Multiple Access Techniques

CDMA

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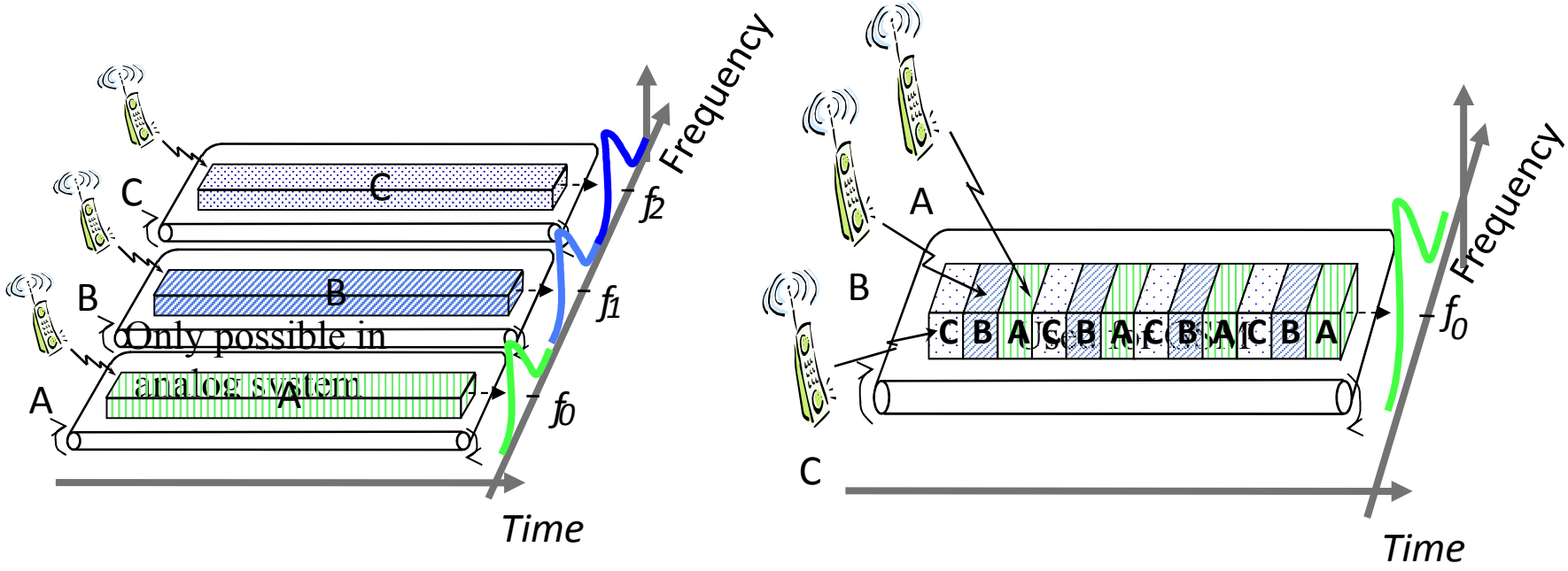
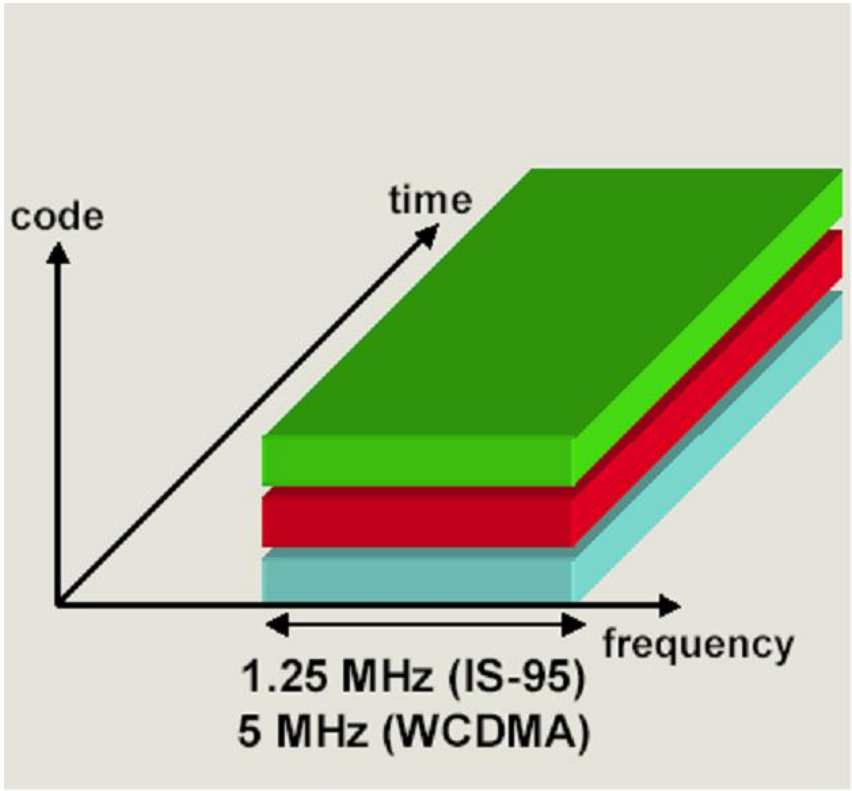
FDMA

TDMA



Introduction

- **Definition:**
- CDMA is a technology that allows multiple users to share the whole spectrum at all the time unlike TDMA and FDMA.
- CDMA has wider bandwidth compared to TDMA & FDMA.
- Requires digital transmission
- Universal frequency reuse



Wideband

- All transmissions are spread to the entire bandwidth and are hence wideband.
- The key feature of these systems is universal frequency reuse: the same spectrum is used in every cell.
- However, simultaneous transmissions can now interfere with each other and links typically operate at low SINRs.
- The two system designs differ in how the users' signals are spread

How CDMA works?

CDMA transmitter:

- The voice has to be digitalize (Pulse Code Modulation (PCM) then compressed)
- Each user is given a unique PN (Pseudorandom Sequence) code.
- The transmitter multiplies the code by the data to get the coded massage (bit)

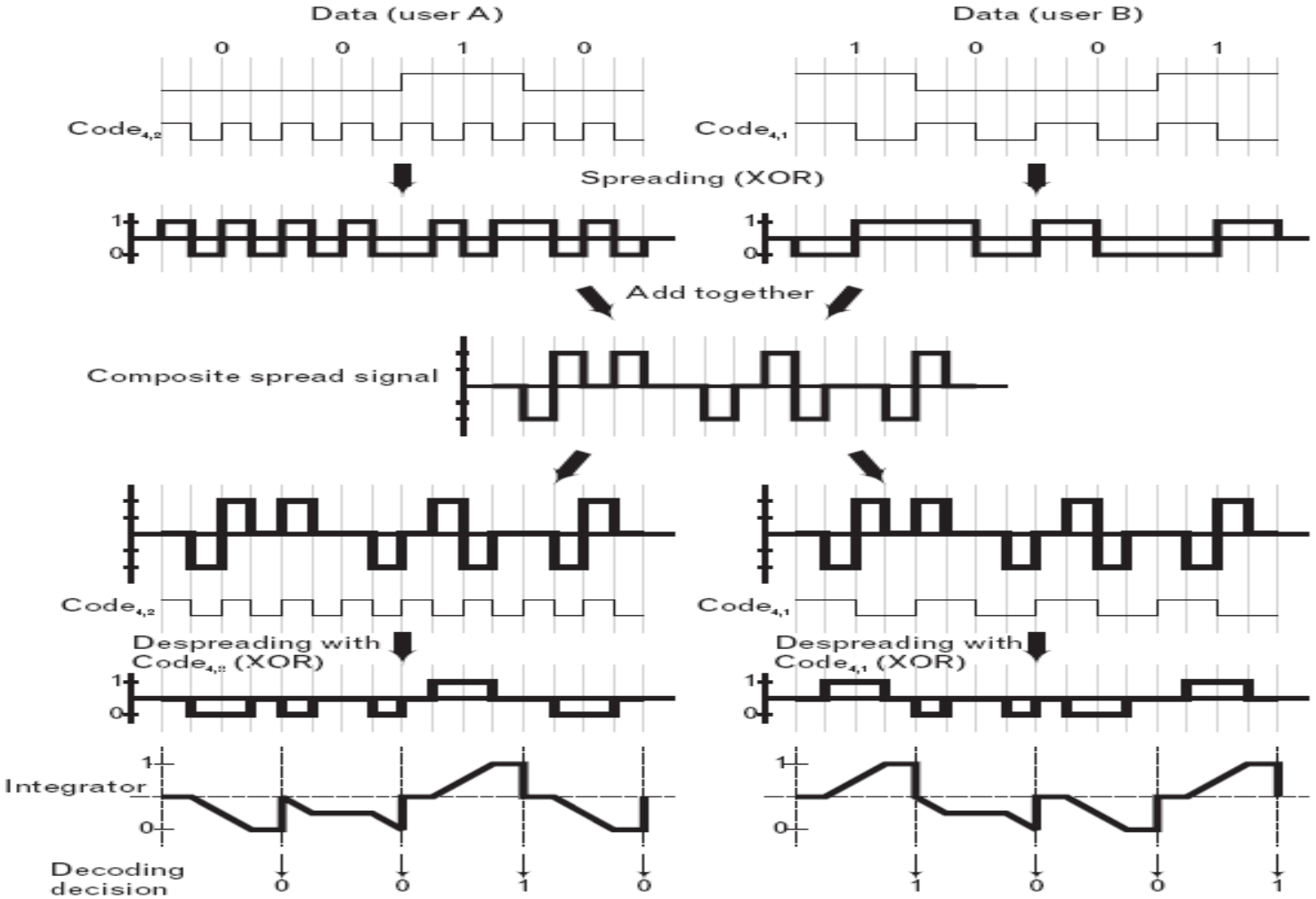
How CDMA works?

CDMA Receiver:

- The received signal is multiplied again by the same code that used in the transmitter to get signals.

- This system supports K users each transmitting its own information.
- The users are identified by k = 1, 2, 3, ..., K. This modulation scheme is used in Binary Phase Shift Keying (BPSK).
- Each user’ s data signal is denoted by dk(t) and each user is assigned a unique pseudo-random code also known as a spreading code denoted by Ck(t).

How CDMA works?



CDMA potential benefits:

- Universal frequency reuse means that users in all cells get the full bandwidth or degrees of freedom of the system.

- Assuming that users' activities are independent of each other, this provides a statistical multiplexing effect to enable the system to accommodate more users than would be possible if every user were transmitting continuously.
- CDMA devices use a **rake receiver**, which exploits multipath delay components to improve the performance of the system.

Rake Receiver

- **Fading** is deviation of the attenuation affecting a signal over certain propagation media.

- Mobile station receives multiple attenuated and delayed replicas of the original signal (multipath diversity channels).

- Two multipath signals are resolvable only if their relative delay exceeds the chip period Tc

- Searcher performs the above task for up to 3 different multipath signals.
- 3 parallel demodulators (RAKE fingers) isolate the multipath components and the RAKE receiver combines them.

Advantages of CDMA

- Efficient practical utilization of fixed frequency spectrum.
- Flexible allocation of resources.
- Many users of CDMA use the same frequency, TDD or FDD may be used
- Multipath fading may be substantially reduced because of large signal bandwidth
- No absolute limit on the number of users, Easy addition of more users.
- Impossible for hackers to decipher the code sent
- Better signal quality
- No sense of handoff when changing cells
- CDMA networks use a scheme called soft handoff, which minimizes signal breakup as a handset passes from one cell to another.
- CDMA is compatible with other cellular technologies; this allows for nationwide roaming

Disadvantages

- Increasing the number of users increases the total level of interference. This allows a more graceful degradation on the performance of a system

- Near-far problem.

  Where stronger (near to the Base Station) user masks the weaker user (far from the Base Station)

CDMA near far problem basics

- The CDMA near far problem arises because handsets may be anywhere within the particular cell boundaries. Some handsets will be close to the base station, whereas others will be much further away.
- In a free space scenario signals decay according a an inverse square law - in other words double the distance and the strength falls away to a quarter.

Signal = k x 1 / d^2

Where:
k = a constant
d = distance

- The result of this is that signals within a cell will have a huge variation in signal strengths. However for CDMA to operate correctly, the receiver must be able to receive all the required signals within the same channel bandwidth and it must be able to decode them.
- For the receiver to be able to decode all the signals in the channel, they should ideally all be at the same signal strength - giving the CDMA near far problem

Power Control in CDMA

- CDMA goal is to maximize the number of simultaneous users
- Capacity is maximized by maintaining the signal to interference ratio at the minimum acceptable
- Power transmitted by mobile station must be therefore controlled
    - Transmit power enough to achieve target

Types of CDMA

Direct Sequence

- The code division multiple access (CDMA) system is based on direct-sequence spread-spectrum.
- Each user transmits its message to the base station using the same frequency, at the same time.
- Here signals from different users interfere with each other.
- But the user distinguishes its message by using a special, unique code. This code serves as a special language that only the transmitter and receiver understand.

Types of CDMA

Frequency Hopping

- fixed sequence of frequency values & Time is divided into slots .
- In the first time slot, a given user transmit to the base station using the first frequency in its frequency hopping sequence.
- In the next time interval, it transmits using the second frequency value in its frequency hopping sequence, and so on.
- This way, the transmit frequency keeps changing in time.