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Wisdom & Virtue

MIRPUR UNIVERSITY OF SCIENCE AND TECHNOLOGY (MUST), MIRPUR

DEPARTMENT OF SOFTWARE ENGINEERING

Computer Networks

Lecture [14]: Bandwidth, Bit Rate & Bit Length of Digital Signals

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(Lecturer)

Topics discussed in Today's Lectures

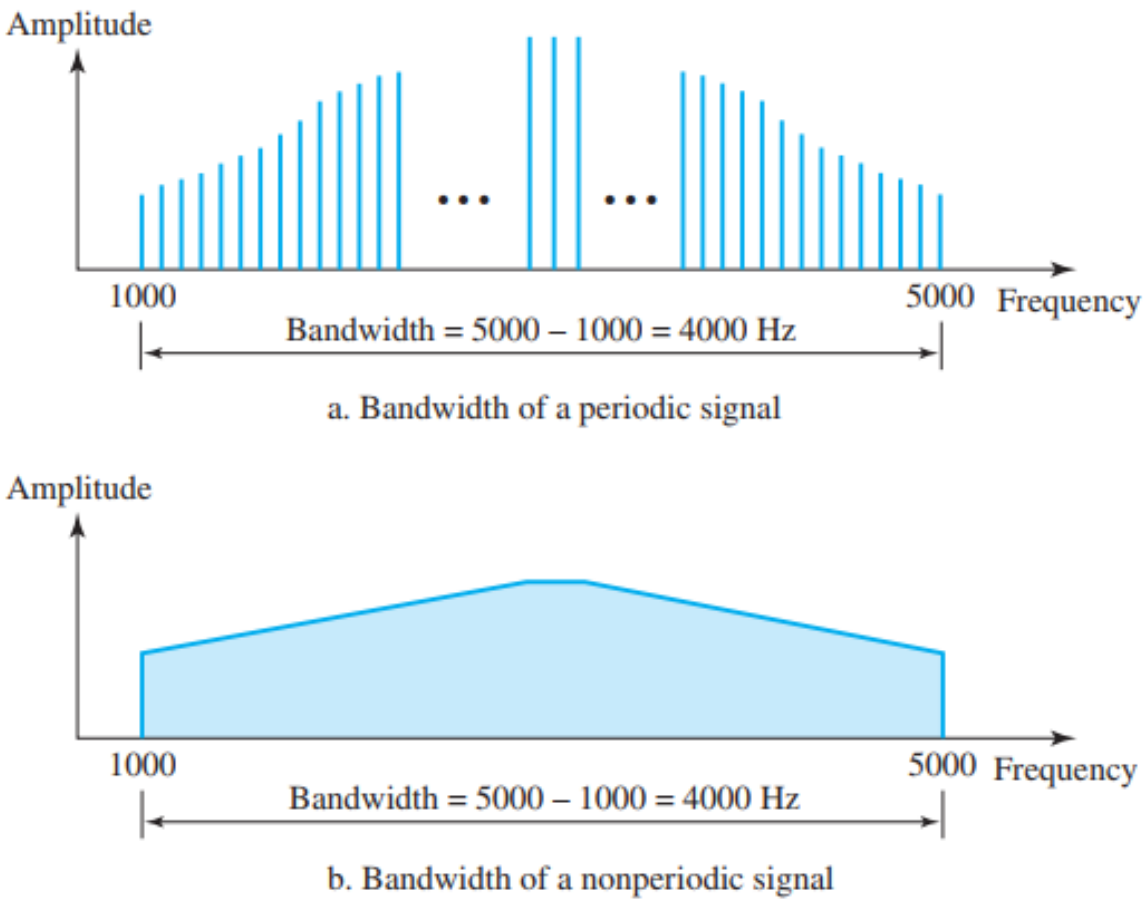
- Bandwidth
- Digital Signals
- Bit Rate
- Bit Length
- Digital Signal as a Composite Analog Signal

Bandwidth

- Range of frequencies contained in a composite signal is its bandwidth
- Bandwidth is normally a difference between two numbers
  - For example, if a composite signal contains frequencies between 1000 and 5000, its bandwidth is 5000 − 1000, or **4000**
- ***Bandwidth*** *of a composite signal is the difference b/n the highest and the lowest frequencies contained in that signal*

Bandwidth-Example

- Figure 3.13 shows concept of bandwidth
- Figure depicts 2 composite signals, one periodic & other nonperiodic
- Bandwidth of periodic signal contains all integer frequencies b/n 1000 & 5000 (1000, 1001, 1002, . . .)
- Bandwidth of nonperiodic signals has same range, but frequencies are continuous



a. Bandwidth of a periodic signal

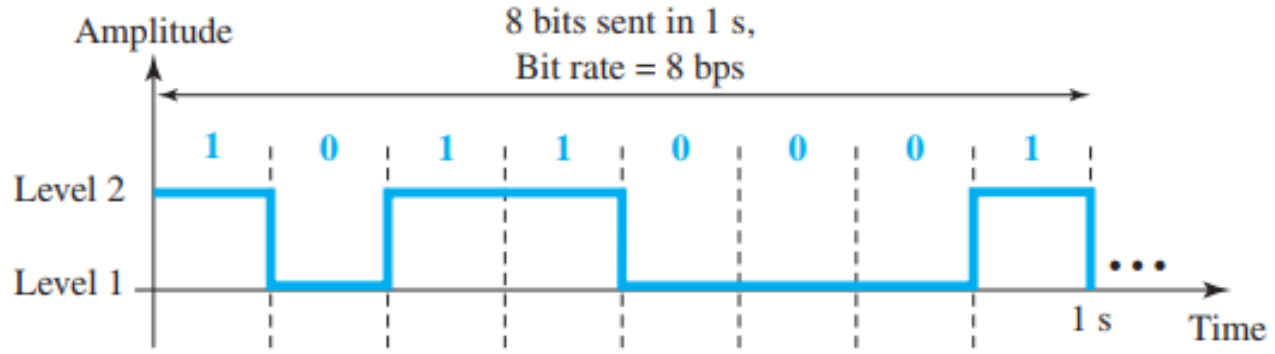
b. Bandwidth of a nonperiodic signal

DIGITAL SIGNALS

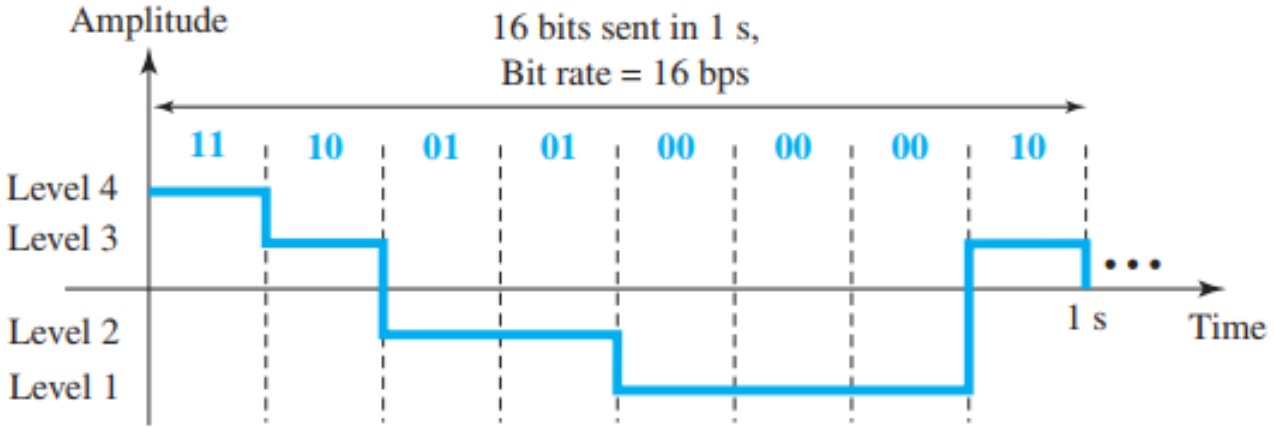
- Info. can also be represented by a digital signal
- For example: 1 can be encoded as a +ve voltage & a 0 as zero voltage
- Digital signal can have more than 2 levels
- We can send more than 1 bit for each level
- Fig. 3.17 shows two signals, one with 2 levels and other with 4 levels
- We send 1 bit per level in part a of the fig. and 2 bits per level in part b of the fig.
- In general, if a signal has L levels, each level needs $\log_2 L$ bits
- For this reason, we can send $\log_2 4 = 2$ bits in part b

DIGITAL SIGNALS

Figure 3.17 *Two digital signals: one with two signal levels and the other with four signal levels*



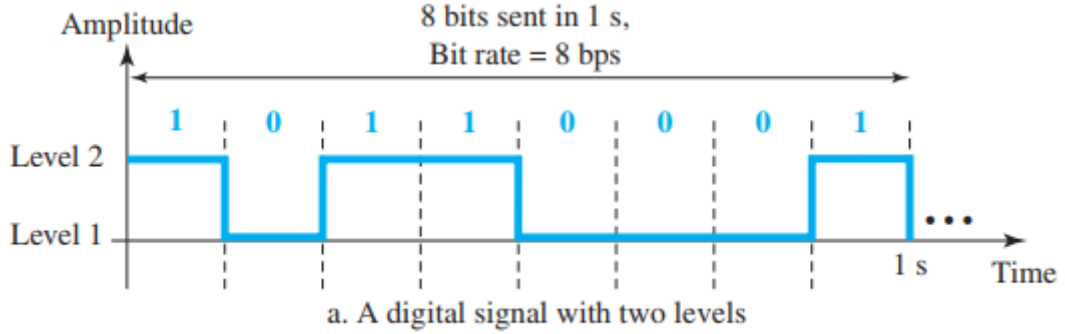
a. A digital signal with two levels



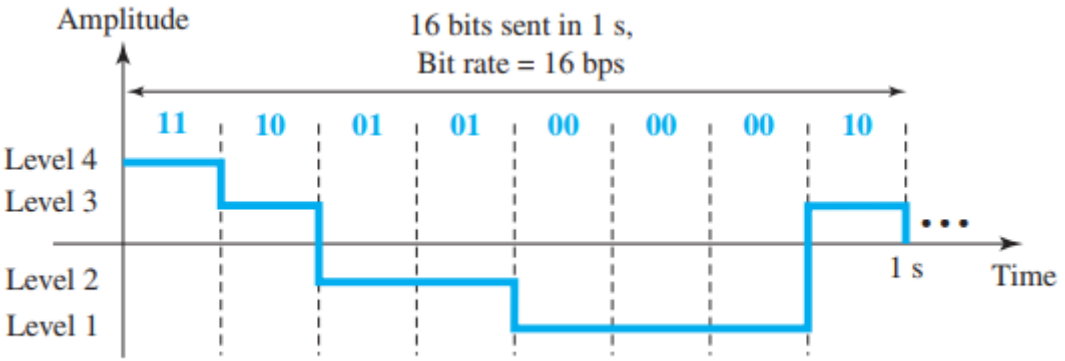
b. A digital signal with four levels

Bit Rate

- Bit rate (instead of frequency)—is used to describe digital signals
- ***Bit rate is the number of bits sent in 1s, expressed in bits per second (bps)***
- Fig. 3.17 shows the bit rate for two signals



a. A digital signal with two levels

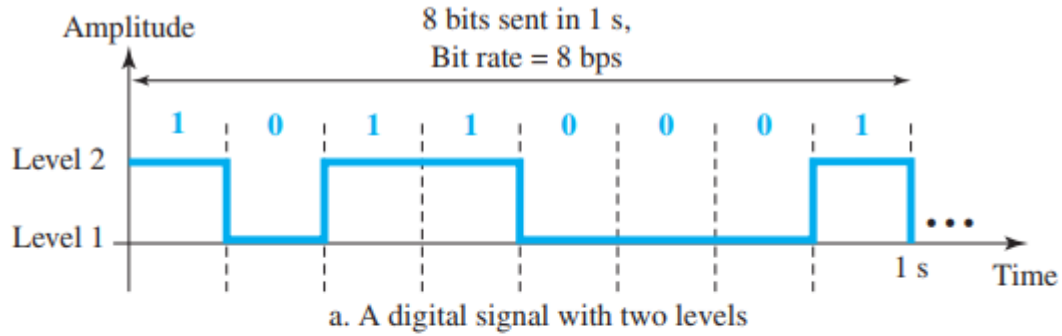


b. A digital signal with four levels

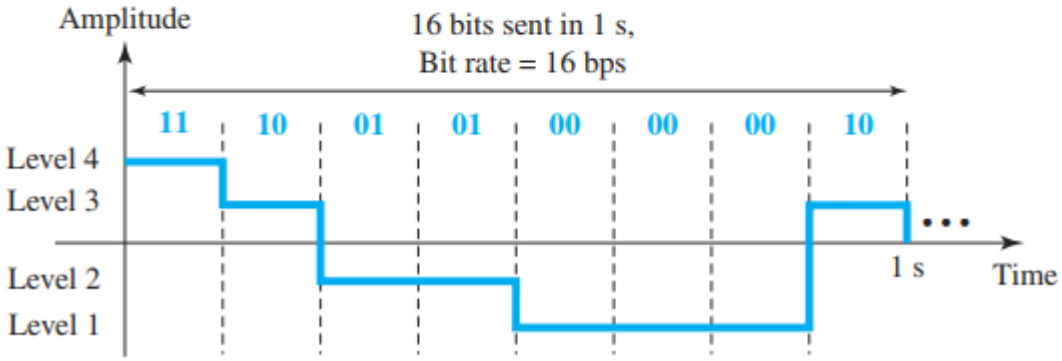
Bit Length

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

Bit length = propagation speed × bit duration



a. A digital signal with two levels



b. A digital signal with four levels

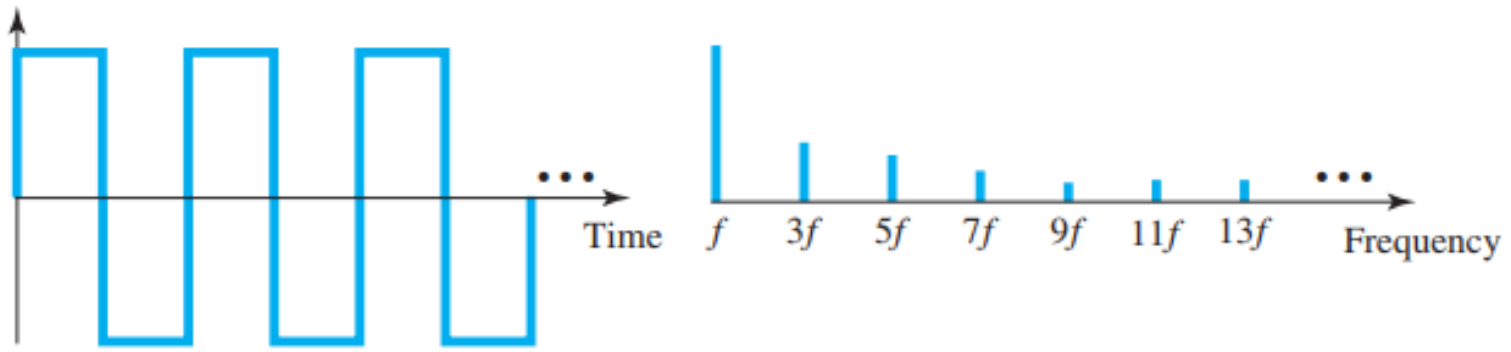
Digital Signal as a Composite Analog Signal

- Digital signal is a composite analog signal
- Digital signal, in the time domain, comprises of connected vertical & horizontal line segments
- Vertical line in time domain means a frequency of infinity (sudden big change in time)
- Horizontal line in time domain means a frequency of zero (no change in time)
- Going from a frequency of zero to a frequency of infinity (& vice versa) implies all frequencies in b/n are part of the domain

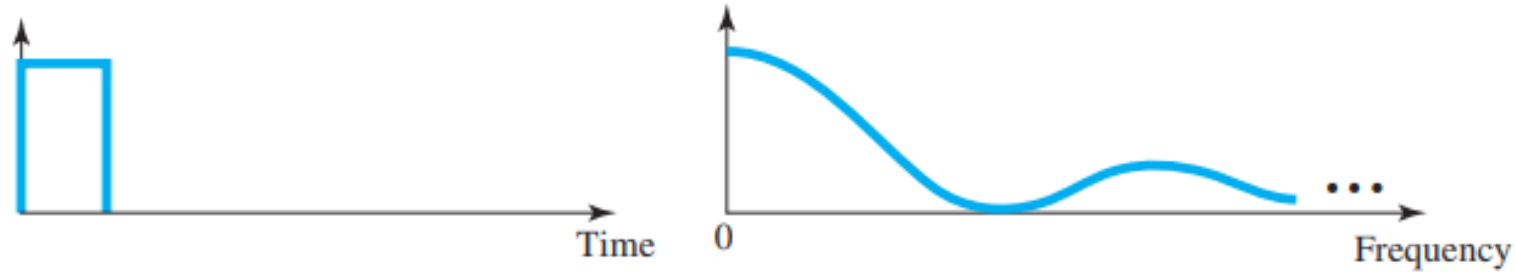
Digital Signal as a Composite Analog Signal

- If the digital signal is periodic, decomposed signal has a frequency domain representation with an infinite bandwidth & discrete frequencies
- If the digital signal is non-periodic, decomposed signal has an infinite bandwidth, but the frequencies are continuous

Figure 3.18 *The time and frequency domains of periodic and nonperiodic digital signals*



a. Time and frequency domains of periodic digital signal



b. Time and frequency domains of nonperiodic digital signal

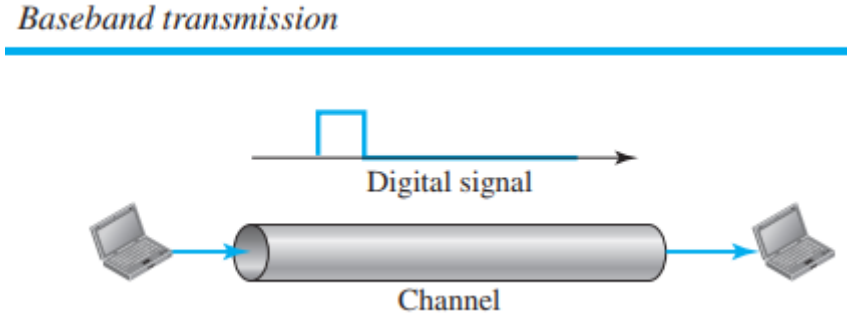
Note that both bandwidths are infinite, but the periodic signal has discrete frequencies while the nonperiodic signal has continuous frequencies.

Transmission of Digital Signals

- A digital signal, periodic or nonperiodic, is a composite analog signal with frequencies b/n zero and infinity
- Consider the case of a nonperiodic digital signal
- We can transmit a digital signal by using one of two different approaches:
  i. Baseband transmission
  ii. Broadband transmission (using modulation)

Baseband Transmission

- Baseband transmission means *sending a digital signal over a channel without changing the digital signal to an analog signal*
- Figure 3.19 shows baseband transmission.

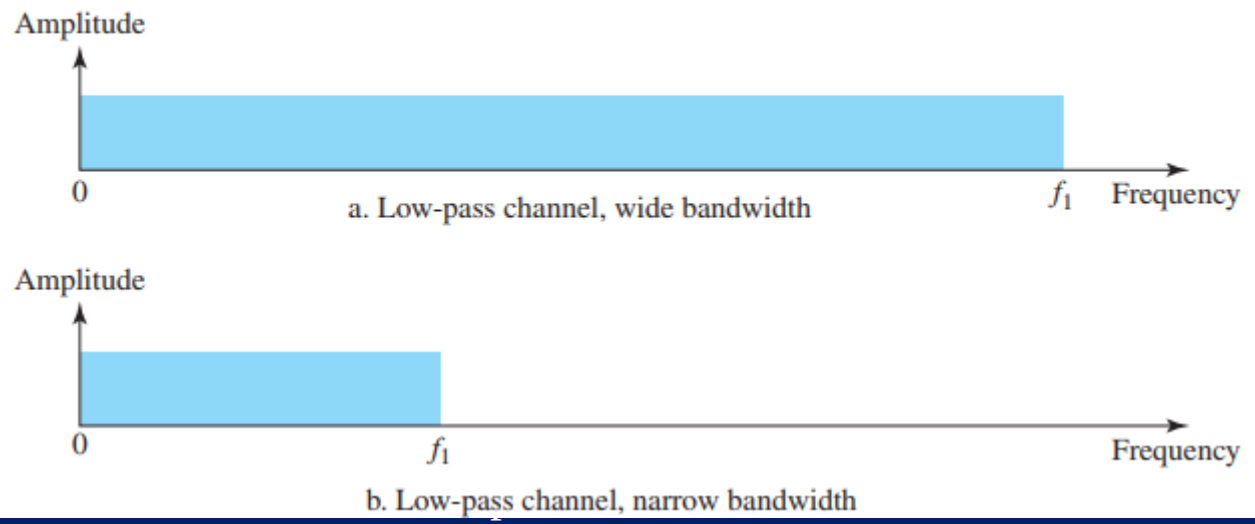


- This transmission requires that we have a low-pass channel, *a channel with a bandwidth that starts from zero*
- This is the case if we have a dedicated medium with a bandwidth constituting only one channel
- i.e. entire bandwidth of a cable connecting two computers is one single channel

Baseband Transmission-Low Pass Channel

- As another example, we may connect several computers to a bus, but not allow more than two stations to communicate at a time
- Figure 3.20 shows two low-pass channels:
  i. One with a narrow bandwidth
  ii. Other with a wide bandwidth
- Low-pass channel with *infinite bandwidth* cannot exist in real

Figure 3.20 *Bandwidths of two low-pass channels*

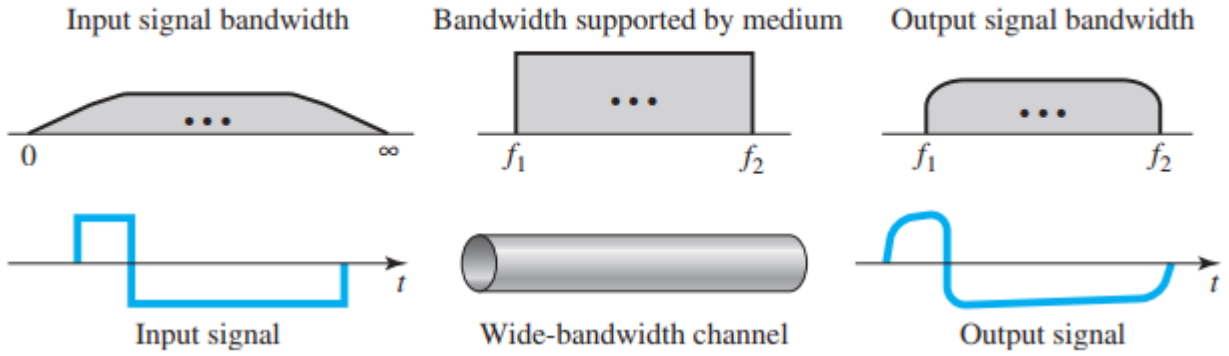


Baseband Transmission-Low Pass Channel

i. Other with a wide bandwidth

- Baseband transmission of a digital signal that preserves the shape of the digital signal is possible only if we have a low-pass channel with an infinite or very wide bandwidth
- Although this may be possible inside a computer (e.g., between CPU and memory), it is not possible between two devices

Figure 3.21 *Baseband transmission using a dedicated medium*



References

Chapter 3

Data Communication and Networking (5th Edition)
By Behrouz A. Forouzan

THANKS