

Lecture 21: Limitations of GSM Technology - Part 1

GSM and CDMA Systems

DI05011011: Mobile Communication

Agenda for Today

- 1. Overview of GSM Limitations
- 2. Bandwidth and Data Rate Constraints
- 3. Spectral Efficiency Issues
- 4. Hard Handoff Drawbacks
- 5. Multipath Fading Vulnerabilities
- 6. Summary and Next Steps

1. Overview of GSM Limitations

- Designed primarily for voice communication, not high-speed data.
- Based on Circuit Switched technology, which is inefficient for bursty data traffic.
- Maximum basic data rate of only 9.6 kbps.
- Fixed channel bandwidth of 200 kHz limits flexibility.

2. The Data Rate Bottleneck

- **Original GSM Data Rate:** 9.6 kbps per user.
- Each user is assigned one time slot out of 8 in a TDMA frame.
- Voice is highly compressed (13 kbps vocoder), leaving little room for data.
- To download a 1 MB image at 9.6 kbps takes over 14 minutes.

Engineering Example: File Transfer over GSM

- **Scenario:** Sending a 500 KB email attachment over basic GSM.
- **Calculation:**
 - - File size: $500 \text{ KB} = 500 \times 1024 \times 8 \text{ bits} = 4,096,000 \text{ bits}$.
 - - Data Rate: $9.6 \text{ kbps} = 9,600 \text{ bits per second}$.
 - - Time $= 4,096,000 / 9,600 = \sim 426 \text{ seconds}$ (over 7 minutes).
- **Conclusion:** Practical data applications required the development of GPRS (2.5G) and EDGE (2.75G) to combine multiple time slots.

3. Spectral Efficiency Issues

- **Spectral Efficiency:** Data rate transmitted over a given bandwidth (bps/Hz).
- GSM uses GMSK (Gaussian Minimum Shift Keying) modulation.
- GMSK provides constant envelope (good for battery) but poor spectral efficiency (~ 1.35 bps/Hz).
- Requires frequency reuse planning (e.g., cluster size of 4, 7, or 12), wasting spectrum.

Frequency Reuse Constraint

- Adjacent cells cannot use the same frequencies (Co-channel interference).
- Only a fraction of the total allocated spectrum is available in a single cell (e.g., 1/7th in a 7-cell cluster).
- Unlike CDMA, where reuse factor is 1, GSM strictly partitions its spectrum.
- **Result:** Lower overall user capacity per square kilometer.

4. Hard Handoff Drawbacks

- GSM utilizes 'Hard Handoff' (Break-before-make).
- The mobile device drops the connection with the old base station before connecting to the new one.
- Creates a noticeable gap (interruption) in voice or data.
- Can lead to dropped calls if the target base station is congested.

5. Vulnerability to Multipath Fading

- Radio signals bounce off buildings, arriving at the receiver at different times (Multipath).
- In TDMA/GSM, delay spreads can cause Inter-Symbol Interference (ISI).
- If delay $\geq$ bit duration, symbols overlap and corrupt data.
- Requires complex Equalizers in the receiver to reconstruct the signal.

Timing Advance Limitation

- To prevent time slots from overlapping at the base station, mobiles far away must transmit earlier.
- This is called 'Timing Advance' (TA).
- GSM TA is limited to 63 steps, where each step is 3.69 microseconds.
- **Max Range:** This limits the absolute maximum radius of a standard GSM cell to exactly 35 kilometers.

Summary of GSM Limitations

- Low data rates (9.6 kbps).
- Circuit-switched inefficiency.
- Low spectral efficiency due to GMSK and frequency reuse.
- Hard handoffs causing dropped calls.
- Strict 35 km cell size limit due to Timing Advance.

- In the next lecture, we will explore:
- **Limitations of CDMA Technology:**
- 1. The Near-Far Problem
- 2. Cell Breathing
- 3. Complex Power Control Requirements