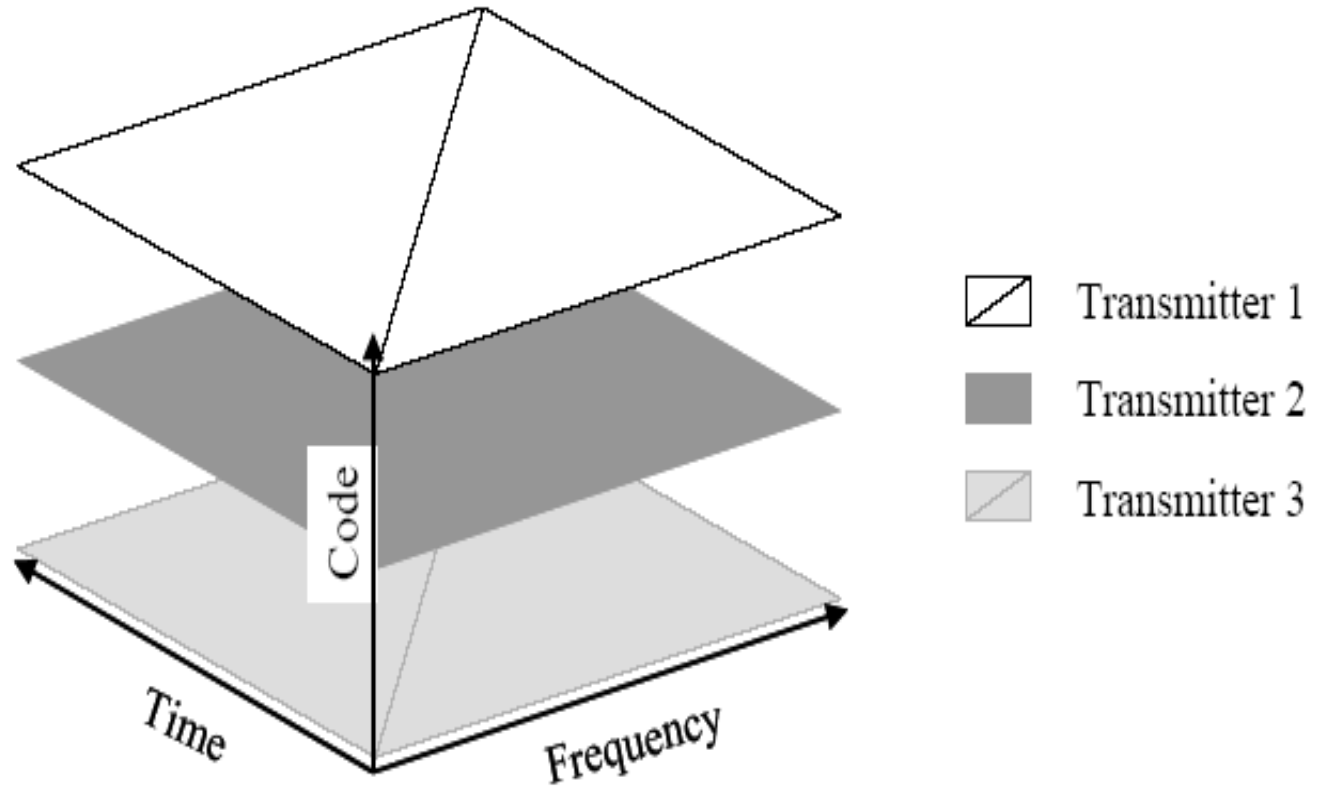# Code Division Multiple Access (CDMA) (1)

- Transmitter may transmit at the same time, in the same channel.
- Each user has its own pseudorandom code which is orthogonal to other users.
- Receivers performs time correlation
- Near-Far problem when many users share the same channel.
- To solve near far problem, Power control is used by each base station.
- Each signal is modified by spreading it over a large bandwidth.
  - This spreading occurs by combining the transmitter signal with a spreading sequence.

Code Division Multiple Access (CDMA) (2)

Code Division Multiple Access (CDMA) (4)

- Features of CDMA
  - Many users of a CDMA system share the same frequency. TDD and FDD may be used.
  - No limit on the number of users in cdma.
  - Multipath fading can be reduced.
  - The symbol (chip) duration is very short and usually much less than the channel delay spread.
  - CDMA uses co channel cells which causes soft handoff due to spatial diversity, which can be deal by MSC
  - The near-far problem occurs at a CDMA RX if an undesired user has a high detected power as compared to the desired user.
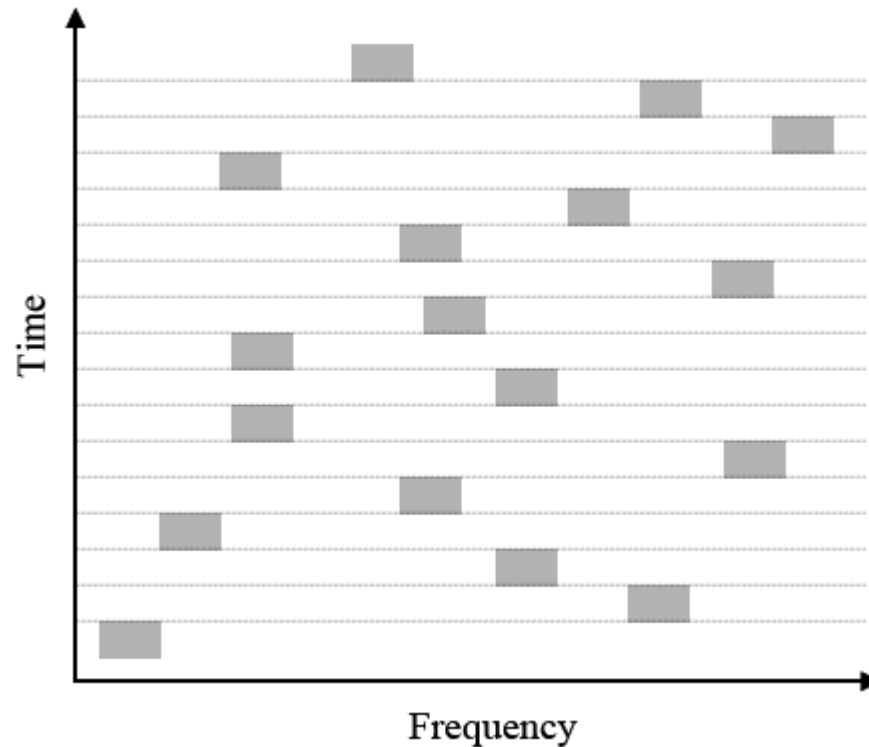
Frequency Hopping (1)

- Frequency hopping is a form of FDMA

- Each transmitter is allocated a group of channels, known as *hop set* .

- The transmitter transmits data in short bursts, choosing one of these channels on which to transmit each burst.
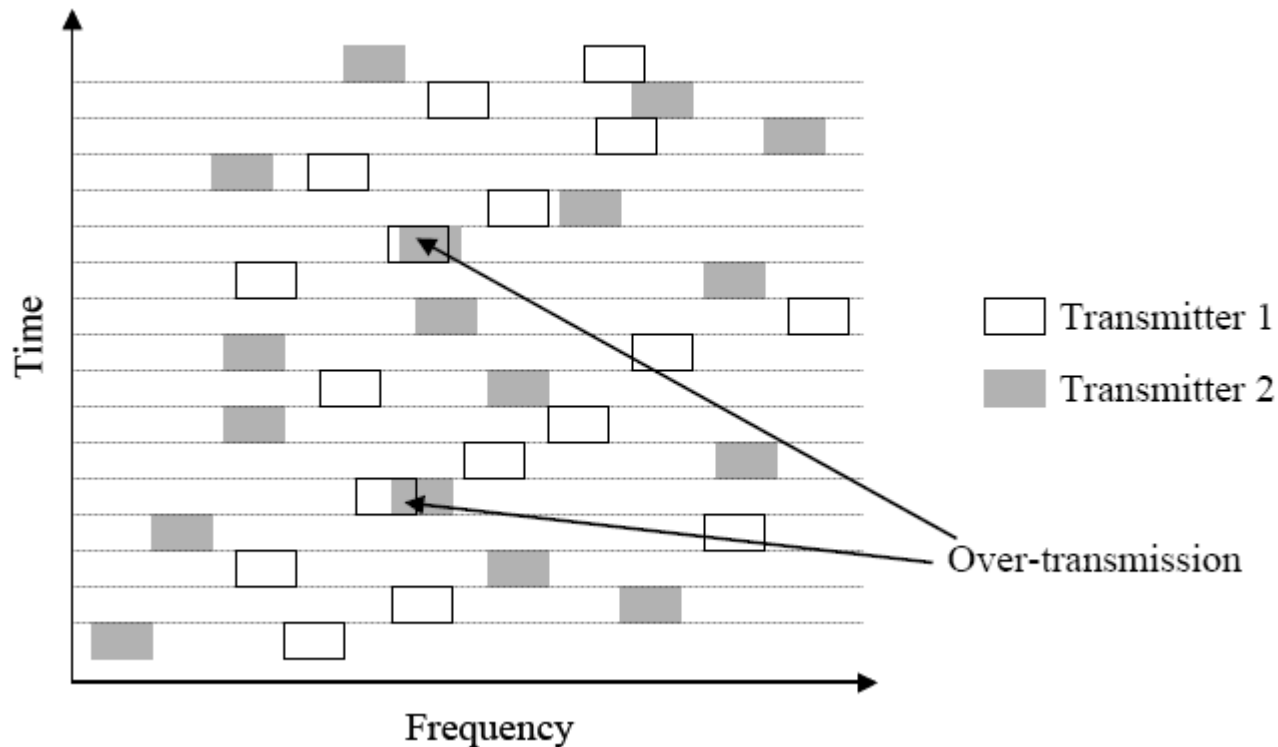
Frequency Hopping (2)

- Time-frequency characteristic of a single transmitter.

Frequency Hopping (3)

● Signal received form a pair of frequency-hopping transmitters.

Spread Spectrum Multiple Access (1)

- A transmission technique in which a PN 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" using a synchronized replica of the PN code.

- Direct Sequence Spread Spectrum (DSSS)

Spread Spectrum Multiple Access (2)

- **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.
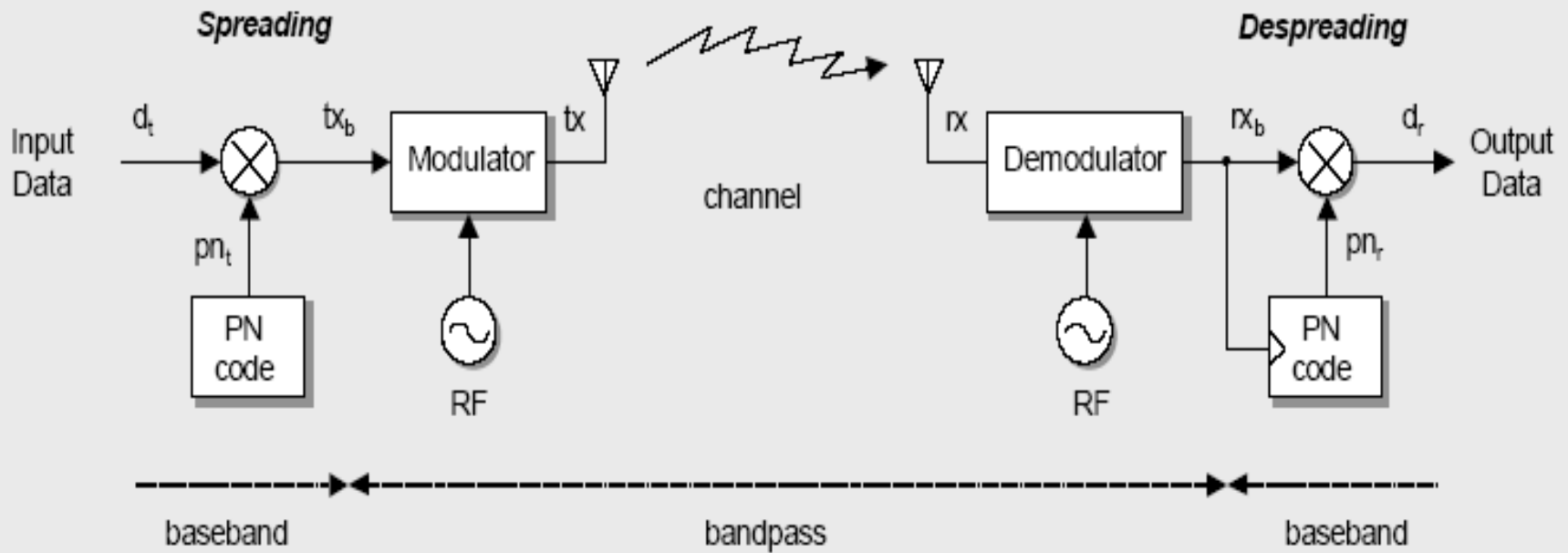
Spread Spectrum Multiple Access (3)
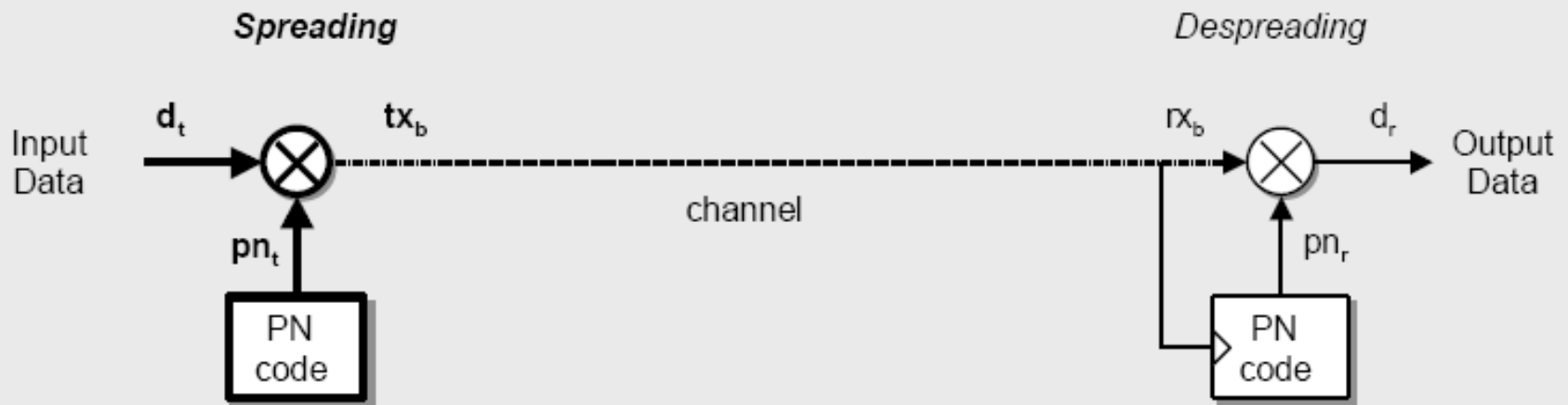
● Direct Sequence Spread Spectrum (DSSS)
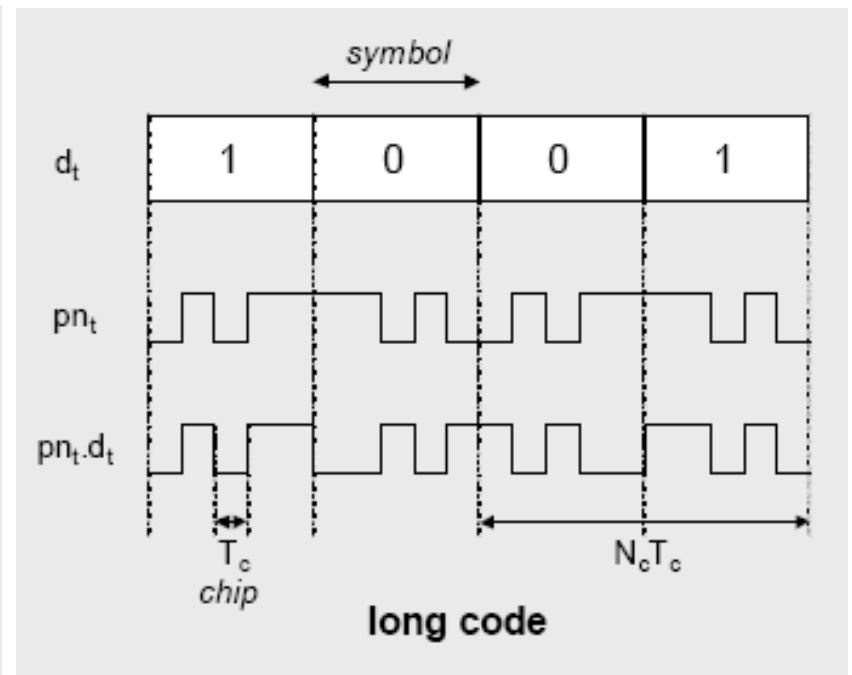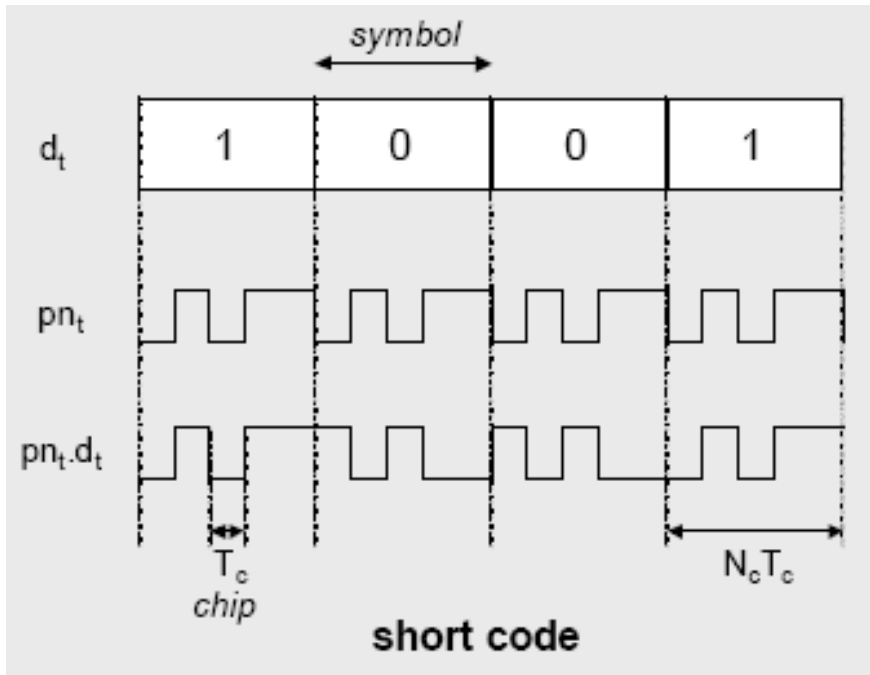
Spread Spectrum Multiple Access (4)

- Basic principle of DSSS
  - For BPSK modulation

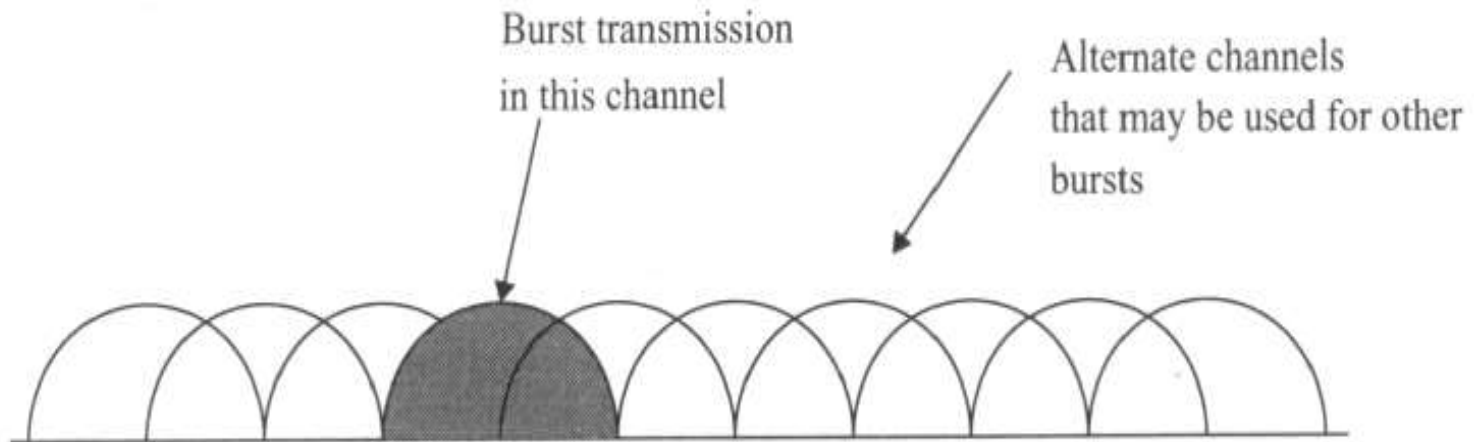# Spread Spectrum Multiple Access (7)

- Modulation

● Hybrid FDMA/CDMA (FCDMA):

> ➤ Alternative to DS-CDMA

> ➤ The available wideband spectrum is divided into a number of subspectras with smaller bandwidths.

> ➤ Each of these smaller suchannels becomes a narrowband CDMA system having processing gain lower than the original CDMA system.

Wideband CDMA

Spectrum of Narrowband CDMA

Spread Spectrum Multiple Access (16)

- Hybrid Direct Sequence/Frequency Hopped Multiple Access (DS/FHMA)
  - This technique consists of a direct sequence modulated signal whose center frequency is made to hop periodically in a pseudorandom fashion.
  - Having an advantage in that they avoid the near-far effect.

Burst transmission in this channel

Alternate channels that may be used for other bursts

Spread Spectrum Multiple Access (17)

- Time Division Frequency Hopping (TDFH)
  - ➤ The subscriber can hop to a new frequency at the start of a new TDMA frame.
  - ➤ Has been adopted in GSM.
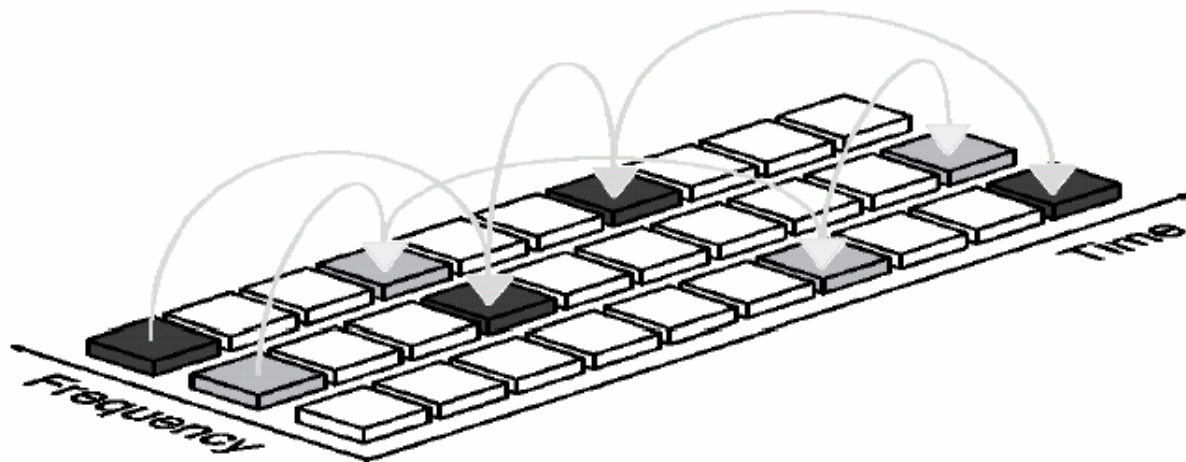
Space Division Multiple Access

- Controls radiated energy for each user in space
- using spot beam antennas
- base station tracks user when moving
- cover areas with same frequency or
  TDMA or CDMA systems
- cover areas with different frequencies
  FDMA systems

Space Division Multiple Access

- primitive applications are "Sectorized antennas"

- in future adaptive antennas simultaneously steer energy in the direction of many users at once
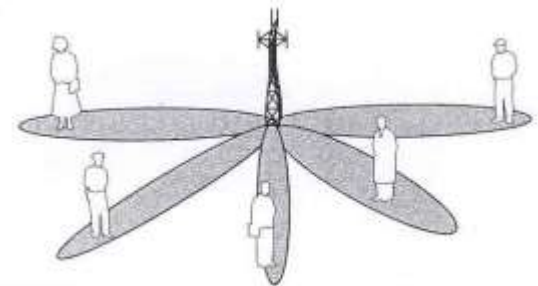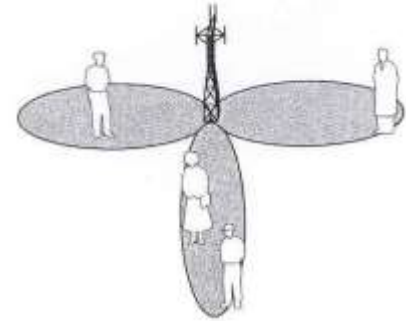
Reverse link problems

- general problem
- different propagation path from user to base
- dynamic control of transmitting power from each user to the base station required
- limits by battery consumption of subscriber units
- possible solution is a filter for each user

Solution by SDMA systems

- adaptive antennas promise to mitigate reverse link problems
- limiting case of beamwidth
- limiting case of infinitely fast track ability
- thereby unique channel that is free from interference
- all user communicate at same time using the same channel

Disadvantage of SDMA

- perfect adaptive antenna system: infinitely large antenna needed
- compromise needed

Packet Radio (1)

- In packet radio (PR) access techniques, many subscribers attempt to access a single channel in an uncoordinated (or minimally coordinated manner.

- Collision from the simultaneous transmissions of multiple transmitters are detected at the BS, in which case an ACK or NACK signal is broadcast by the BS to alert the desired user of received transmission.

- PR multiple access is very easy to implement but has low spectral efficiency and may include delays.

- The subscribers use a contention technique to transmit on a common channel.
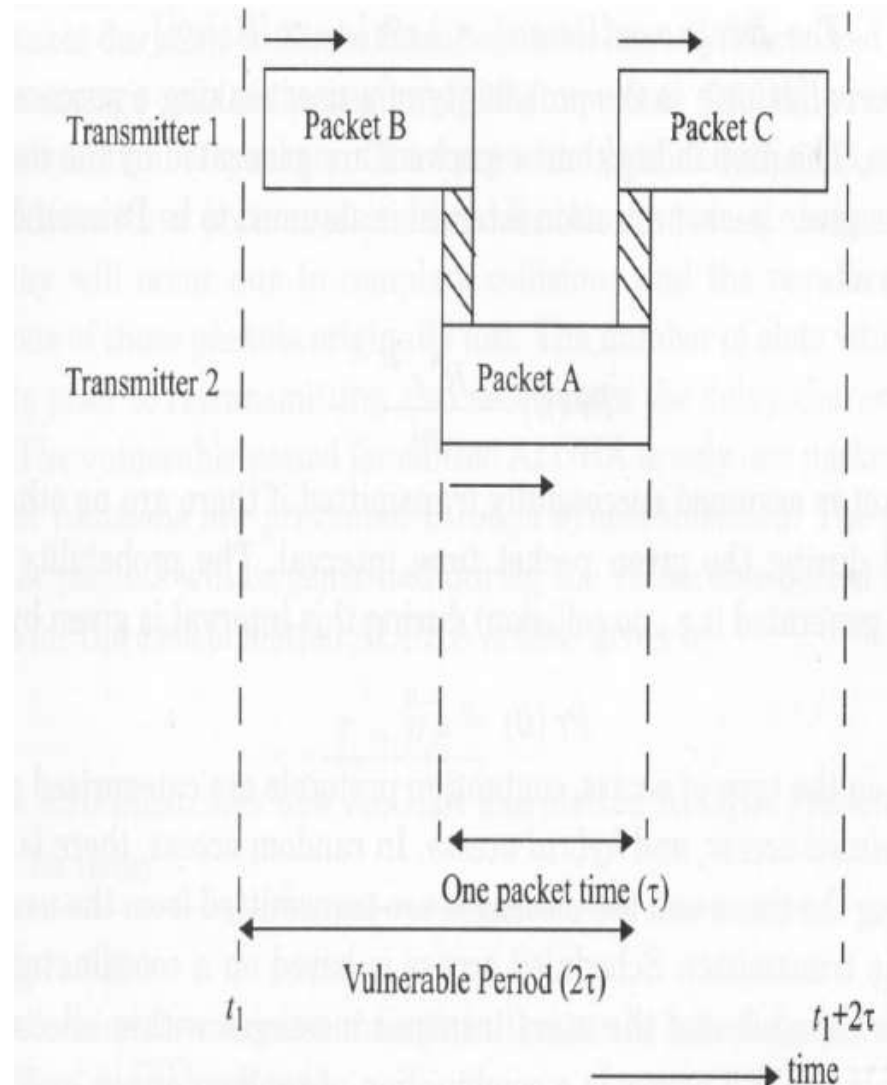
Packet Radio (2)

- ALOHA protocols, developed for early satellite systems, allow each subscriber to transmit whenever they have data to sent.

- The transmitting subscribers listen to the acknowledgement feedback to determine if transmission has been successful or not.

- If a collision occurs, the subscriber waits a random amount of time, and then transmits the packet.

- The performance of contention techniques can be evaluated by throughput (T), which is defined as the average number of message successfully transmitted per unit time, and the average delay (D) experienced by a typical message burst.

Packet Radio (3)

● **Packet Radio Protocols**

 ➢ V_p , vulnerable period is defined as the time interval during which the packets are susceptible to collisions with transmission form other user.

 ➢ Packet A suffer a collision if other terminals transmit packets during the period t_1 to $t_1 + 2\tau$

Transmitter 1 | Packet B | Packet C

Transmitter 2 | Packet A

One packet time (τ)

t_1

Vulnerable Period (2τ)

$t_1 + 2\tau$

time

Packet Radio (6)

- Type of Access
  - Contention protocols are categorized as:
    - Random Access: there is no coordination among that users and the messages are transmitted from the users as they arrive at the transmitter.

    - Scheduled Access: based on a coordinated access of users on the channel and the users transmit messages within allotted slots or time intervals.

    - Hybird Access: a combination of random access and scheduled.

Packet Radio (7)

- Pure ALOHA

  - The pure ALOHA protocol is random access protocol used for data transfer and a user accesses a channel as soon as a message is ready to be transmitted.

  - After a transmission, the user waits for an acknowledgment on either the same channel or a separate feedback channel.

  - In case of collisions, the terminal waits for a random period of time and retransmits the message.

  - For pure ALOHA, the vulnerable period is double the packet duration   ,

Packet Radio (8)

- Slotted ALOHA
  - In slotted ALOHA, time is divided into equal time slots of length greater than the packet duration τ .
  - The subscribers each have synchronized clocks and transmit a message only at the beginning of a new time slot.
  - The vulnerable period of slotted ALOHA is only one packet duration, since partial collisions are prevented through synchronization.
  - The probability that no other packets will be generated during the vulnerable period.

Packet Radio (9)

- **Carrier Sense Multiple Access (CSMA)**
  - ➢ CSMA protocols are based on the fact that each terminal on the network is able to monitor the status of the channel before transmitting information.

  - ➢ In CSMA, detection delay and propagation delay are two important parameters.
    - Detection delay is a function of he receiver hardware and is the time required for a terminal to sense whether or not the channel is idle.
    - Propagation delay is a relative measure of how fast it takes for a packet to travel from a BS to a MS.

Packet Radio (10)

- Several variations of the CSMA strategy
  - ➤ 1-persistent CSMA

  - ➤ Non-persistent CSMA

  - ➤ *p*-persistent CSMA

  - ➤ CSMA/CD

  - ➤ Data sense multiple access(DSMA)