

Lecture 15: CDMA Principles and Spread Spectrum Types

GSM and CDMA Systems

DI05011011: Mobile Communication

Agenda for Today

- 1. What is CDMA?
- 2. The Principle of CDMA (Orthogonality)
- 3. The Cocktail Party Analogy
- 4. Power Control in CDMA
- 5. Soft Handoff
- 6. Advantages of CDMA
- 7. Types of Spread Spectrum Techniques
- 8. DSSS vs. FHSS (Brief Intro)
- 9. Summary

What is CDMA?

- **Code Division Multiple Access (CDMA):**
- - Based on Spread Spectrum technology.
- - Unlike FDMA (separating users by frequency) or TDMA (separating users by time slots).
- - In CDMA, **all users transmit on the same frequency at the exact same time.**
- - Users are separated mathematically using unique, orthogonal codes assigned to each transmitter.

The Principle of CDMA: Orthogonal Codes

- How do signals not interfere?
- - Each user's data is multiplied by a unique 'spreading code' (e.g., Walsh codes).
- - These codes are **Orthogonal**.
- - Mathematical property: When you multiply two different orthogonal codes together and sum the result, it equals zero.
- - The receiver multiplies the incoming combined signal by the *desired* user's code. Only that user's data emerges; the rest of the signals cancel out to zero (noise).

The Cocktail Party Analogy

- **FDMA:** People talking in separate rooms.
- **TDMA:** People in the same room, but taking turns talking one by one.
- **CDMA:** Everyone in the same room, talking at the same time, but in completely **different languages**.
 - - If you only understand English, the Spanish and French conversations just sound like background noise.
 - - The 'language' is the spreading code.

Crucial Requirement: Power Control

- The Near-Far Problem:
- - If User A is close to the tower and User B is far away, User A's signal will drown out User B's signal (the loud person at the party).
- - Since everyone shares the same frequency, strict power control is mandatory.
- **Solution:**
- - The Base Station constantly commands mobiles to adjust their transmit power (hundreds of times per second).
- - Goal: Every mobile's signal must arrive at the Base Station with the **exact same power level**.

- **Hard Handoff (GSM):** "Break before make."
- - MS disconnects from Tower A, then connects to Tower B. Brief interruption.
- **Soft Handoff (CDMA):** "Make before break."
- - Because all cells use the same frequency, an MS can communicate with Tower A and Tower B *simultaneously* during the transition.
- - The core network combines the signals from both towers, improving call quality at cell edges.
- - Eliminates dropped calls during handoffs.

Advantages of CDMA

- **1. Increased Capacity:** Soft capacity limits. You can always add one more user, it just slightly increases the noise floor for everyone else.
- **2. Better Call Quality:** Soft handoffs prevent drops; multipath fading is mitigated.
- **3. Security:** Spread spectrum is inherently difficult to intercept without knowing the specific code.
- **4. Frequency Reuse of 1:** Every cell uses the same frequency band. No complex frequency planning required like in GSM.

Types of Spread Spectrum Techniques

- Spread Spectrum can be implemented in several ways to achieve the bandwidth spreading we discussed in Lecture 14.
- The two primary techniques are:
- **1. DSSS (Direct Sequence Spread Spectrum):**
 - - The data is directly multiplied by a high-speed code sequence.
- **2. FHSS (Frequency Hopping Spread Spectrum):**
 - - The carrier frequency hops around rapidly across a wide band.

Direct Sequence Spread Spectrum (DSSS) - Concept

- - Each bit of user data is represented by multiple bits in the transmitted signal, called **chips**.
- - A spreading code (e.g., 11 bits long) represents a '1', and its inverse represents a '0'.
- - The signal is continuously spread across the entire wide bandwidth simultaneously.
- - Used heavily in 3G Cellular (WCDMA), Wi-Fi (802.11b), and GPS.

Frequency Hopping Spread Spectrum (FHSS) - Concept

- - The data is transmitted using a narrow bandwidth.
- - However, that narrow band changes frequency rapidly, hopping across a very wide total bandwidth.
- - The spreading occurs over time, rather than simultaneously.
- - Used heavily in Bluetooth and military radios.

- CDMA allows users to share the exact same frequency and time using orthogonal codes.
- It solves the Near-Far problem through strict, rapid power control.
- Soft Handoff (make before break) improves reliability.
- CDMA offers higher capacity and a frequency reuse factor of 1.
- Spread Spectrum is mainly categorized into DSSS (spreading via chips) and FHSS (spreading via hopping).

- In the next lecture, we will look deeper into the spread spectrum techniques:
- **1. Deep Dive into DSSS:** How chips multiply data.
- **2. Deep Dive into FHSS:** Hop sequences.
- **3. Comparison:** GSM vs. CDMA Technology.