

Lecture 3: 1.3 Cell types: Macro, Micro, Pico, Selective and Umbrella cell

Fundamental of Cellular Communication

DI05011011: Mobile Communication

Agenda for Today

- 1. Why do we need different cell sizes?
- 2. Macro Cells: Wide Area Coverage
- 3. Micro Cells: Urban Capacity
- 4. Pico Cells & Femto Cells: Indoor & Targeted Coverage
- 5. Selective Cells: Directed Coverage
- 6. Umbrella Cells: Managing Fast-Moving Users
- 7. Comparison of Cell Types
- 8. Summary

Why Different Cell Sizes?

- A cellular network must serve varying landscapes and user densities:
- - **Rural areas:** Few users over vast distances. Need large coverage to save cost.
- - **Urban areas:** Dense population. A large cell would run out of capacity instantly.
- - **Indoors:** Radio waves from outdoor towers struggle to penetrate large buildings.
- **Solution:** Vary the transmission power and antenna height to create cells of different sizes tailored to the specific environment.

1. Macro Cell

- **Coverage:** 1 km to 30 km radius.
- **Location:** Rural areas, highways, and suburbs.
- **Antenna Placement:** High up on tall towers, hills, or tall building roofs.
- **Transmitter Power:** High (tens of Watts).
- **Characteristics:**
 - - Provides basic wide-area coverage.
 - - Low capacity per square kilometer.
 - - Good for fast-moving users (e.g., cars on a highway) as it minimizes handoffs.

2. Micro Cell

- **Coverage:** 200 meters to 1 km radius.
- **Location:** Dense urban areas, city centers, shopping districts.
- **Antenna Placement:** Below rooftop level, on streetlamps, utility poles, or side of buildings.
- **Transmitter Power:** Medium/Low.
- **Characteristics:**
 - - Designed to increase network capacity in crowded areas.
 - - Overcomes blocking by tall city buildings.
 - - Relies heavily on frequency reuse over small distances.

3. Pico Cell

- **Coverage:** 4 to 200 meters.
- **Location:** Indoors, airports, train stations, large office buildings, malls.
- **Antenna Placement:** Inside buildings, on ceilings or walls.
- **Transmitter Power:** Very Low.
- **Characteristics:**
 - - Fills in 'dead zones' where outdoor macro/micro signals cannot penetrate.
 - - Handles extremely dense, localized traffic (e.g., thousands of people waiting in an airport terminal).

Femto Cell (Bonus Context)

- **Coverage:** ~10 meters.
- **Location:** Homes or small businesses.
- **Characteristics:**
 - - Essentially a personal base station.
 - - Connects to the mobile operator's network via the user's home broadband internet (DSL/Fiber).
 - - Used to solve severe indoor coverage issues in residential areas.
 - - Extremely low power, basically the size of a Wi-Fi router.

4. Selective Cell

- Not defined merely by size, but by the *shape* of coverage.
- **Concept:** Using directional antennas to shape coverage into specific sectors rather than a 360-degree circle/hexagon.
- **Location:** Tunnels, valleys, long corridors, or edges of a network.
- **Characteristics:**
 - - Focuses radio energy only where it's needed.
 - - Reduces interference in unwanted directions.
 - - Example: A cell specifically pointing down a highway, rather than radiating into empty fields.

5. Umbrella Cell Concept

- **The Problem:** In a city full of small micro cells, a fast-moving car will have to switch (handoff) from cell to cell every few seconds, straining the network.
- **The Solution:** The Umbrella Cell.
 - - A large Macro cell (the Umbrella) is overlaid on top of several Micro cells.
 - - **Slow users (pedestrians):** Handled by the Micro cells for high capacity.
 - - **Fast users (cars):** Handled by the large Umbrella cell to minimize frequent handoffs.

Visualizing the Umbrella Cell

- - Imagine a large circle (Umbrella Cell) covering a 5km radius.
- - Inside that circle, there are 20 small hexagons (Micro Cells).
- - The system uses speed estimation:
- - User in a car -> Assigned to Umbrella Cell.
- - User sitting in a cafe -> Assigned to Micro Cell.
- - Result: Reduced switching load on the Mobile Switching Center (MSC).

Comparison Summary Table

- — Cell Type — Coverage Radius — Environment — Transmit Power —
- —————
- — Macro — 1 - 30 km — Rural / Hwy — High —
- — Micro — 0.2 - 1 km — Urban — Medium —
- — Pico — 4 - 200 m — Indoors — Low —
- — Femto — ~10 m — Home — Very Low —

- Networks use a mix of cell sizes to balance coverage, capacity, and cost.
- **Macro cells:** Large coverage, low capacity, rural areas.
- **Micro/Pico cells:** Small coverage, high capacity, urban/indoor areas.
- **Selective cells:** Custom-shaped coverage using directional antennas.
- **Umbrella cells:** Macro cells overlapping micro cells to serve fast-moving users and reduce handoffs.

- Now that we know what a cell is, how do we arrange them together without their frequencies interfering with each other?
- In the next lecture, we will cover:
- **1.4 Explain concept of cluster**
- - Grouping cells together.
- - Rules of frequency reuse within a cluster.