diagram of a digital communication system

Block diagram showing: Source → (Info.) → Transmitter → (Transmitted signal) → Channel → (Received signal) → Receiver → (Received info.) → User, with Noise entering the Channel.

Block diagram of a digital communication system

Transmitter

$\rightarrow$ Formatter $\rightarrow$ Source encoder $\rightarrow$ Channel encoder $\rightarrow$ Modulator $\rightarrow$

Receiver

$\leftarrow$ Formatter $\leftarrow$ Source decoder $\leftarrow$ Channel decoder $\leftarrow$ Demodulator $\leftarrow$

Digital communication system …

- ## Important features of a DCS:

  - – Transmitter sends a waveform from a finite set of possible waveforms during a limited time

  - – Channel distorts, attenuates the transmitted signal and adds noise to it.

  - – Receiver decides which waveform was transmitted from the noisy received signal

  - – Probability of erroneous decision is an important measure for the system performance
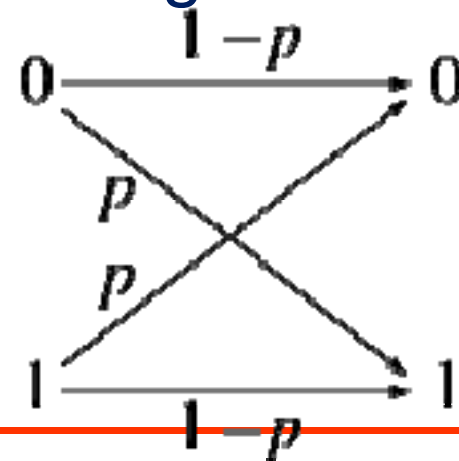
A simple procedure

- ## Binary Symmetric channel
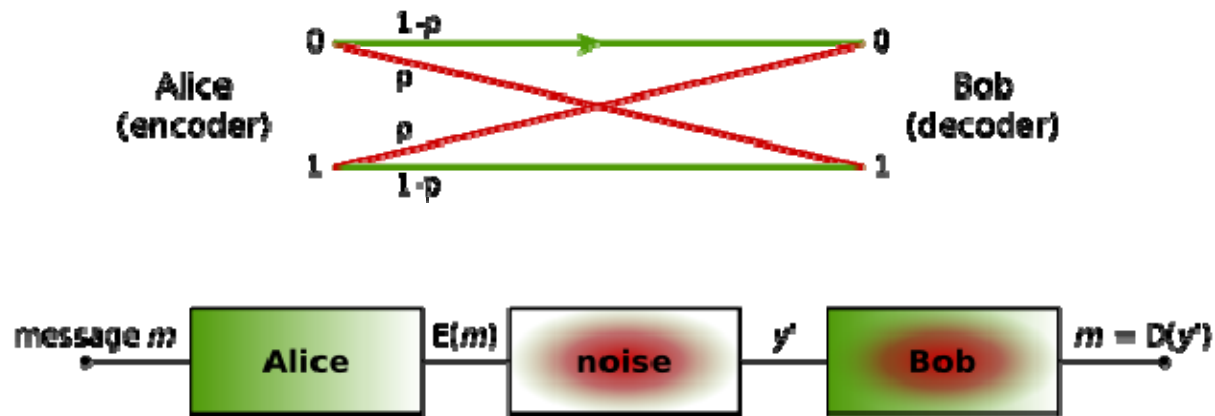
Decoding Procedure

➢p is the probability of error. That is the probability of sending a 0 and receive a 1 or the probability of sending a 1 and receiving a zero.

➢p is usually very small. Let p=0.01.   That is, a possibility of 1 bit error in transmitting 100 bits. Bit Error rate=BER=10^{-2}

Reducing the Bit Error Rate

Procedure:

1. Repeat at the transmitter the same bit 5 times

2. The receiver uses the majority of bits in a sequence of 5 digits decision rule.

Calculate the new Bit Error Rate

In transmitting 00000, we may receive

00000	01000	10000	11000
00001	01001	10001	11001
00010	01010	10010	11010
00011	01011	10011	11011
00100	01100	10100	11100
00101	01101	10101	11101
00110	01110	10110	11110
00111	01111	10111	11111

When do we make an error

- 3 bits are in error: Total number = 10
- 4 bits are in error: Total number = 5
- 5 bits are in error: Total number = 1

The new BER: 10ppp(1-p)(1-p)

$\qquad$ +5pppp(1-p)

$\qquad$ +ppppp

In numerical value with p=0.01, the new BER= 10^{-5}

Classification of signals

- ## Deterministic and random signals

    - Deterministic signal: No uncertainty with respect to the signal value at any time.

    - Random signal: Some degree of uncertainty in signal values before it actually occurs.

        - Thermal noise in electronic circuits due to the random movement of electrons

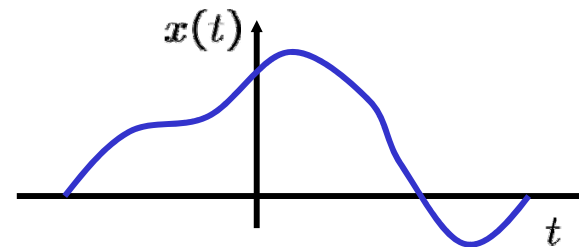   - Reflection of radio waves from different layers of ionosphere

Classification of signals …
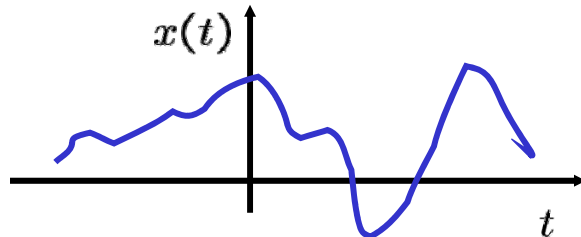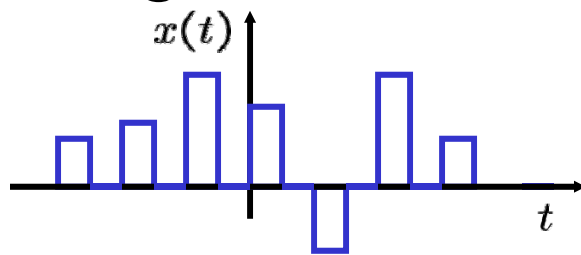
- ## Periodic and non-periodic signals
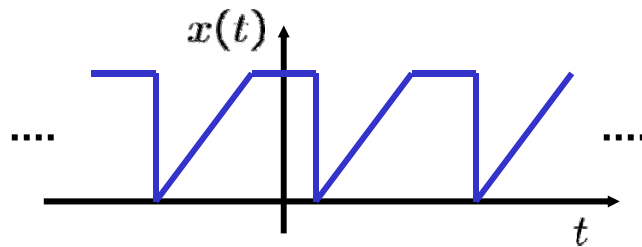
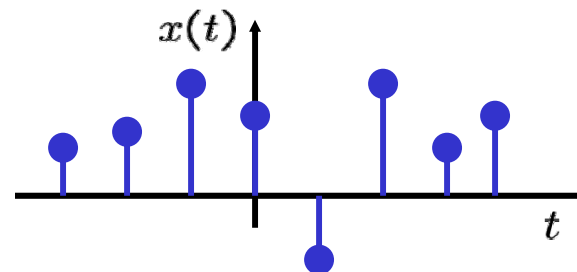**A periodic signal**

A non-periodic signal

- ## Analog and discrete signals

Analog signals

A discrete signal

Random process

- A random process is a collection of time functions, or signals, corresponding to various outcomes of a random experiment. For each outcome, there exists a deterministic function, which is called a sample function or a realization.

$X_1(t)$

$X_2(t)$

$X_N(t)$

$\{X_i(t_k)\}_{i=1}^{N}$ **Random variables**

Sample functions or realizations (deterministic function)

Real number

t_k

time (t)