
Spread Spectrum

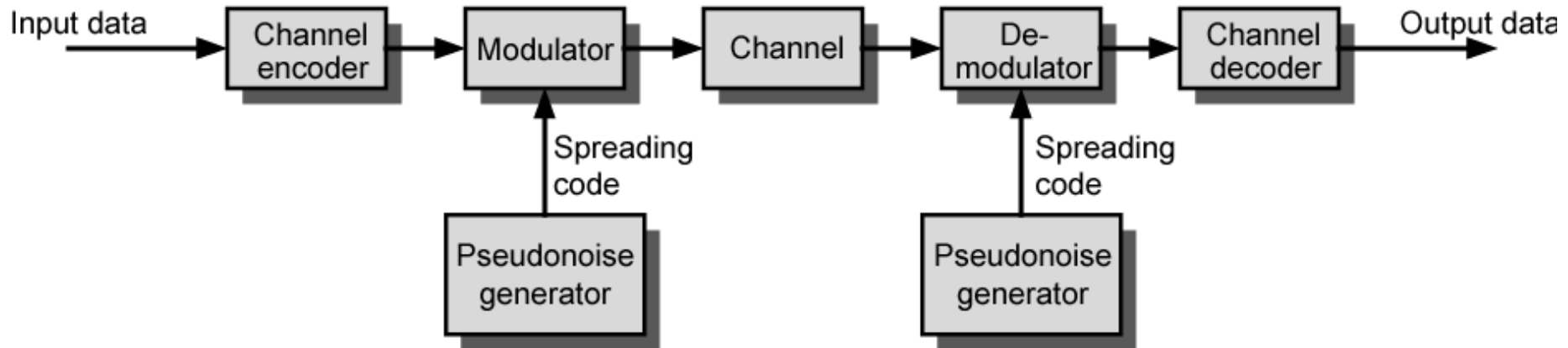
Spread Spectrum

- Analog or digital data
- Analog signal
- Spread data over wide bandwidth
- Makes jamming and interception harder
- Frequency hopping
 - 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



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

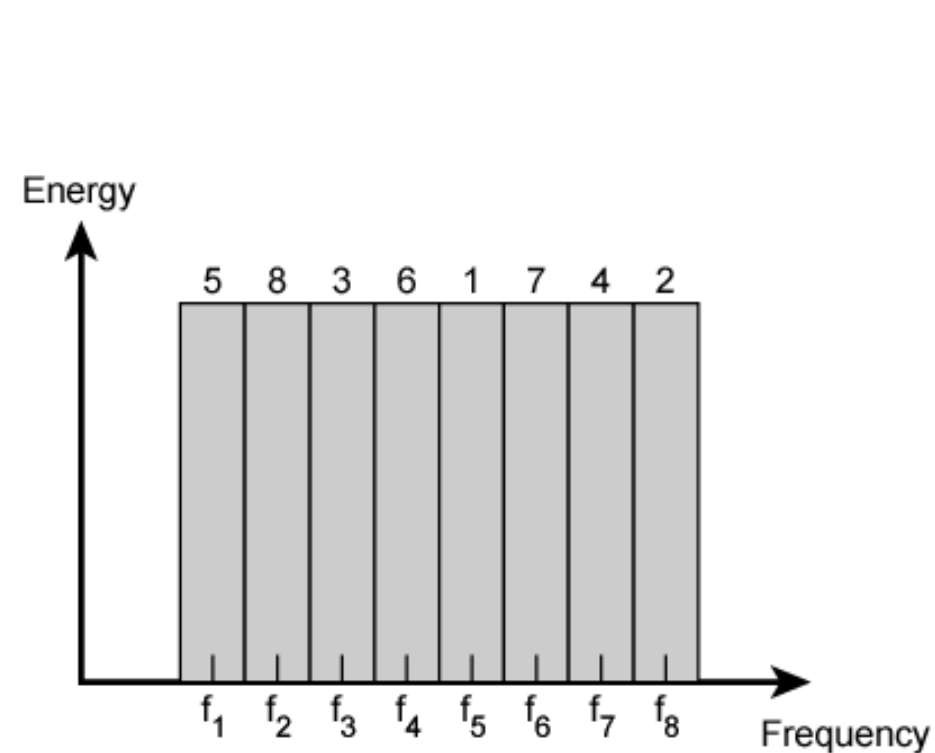
Frequency Hopping Spread Spectrum (FHSS)

- 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

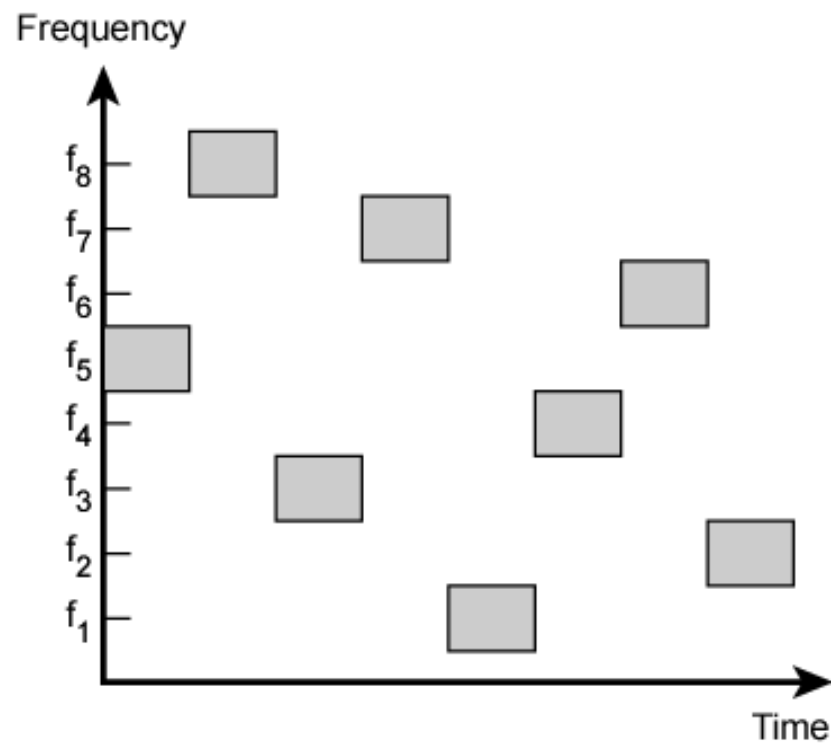
Basic Operation

- 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

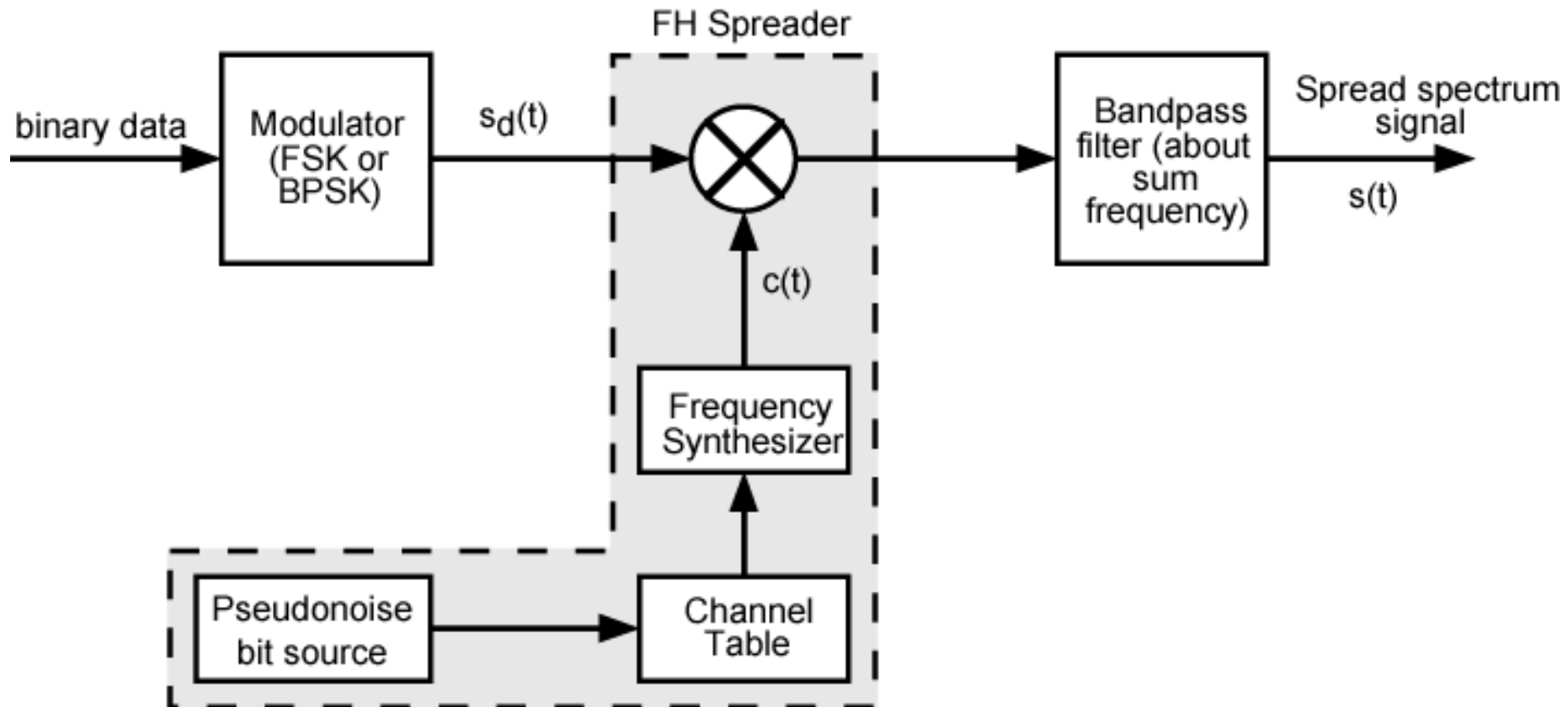


(a) Channel assignment

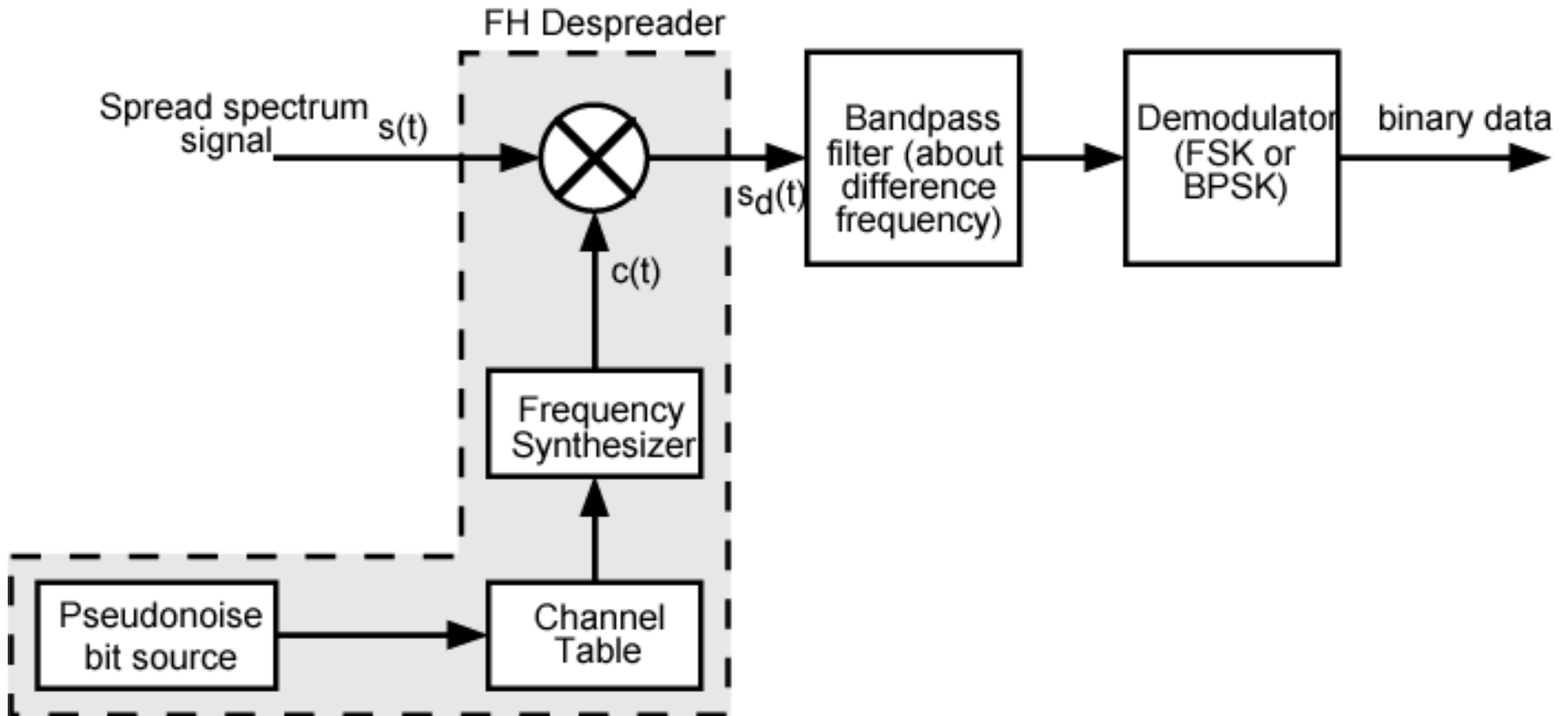


(b) Channel use

Frequency Hopping Spread Spectrum System (Transmitter)



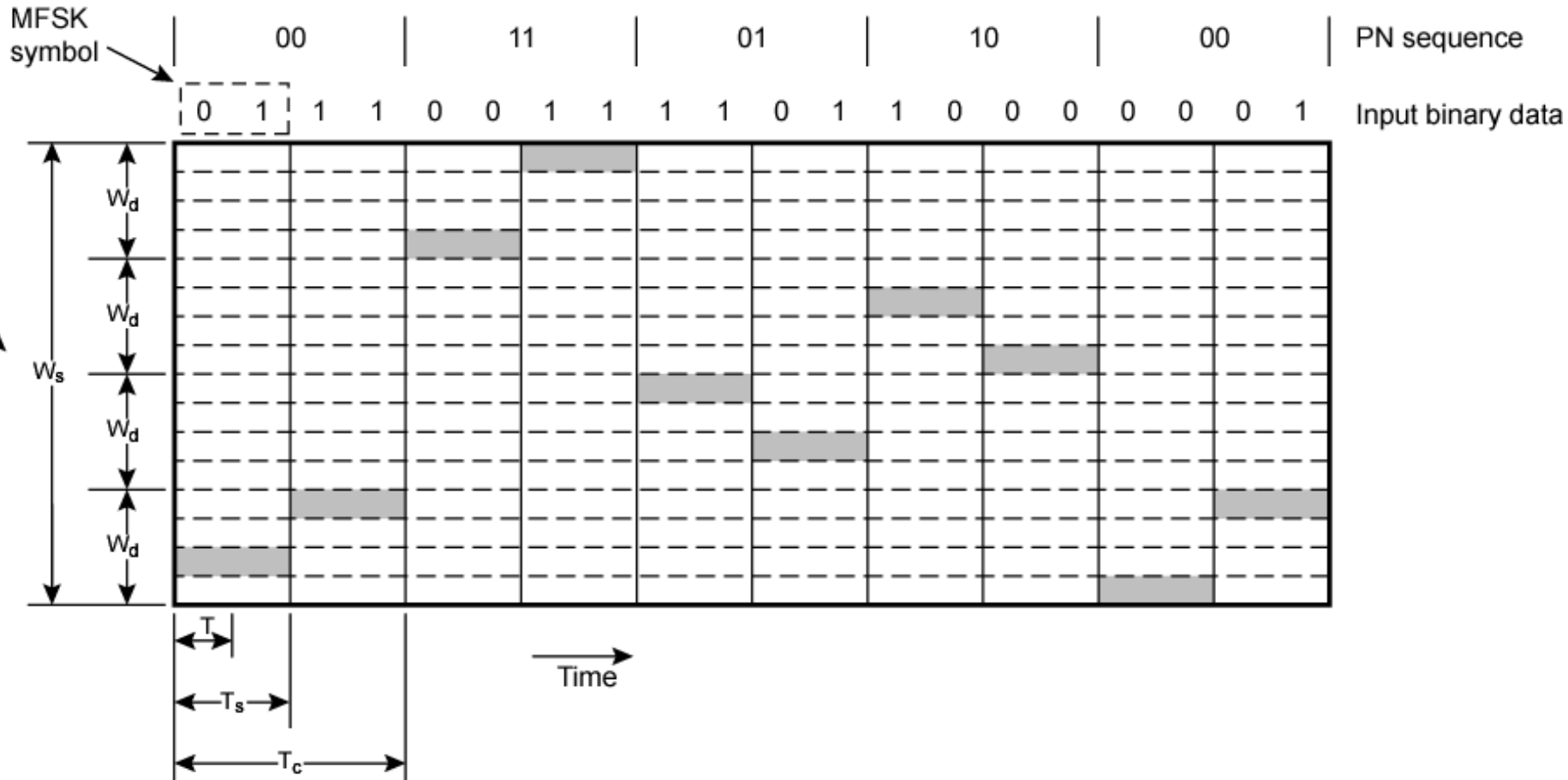
Frequency Hopping Spread Spectrum System (Receiver)



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)

