ELC 406A
Advanced Digital Communication

Lecture 4

Multiple Access Techniques

What is the Diffrence??

- Multiplexing
- Duplex
- Multiple Access

Multiplexing

- Same transmitter has multiple analog message signals or digital data streams. They are combined into one signal over a shared medium.
- Frequency Division Multiplexing (FDM)
- Time Division Multiplexing (TDM)
- Example : TV, Radio, Telephones

Duplex

- "Duplex" allows for a "two-way" comm. between two connected parties
- Frequency Division Duplex (FDD)
- Time Division Duplex (TDD)
- Example: Telephones

Multiple Access

- Several terminals connected to the same transmission medium to to share its capacity.
- Example: Cellular phones

Multiple Access Techniques

FDMA

TDMA

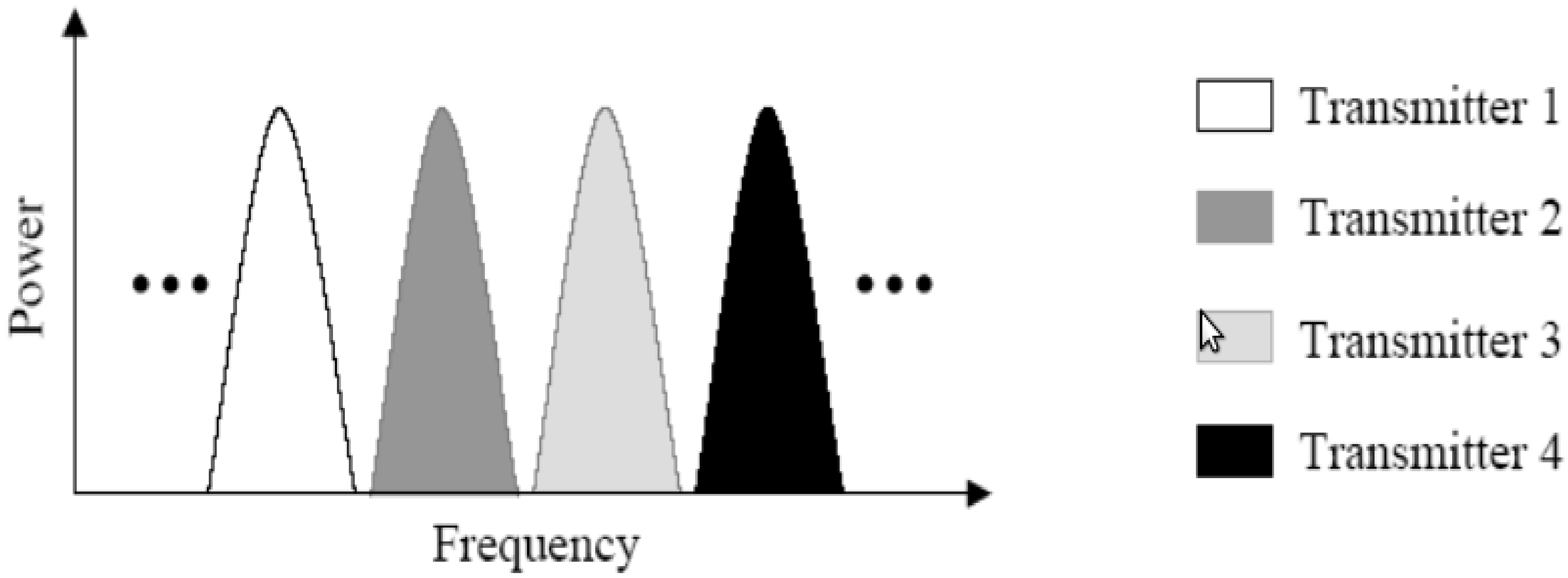
CDMA

OFDMA

FDMA

- Used in conventional telephone systems and satellite communication systems.
- User gets a certain frequency band assignement.
- If some users are in-active, not the whole resource (frequency-spectrum) is used.
- Assignment of the channels can be done centrally or by carrier sensing (The latter possibility enables random-access.)

FDMA



Power
Frequency
Transmitter 1
Transmitter 2
Transmitter 3
Transmitter 4

Capacity : FDMA

- No Guard Bands

$$K = \frac{W}{2R_u}$$

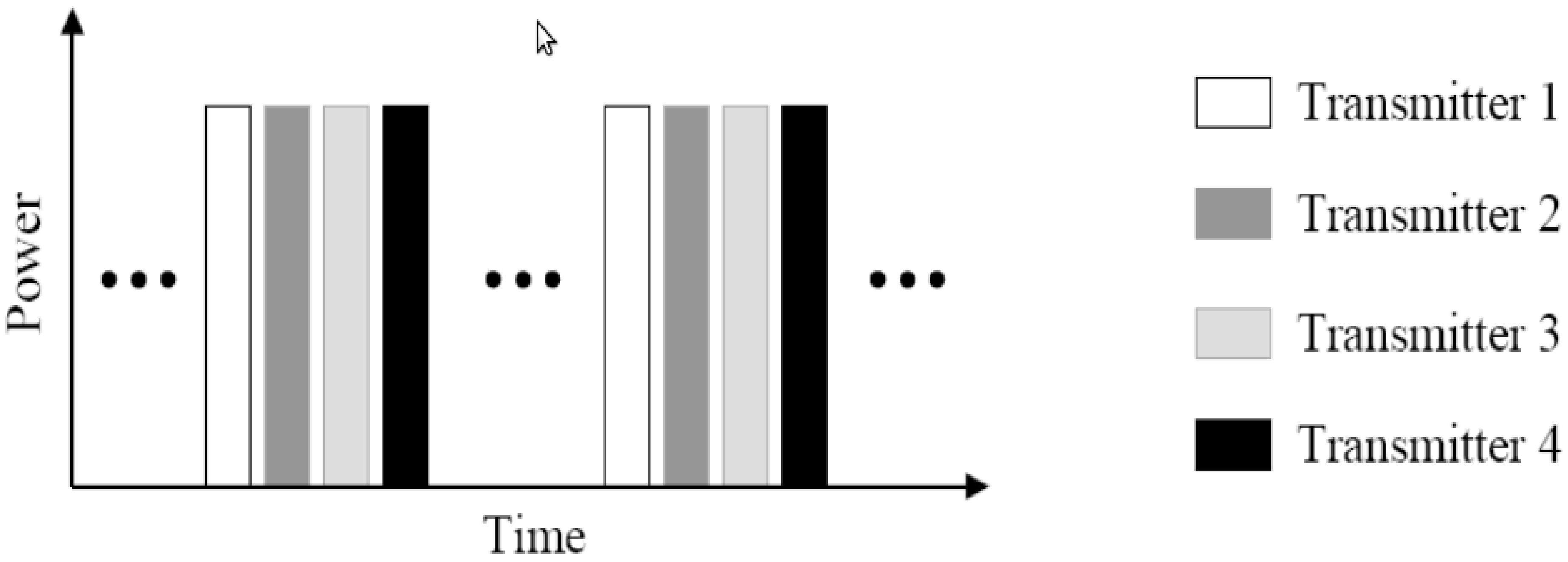
- With Guard Bands

$$K = \frac{W + GB}{2R_u + GB}$$

TDMA

- User is assigned (one/a set of) time-slots within a 'Time Frame'.
- A transmitting user sends its data in the designated time-slot(s), and waits for the remaining time-frame duration till the next time frame.
- Precise time synchronization among all users is an important feature of TDMA multiple access strategy.
- Usually, a central unit controls the synchronization and the assignment of time-slots.

TDMA


Power
Time
Transmitter 1
Transmitter 2
Transmitter 3
Transmitter 4

Capacity : TDMA

- Without Overhead

$$K = \frac{W}{2R_u}$$

- With Overhead

$$K = \frac{W}{2R_u}\left(1 - \frac{Syn}{N} R_u\right)$$

Example

- The global system for mobile communications (GSM) utilizes the frequency band 935–960 MHz for the forward link and frequency range 890–915 MHz for the reverse link. Each band is broken into radio channels of 200 kHz. Each radio channel consists of eight time slots.
- If no guard band is assumed, find the number of simultaneous users that can be accommodated in GSM.

Example

How many users can be accommodated if a guard band of 100 kHz is provided at the upper and the lower end of the GSM spectrum?

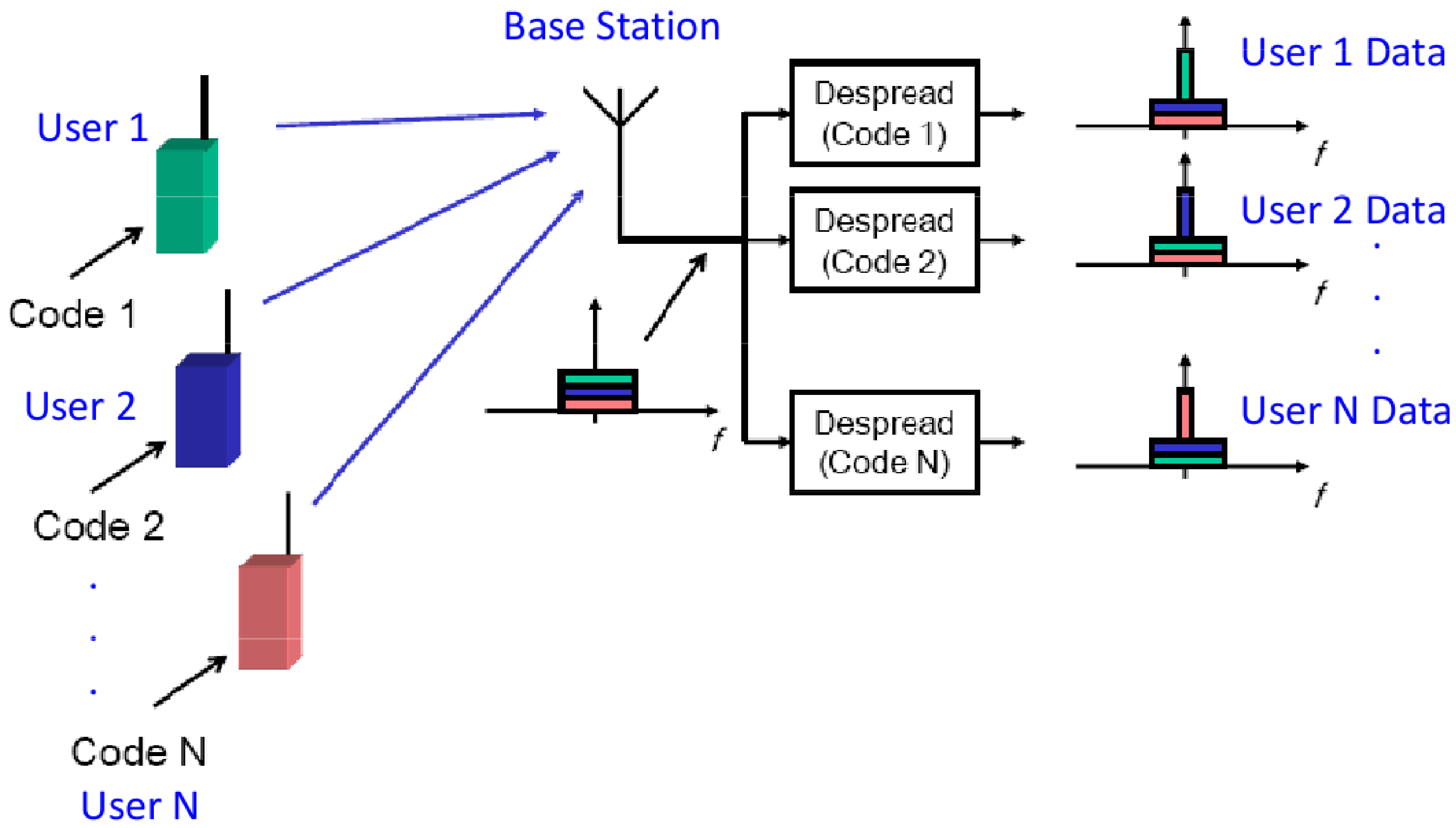
Solution

- The number of simultaneous users that can be accommodated in GSM
- In the first case is equal to 1000.
- In the second case is equal to 992.

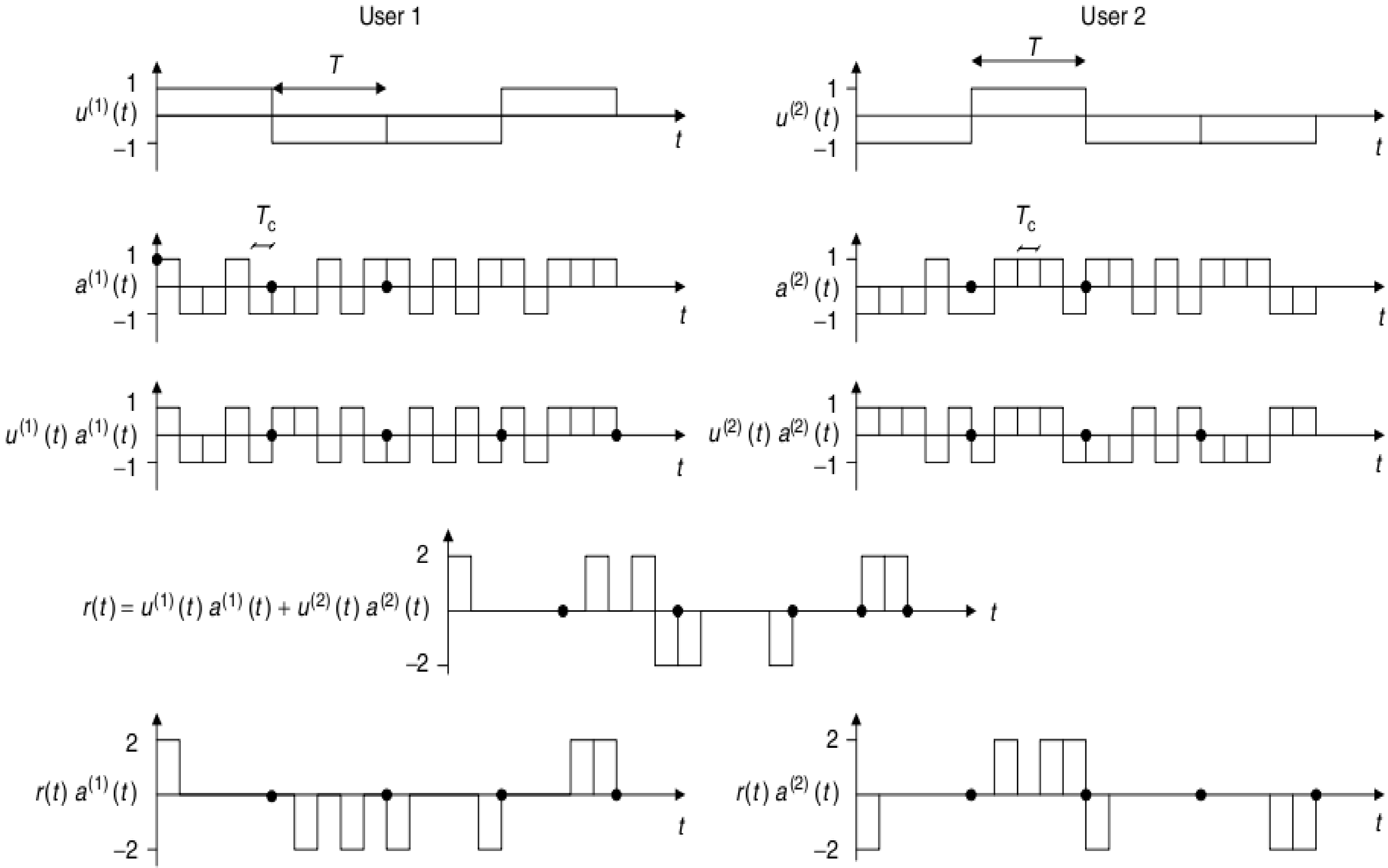
CDMA

- Spreading codes are assigned to users to access the bandwidth simultaneously.
- The spreading codes are chosen with low cross-correlation among them.
- The signals from undesired transmitters appear as noise.
- CDMA does not need very precise time synchronization among the users, random-access protocols can be implemented easily.

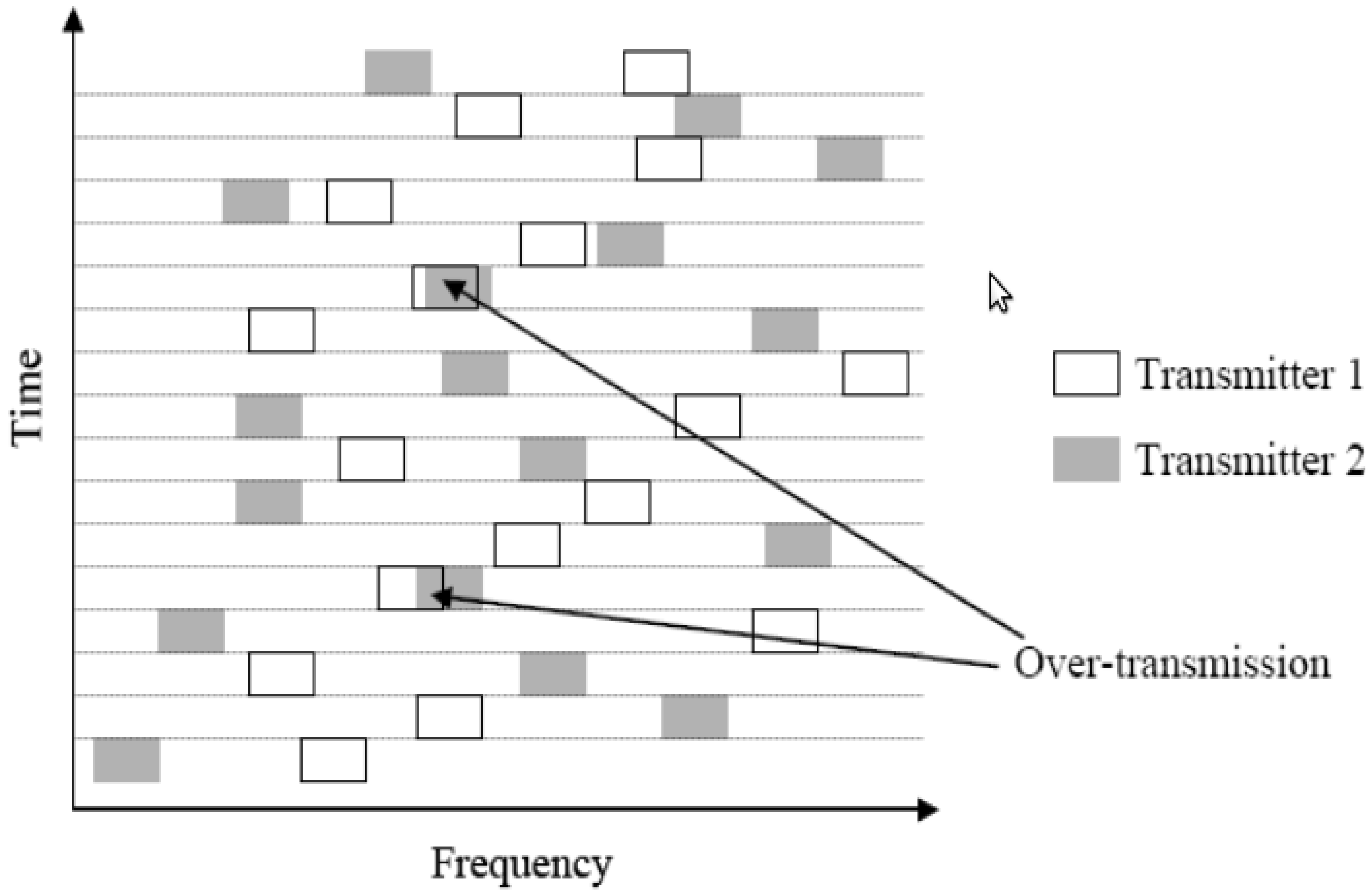
CDMA-DS


Base Station
User 1
Code 1
User 2
Code 2
Code N
User N
Despread (Code 1)
Despread (Code 2)
Despread (Code N)
User 1 Data
User 2 Data
User N Data
f

CDMA-DS


User 1
User 2
T
T
$u^{(1)}(t)$
$u^{(2)}(t)$
T_c
T_c
$a^{(1)}(t)$
$a^{(2)}(t)$
$u^{(1)}(t)\,a^{(1)}(t)$
$u^{(2)}(t)\,a^{(2)}(t)$
$r(t) = u^{(1)}(t)\,a^{(1)}(t) + u^{(2)}(t)\,a^{(2)}(t)$
$r(t)\,a^{(1)}(t)$
$r(t)\,a^{(2)}(t)$
1
–1
2
–2
t

CDMA-FH



Time
Transmitter 1
Transmitter 2
Over-transmission
Frequency

Capacity : CDMA

- Orthogonal codes
- Soft Capacity

Capacity : CDMA

- DS-SS

$$K = \beta \left(1 + \frac{2T_b / T_c}{\alpha . SNR_{accepted}} \right)$$

Capacity : CDMA

- FH-SS (Slow)

$$P_e = 1 - \left(1 - \frac{1}{N_f}\right)^{K-1}$$

- FH-SS (Fast)

$$P_{eh} = 1 - \left(1 - \frac{1}{N_f}\right)^{K-1}$$

$$P_e = \sum_{i=n}^{N_h} \binom{N_h}{i} \cdot P_{eh}^{i} \cdot \left(1 - P_{eh}\right)^{N_h - i}$$

Questions ???

Thank You