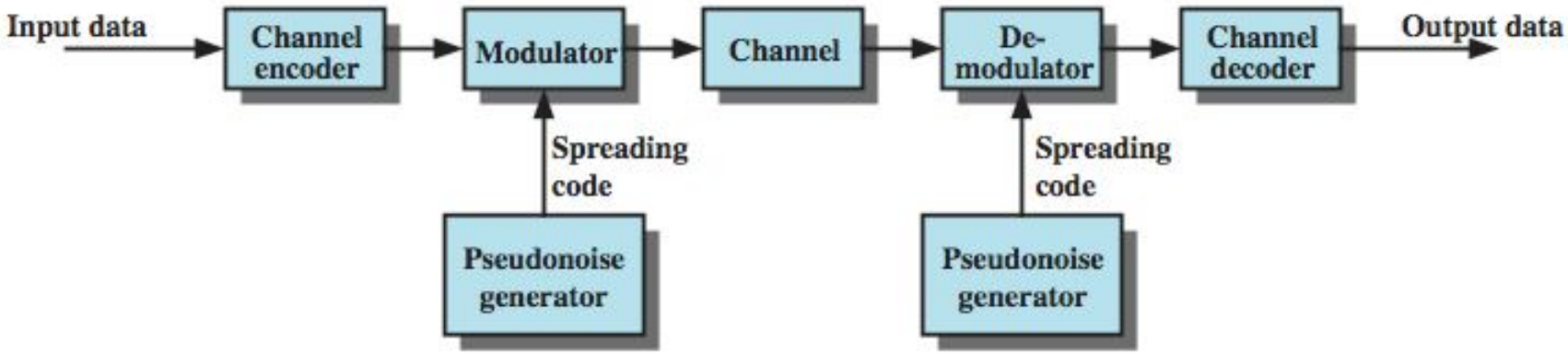
Data Communications

0 9 – Spread Spectrum

Spread Spectrum

- important encoding method for wireless communications
- analog & digital data with analog signal
- spreads data over wide bandwidth
- makes jamming and interception harder
- two approaches, both in use:
  - Frequency Hopping
  - Direct Sequence

General Model of Spread Spectrum System



Spread Spectrum Advantages

- immunity from noise and multipath distortion
- can hide / encrypt signals
- several users can share same higher bandwidth with little interference
  - CDM/CDMA Mobile telephones

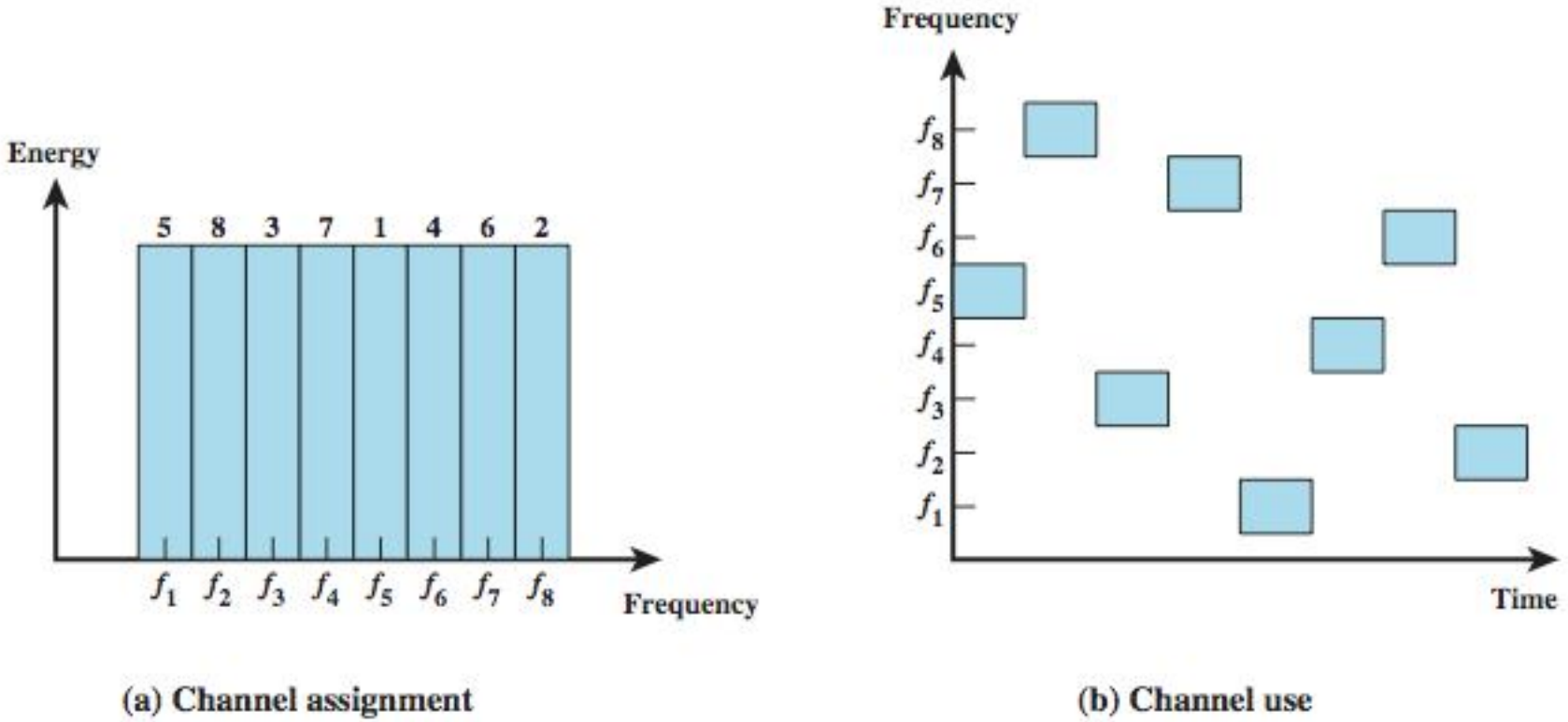
Pseudorandom Numbers

- generated by a deterministic algorithm
  - not actually random
  - but if algorithm good, results pass reasonable tests of randomness
- starting from an initial seed
- need to know algorithm and seed to predict sequence
- hence only receiver can decode signal

Frequency Hopping Spread Spectrum (FHSS)

- signal is 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

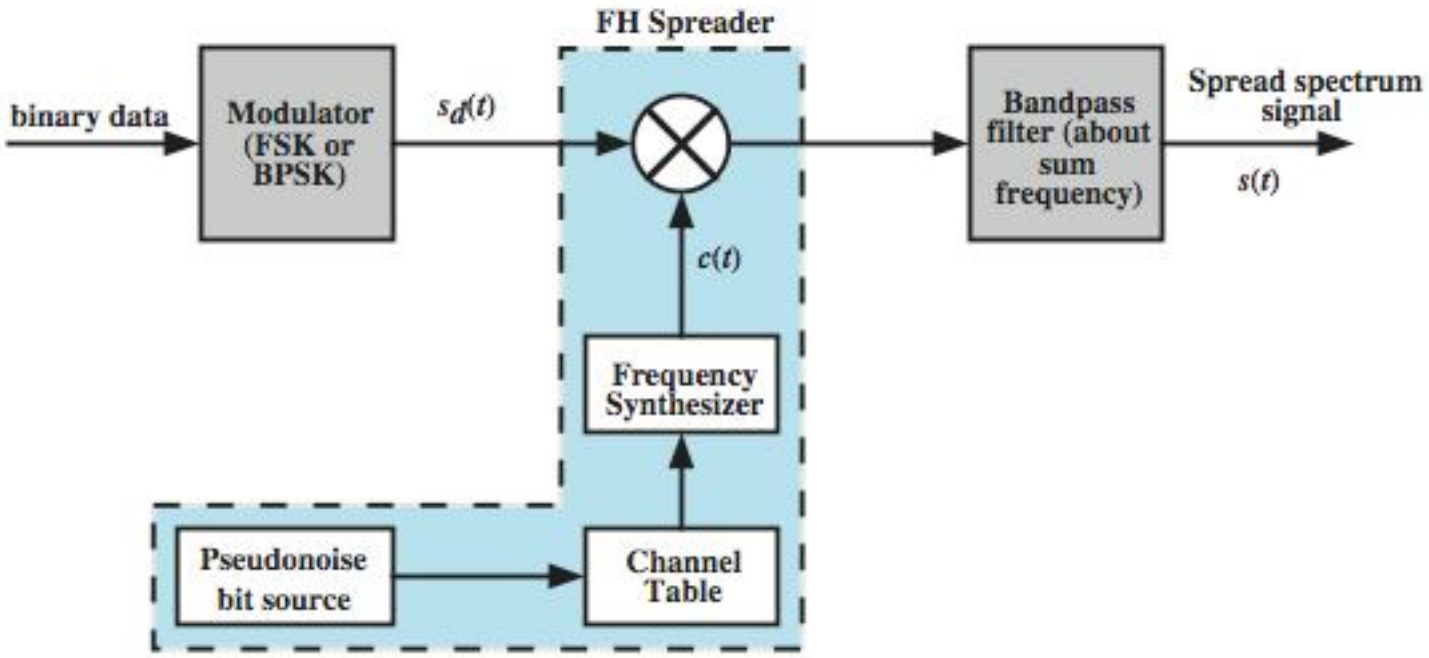
Frequency Hopping Example



(a) Channel assignment

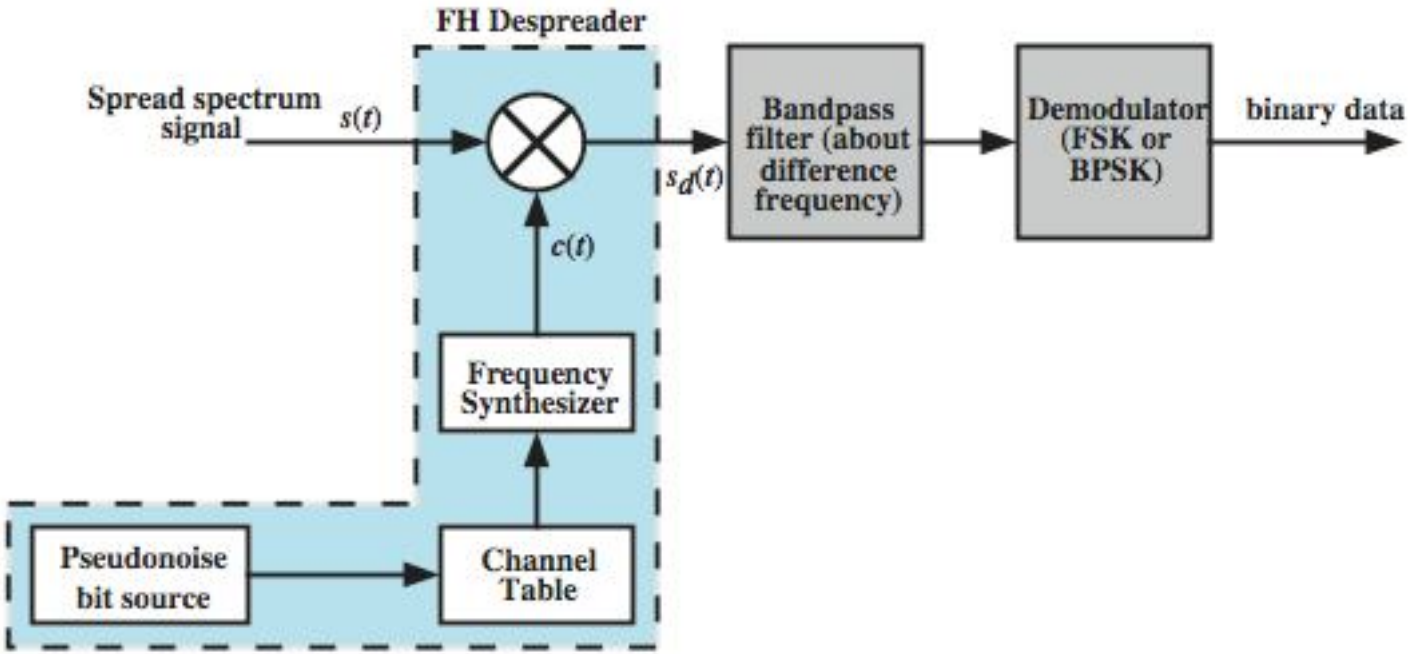
(b) Channel use

FHSS (Transmitter)



(a) Transmitter

Frequency Hopping Spread Spectrum System (Receiver)

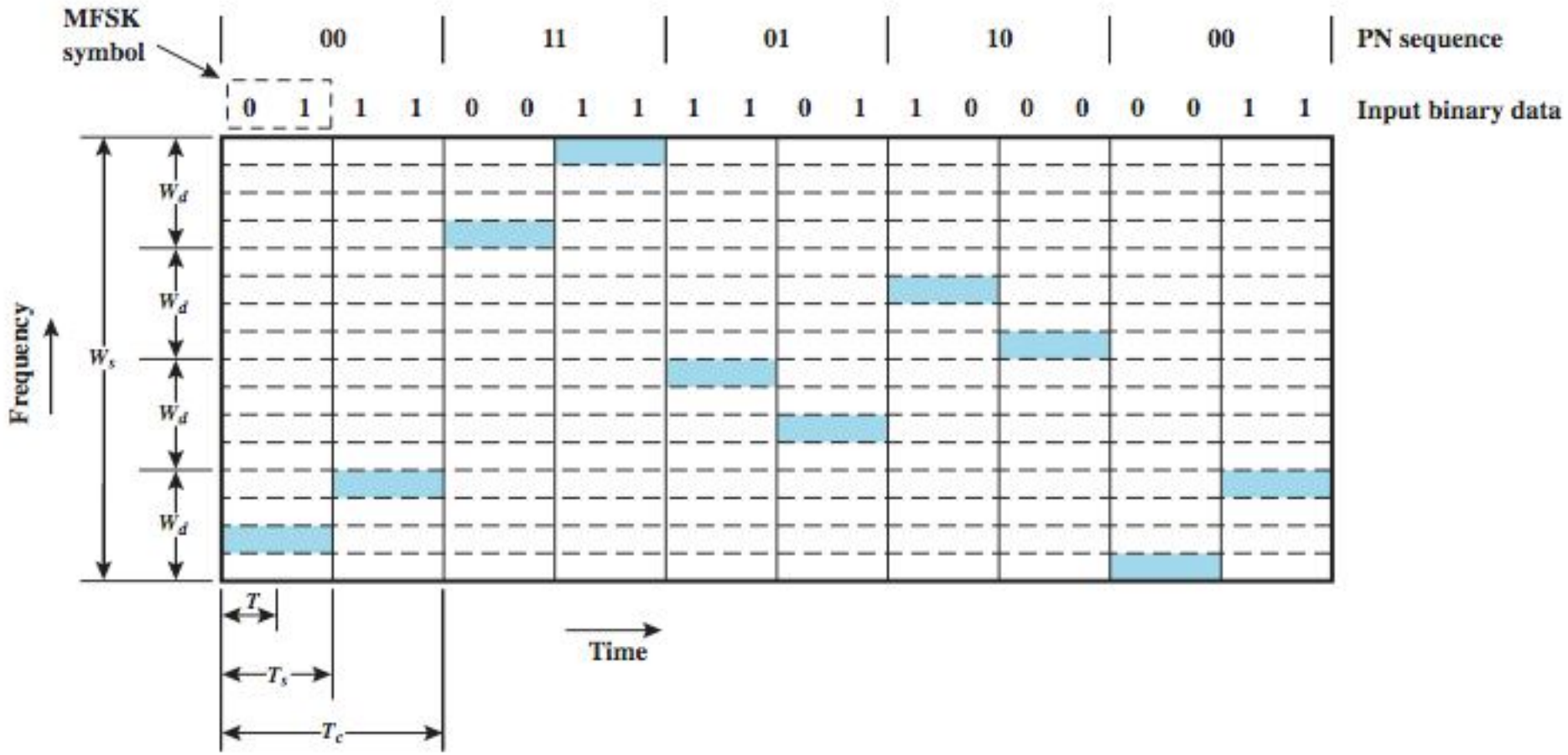


(b) Receiver

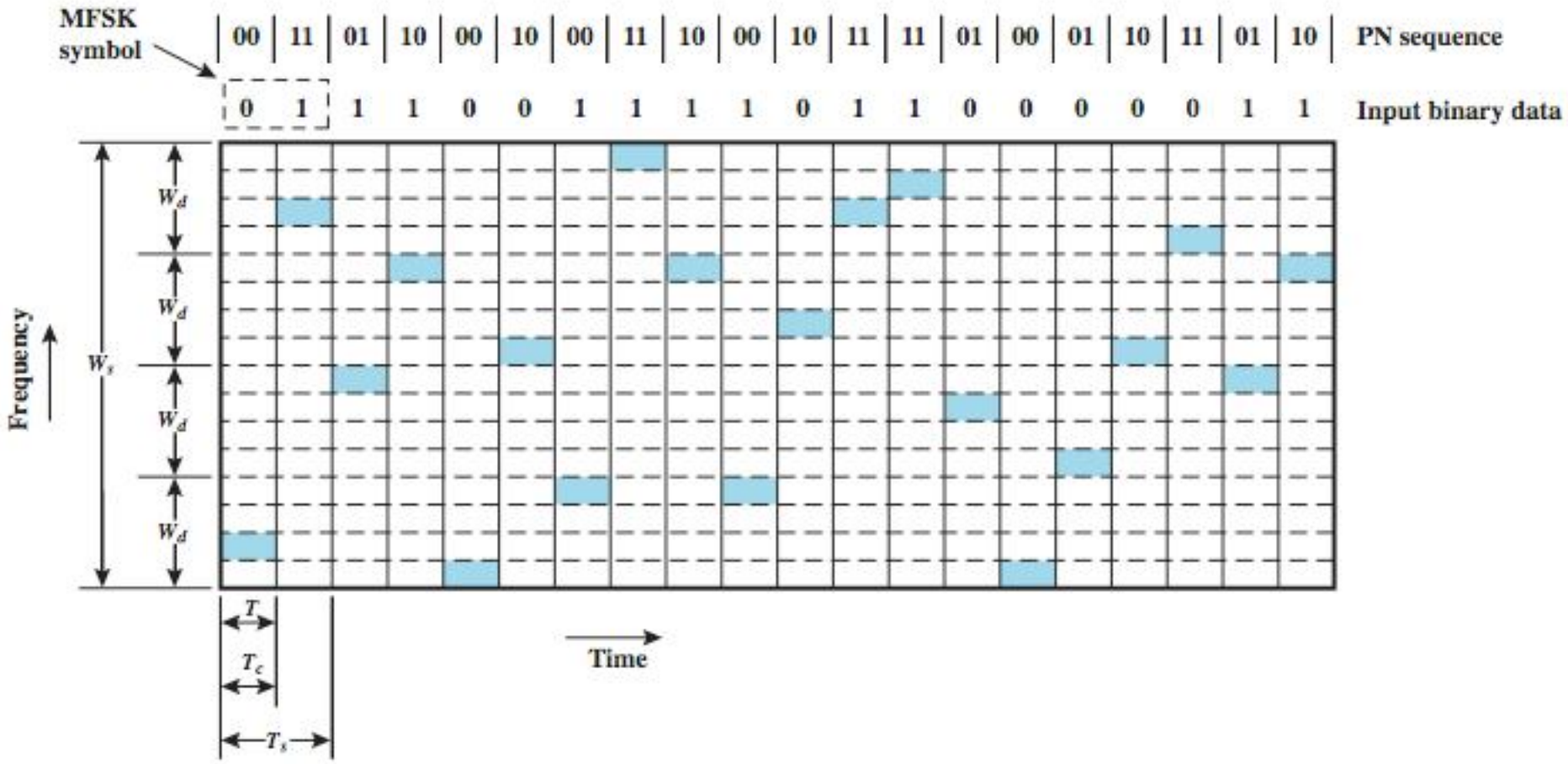
Slow and Fast FHSS

- commonly use multiple FSK (MFSK)
- have 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 $T_c < T_s$
- FHSS quite resistant to noise or jamming
  - with fast FHSS giving better performance

Slow MFSK FHSS



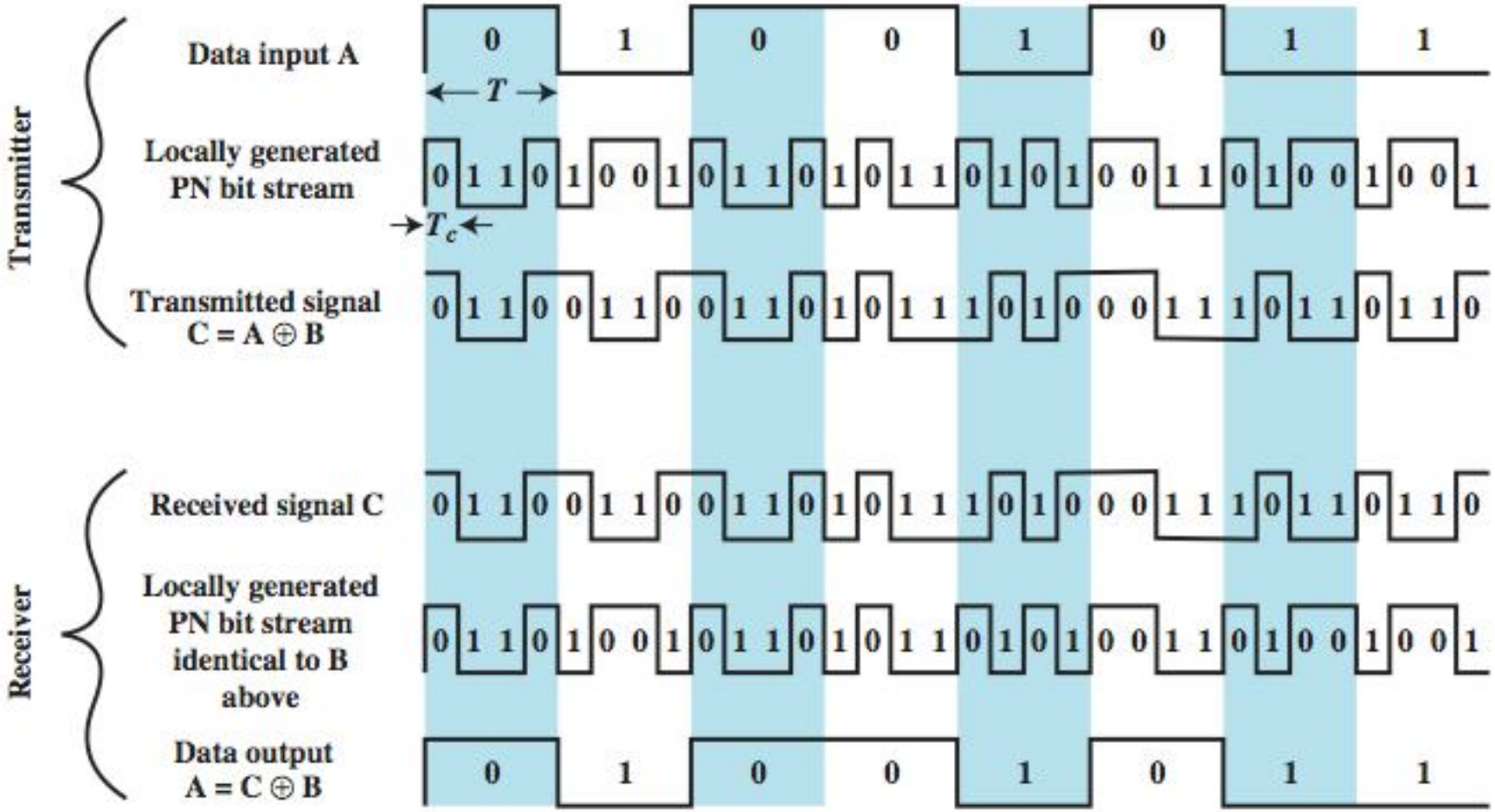
Fast MFSK FHSS



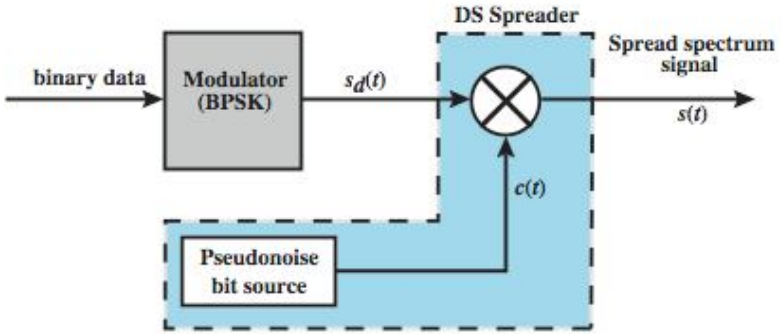
Direct Sequence Spread Spectrum (DSSS)

- each bit is represented by multiple bits using a spreading code
- this spreads signal across a wider frequency band
- has performance similar to FHSS

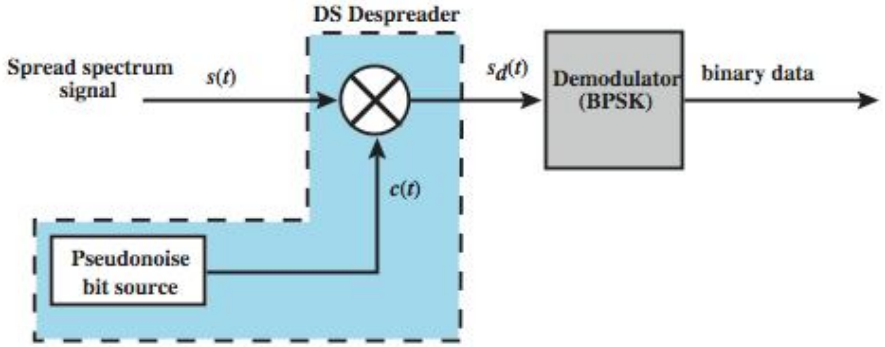
Direct Sequence Spread Spectrum Example



Direct Sequence Spread Spectrum System

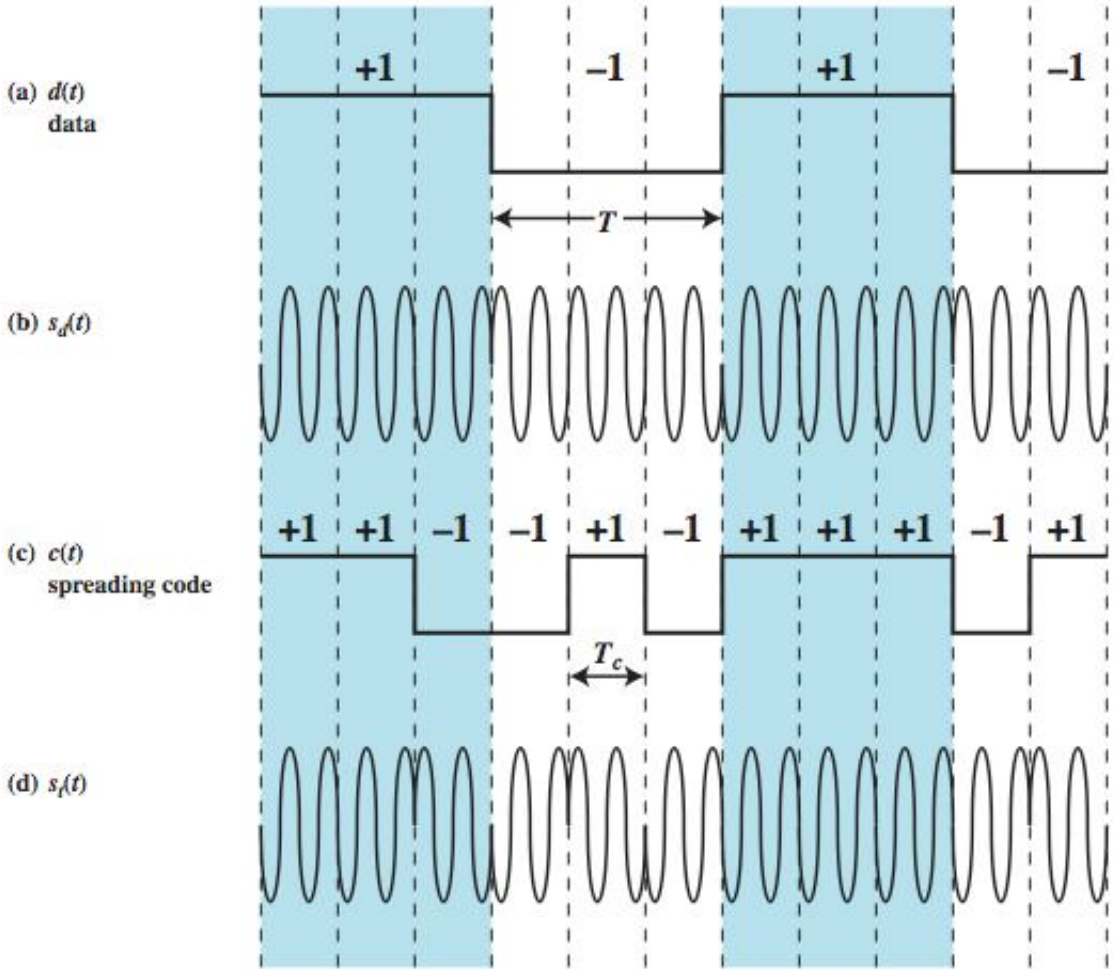


(a) Transmitter

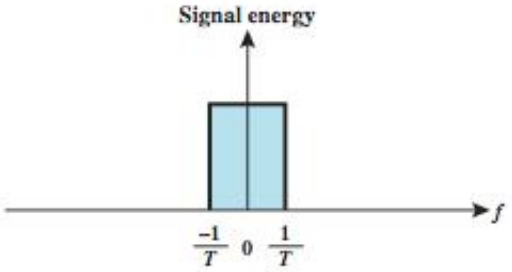


(b) Receiver

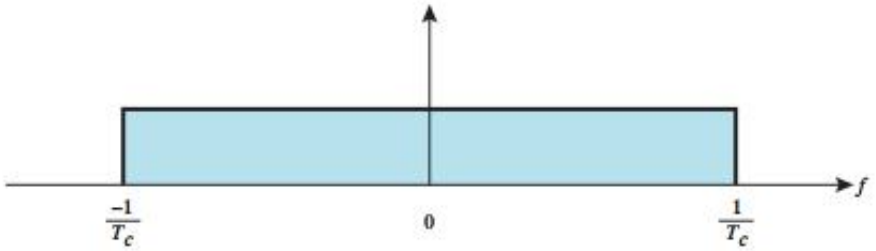
DSSS Example Using BPSK



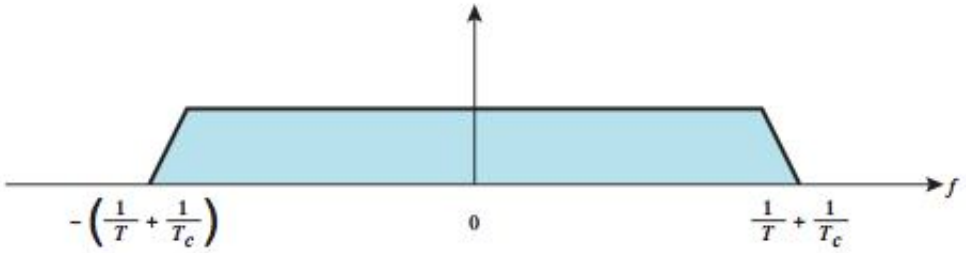
Approximate Spectrum of DSSS Signal



(a) Spectrum of data signal



(b) Spectrum of pseudonoise signal

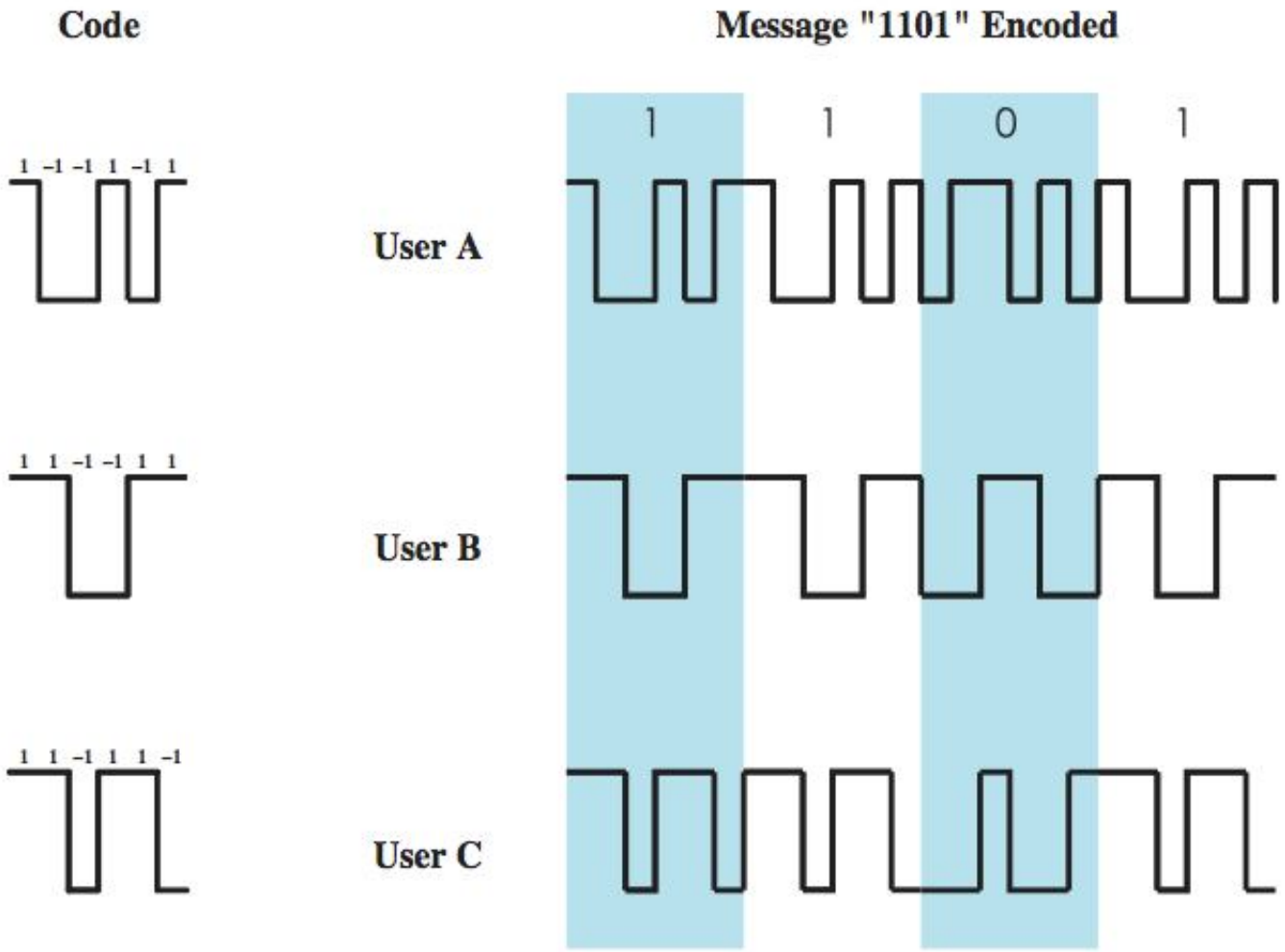


(c) Spectrum of combined signal

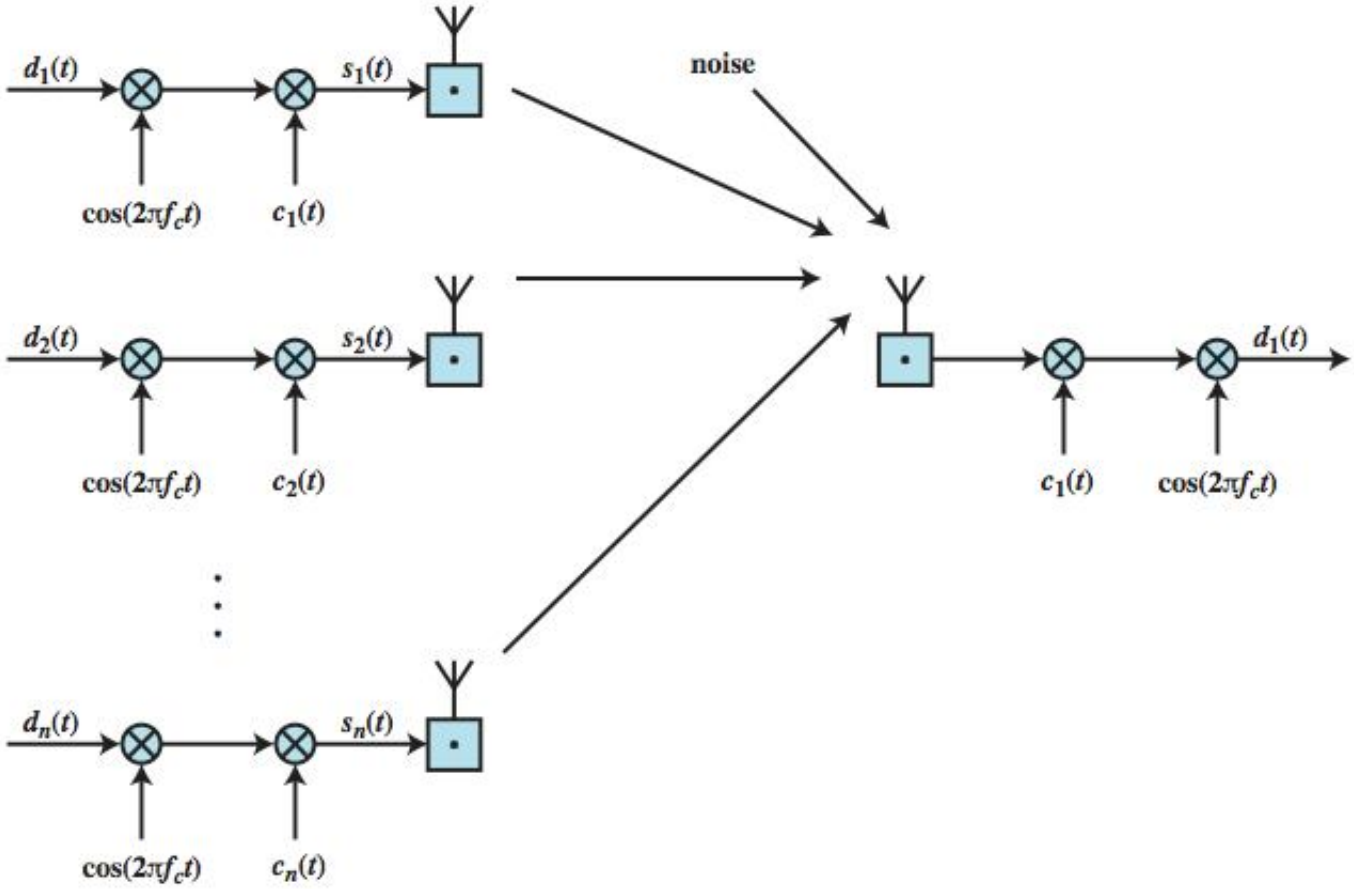
Code Division Multiple Access (CDMA)

- a multiplexing technique used with spread spectrum
- given a data signal rate D
- break each bit into *k* chips according to a fixed chipping code specific to each user
- resulting new channel has chip data rate *kD* chips per second
- can have multiple channels superimposed

CDMA Example



CDMA for DSSS



Summary

- looked at use of spread spectrum techniques:
- FHSS
- DSSS
- CDMA