

Lecture 6: 1.6 Co-channel and adjacent channel interference

Fundamental of Cellular Communication

DI05011011: Mobile Communication

Agenda for Today

- 1. Introduction to Interference
- 2. Concept of Co-channel Interference (CCI)
- 3. Signal to Interference Ratio (SIR)
- 4. Mitigating Co-channel Interference
- 5. Concept of Adjacent Channel Interference (ACI)
- 6. Near-Far Effect
- 7. Mitigating Adjacent Channel Interference
- 8. Comparing CCI and ACI
- 9. Summary and Next Steps

What is Interference?

- Interference is the major limiting factor in the performance of cellular radio systems.
- It causes crosstalk, noise, and dropped calls.
- Sources of interference:
 - - Another mobile in the same cell
 - - A call in progress in a neighboring cell
 - - Other base stations operating in the same frequency band
 - - Non-cellular systems leaking energy into the cellular frequency band

Co-Channel Interference (CCI)

- Frequency reuse implies that in a given coverage area, there are several cells that use the same set of frequencies.
- These cells are called co-channel cells.
- Interference between signals from these co-channel cells is called co-channel interference.
- CCI cannot be combated by simply increasing the carrier power of a transmitter.

Visualizing Co-Channel Cells

- Consider a cellular cluster of size $N = 7$.
- Cell 'A' in the center cluster uses frequency set 1.
- The first tier of co-channel cells (also using frequency set 1) surrounds the center cluster.
- There are 6 equidistant co-channel cells in the first tier.
- These 6 cells are the primary source of co-channel interference for Cell 'A'.

Signal to Interference Ratio (SIR)

- Quality of a voice channel is determined by the Signal-to-Interference Ratio (SIR).
- $SIR = S / I$, where S is the desired signal power, and I is the interference power.
- For a mobile unit, I = sum of interference from all co-channel cells.
- In a fully equipped hexagonal grid, there are 6 primary co-channel interferers.
- SIR is heavily dependent on the ratio D/R (co-channel reuse ratio).

Co-Channel Reuse Ratio (Q)

- The co-channel reuse ratio, Q , is defined as $Q = D / R$.
- Where D is the distance to the nearest co-channel cell, and R is the cell radius.
- For hexagonal geometry, $Q = \sqrt{3 * N}$.
- A small Q means small cluster size (N), leading to higher capacity but lower SIR (more interference).
- A large Q means larger cluster size, lower capacity, but higher SIR (better quality).

Calculating SIR Requirements

- Assume a system requires an SIR of 18 dB for acceptable voice quality.
- Using propagation models, we can relate SIR to Q.
- If $SIR = (\sqrt{3N})^4 / 6$ (assuming path loss exponent $n=4$).
- Solving for N, we find that $N=7$ provides an SIR of approximately 18.66 dB.
- Therefore, a cluster size of $N=7$ is often chosen as a baseline for acceptable CCI.

Adjacent Channel Interference (ACI)

- Interference resulting from signals which are adjacent in frequency to the desired signal.
- Results from imperfect receiver filters which allow nearby frequencies to leak into the passband.
- Most severe when an adjacent channel user is transmitting in close proximity to a receiver while the receiver attempts to receive a signal from a distant station.

The Near-Far Effect

- ACI becomes a severe problem due to the 'Near-Far Effect'.
- Scenario: A mobile close to the base station is transmitting on a channel adjacent to a mobile far from the base station.
- The base station receives a very strong signal from the near mobile and a very weak signal from the far mobile.
- The strong signal can 'bleed' through the filter and drown out the weak desired signal.

Mitigating Adjacent Channel Interference

- 1. Precise Filtering: Better receiver filters with sharp cutoffs reduce leakage.
- 2. Channel Assignment: Do not assign adjacent channels to the same cell.
 - - E.g., if a cell uses channel 1, do not assign channels 2 or 3 to the same cell.
 - - Maximize frequency separation between channels in the same cell.
- 3. Power Control: Force mobile units to adjust their transmit power based on distance to the base station.

- **Co-Channel (CCI):**

- - Same frequency.
- - Caused by frequency reuse in different cells.
- - Mitigated by increasing cluster size (N) or distance (D).

- **Adjacent Channel (ACI):**

- - Neighboring frequency.
- - Caused by imperfect filtering and near-far effect.
- - Mitigated by channel allocation and power control.

- Interference limits capacity and quality in cellular systems.
- Co-channel interference arises from reusing the same frequencies in distant cells.
- CCI is managed by controlling the D/R ratio (cluster size).
- Adjacent channel interference comes from signals on nearby frequencies leaking through filters.
- ACI is exacerbated by the near-far effect.
- ACI is managed through clever channel assignment and strict power control.

- In the next lecture, we will discuss Channel Assignment Strategies:
- 1. Fixed Channel Assignment (FCA)
- 2. Dynamic Channel Assignment (DCA)
- 3. How to allocate our precious frequency resources efficiently to manage traffic and minimize interference.