Computer Network

Lecture-9

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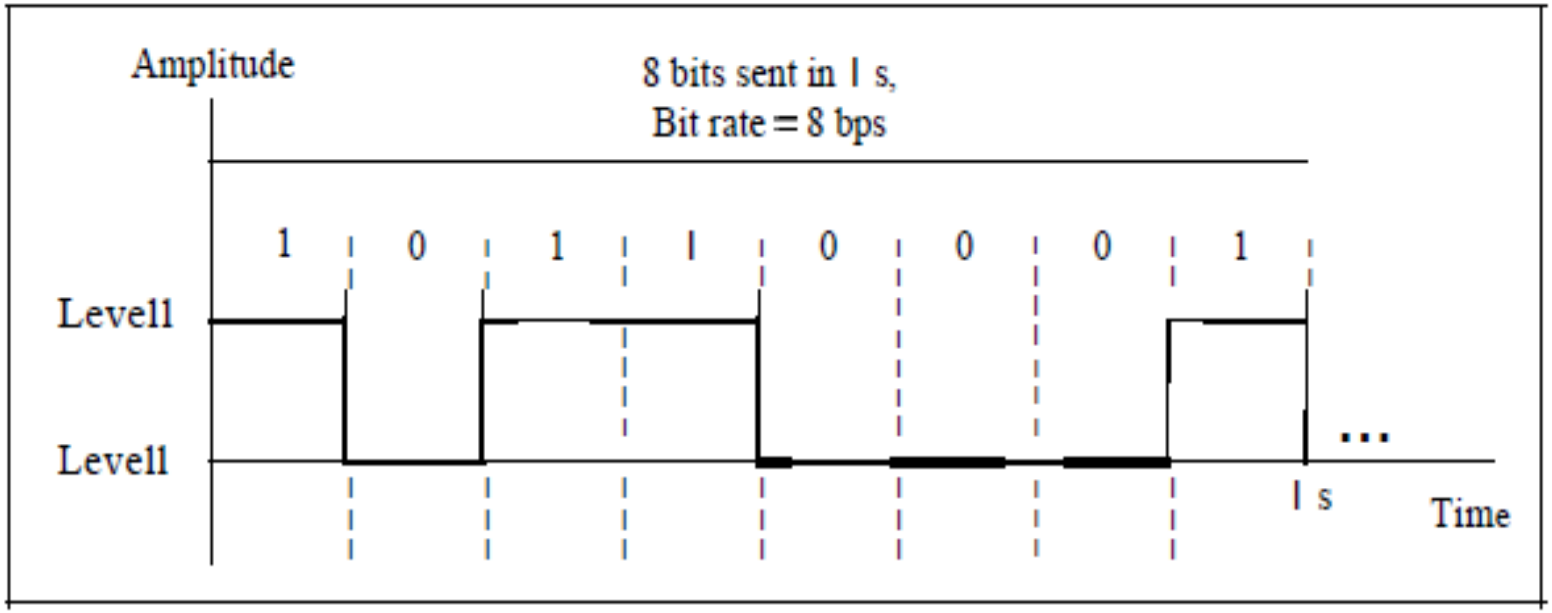
Physical Layer

Digital Signal

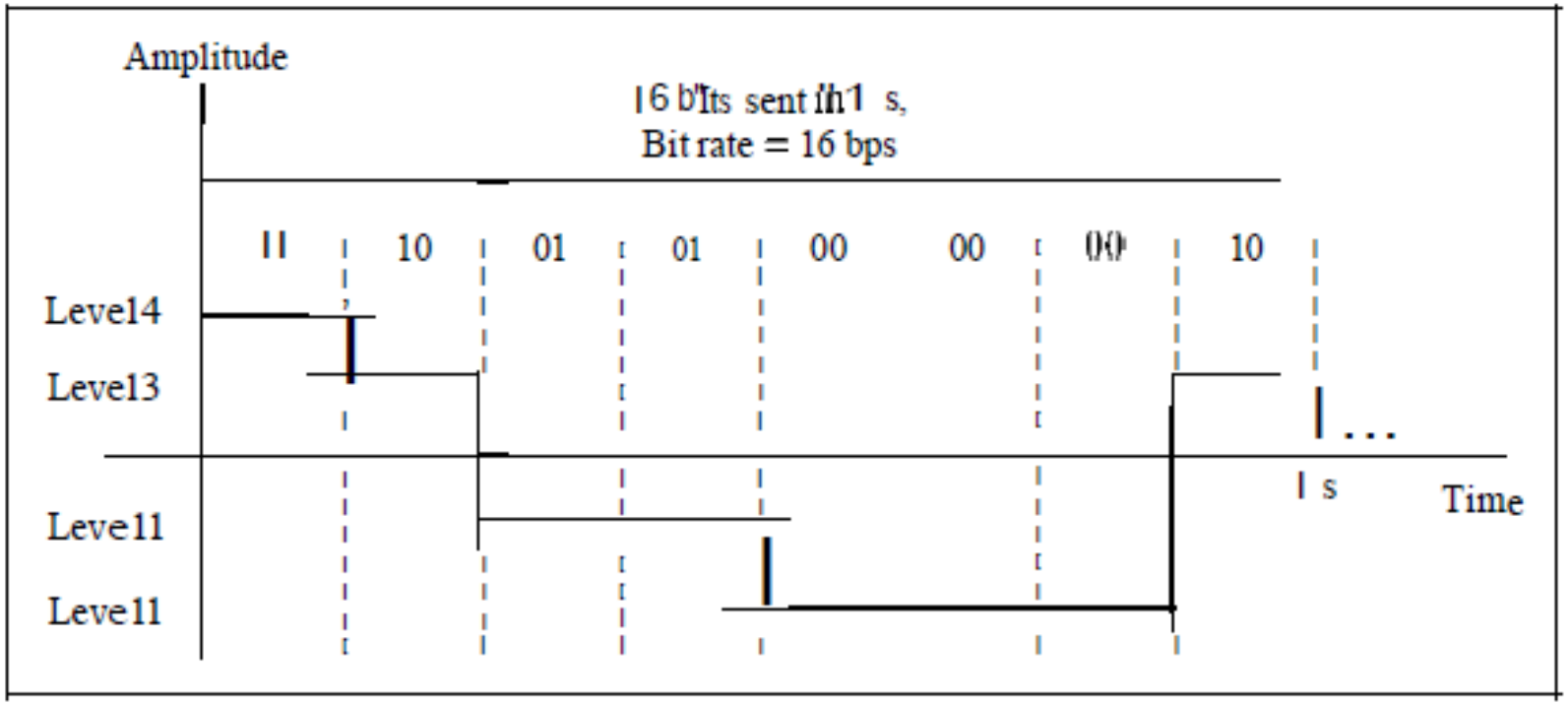
In addition to being represented by an analog signal, information can also be represented by a digital signal. For example, a 1 can be encoded as a positive voltage and a 0 as zero voltage.

A digital signal can have more than two levels. In this case, we can send more than 1 bit for each level. Following figure shows two signals, one with two levels and the other with four.



a. A digital signal with two levels

Digital Signal



b. A digital signal with four levels

Note: If a signal has L levels, each level needs $\log_2 L$ bits.

Digital Signal

Example: A digital signal has eight levels. How many bits are needed per level?

Solution: Here, number of levels, L = 8.

Therefore, number of bits per level = $\log_2 L = \log_2 8 = 3$

Example: A digital signal has nine levels. How many bits are needed per level?

Solution: Here, number of levels, L = 9.

Therefore, number of bits per level = $\log_2 L = \log_2 9 = 3.17$ bits

However, this answer is not realistic. The number of bits sent per level needs to be an integer as well as a power of 2. For this example, 4 bits can represent one level.

Digital Signal

Bit rate

The bit rate is the number of bits sent in 1 second. It is expressed in bits per second (bps).

Bit length

The bit length is the distance one bit occupies on the transmission medium.

Bit length =propagation speed x bit duration

Digital Signal

Baud rate

It is the rate at which a signal level changes over a given period of time.

Baud rate = Bit rate / bits per signal level

When binary bits are transmitted as an electrical signal with two levels 0 and 1, the bit rate and baud rate are the same.

Example:

Consider bit rate is 8 bps and number of signal levels is 4. find baud rate.

Solution: Number of bits required per signal level = 2

Therefore, Baud rate = 8/2 = 4 bauds

TRANSMISSION IMPAIRMENT

- Signals travel through transmission media, which are not perfect.
- The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received.
- Three causes of impairment are attenuation, distortion, and noise.

Attenuation

Attenuation means a loss of energy. When a signal, simple or composite, travels through a medium, it loses some of its energy in overcoming the resistance of the medium. Some of the electrical energy in the signal is converted to heat. To compensate for this loss, amplifiers are used to amplify the signal.

Attenuation

Decibel

The decibel (dB) measures the relative strengths of two signals or one signal at two different points.

Note: The decibel is negative if a signal is attenuated and positive if a signal is amplified.

$$\mathrm{dB} = 10 \log_{10} \frac{P_2}{P_1}$$

Variables P_1 and P_2 are the powers of a signal at points 1 and 2, respectively.

Attenuation

Example: Suppose a signal travels through a transmission medium and its power is reduced to one-half. Find its attenuation.

Solution:

Clearly $P_2 = P_1/2$,

Therefore ,

$$\text{Attenuation(dB)} = 10 \log_{10} (P_2/P_1) = 10 \log_{10} (1/2)$$

$$= 10*(-0.3) = -3 \text{ dB}$$

Example: A signal travels through an amplifier, and its power is increased 10 times. Find its attenuation.

Solution:

Clearly $P_2 = 10P_1$,

Therefore ,

$$\text{Attenuation(dB)} = 10 \log_{10} (P_2/P_1)$$

$$= 10* \log_{10}(10)$$

$$= 10 \text{ dB}$$

Distortion

Distortion means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies. Each signal component has its own propagation speed (see the next section) through a medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase if the delay is not exactly the same as the period duration. In other words, signal components at the receiver have phases different from what they had at the sender. The shape of the composite signal is therefore not the same. Following figure shows the effect of distortion on a composite signal.