Spread Spectrum

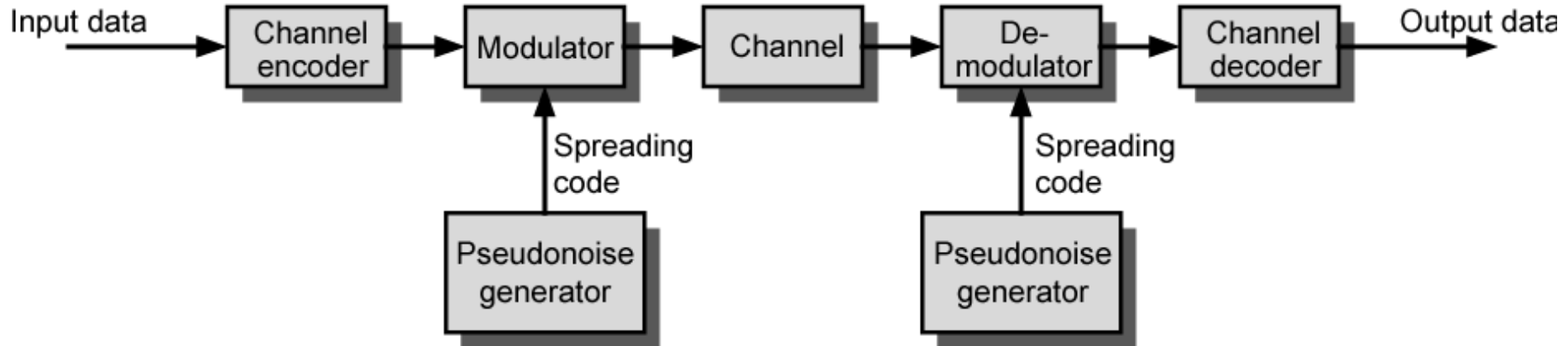# Spread Spectrum

- Analog or digital data

- Analog signal

- Spread data over wide bandwidth

- Makes jamming and interception harder

- Frequency hoping
  - Signal broadcast over seemingly random series of frequencies

- Direct Sequence
  - Each bit is represented by multiple bits in transmitted signal
  - Chipping code

Spread Spectrum Concept

- Input fed into channel encoder
  - Produces narrow bandwidth analog signal around central frequency
- Signal modulated using sequence of digits
  - Spreading code/sequence
  - Typically generated by pseudonoise/pseudorandom number generator
- Increases bandwidth significantly
  - Spreads spectrum
- Receiver uses same sequence to demodulate signal
- Demodulated signal fed into channel decoder

General Model of Spread Spectrum System

Input data → Channel encoder → Modulator → Channel → De-modulator → Channel decoder → Output data

Modulator ← Spreading code ← Pseudonoise generator

De-modulator ← Spreading code ← Pseudonoise generator

Gains

- Immunity from various noise and multipath distortion
  - Including jamming
- Can hide/encrypt signals
  - Only receiver who knows spreading code can retrieve signal
- Several users can share same higher bandwidth with little interference
  - Cellular telephones
  - Code division multiplexing (CDM)
  - Code division multiple access (CDMA)

Pseudorandom Numbers

- Generated by algorithm using initial seed
- Deterministic algorithm
  - Not actually random
  - If algorithm good, results pass reasonable tests of randomness
- Need to know algorithm and seed to predict sequence

Frequency Hopping Spread Spectrum (FHSS)

- Signal broadcast over seemingly random series of frequencies

- Receiver hops between frequencies in sync with transmitter

- Eavesdroppers hear unintelligible blips

- Jamming on one frequency affects only a few bits

Basic Operation

- Typically 2^k carriers frequencies forming 2^k channels

- Channel spacing corresponds with bandwidth of input

- Each channel used for fixed interval
  - 300 ms in IEEE 802.11
  - Some number of bits transmitted using some encoding scheme
    - May be fractions of bit (see later)
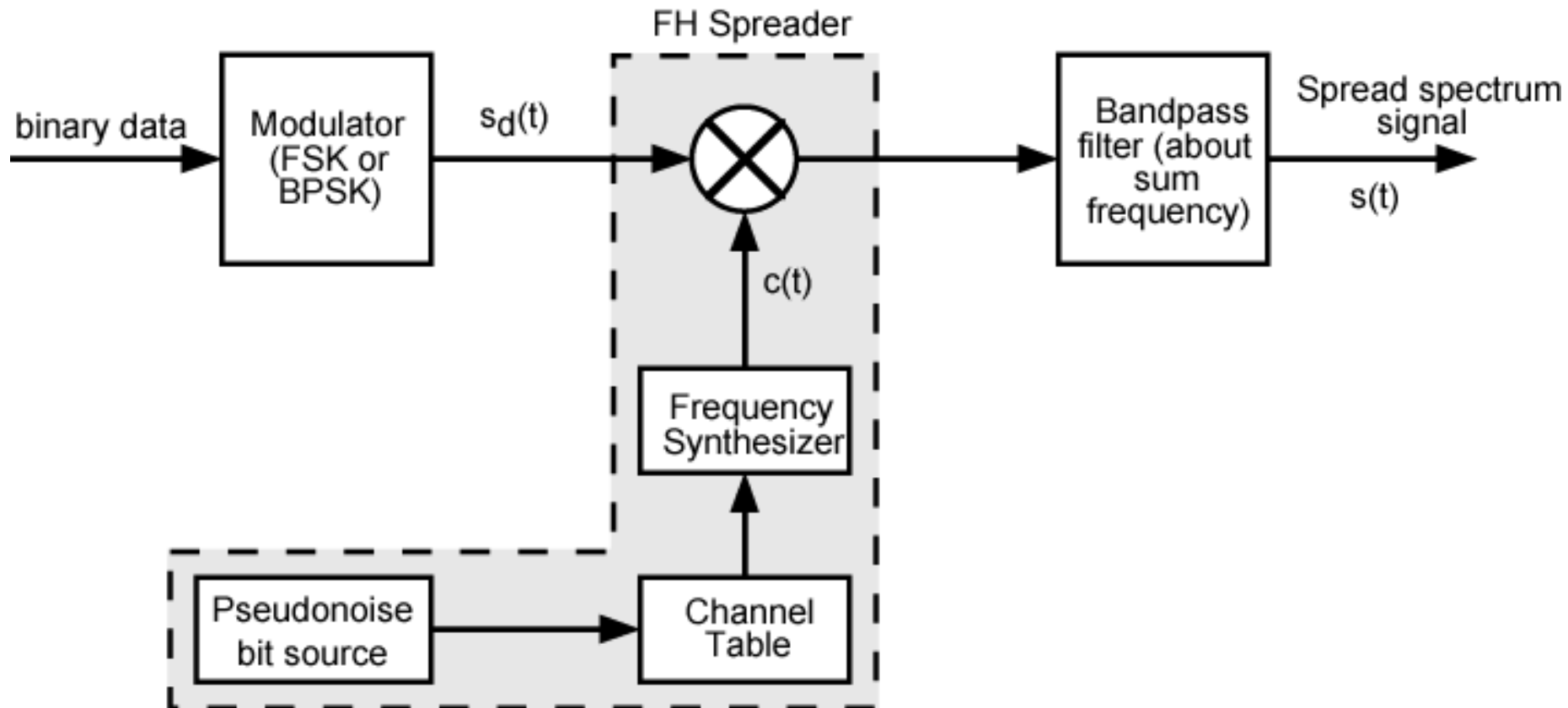 - Sequence dictated by spreading code

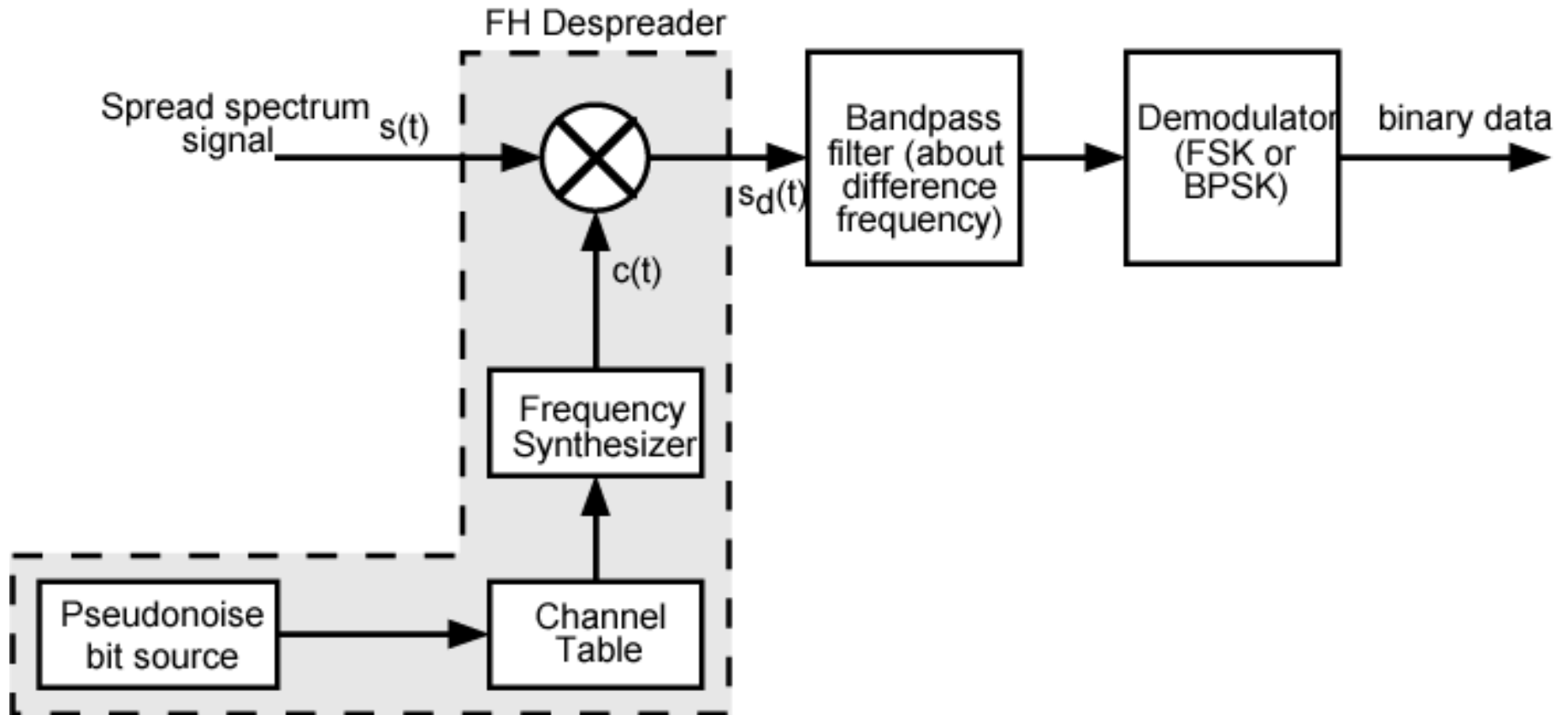# Frequency Hopping Example
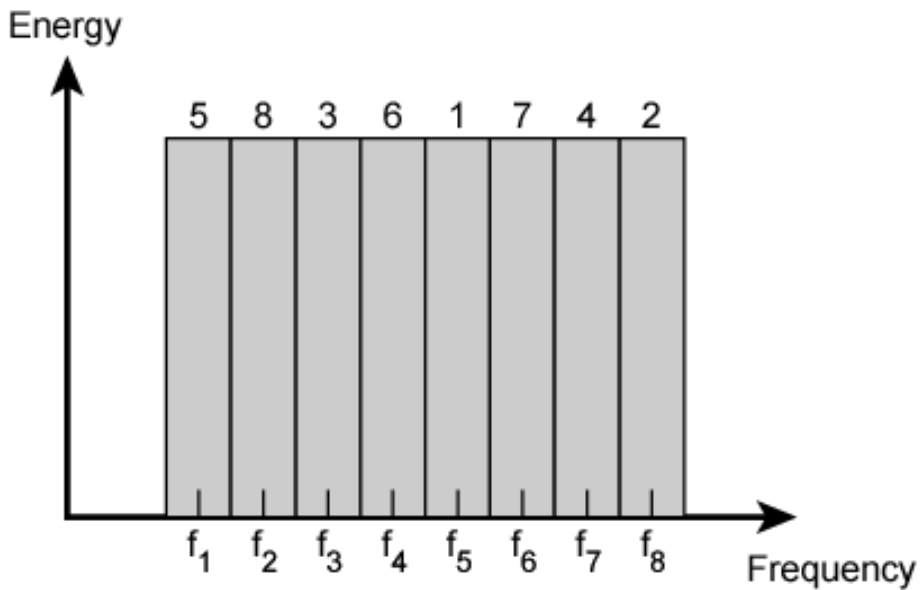
(a) Channel assignment
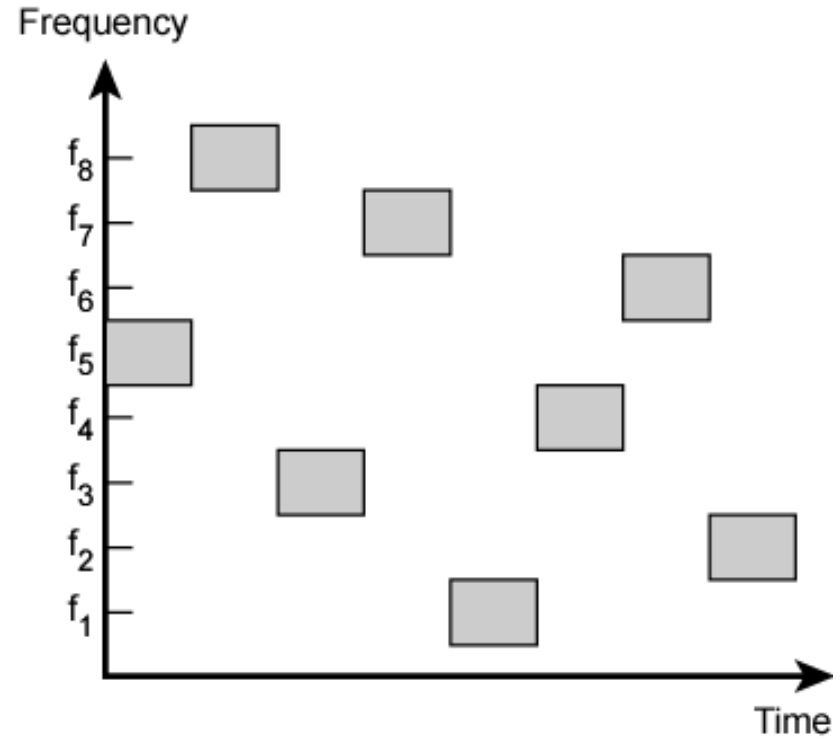
(b) Channel use

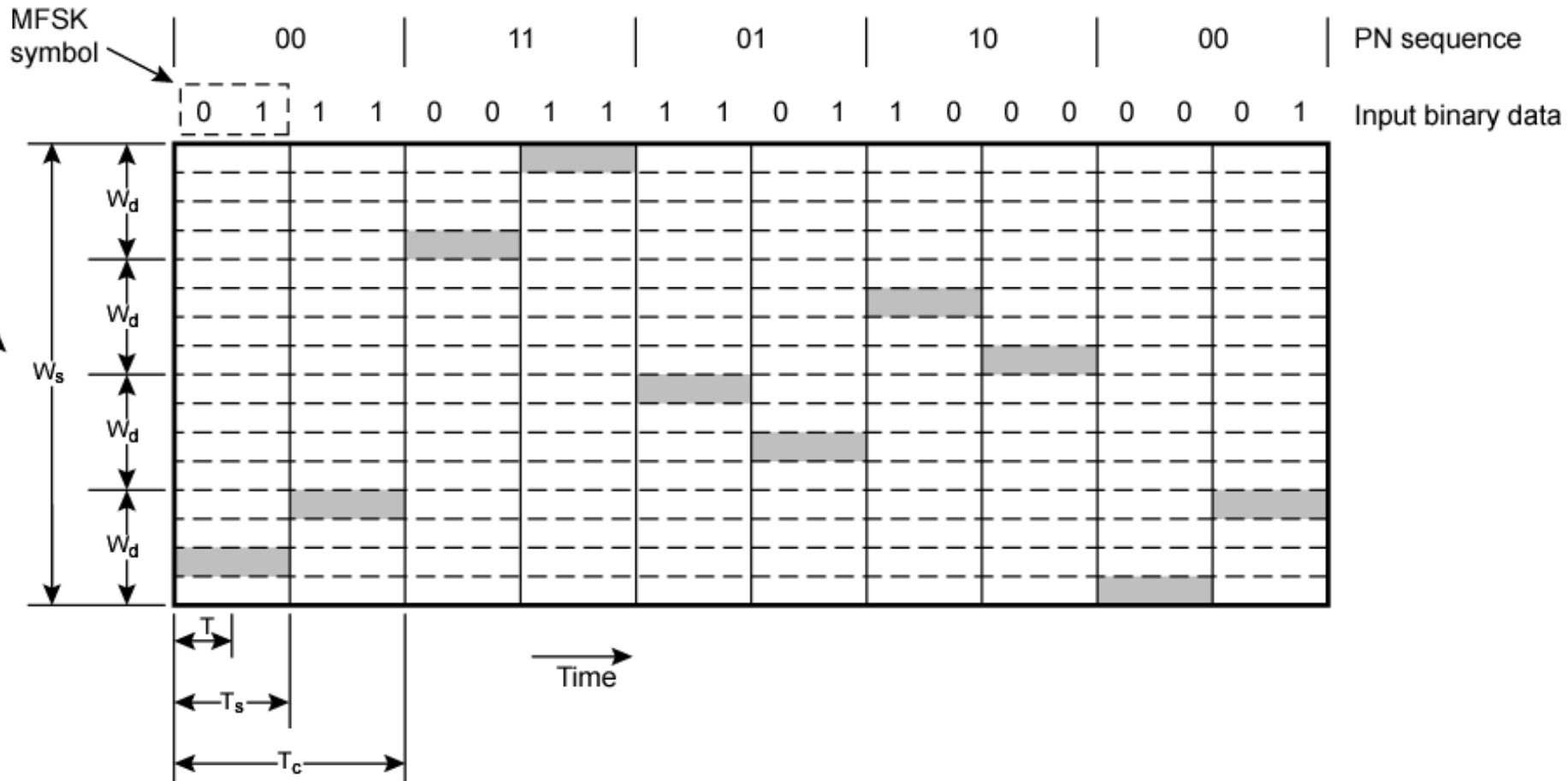# Frequency Hopping Spread Spectrum System (Transmitter)

Frequency Hopping Spread Spectrum System (Receiver)

Slow and Fast FHSS

- Frequency shifted every T_c seconds
- Duration of signal element is T_s seconds
- Slow FHSS has $T_c \geq T_s$
- Fast FHSS has $T_c < T_s$
- Generally fast FHSS gives improved performance in noise (or jamming)

Slow Frequency Hop Spread Spectrum Using MFSK (M=4, k=2)

Fast Frequency Hop Spread Spectrum Using MFSK (M=4, k=2)