Computer Networks 1

DATA TRANSMISSION

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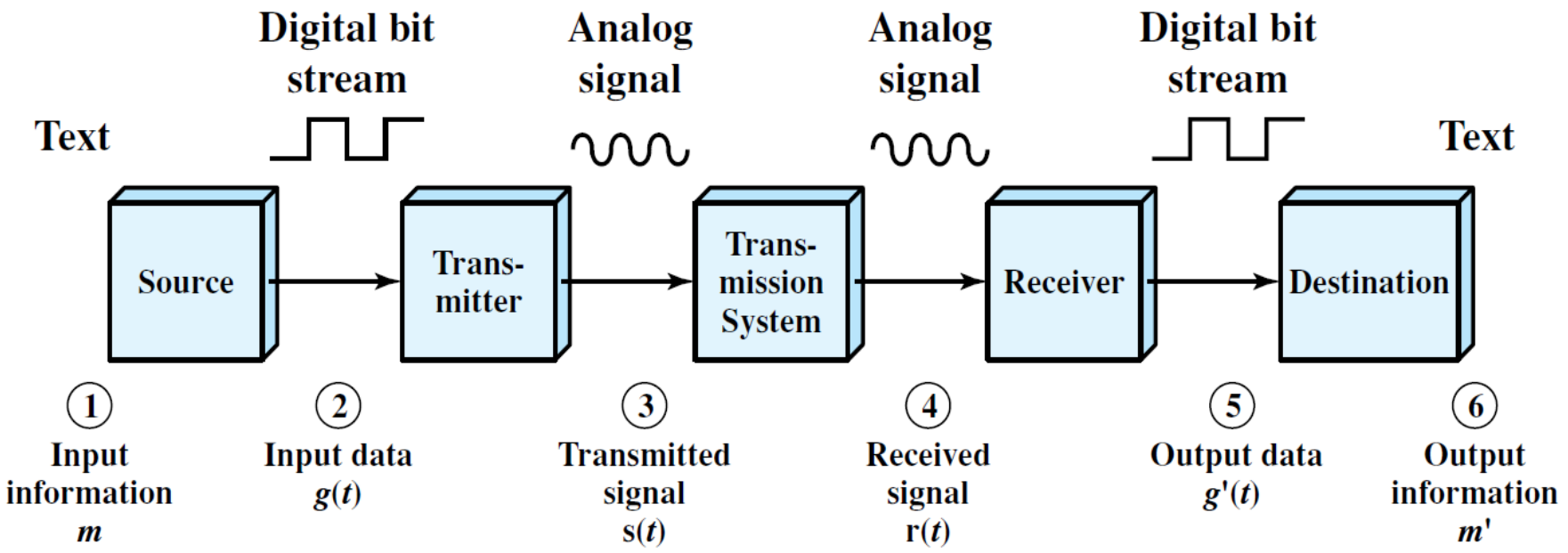
DEFINITIONS

- Data
  - Entities that convey meaning
- Signals
  - Electric or electromagnetic representations of data
- Data Transmission
  - Communication of data
  - Through propagation and processing of signals representing them

DATA COMMUNICATIONS SYSTEM



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DATA TYPES

Analog Data

- Continuous values
- Examples
  - audio, video

Digital Data

- Discrete values
  (not necessarily binary)
- Examples
  - integers, text characters
    - 194, “Hello”,Chapter12

SIGNAL TYPES

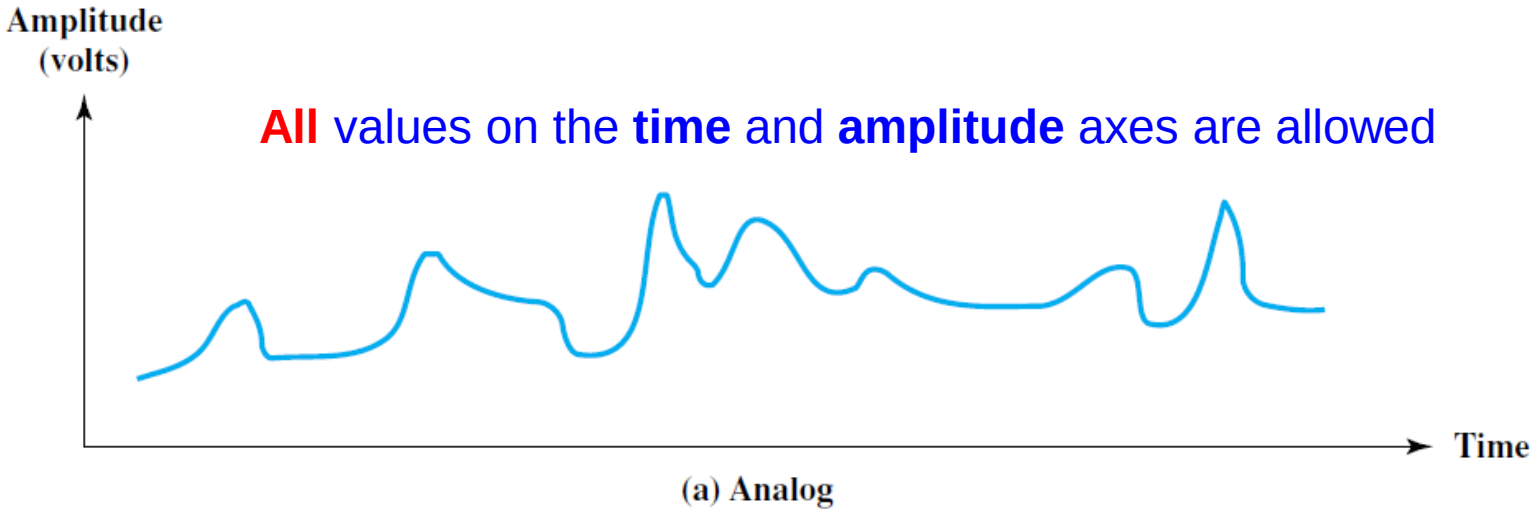
Analog signal

- Continuously variable in time and amplitude

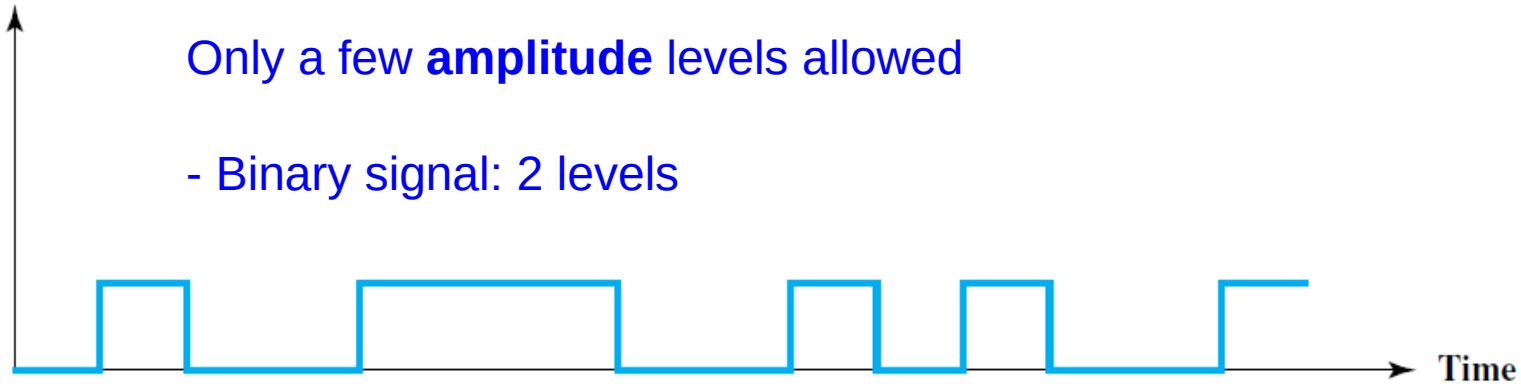
Digital signal

- Amplitude takes only a finite number of discrete levels

ANALOGUE & DIGITAL SIGNALS



(a) Analog



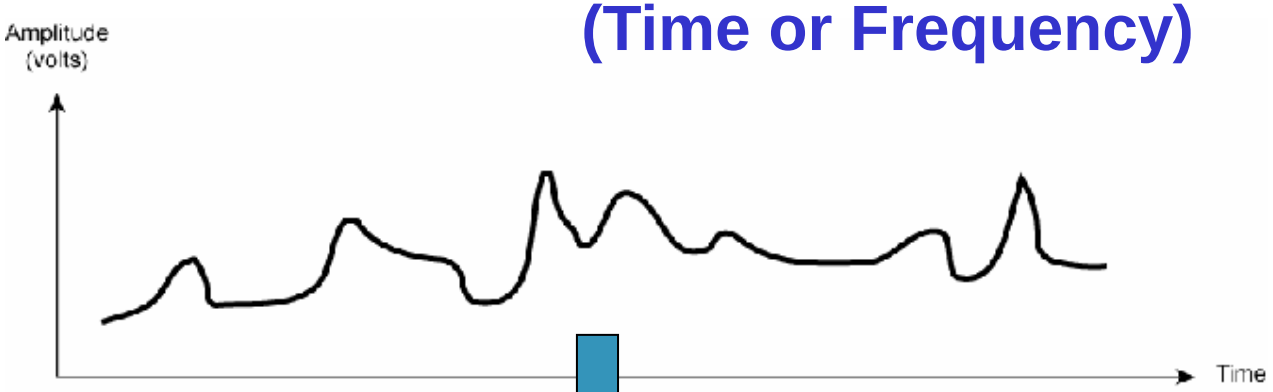
(b) Digital

CONTINUOUS VERSUS DISCRETE

Availability of the signal over the horizontal axis (Time or Frequency)

Continuous:

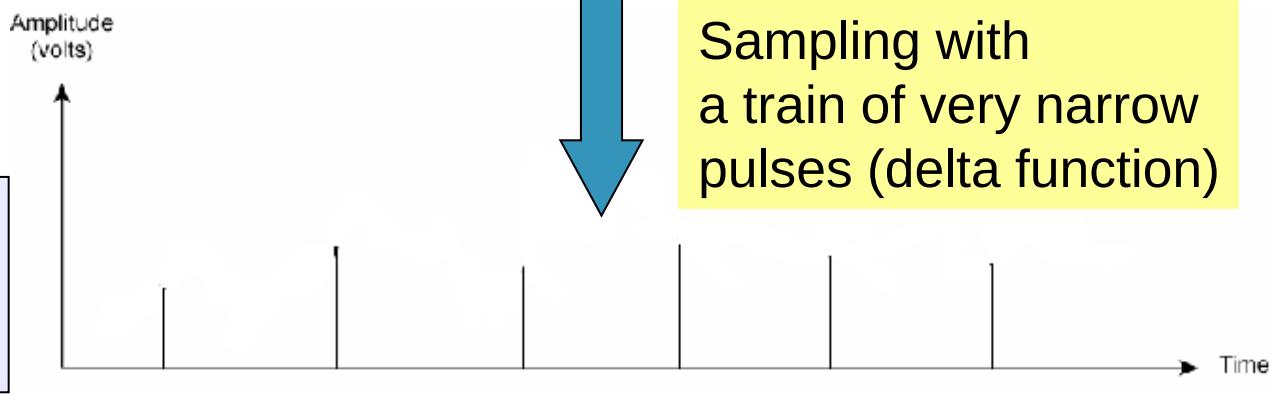
Signal is defined at *all points* on the horizontal axis



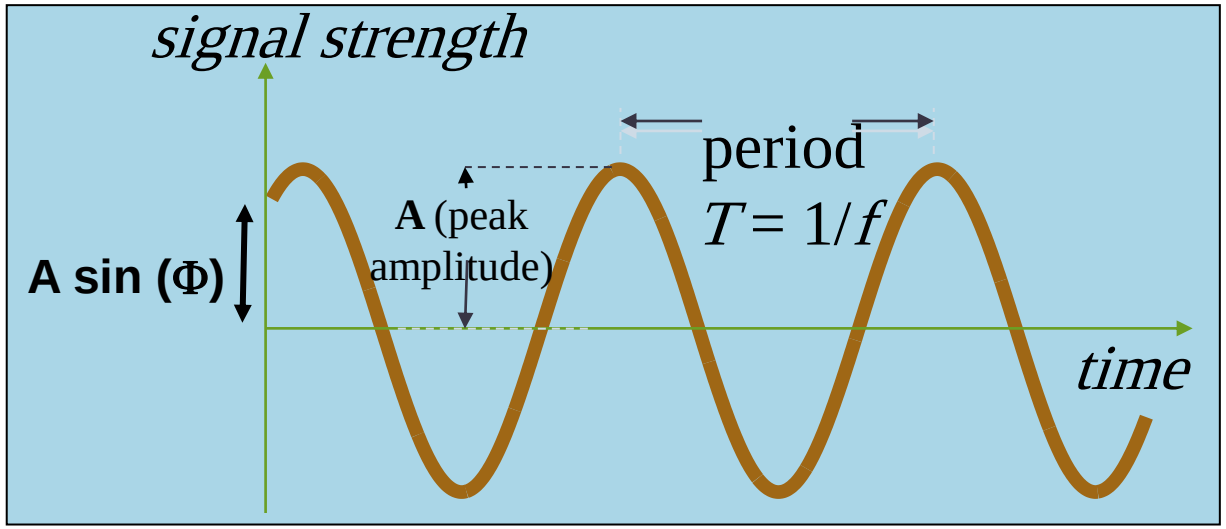
Sampling with a train of very narrow pulses (delta function)

Discrete:

Signal is defined Only at *certain points* on the horizontal axis



SINE WAVES



- General form: $x(t) = A\sin(2\pi ft + \phi)$
  - ω
- Angular Frequency (ω), Radians/s
  - ω = radians per second = $2\pi f = 2\pi / T$
- Temporal (time) Period, $T = 1/f$
- Phase Angle (ϕ), Radians

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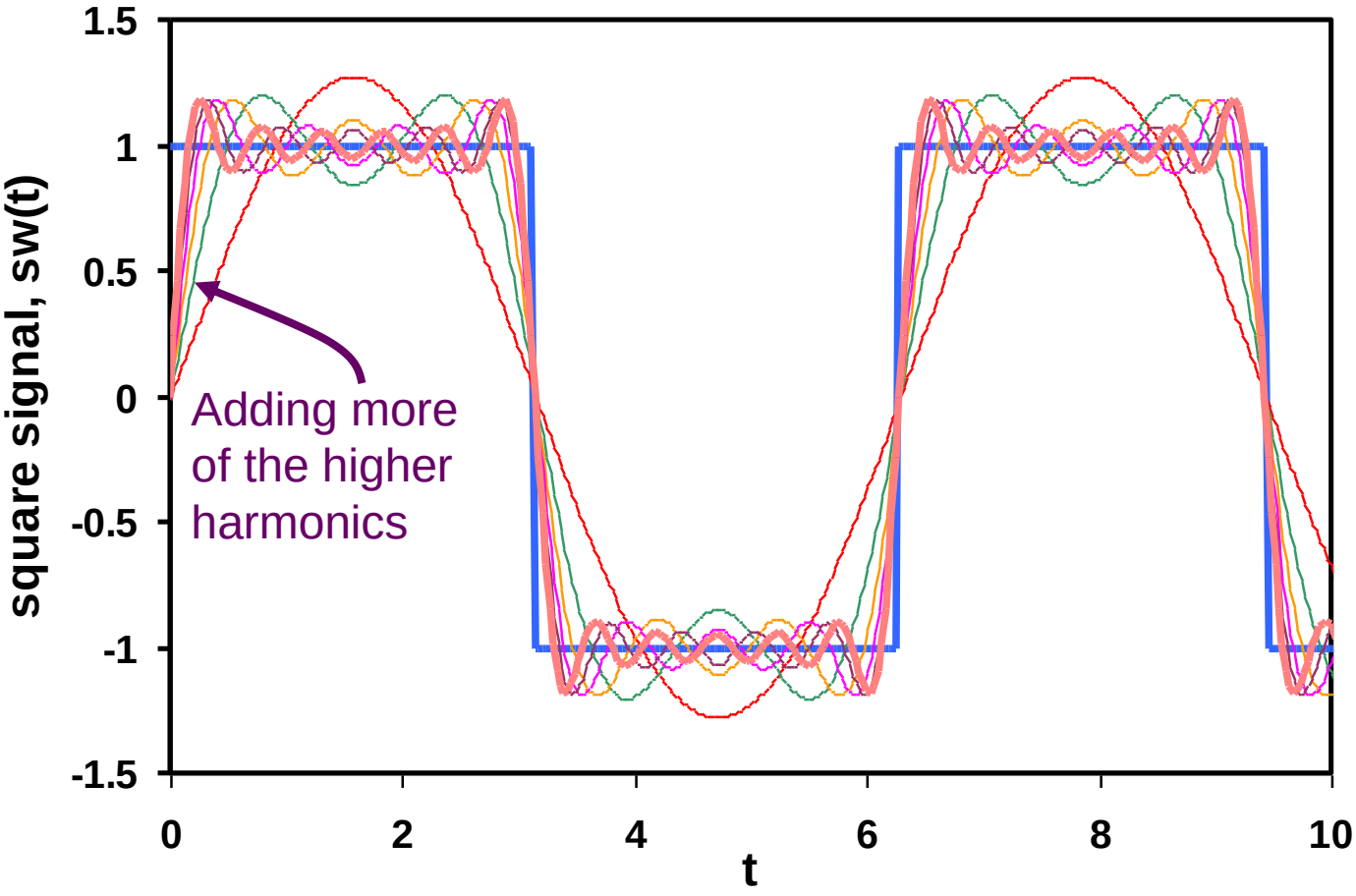
FREQUENCY DOMAIN CONCEPTS

- Response of systems to a sine waves is easy to analyze
- signals we deal with in practice are not all sine waves
- Can we relate waves we deal with in practice to sine waves?
- Fourier analysis shows that any signal can be treated as the sum of many sine wave components having different frequencies, amplitudes, and phases
- This forms the basis for frequency domain analysis
- Dealing with functions in the frequency domain is simpler

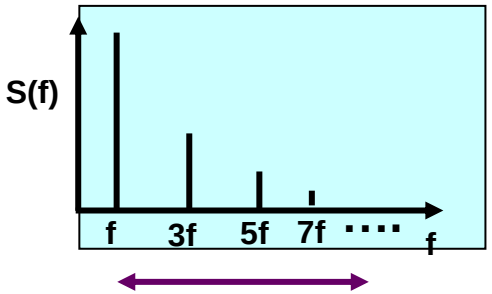
ASYMPTOTICALLY APPROACHING A SQUARE WAVE



Combining the fundamental + an infinite number of odd harmonics at proper amplitudes

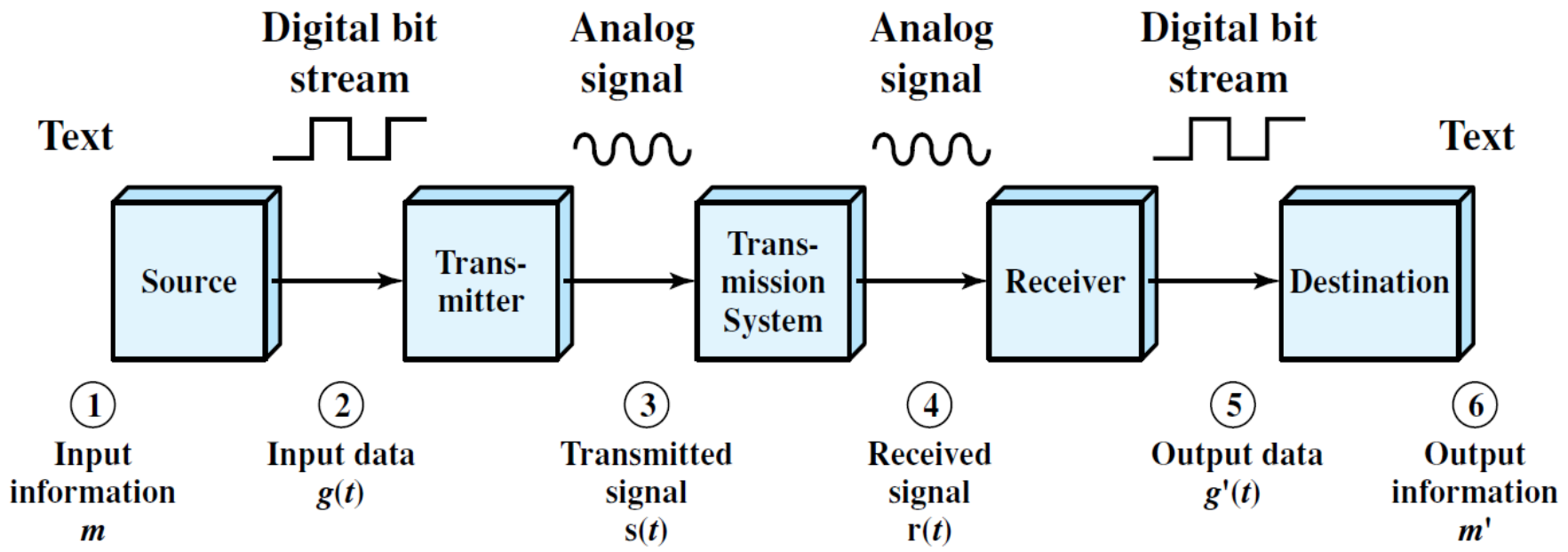
SPECTRUM & BANDWIDTH OF A SIGNAL

- Spectrum of a signal
  - Range of frequencies contained in a signal
- Absolute (theoretical) Bandwidth (BW):
  - Is the full width of spectrum = fmax- fmin
  - But in many situations, fmax = ∞!
    (e.g. a square wave)



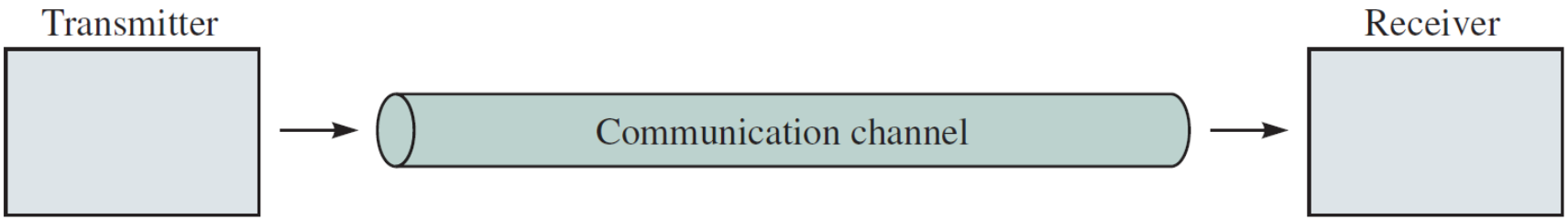
- Effective Bandwidth
  - Often called just *bandwidth*
  - Narrow band of frequencies containing *most* of the signal energy
  - Somewhat arbitrary: what is "most"?
    - e.g. that contains say 95% of the energy of the signal

DATA COMMUNICATIONS SYSTEM

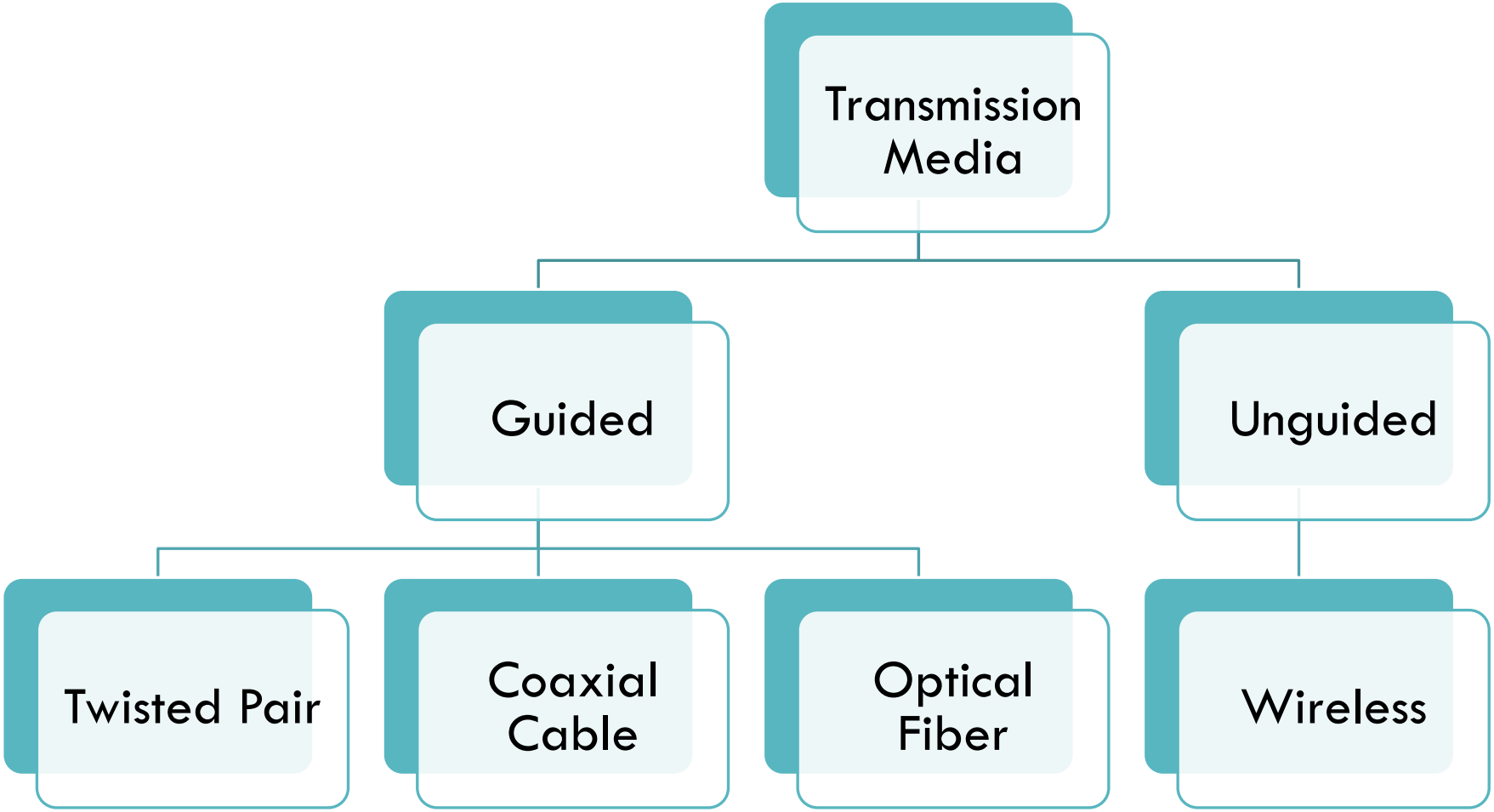


TRANSMISSION SYSTEM

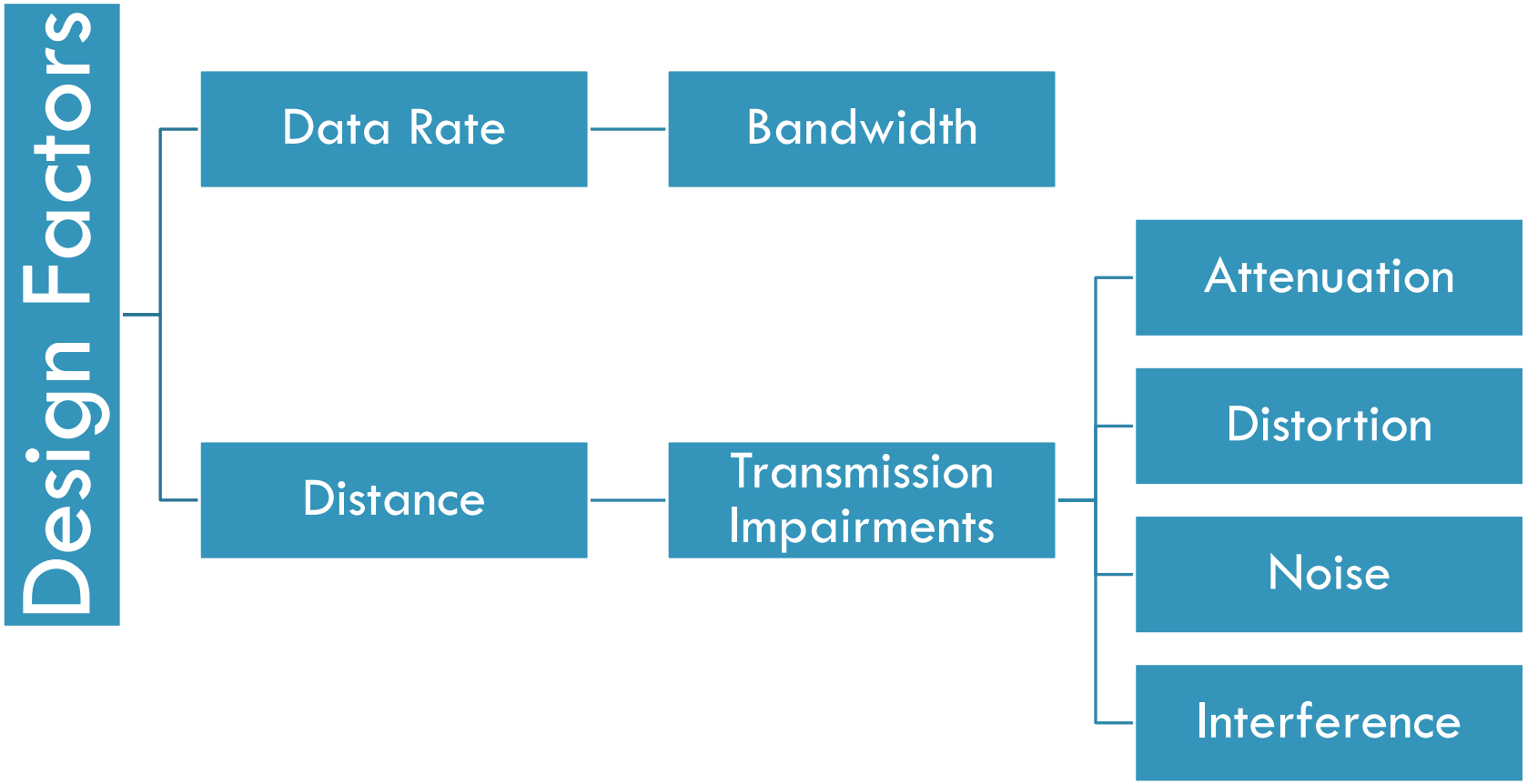
- Transmission Medium:
  - Transmitting Electromagnetic Wave
  - Channel
    - Designing of Tx/Rx



TRANSMISSION MEDIA

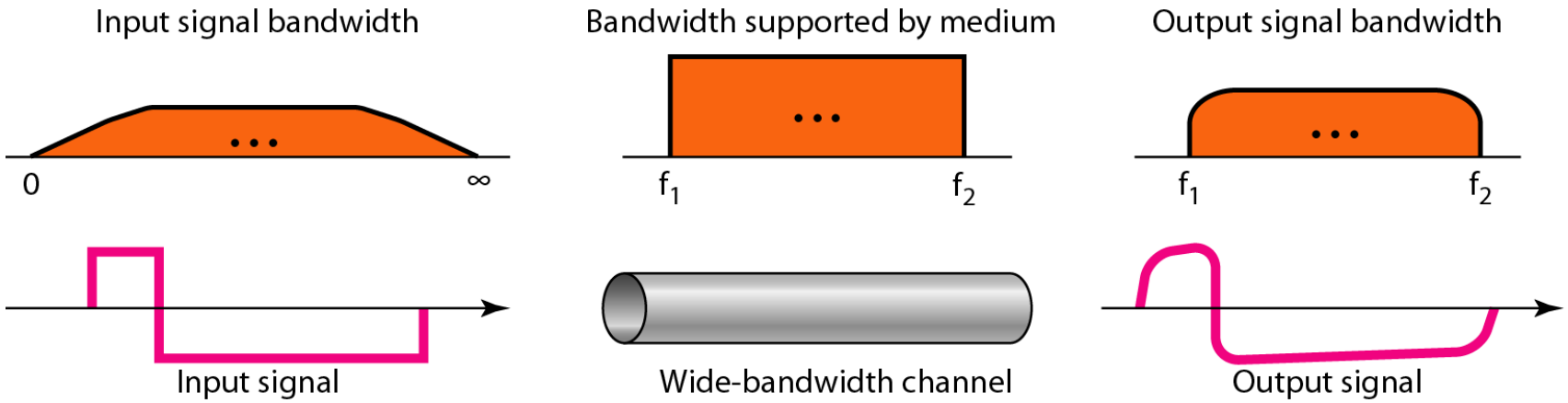


KEY CONCERNS OF TRANSMISSION MEDIUM



BANDWIDTH OF A TRANSMISSION SYSTEM

- Is the Range of signal frequencies that are adequately passed by the system
- Effectively, the transmission system (TX, medium, RX) acts as a filter
  - Poor transmission media, e.g. twisted pairs, have a narrow bandwidth



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TRANSMITTER/ RECEIVER FUNCTIONS

Transmitter

Amplification

Modulation

Coding

Receiver

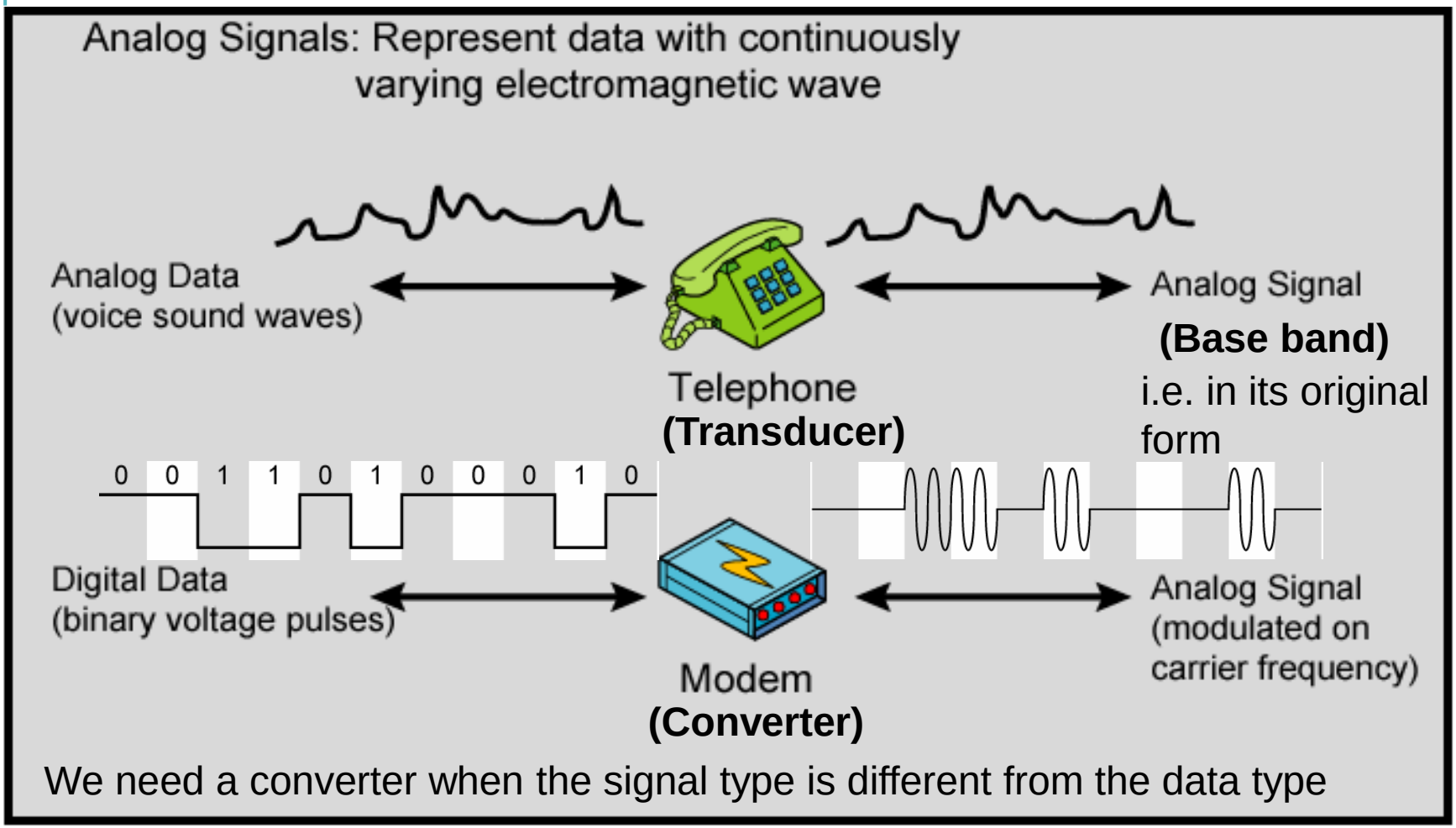
Amplification

Demodulation

Decoding

Filtering

MODULATION



We need a converter when the signal type is different from the data type

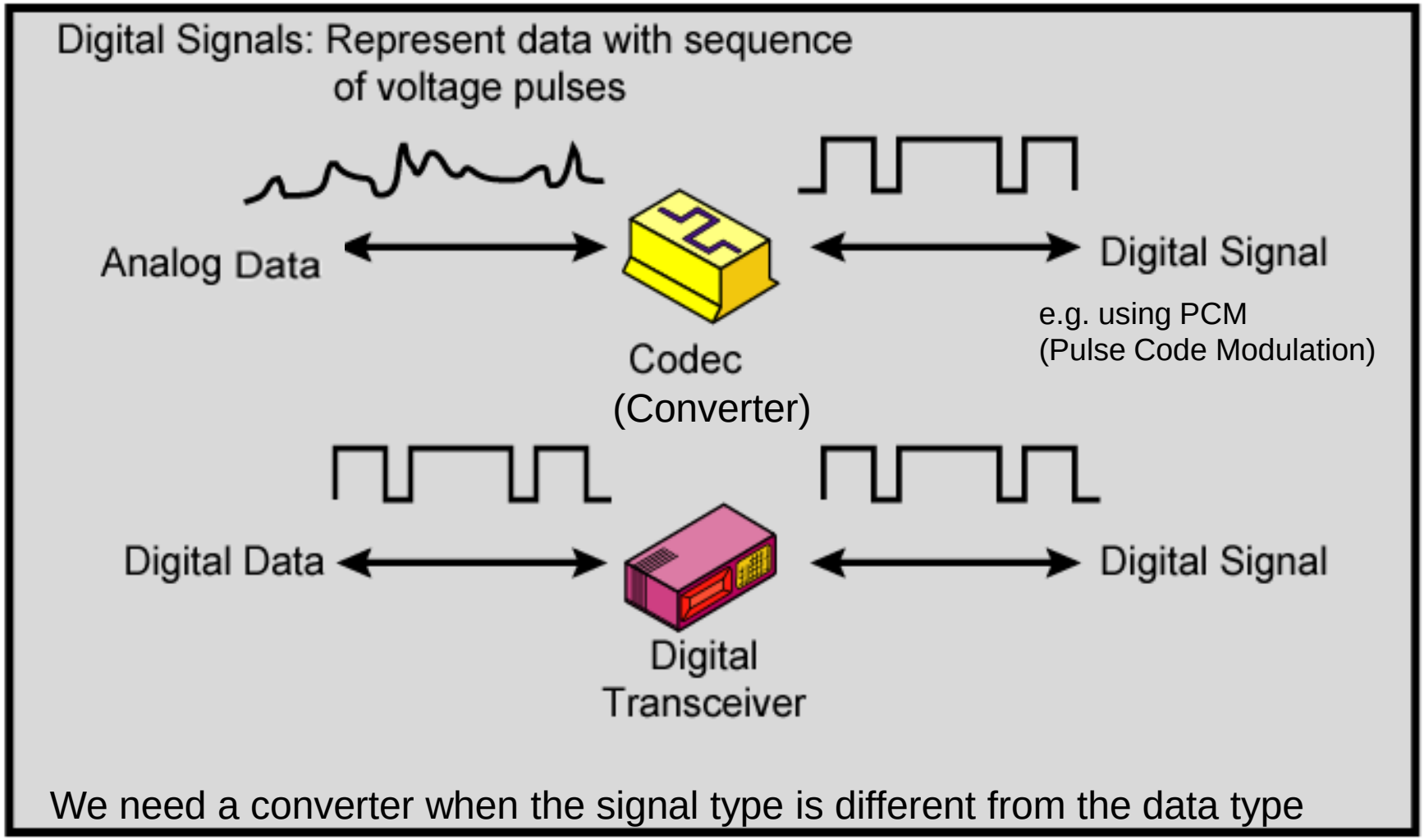
ANALOG DATA TO ANALOG SIGNAL
SPEECH TRANSMISSION

- Mechanical sound waves (data)
  - Easily converted into electromagnetic signal
  - For processing and transmission
    - Mechanical waves (Sound) of varying pitch and loudness (Data)

      is represented as:

      Electromagnetic signals of different frequencies and amplitudes (Signal)

ENCODING

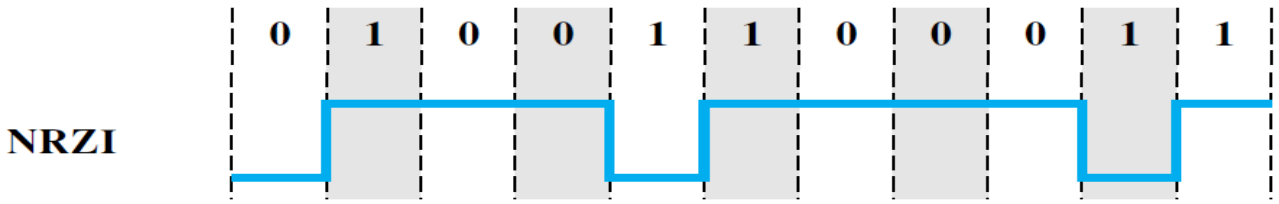

Digital Signals: Represent data with sequence of voltage pulses
Analog Data
Digital Signal
e.g. using PCM
(Pulse Code Modulation)
Codec
(Converter)
Digital Data
Digital Signal
Digital
Transceiver
We need a converter when the signal type is different from the data type

TYPES OF MODULATION AND ENCODING

Line Coding	• Digital Data, Digital Signals
Source Coding	• Analog Data, Digital Signals
Digital Modulation	• Digital Data, Analog Signals
Analog Modulation	• Analog Data, Analog Signals

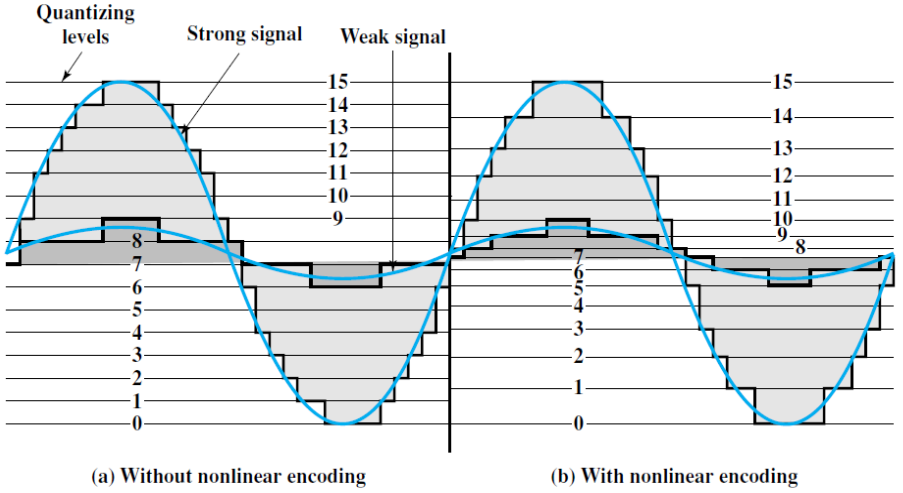
DIGITAL DATA, DIGITAL SIGNAL

- The simplest form
  - Assigning one voltage level to binary one and another to binary zero
- More complex encoding schemes
  - Using to improve performance
    - Altering the spectrum of the signal
    - Providing synchronization capability

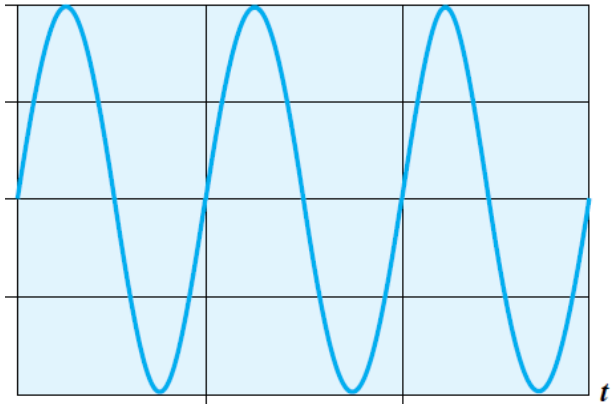


ANALOG DATA, DIGITAL SIGNAL

- Digitizing analog data to use digital transmission facilities
- The simplest technique
  - Pulse code modulation (PCM)
    - Sampling the analog data
    - Quantizing the samples



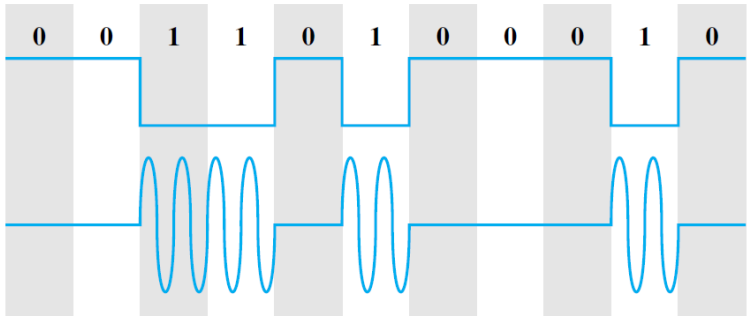
ANALOG SIGNALING



- Carrier signal
  - A continuous constant-frequency signal
  - Its frequency is compatible with the transmission medium
- Modulation
  - Encoding source data onto a carrier signal with frequency f_c
  - Operation on one or more of the 3 fundamental parameters
    - Amplitude
    - Frequency
    - Phase

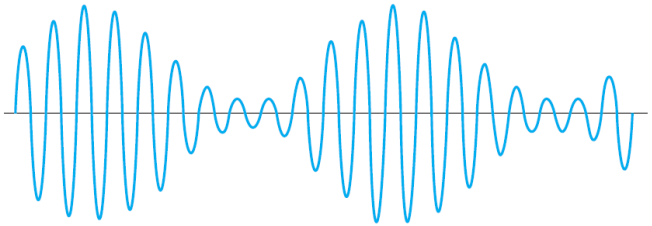
DIGITAL DATA, ANALOG SIGNAL

- A modem converts digital data to an analog signal
- To be transmitted over an analog line
- Altering one or more characteristics of a carrier signal to represent binary data
- The basic techniques
  - Amplitude shift keying (ASK)
  - Frequency shift keying (FSK)
  - Phase shift keying (PSK)



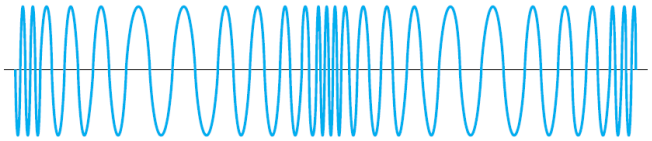
ANALOG DATA, ANALOG SIGNAL

- Analog data are modulated by a carrier signal
- Produce an analog signal in a different frequency band
- Can be utilized on an analog transmission system
- The basic techniques
  - Amplitude modulation (AM)



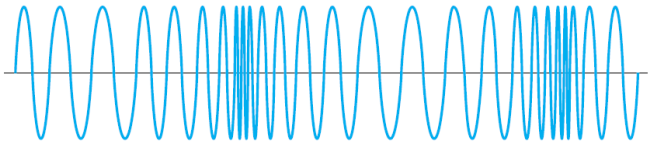
Amplitude-modulated (DSBTC) wave

  - Phase modulation (PM)



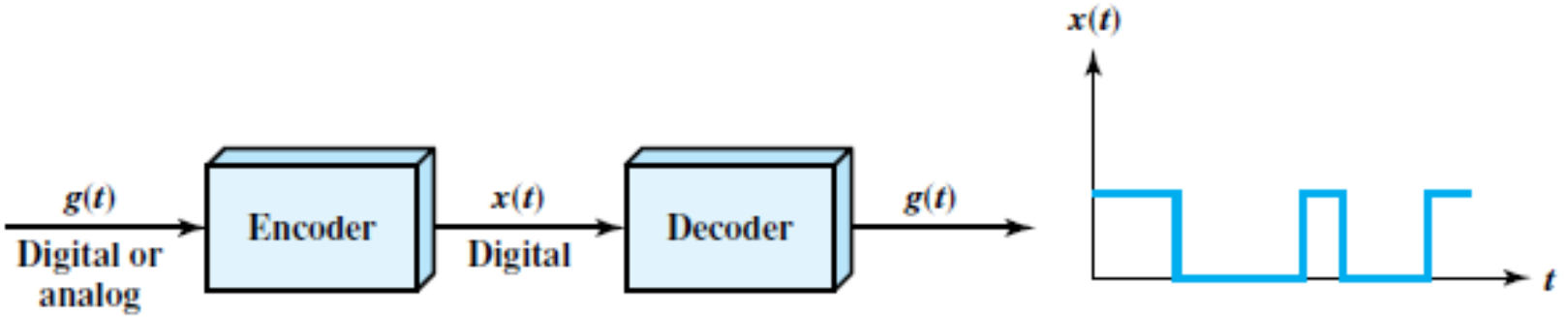
Phase-modulated wave

  - Frequency modulation (FM)

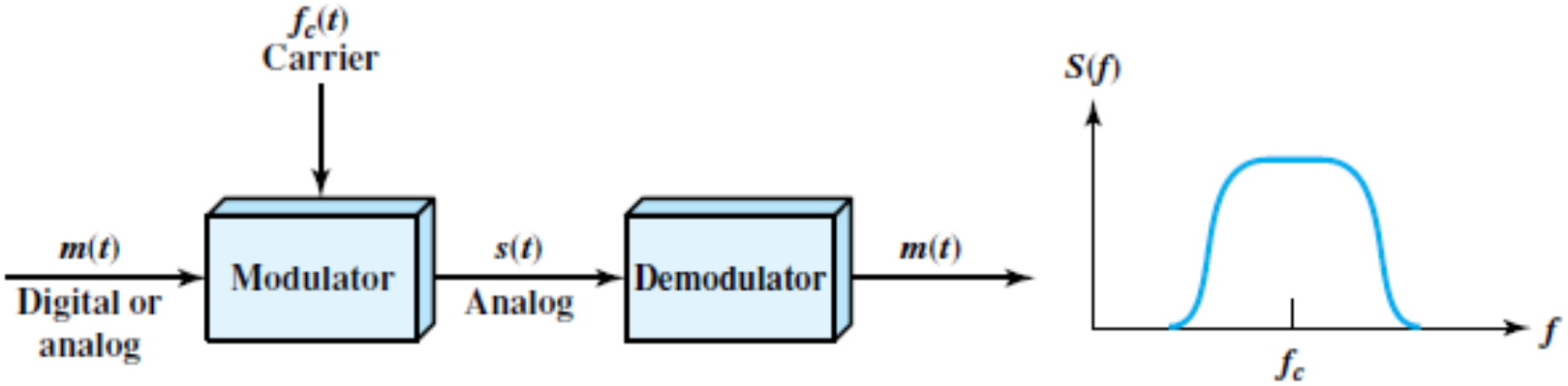


Frequency-modulated wave

ENCODING AND MODULATION TECHNIQUES



(a) Encoding onto a digital signal



(b) Modulation onto an analog signal

ANALOG TRANSMISSION

- Transmitting analog signals
  - Without regard to their content
  - Signals may represent analog data or digital data
- Amplifiers overcome attenuation
- Amplifiers boosts the noise components
  - Cumulative noise and distortion
  - More distortion in case of cascaded amplifiers
- Introducing errors in digital data

DIGITAL TRANSMISSION

- Assume digital content
  - Transmitted signal can be digital or analog
- Repeaters overcome attenuation
  - Extract the data bit stream from the received signal
  - Recovers the pattern of 1s and 0s
  - Retransmit a fresh, strong signal representing the bit stream
- Noncumulative noise and distortion

SIGNALS AND TRANSMISSION

	Analog Transmission	Digital Transmission
Analog Signal	Analog Data/ Digital Data	Digital Data
Digital Signal	Not used	Digital Data/ Encoded Analog Data

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DIGITAL TRANSMISSION ADVANTAGES

- Digital technology
  - Cheaper and Smaller
- Data integrity
  - Noncumulative noise and distortion
  - Transmit data longer distances
- Capacity utilization
  - More easily and cheaply multiplexing (TDM)
- Security and privacy
  - Easily apply encryption techniques
- Integration
  - Similarly treat with voice, video, and digital data