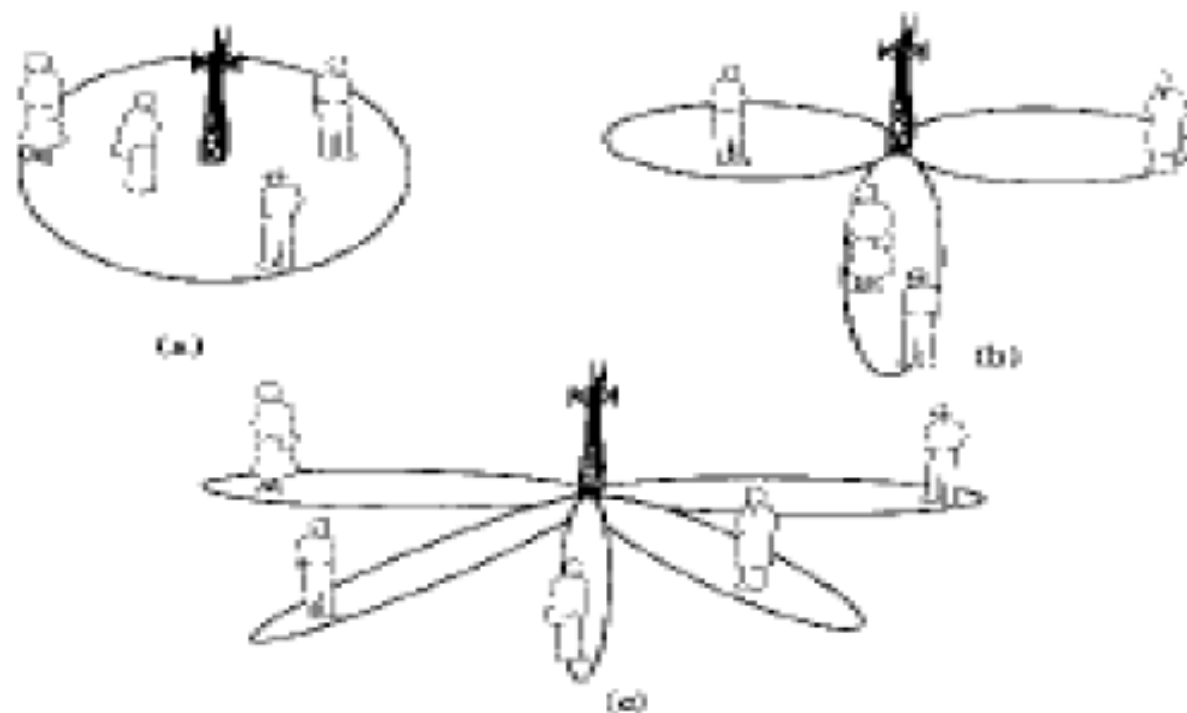


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# SDMA Space Division Multiple Access

- SDMA controls the radiated energy for each user in space. It serves different users by using spot beam antennas.
  - These different areas covered by the antenna beam may be served by the same frequency (in TDMA or CDMA) or different frequencies (in FDMA system).
  - Sectorized antennas (b) may be thought of as a primitive application of SDMA.
  - - An ideal adaptive antenna (c) is able to form a beam for each user in the cell of interest, and the base station tracks each user in the cell as it moves.
-

# SDMA Space Division Multiple Access



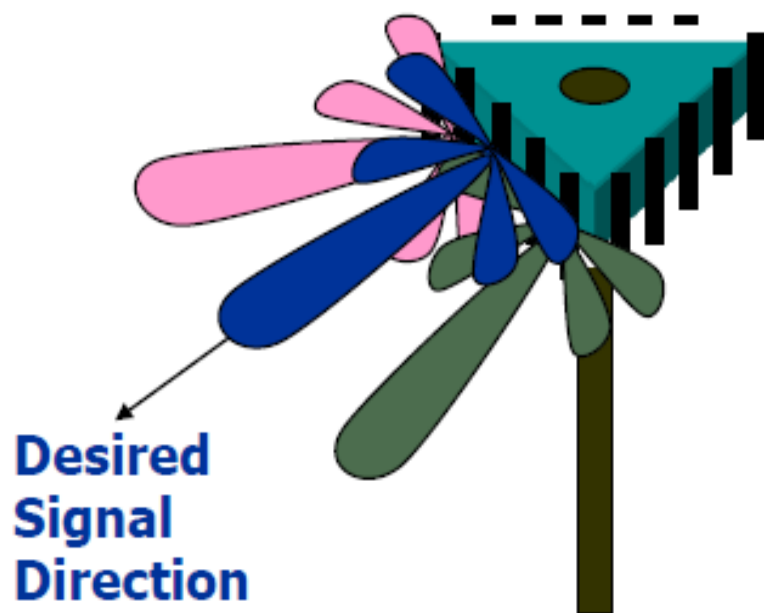
# SDMA

## ■ Features

- A large number of independently steered high-gain beams can be formed without any resulting degradation in SNR ratio.
  - Beams can be assigned to individual users, thereby assuring that all links operate with maximum gain.
  - Adaptive beamforming can be easily implemented to improve the system capacity by suppressing cochannel interference.
-

# SDMA Space Division Multiple Access

- Use highly directional Antenna
  - The receiver selects the beam that provides the greatest signal enhancement and interference reduction
  - Smart antenna systems can adjust their antenna pattern to enhance the desired signal, null or reduce interference.



# SDMA Pros and Cons

## Advantages

- BW increases with  $\text{km}^2$
- Simple system

## Disadvantages

- Restricted Geometry
  - terminals in same direction cannot share
- May have unused BW
  - if no terminals in given zone, bw not used

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# Spread Spectrum Multiple Access

## **Spread spectrum systems**

The desired signal is transmitted over a bandwidth which is much larger than the Nyquist bandwidth.

It is first developed for military applications for

1. Security
  2. Undetectability: minimum probability of being detected
  3. Robust against intentional jammers
-

# Spread Spectrum Multiple Access

## Applications

- Security
  - Robust against unintentional interference
  - It is not bandwidth efficient when used by a single user but has the capability to overcome narrowband jamming signals (cannot overcome AWGN or wideband jamming signal) and multipath.
  - Providing multiple access
  - If many users can share the same spread spectrum bandwidth without interfering with one another, bandwidth efficient improved but will affect the capability to overcome jamming.
-

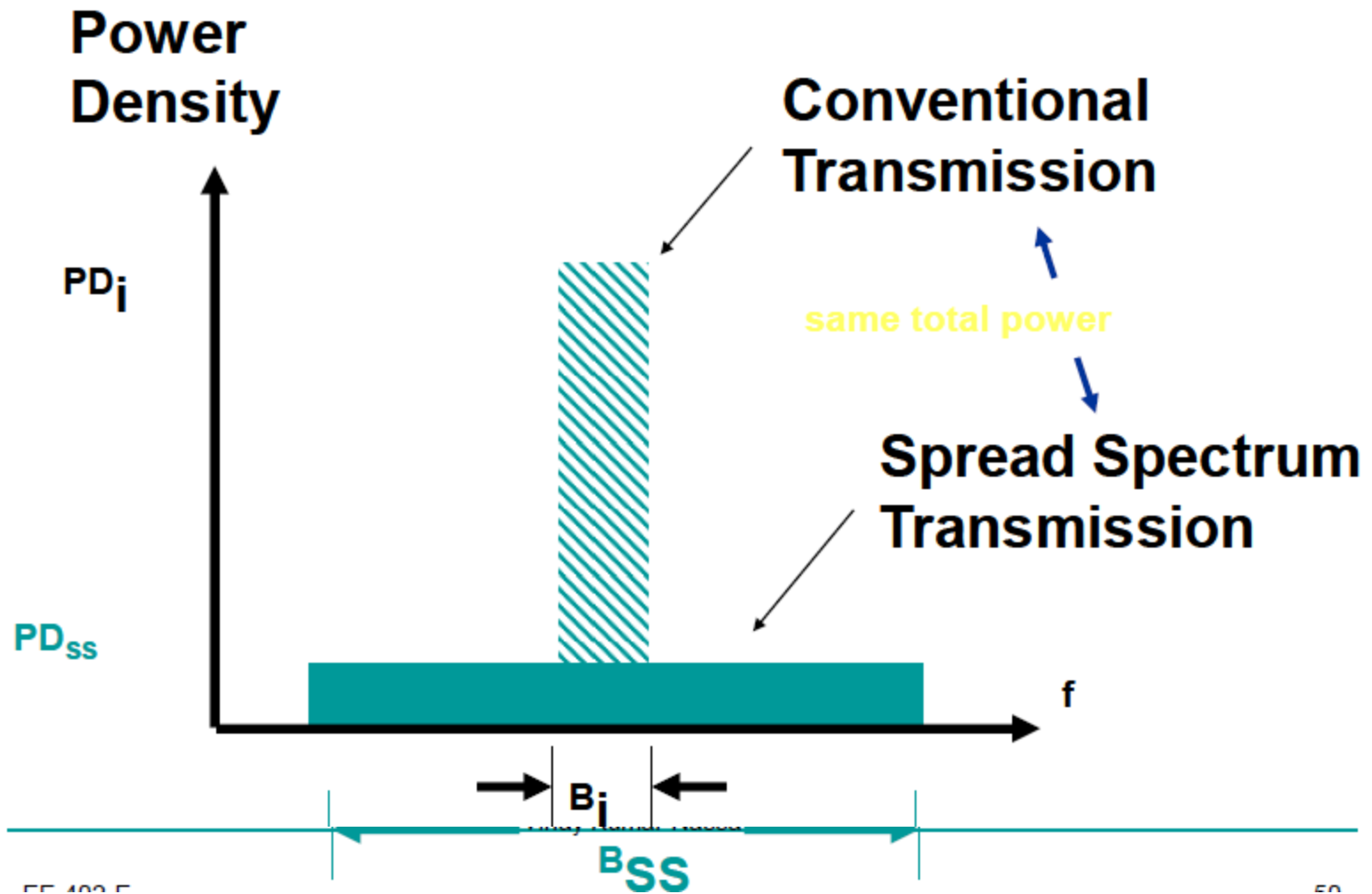


# Spread Spectrum Multiple Access

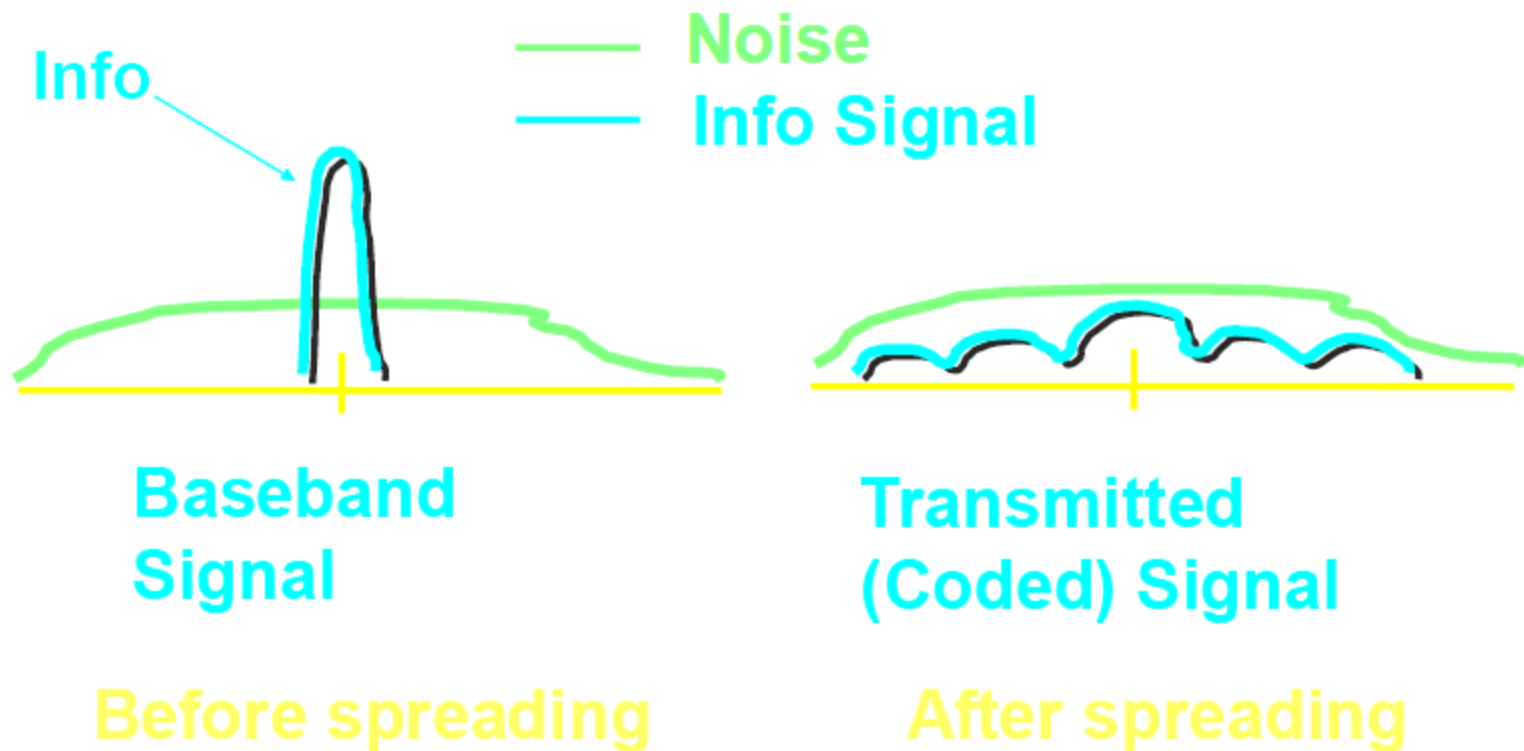
- A transmission technique in which a PN(Pseudo Noise) code, independent of information data, is employed as a modulation waveform to “spread” the signal energy over a bandwidth much greater than the signal information bandwidth.
  - At the receiver the signal is “despread”(Correlate) using a synchronized replica of the PN code.
  - Direct Sequence Spread Spectrum (DSSS)
  - Frequency Hopping Spread Spectrum (FHSS)
-



# Spread Spectrum - illustrated



# Spreading Process



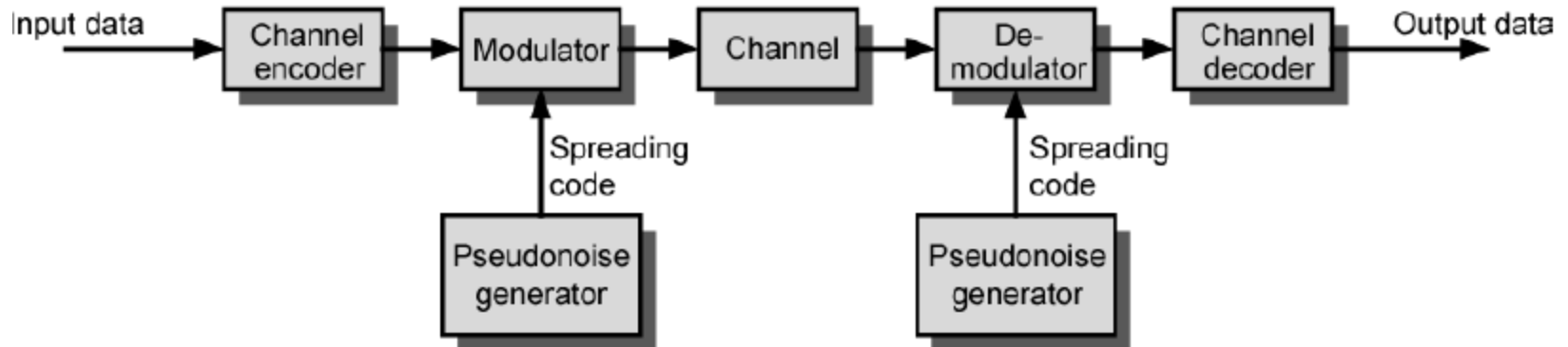
How can you recover signal  $<$  noise

---

# 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



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# Gains

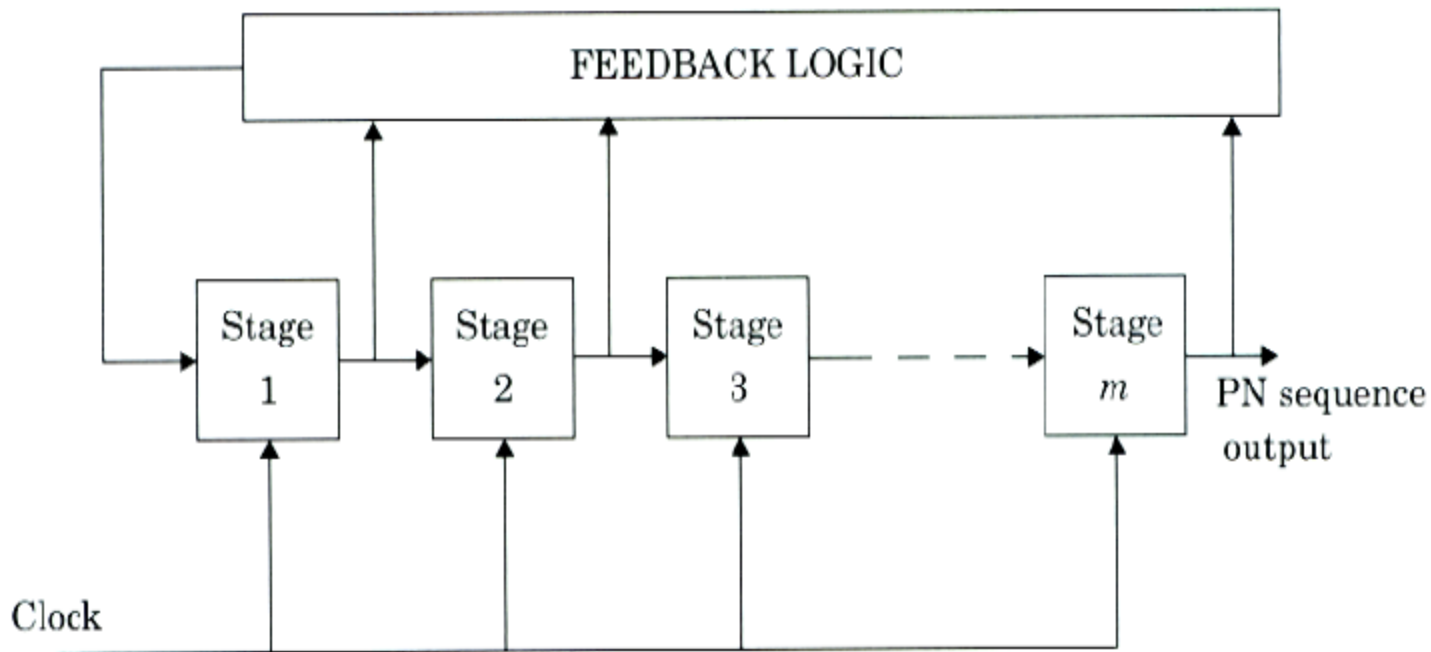
- Immunity from various noise and multipath distortion
    - Including jamming
  - Can hide/encrypt signals
    - Only receiver who knows spreading code can retrieve signal
  - Several users can share same higher bandwidth with little interference
    - Cellular telephones
    - Code division multiplexing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

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# 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
-

# PN Sequence Generator



**Figure 6.48** Block diagram of a generalized feedback shift register with  $m$  stages.



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# Spread Spectrum Multiple Access

- Direct Sequence Spread Spectrum (DSSS)

- A carrier is modulated by a digital code in which the code bit rate is much larger than the information signal bit rate. These systems are also called pseudo-noise systems.
  - Also called code division multiple access (CDMA)
  - A **short code** system uses a PN code length equal to a data symbol.
  - A **long system** uses a PN code length that is much longer than a data symbol.
-

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# Direct Sequence Spread Spectrum (DSSS)

- Each bit represented by multiple bits using spreading code
  - Spreading code spreads signal across wider frequency band
    - In proportion to number of bits used
    - 10 bit spreading code spreads signal across 10 times bandwidth of 1 bit code
  - One method:
    - Combine input with spreading code using XOR
    - Input bit 1 inverts spreading code bit
    - Input zero bit doesn't alter spreading code bit
    - Data rate equal to original spreading code
  - Performance similar to FHSS
-

# Direct Sequence Spread Spectrum Example

