Chapter 4: Communication system

4.1. Digital communication system

4.2. Information source

4.3. Source coder

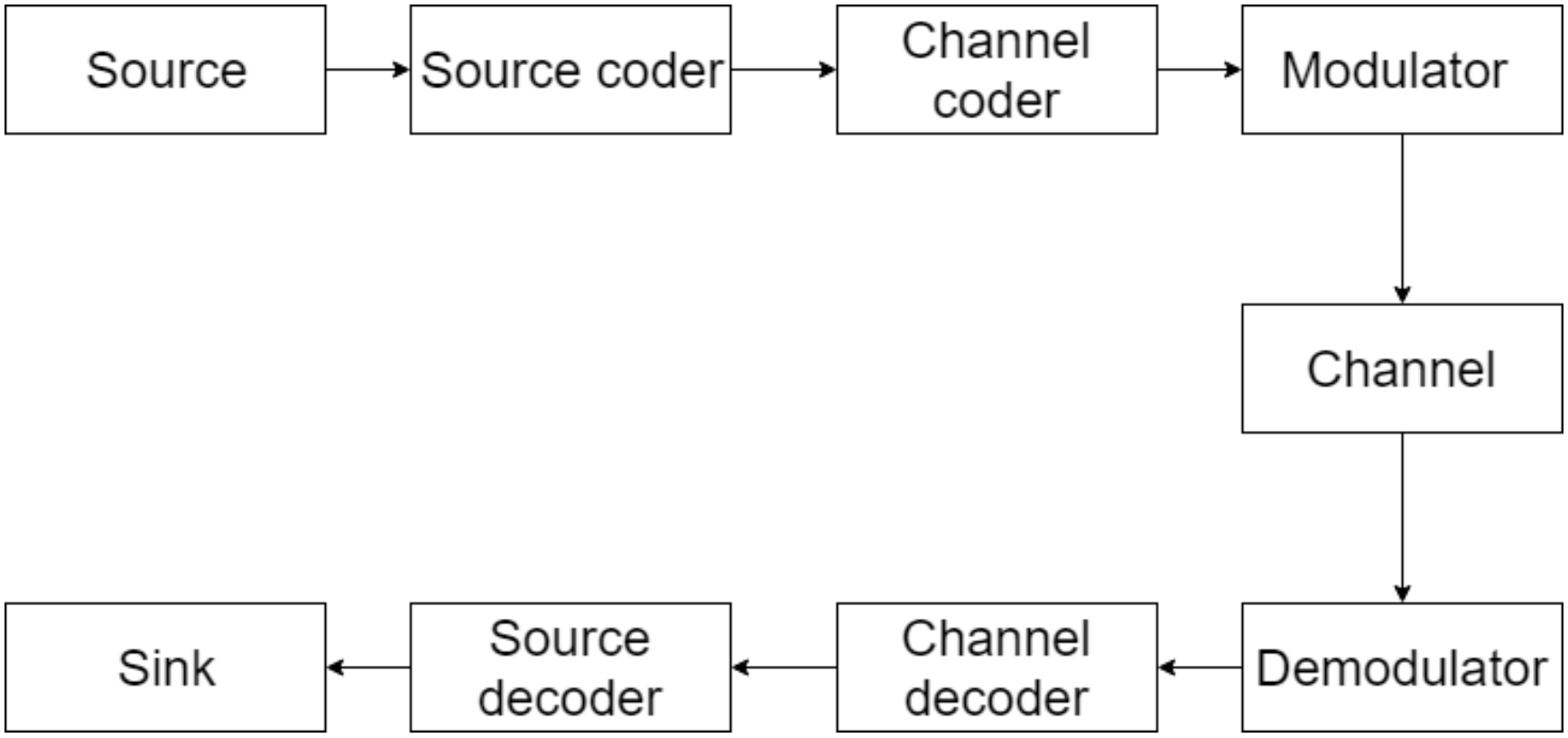
4.4. Channel coder

4.5. Modulator

4.6. Channel

4.7. Other components

4.1. Digital communication model



4.2. Information source

- Generate information
- Normally, information is generated in form of data
  - Each generated element of source represent by a source symbol (character)
    - Set of all different symbols called source alphabet
  - Example: speech, text are data
    - Contain the information that human want to transmit
- Commonly, source is denoted by symbol S
- Source can be discrete source or continuous source
  - Normally, continuous source is converted to discrete source so that the source is suitable with digital communication system

4.3. Source coder

- Coding:
  - use finite set of code symbols (code alphabet) to represent information
  - To represent a information of source, we need use a combination of code symbols constructed according to a definite law
  - To ensure no loss of information, an information is represented by only single combination
- Source coder:
  - Use finite set of code symbols to represent information of source (source symbol) by minimum number of code symbols
  - Source coder can also be called as data compressor (information compressor)

4.4. Channel coder

- Protection against errors in the channel.
- To prevent error , it needs to add some symbols that do not carry information so that the decoding side can detect the errors and correct the detected errors.
- E.g: From information 0 or 1, amount of information of each information is 1 bit. We can add another bit that does not carry the information to create codewords “00” and “11” to ensure that the number of “1” in the codewords is even. Amount of information in the new codewords is still 1.
  - During transmission, if codeword has 1-error → the number of “1” in received result is odd → error

4.5. Modulator

- Each symbol is assigned to a waveform (signal)
- Normally, each code symbol is coded by a binary sequence
  - Each value of binary is mapped to a parameter value of physical process (carrier)
- Modulating process does not modify the information
- E.g: speaking is modulating process. Each information is assigned to a defined spectrum of airflow
  - Variation of airflow pressure: similar saw-tooth signal
- Modulating converts data into signal

4.6. Channel

4.6.1. Definition of channel

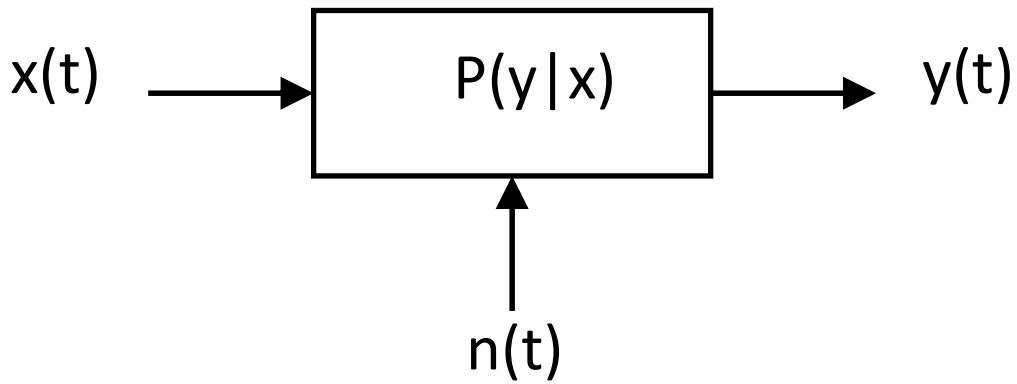
4.6.2. Types of channel

4.6.1. Definition of channel

- Physical medium to send signal that carry information from transmitter to receiver.
- Physical medium has 5 effects to the propagation signal inside this medium
  - Attenuation: signal power will reduces by the length of the transmission line
    - Information theory: ignore
  - Limited bandwidth: only signal in a determined frequency band can propagate
    - Information theory: ignore
  - Delay: needed time for signal can transmit from input to output of the medium
  - Nonlinearity of medium: if amplitude of input signal is outside of linear area of transmission characteristics
    - Output signal: different to input signal (nonlinear distortion)
    - Information theory: ignore
  - Noise: output signal is randomly changed when input signal stays at a certain level
    - To prevent noise, it needs acquire the knowledge (information) of the noise
    - Information theory: focus
      - Two different types of noises: additive noise, multiplicative noise
        - Additive noise: Output = Input + Noise $(y(t)= x(t) + n(t))$
        - Multiplicative noise: Output = Input * Noise $(y(t)= x(t) * n(t))$
      - To processing multiplicative noise, multiplicative noise needs to be transferred to corresponding additive noise by homomorphic operation
      - In information theory, channel has only additive noise (additive channel)
    - Noise can be generated by inside of the medium or outside of the medium
      - Noise is considered as a second source in information theory
    - Normally, noise has Gaussian distribution

4.6.1. Definition of channel (Cont.)

- Need to investigate transfer function of channel
- Channel has noise → transfer function: not determined
- Choose conditional probability P(y|x) to have a output signal y when a determined input signal x is sent
- P(y|x) denoted transfer probability



4.6.2. Types of channel

- Discrete channel: discrete input signal and discrete output signal
  - Discrete memoryless channel:
    - Its treatment of a symbol input at a certain time does not depend on the symbols input at any earlier time.
    - Defined by a discrete input alphabet X, a discrete output alphabet Y, and a transfer probability function P(y|x)
    - Often used to model communication channels
  - Discrete memory channel: its action depends on its inputs at a number of earlier times.
  - The discrete channel can also be classified by number of input signals and the number of output signals.
    - Binary channel: input signal and output signal are binary
- Continuous channel: continuous input signal and continuous output signal

4.7. Other components

- Demodulator: convert signal to data
- Channel decoder: analyze received string of symbols to detect and correct detected errors
- Source decoder: convert corrected string of symbols to information
- Sink: receive and use information