# Data and Computer Communications

## Chapter 9 – Spread Spectrum

Eighth Edition

by William Stallings

Lecture slides by Lawrie Brown

# Spread Spectrum

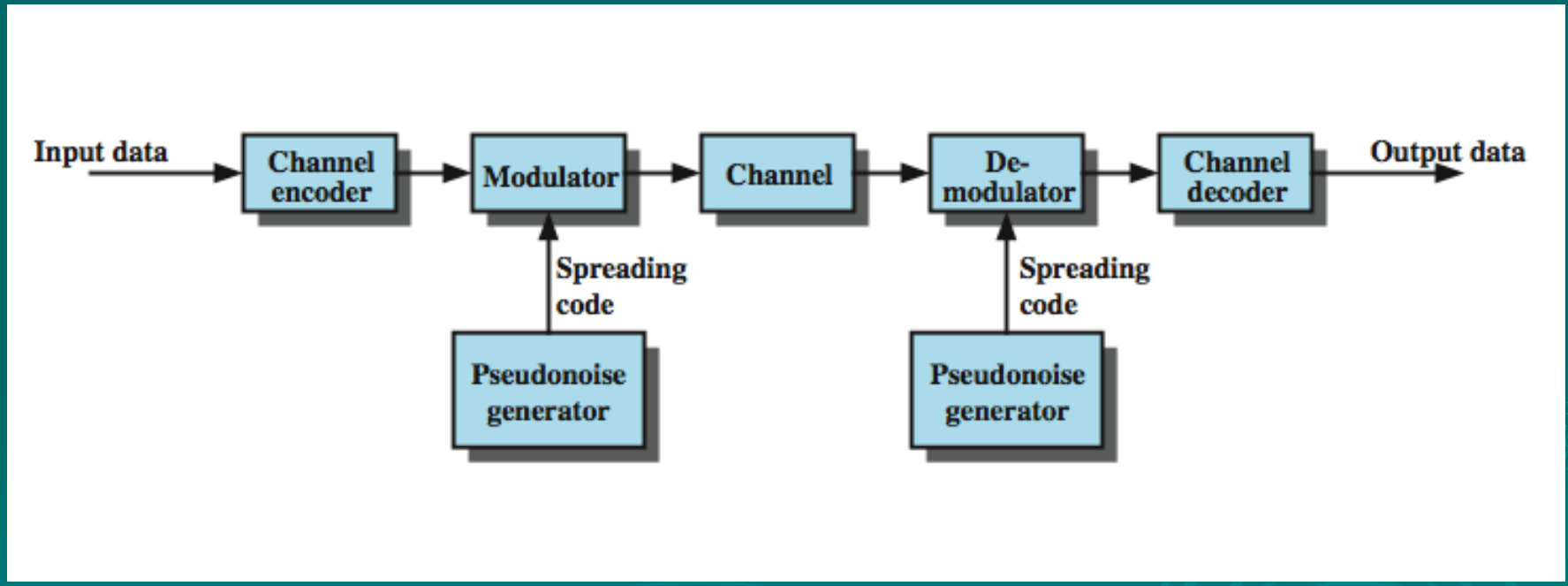
*All creative people want to do the unexpected.*

*—Ecstasy and Me: My Life as a Woman*,
Hedy Lamarr

# 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

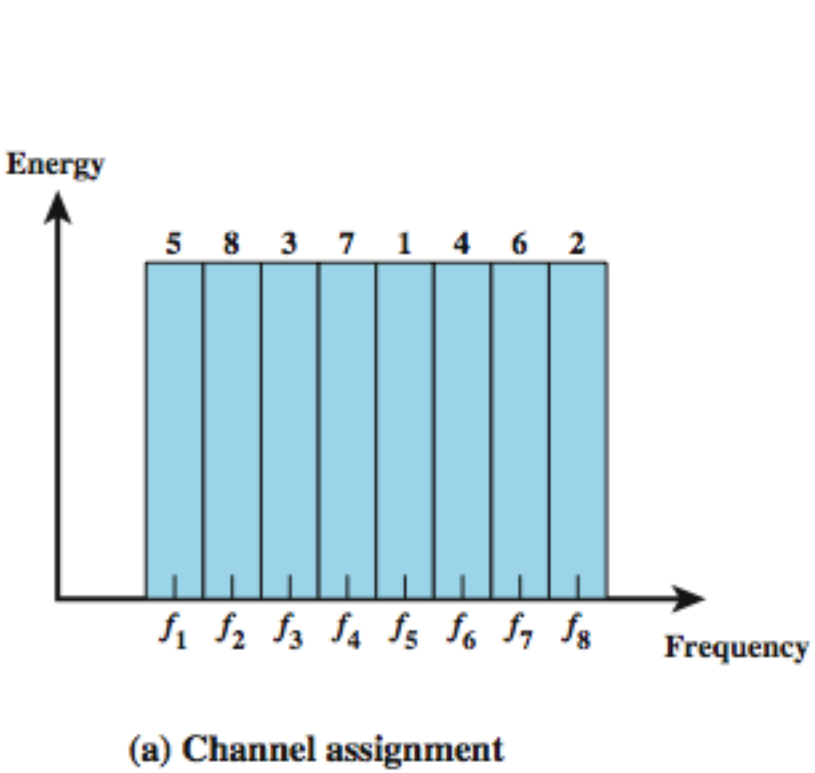
# Pseudorandom Numbers

- 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

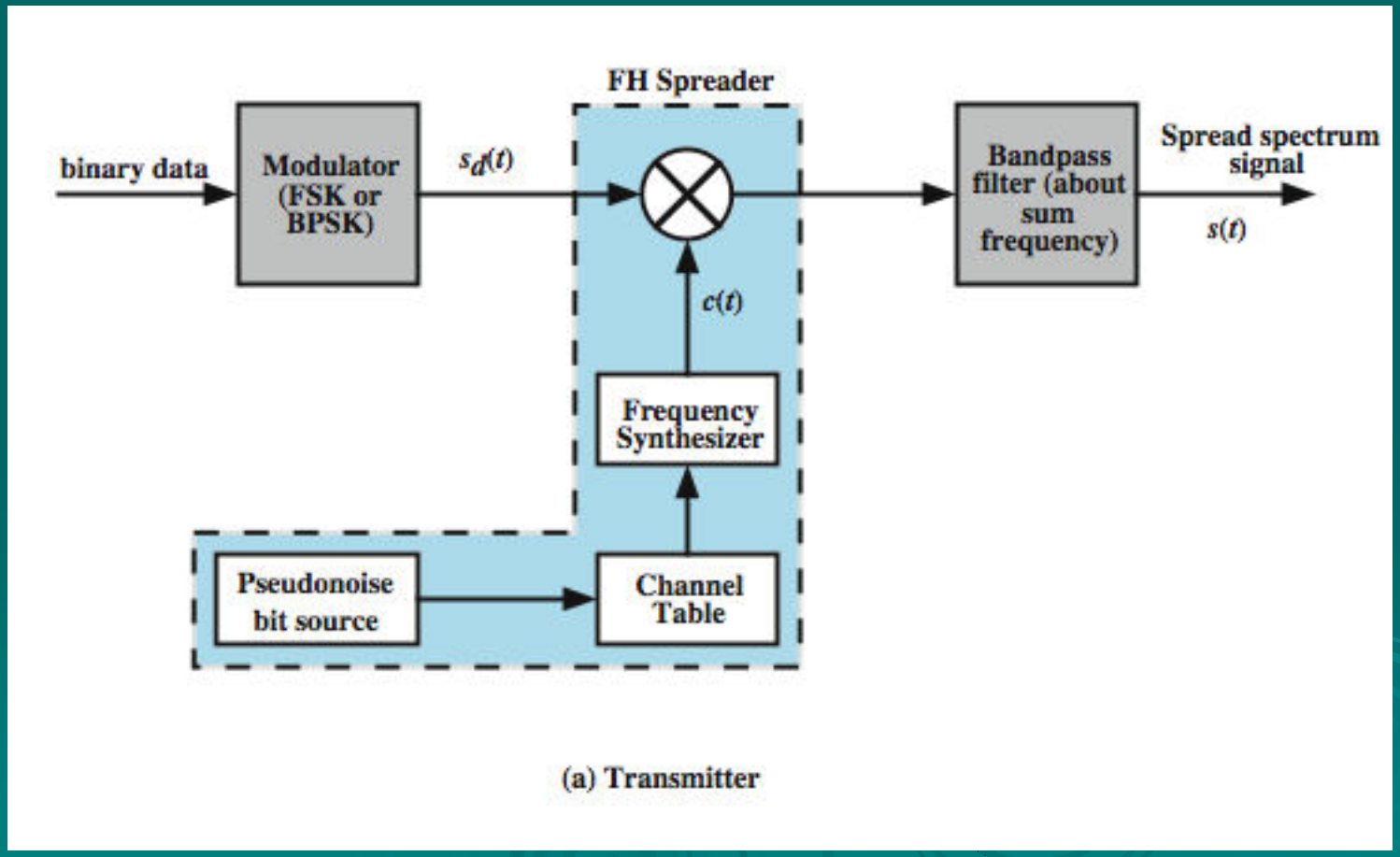
# Frequency Hopping Spread Spectrum (FHSS)

- 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

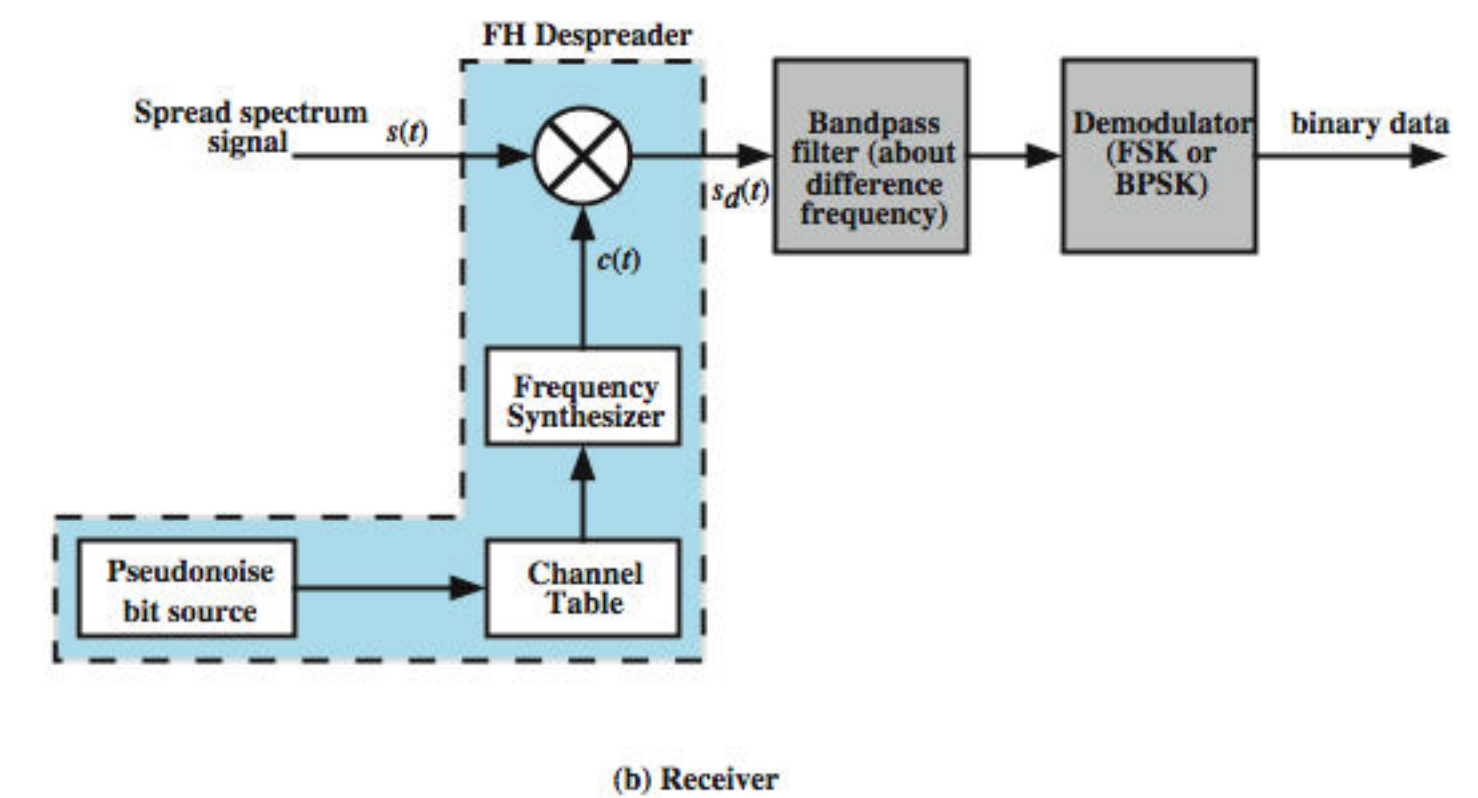


# FHSS (Transmitter)




(a) Transmitter

# Frequency Hopping Spread Spectrum System (Receiver)

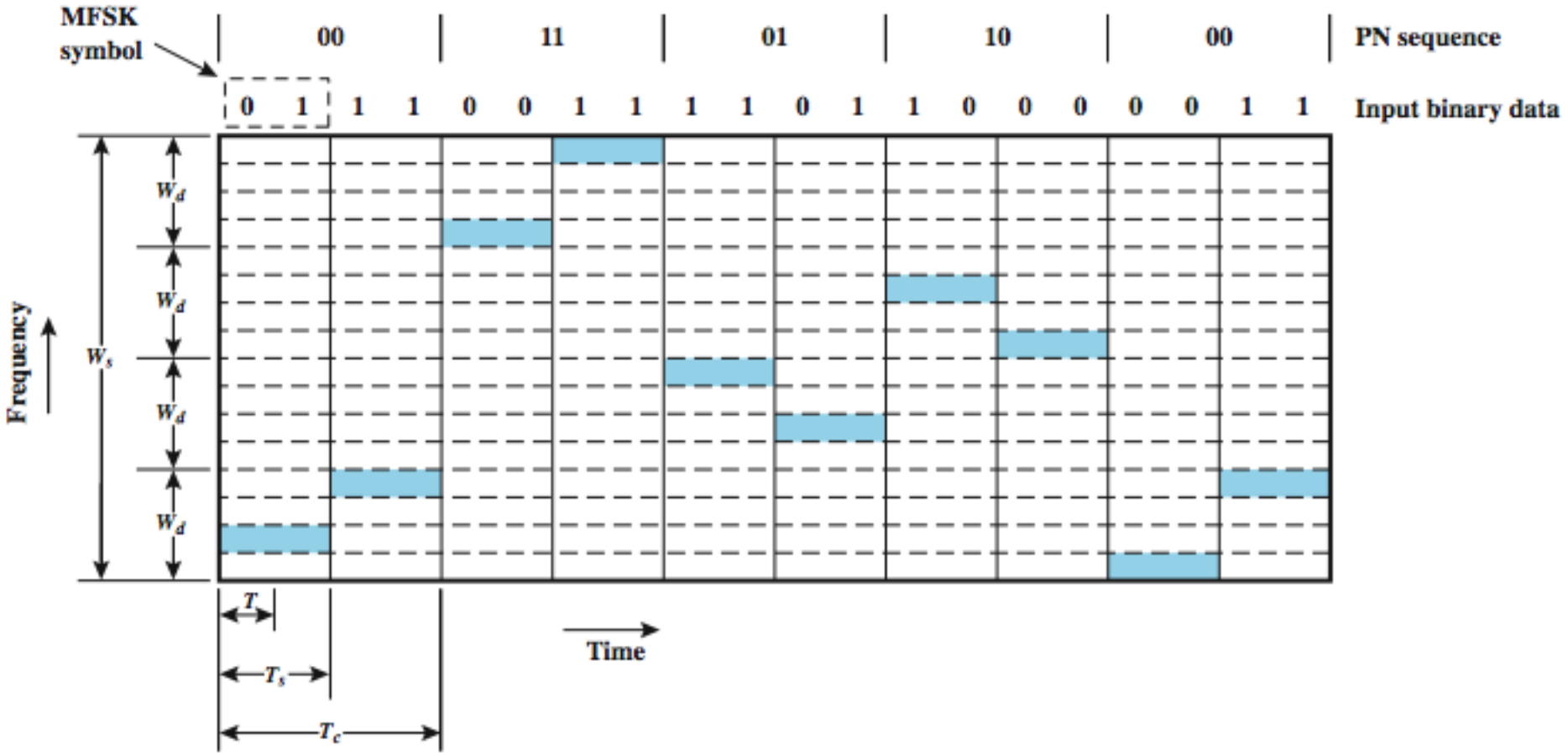



(b) Receiver

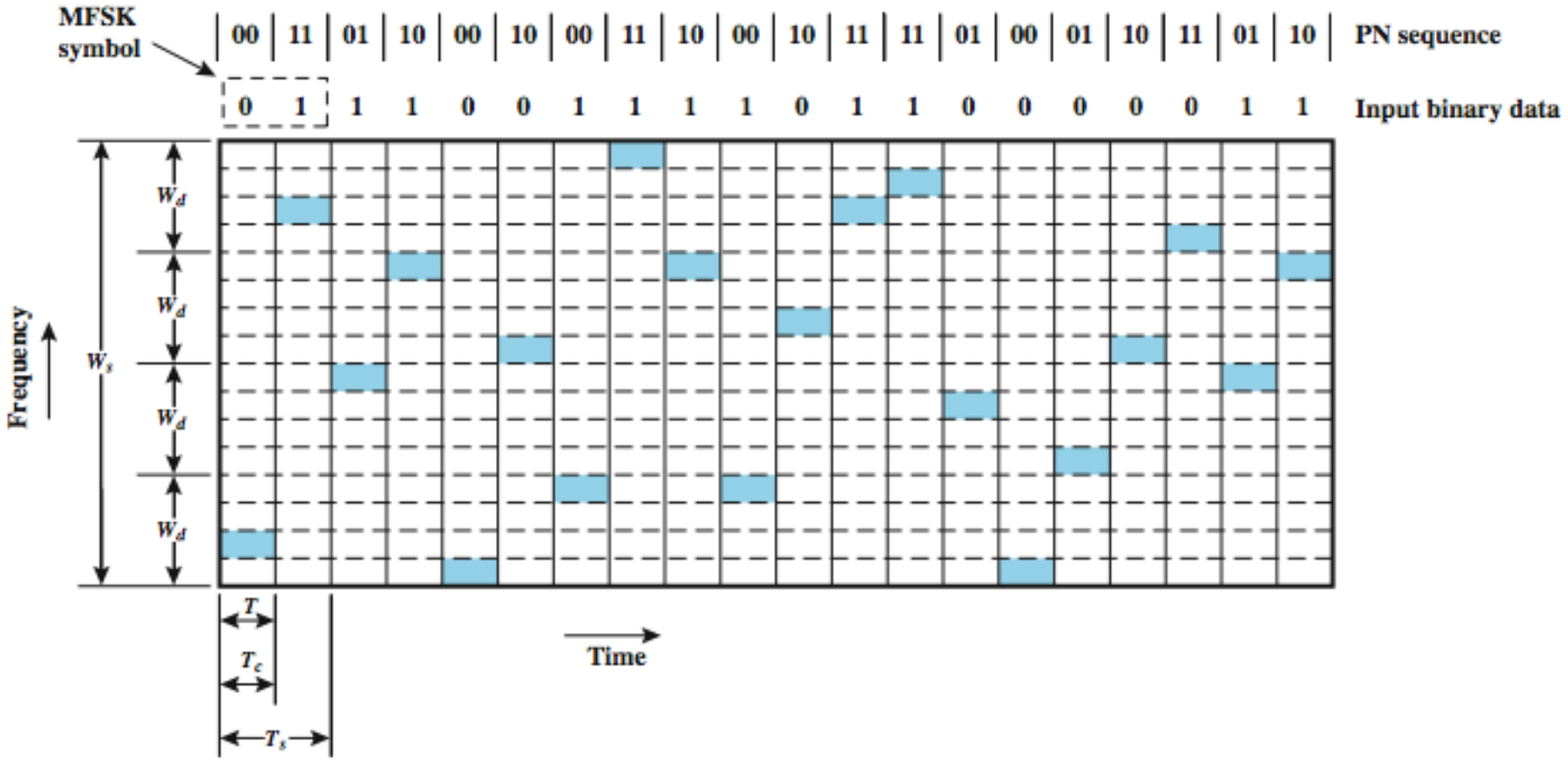
# Slow and Fast FHSS

- 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



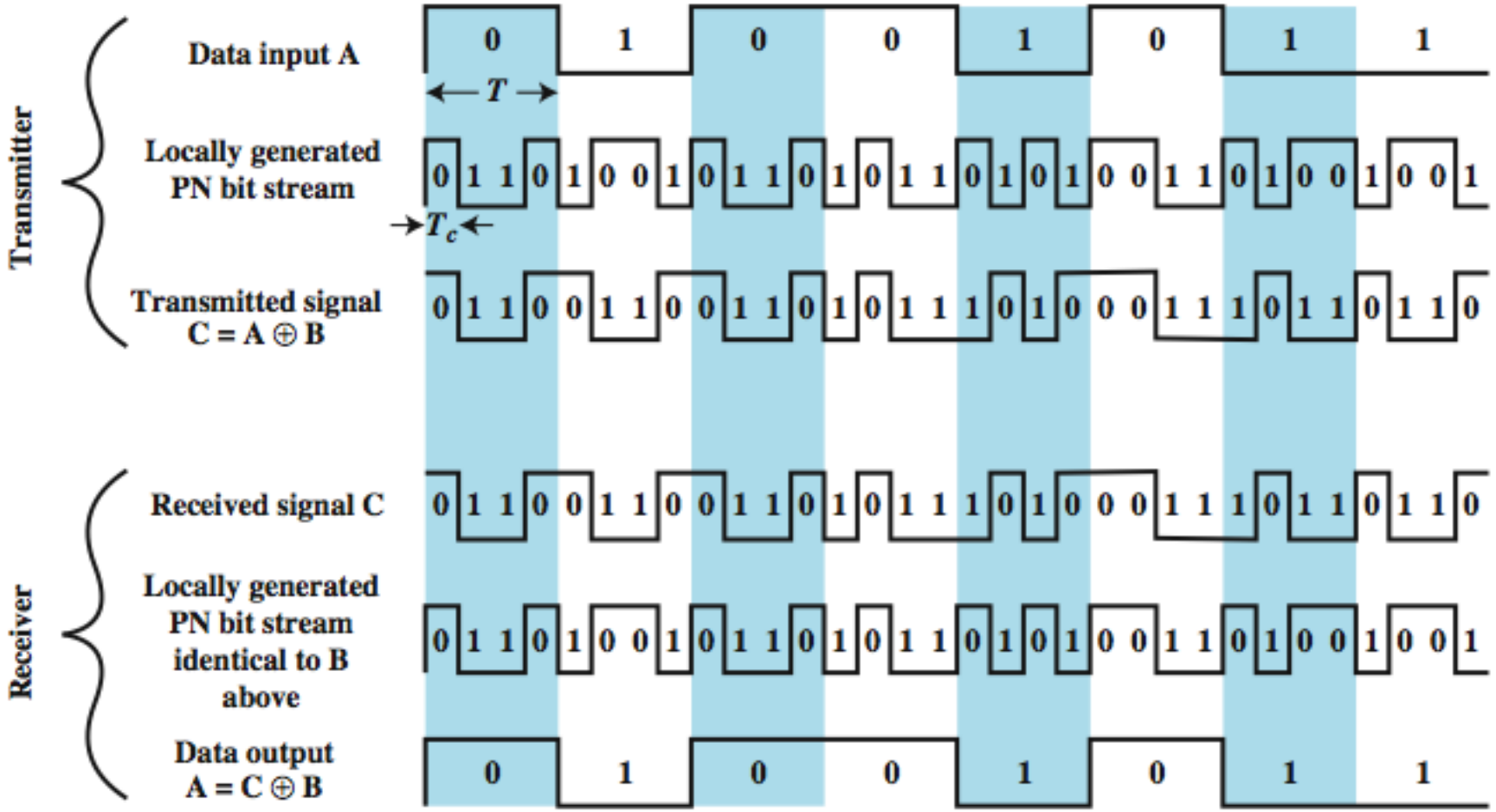
# Fast MFSK FHSS



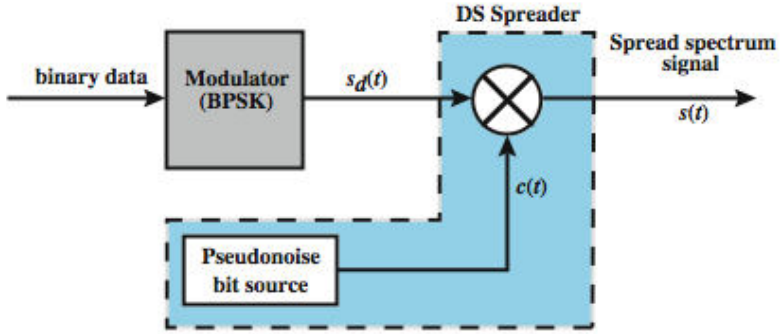
# Direct Sequence Spread Spectrum (DSSS)

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

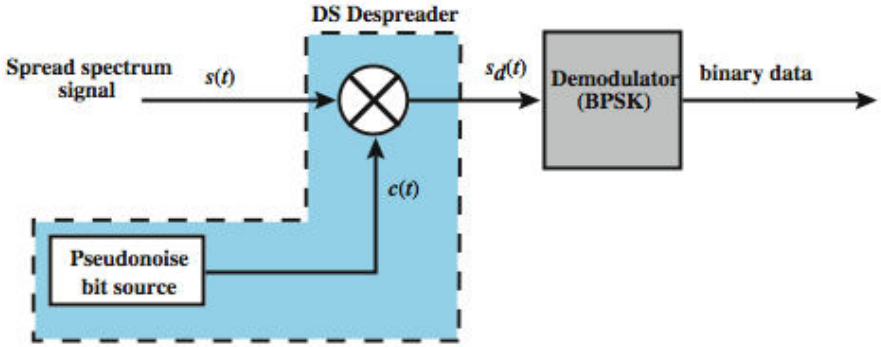
# Direct Sequence Spread Spectrum Example



# Direct Sequence Spread Spectrum System

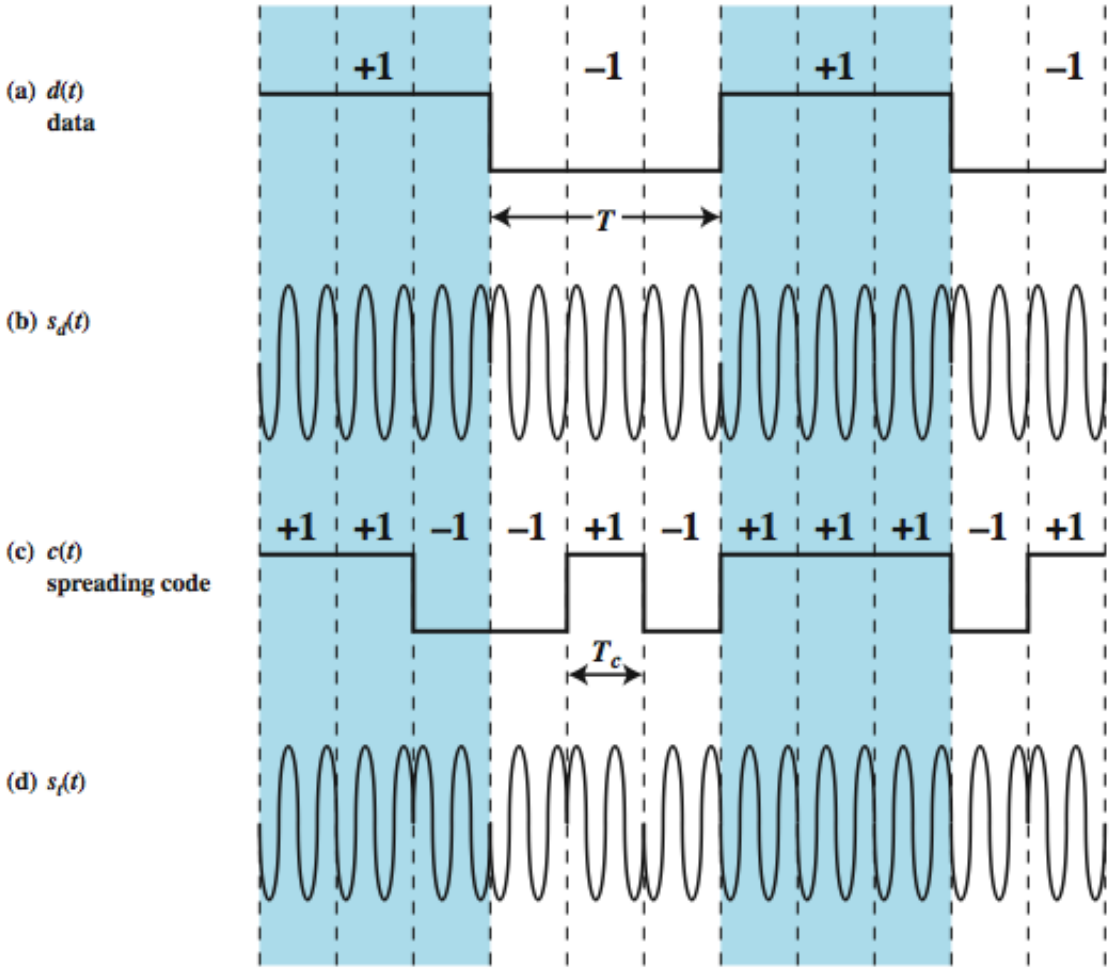



(a) Transmitter

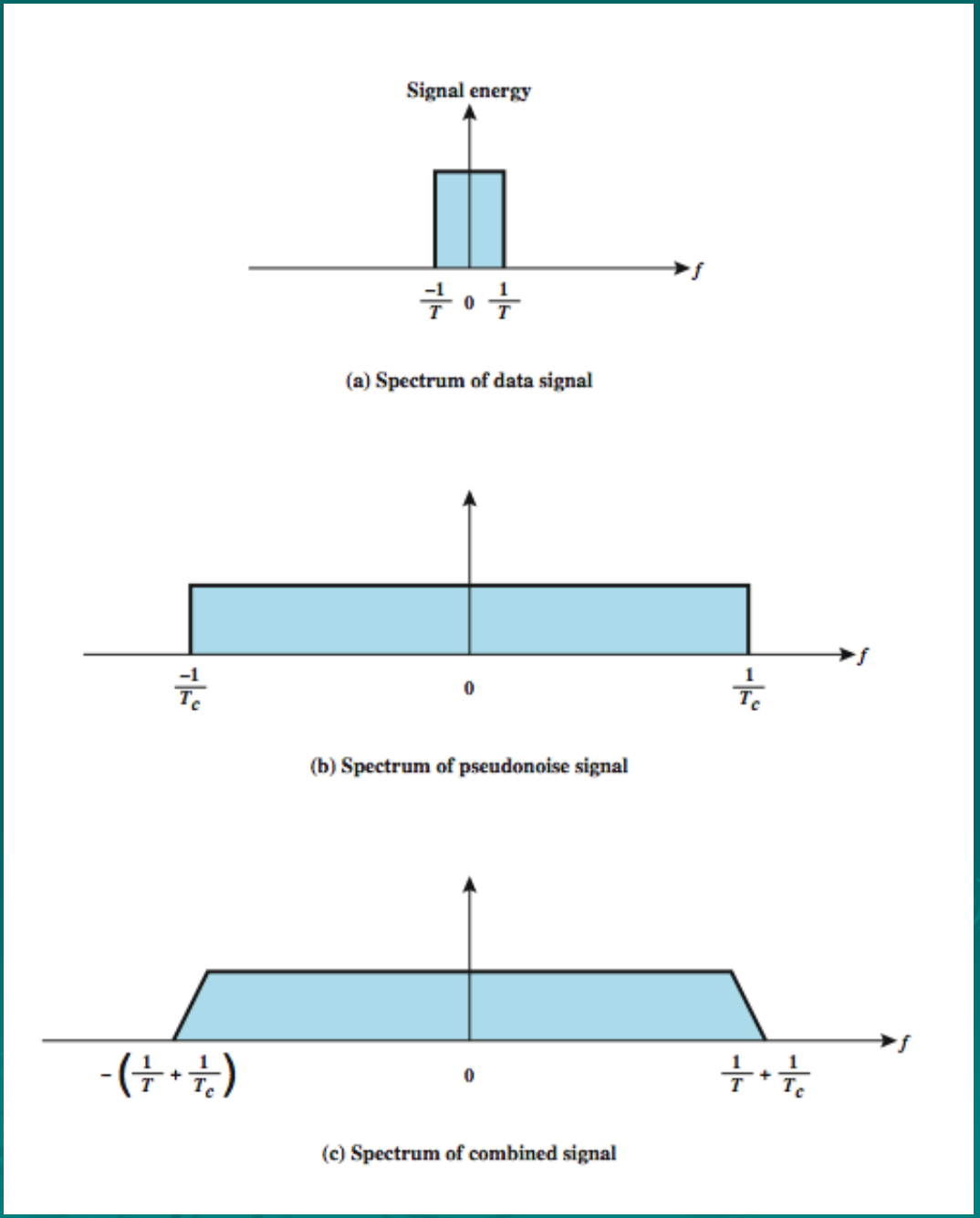



(b) Receiver

# DSSS Example Using BPSK



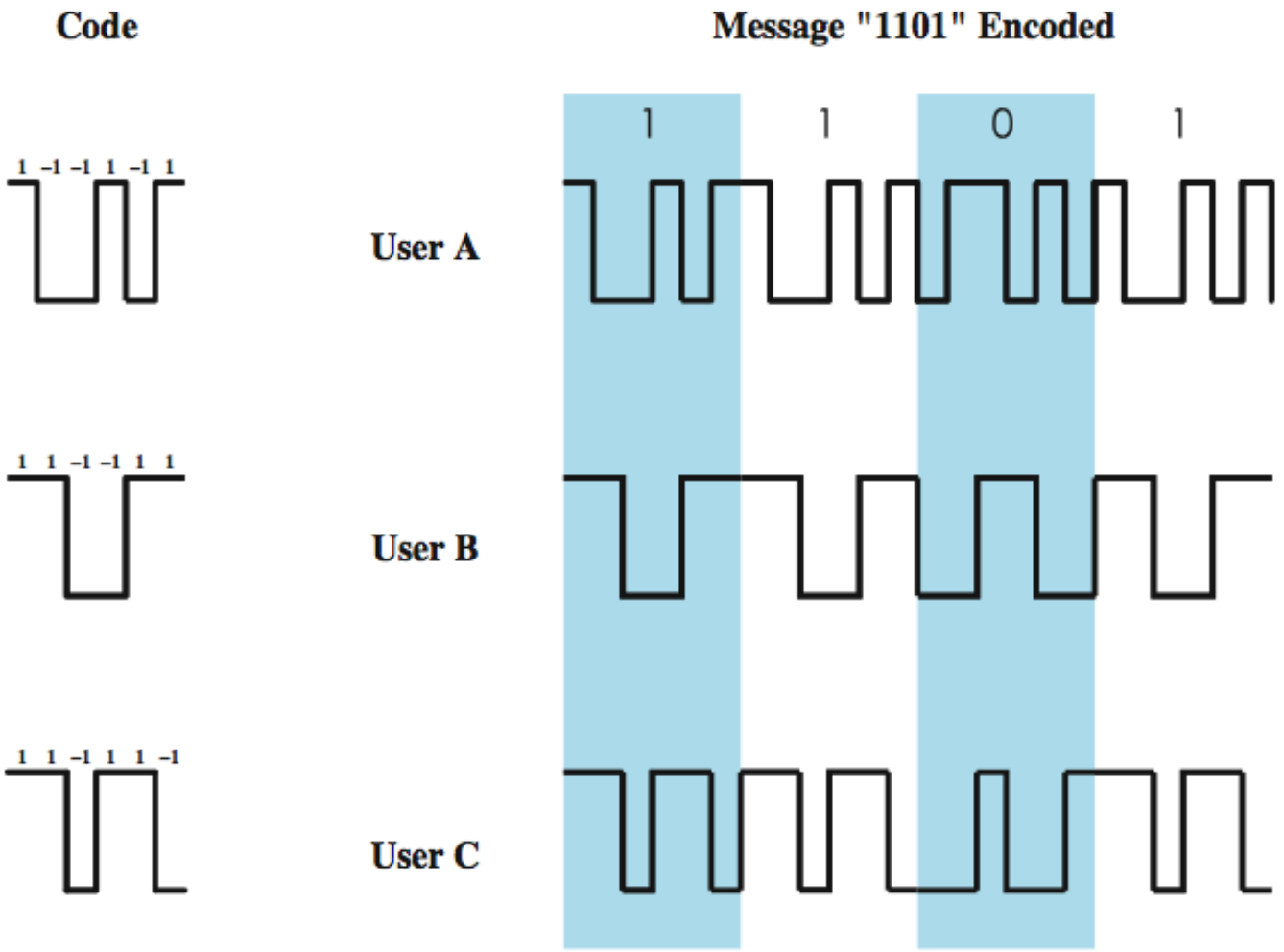
# Approximate Spectrum of DSSS Signal



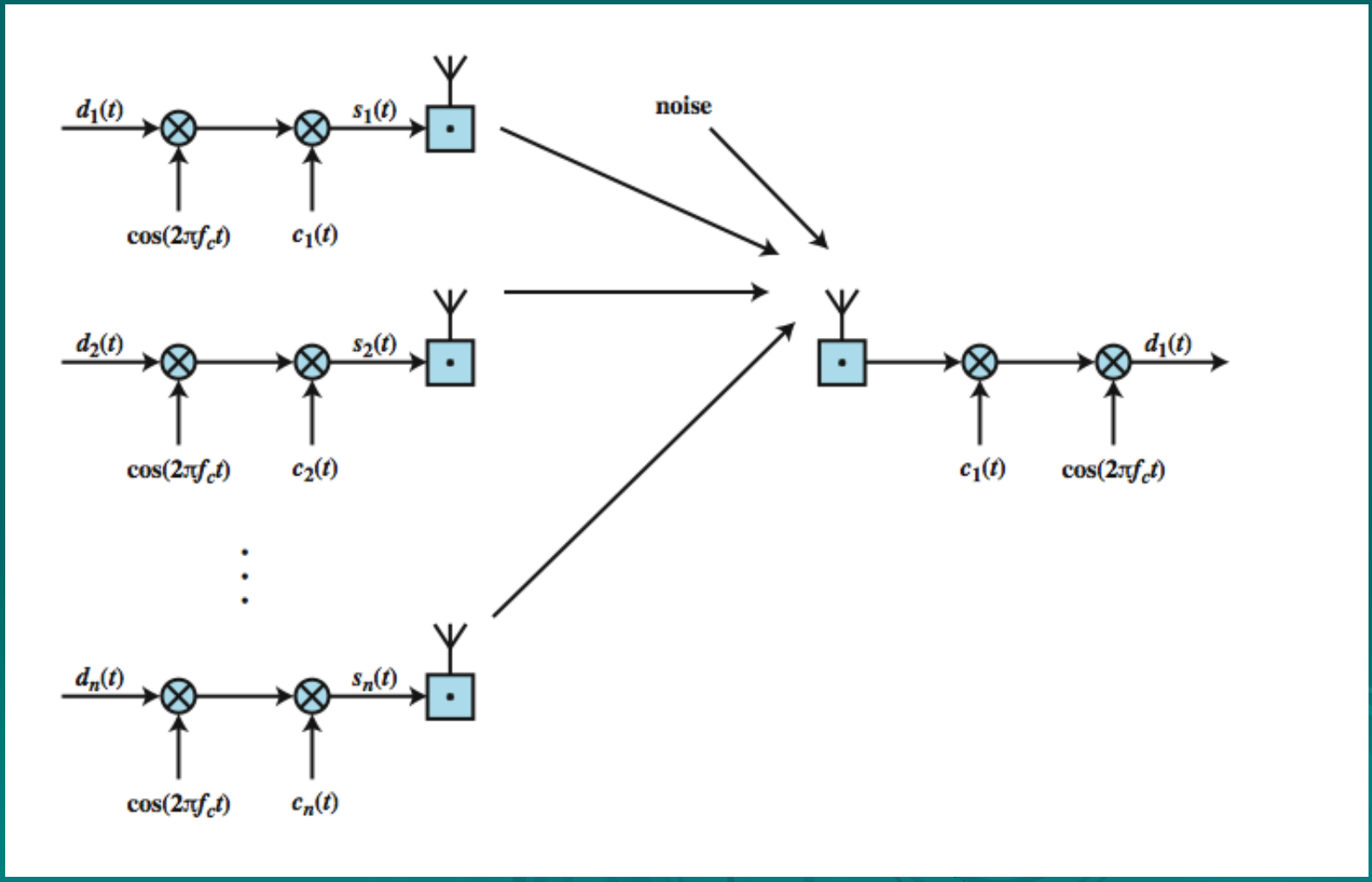
# Code Division Multiple Access (CDMA)

- 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