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ECS452 2016/2 Part I.1 Dr.Prapun

1 Elements of a Digital Communication System

1.1. Figure 1 illustrates the functional diagram and the basic elements of a digital communication system.

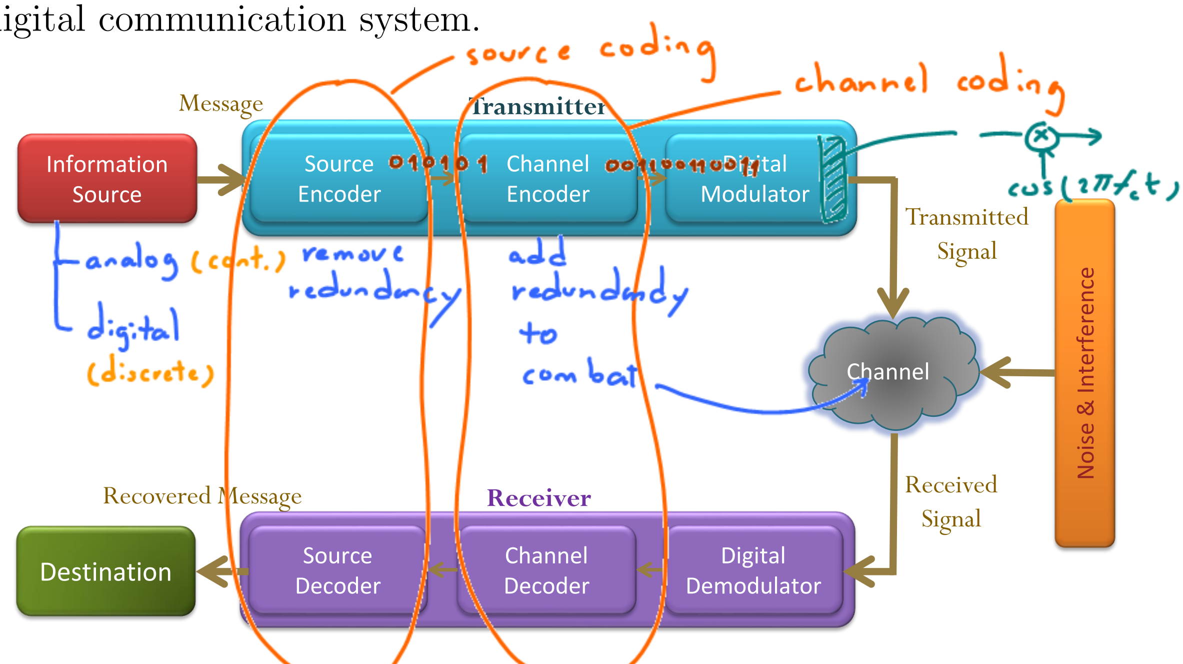


Figure 1: Basic elements of a digital communication system

1.2. The source output may be either

- an **analog** signal, such as an audio or video signal,

or

- a **digital** signal, such as the output of a computer, that is discrete in time and has a finite number of output characters.

In ECS 332, we talked about the conversion from analog signal to bits via the process of sampling and quantization < uniform / non-uniform

① PCM → ② DPCM ③ DM

1.3. Source Coding: The messages produced by the source are converted into a sequence of bits.

- This process is called source coding or source encoding.
- For this course, we want to also represent the source output (message) by as few bits as possible.
  - In other words, we seek an efficient representation of the source output that results in little or no redundancy.
  - Therefore, source coding may be referred to as **data compression**. (Huffman coding)

1.4. Channel Coding:

- Introduce, in a controlled manner, some *redundancy* in the binary information sequence that can be used at the receiver to overcome the effects of noise and interference encountered in the transmission of the signal through the channel.
  - The added redundancy serves to increase the reliability of the received data and improves the fidelity of the received signal.
- See Examples 1.5 and 1.6.

Example 1.5. Trivial channel coding: Repeat each binary digit n times, where n is some positive integer.

Example 1.6. More sophisticated channel coding: Taking k information bits at a time and mapping each k-bit sequence into a unique n-bit sequence, called a **codeword**.

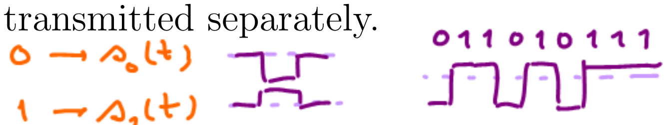
- The amount of redundancy introduced by encoding the data in this manner is measured by the ratio n/k. The reciprocal of this ratio, namely k/n, is called the rate of the code or, simply, the **code rate**.

1.7. The binary sequence at the output of the channel encoder is passed to the **digital modulator**, which serves as the interface to the physical (analog) communication channel.

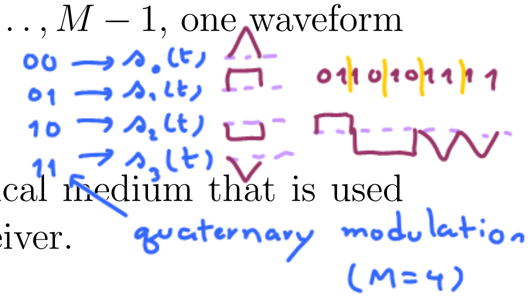
- Since nearly all the communication channels encountered in practice are capable of transmitting electrical signals (waveforms), the primary purpose of the digital modulator is to map the binary information sequence into signal waveforms.

In ECS332, we studied line coding.

- The digital modulator may simply map the binary digit 0 into a waveform $s_0(t)$ and the binary digit 1 into a waveform $s_1(t)$. In this manner, each bit from the channel encoder is transmitted separately.
We call this **binary modulation**.



- The modulator may transmit b coded information bits at a time by using $M = 2^b$ distinct waveforms $s_i(t), i = 0, 1, \ldots, M-1$, one waveform for each of the 2^b possible b-bit sequences.
We call this ***M*-ary modulation** ($M > 2$).



1.8. The **communication channel** is the physical medium that is used to send the signal from the transmitter to the receiver.

- The physical channel may be
  - a pair of wires that carry the electrical signal, or
  - an optical fiber that carries the information on a modulated light beam, or
  - an underwater ocean channel in which the information is transmitted acoustically, or
  - free space over which the information-bearing signal is radiated by use of an antenna.

  Other media that can be characterized as communication channels are data storage media, such as magnetic tape, magnetic disks, and optical disks.

- Whatever the physical medium used for transmission of the information, the essential feature is that the transmitted signal is corrupted in a random manner by a variety of possible mechanisms, such as additive **thermal noise** generated by electronic devices; man-made noise, e.g., automobile ignition noise; and **atmospheric noise**, e.g., electrical lightning discharges during thunderstorms.

- Other channel impairments including noise, attenuation, distortion, fading, and interference (such as interference from other users of the channel).

1.9. At the receiving end of a digital communication system, the digital demodulator processes the channel-corrupted transmitted waveform and reduces the waveforms to a sequence of numbers that represent estimates of the transmitted data symbols (binary or M-ary).

This sequence of numbers is passed to the channel decoder, which attempts to reconstruct the original information sequence from knowledge of the code used by the channel encoder and the redundancy contained in the received data.

- A measure of how well the demodulator and decoder perform is the frequency with which errors occur in the decoded sequence. More precisely, the average probability of a bit-error at the output of the decoder is a measure of the performance of the demodulator-decoder combination.

- In general, the probability of error is a function of the code characteristics, the types of waveforms used to transmit the information over the channel, the transmitter power, the characteristics of the channel (i.e., the amount of noise, the nature of the interference), and the method of demodulation and decoding.

1.10. As a final step, when an analog output is desired, the source decoder accepts the output sequence from the channel decoder and, from knowledge of the source encoding method used, attempts to reconstruct the original signal from the source.

- Because of channel decoding errors and possible distortion introduced by the source encoder, and perhaps, the source decoder, the signal at the output of the source decoder is an approximation to the original source output.

- The difference or some function of the difference between the original signal and the reconstructed signal is a measure of the distortion introduced by the digital communication system.

distortion