INTEGRATED TECHNICAL EDUCATION CLUSTER
AT ALAMEERIA

E-716-A
Mobile Communications Systems

Lecture #5
Basic Concepts of Cellular Transmission (p2)

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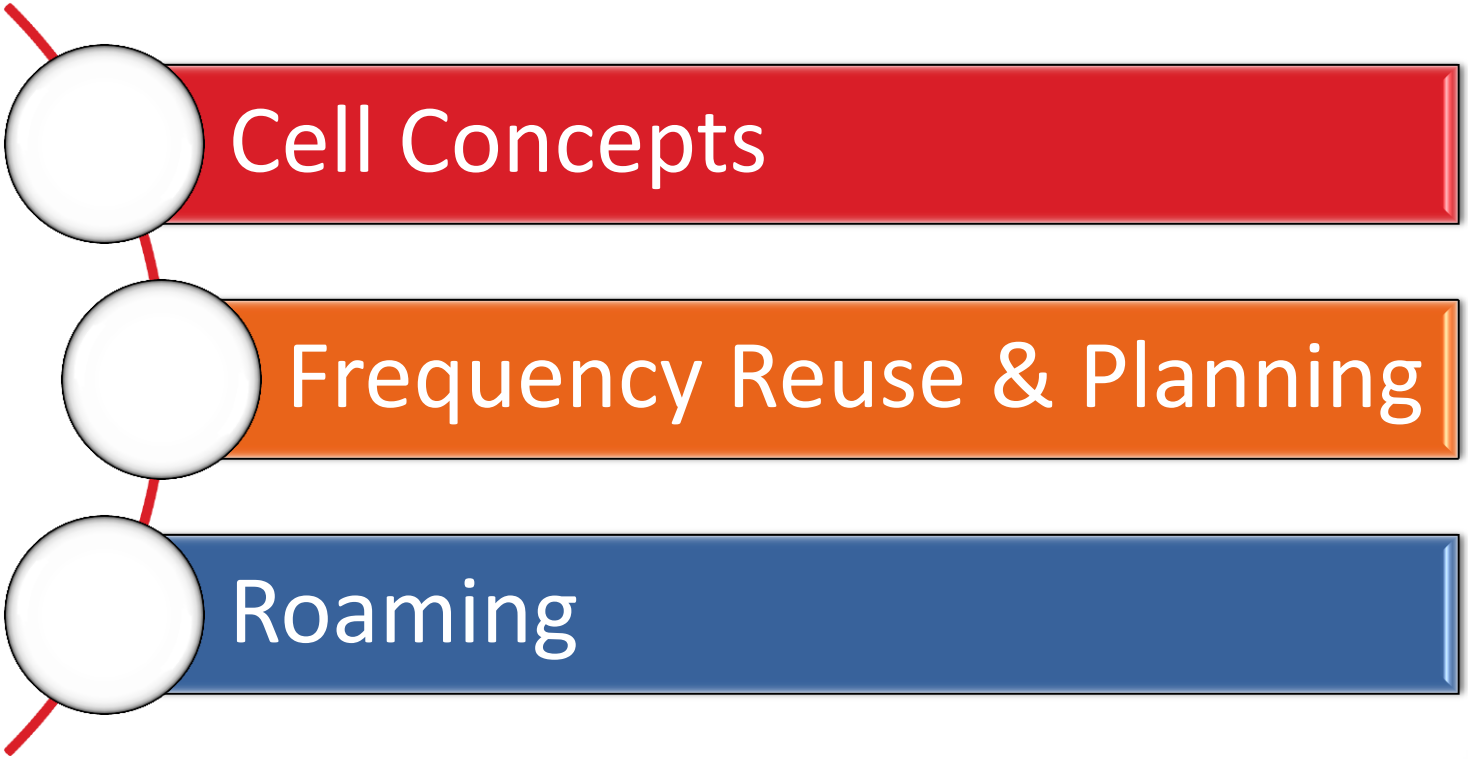
Agenda



CELL STRUCTURE, PATTERNS & TYPES

Cell Structure

- Area divided into cells
  - Each with own antenna
  - Each with own range of frequencies
  - Served by base station
    - Transmitter, receiver, control unit
  - Mobile stations communicate only via the base station
  - Adjacent cells on different frequencies to avoid crosstalk

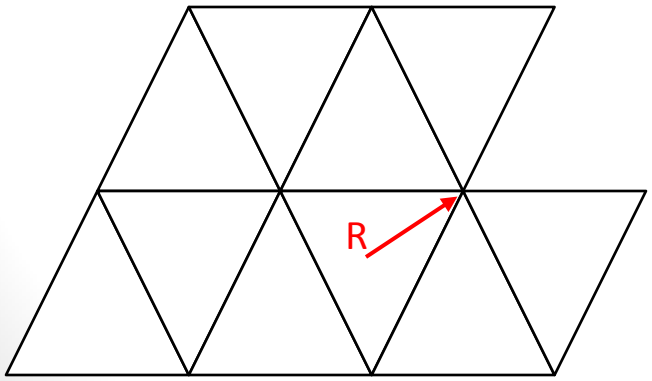
Cell Structure ..

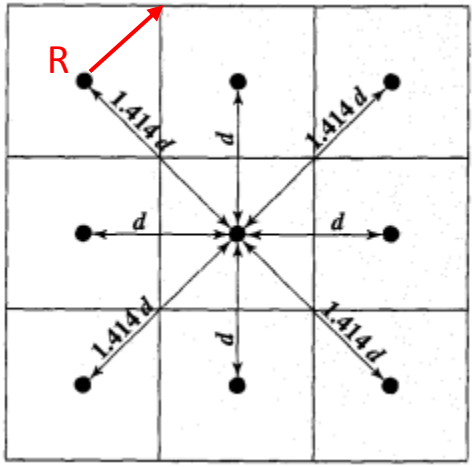
- Advantages of cell structures
  - higher capacity, higher number of users
  - less transmission power needed
  - more robust, decentralized
  - base station deals with interference, transmission area etc. locally
- Problems
  - fixed network needed for the base stations
  - handover (changing from one cell to another) necessary
  - interference with other cells

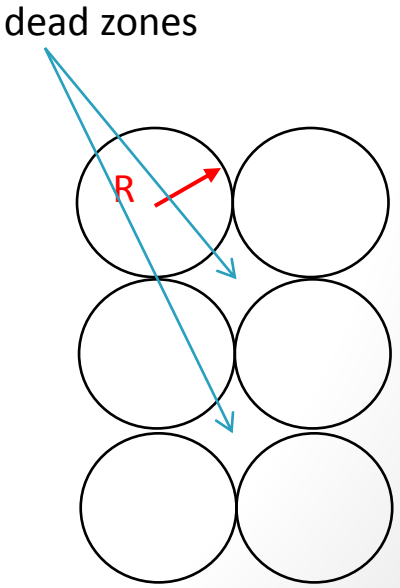
- Cell sizes from some 100 m in cities to, e.g., 35 km on the country side (GSM)

Cell Patterns

- Square & Triangle Patterns
  - Not suitable (different distance from the cell's centre to different point in the perimeter)
  - Square for example :
    - Width *d* cell has four neighbors at distance *d* and four at distance 1.414 *d*
    - Better if all adjacent antennas equidistant
      - Simplifies choosing and switching to new antenna
- Circular Patterns
  - Ideal shape, but has dead zones

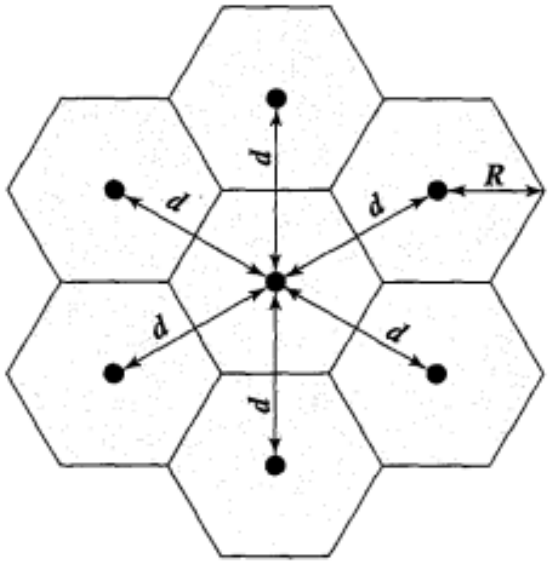


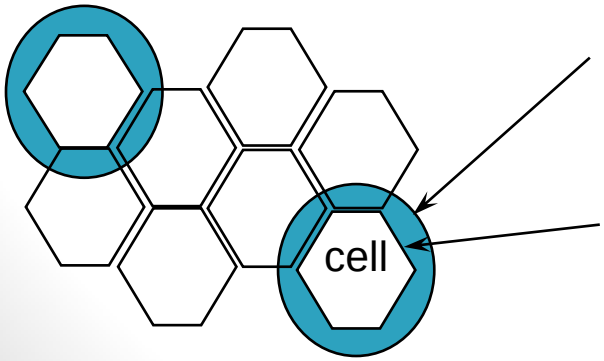




Cell Patterns..

- Hexagon
  - Provides equidistant antennas
  - Radius defined as radius of circum-circle
    - Distance from center to vertex equals length of side
  - Distance between centers of cells radius *R* is 1.7 *R*
  - Not always precise hexagons in reality
    - Topographical limitations
    - Local signal propagation conditions
    - Location of antennas





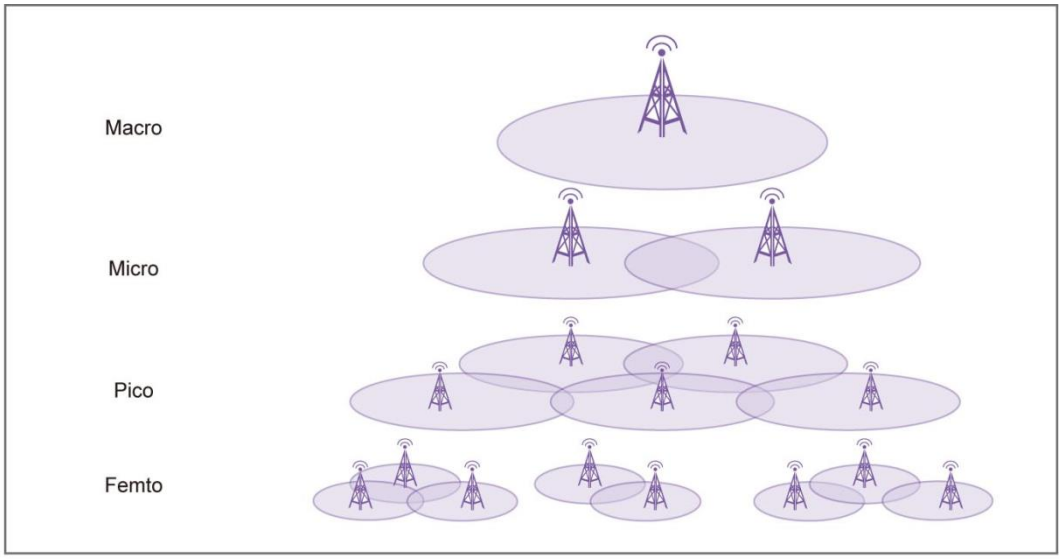
possible radio coverage of the cell

idealized shape of the cell

Cell Types

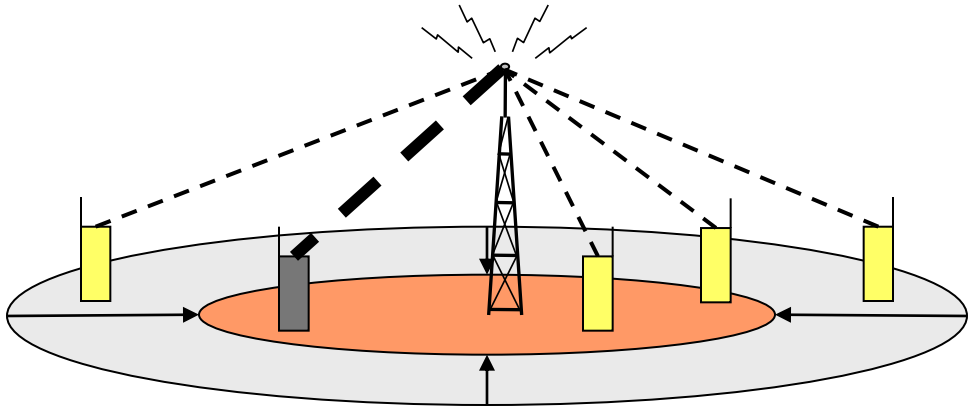
- Macro cell: 1-10km
- Micro cell: 100m-1 km – Shopping centres, airports etc.
- Pico cells: 10 – 100 m – Inside building
- Femto-cells: – Indoor, homes.

- Small cells → more bandwidth → more users → more base station → complex networks → leading to more interference and hand overs.



Cell breathing

- CDM systems: cell size depends on current load
- Additional traffic appears as noise to other users
- If the noise level is too high users drop out of cells



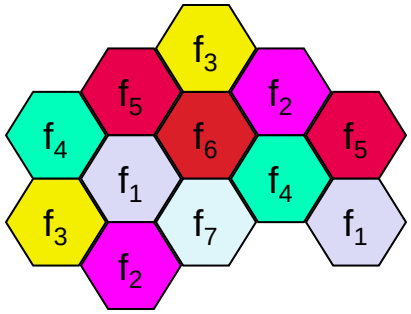
FREQUENCY REUSE & PLANNING

Frequency Reuse

- Adjacent cells assigned different frequencies to avoid interference or crosstalk
- Objective is to reuse frequency in nearby cells
  - 10 to 50 frequencies assigned to each cell
  - Transmission power controlled to limit power at that frequency escaping to adjacent cells
  - The issue is to determine how many cells must intervene between two cells using the same frequency

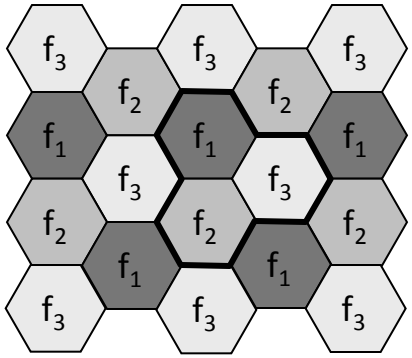
Frequency Planning

- Frequency reuse only with a certain distance between the base stations
- Standard model using 7 frequencies:

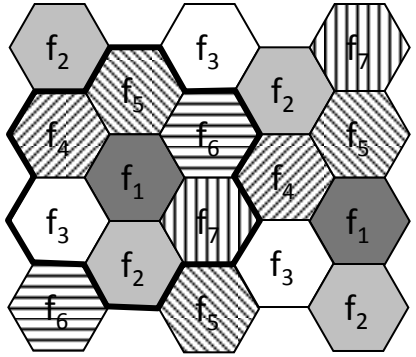


- Fixed frequency assignment:
  - certain frequencies are assigned to a certain cell
  - problem: different traffic load in different cells
- Dynamic frequency assignment:
  - base station chooses frequencies depending on the frequencies already used in neighbor cells
  - more capacity in cells with more traffic
  - assignment can also be based on interference measurements

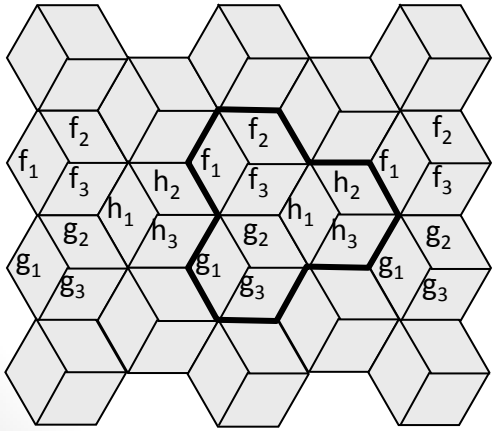
Frequency Planning ..



3 cell cluster



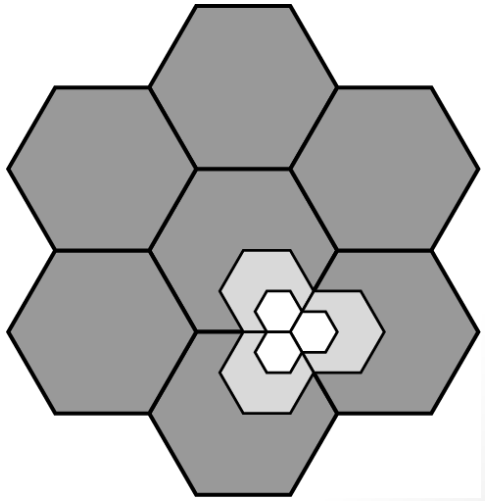
7 cell cluster



3 cell cluster
with 3 sector antennas

Increasing Capacity

- Add new channels
  - Not all channels used to start with
- Frequency borrowing
  - Taken from adjacent cells by congested cells
  - Or assign frequencies dynamically
- Cell splitting
  - Non-uniform distribution of topography and traffic
  - Smaller cells in high use areas
    - Original cells 6.5 – 13 km
    - 1.5 km limit in general
    - More frequent handoff
    - More base stations



Increasing Capacity..

- Cell Sectoring
  - Cell divided into wedge shaped sectors
  - 3 – 6 sectors per cell
  - Each with own channel set
    - Subsets of cell's channels
  - Directional antennas
- Micro/Pico/Femto cells
  - Move antennas from tops of hills and large buildings to tops of small buildings and sides of large buildings
    - Even lamp posts
  - Form Micro/Pico/Femto cells
  - Reduced power
  - Good for city streets, along roads and inside large buildings

ROAMING

Roaming

- What is roaming?

  The ability for a cellular customer to automatically make and receive voice calls, send and receive data, or access other services when traveling outside the geographical coverage area of the home network, by means of using a visited network.
- The range in roaming rates extends to a diversity in tariff structures.

Roaming types

- Different types of roaming:
  - National roaming
  - International roaming or global roaming
  - Inter-technology roaming
  - Inter-regional roaming
  - GSM roaming
  - GPRS roaming
  - SMS roaming
  - MMS roaming.

Roaming Process

- The details of the roaming process differ among types of cellular networks.
- In general, the process resembles the following:
- Location updating is the mechanism that is used to determine the location of an MS in the idle state (Connected to the network, but with no active call).
  1. When the mobile device is turned on or is transferred via a handover to the network, this new "visited" network sees the device, notices that it is not registered with its own system, and attempts to identify its home network.
  2. If there is no roaming agreement between the two networks, maintenance of service is impossible, and service is denied by the visited network.
  3. The visited network contacts the home network and requests service information (including whether or not the mobile should be allowed to roam) about the roaming device using the IMSI number.
  4. If successful, the visited network begins to maintain a temporary subscriber record for the device.
  5. Likewise, the home network updates its information to indicate that the cell phone is on the host network so that any information sent to that device can be correctly routed.

- For more details, refer to:
  - Chapter 2, J. Chiller, Mobile Communications, 2003.
  - Chapter 10, W. Stallings, Wireless Communications and Networks, 2005.
- The lecture is available online at:
  - https://speakerdeck.com/ahmad_elbanna
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