Subject: Mobile Communications

Class: 4th

Lecture Two

The Cellular Concept-System Design

By

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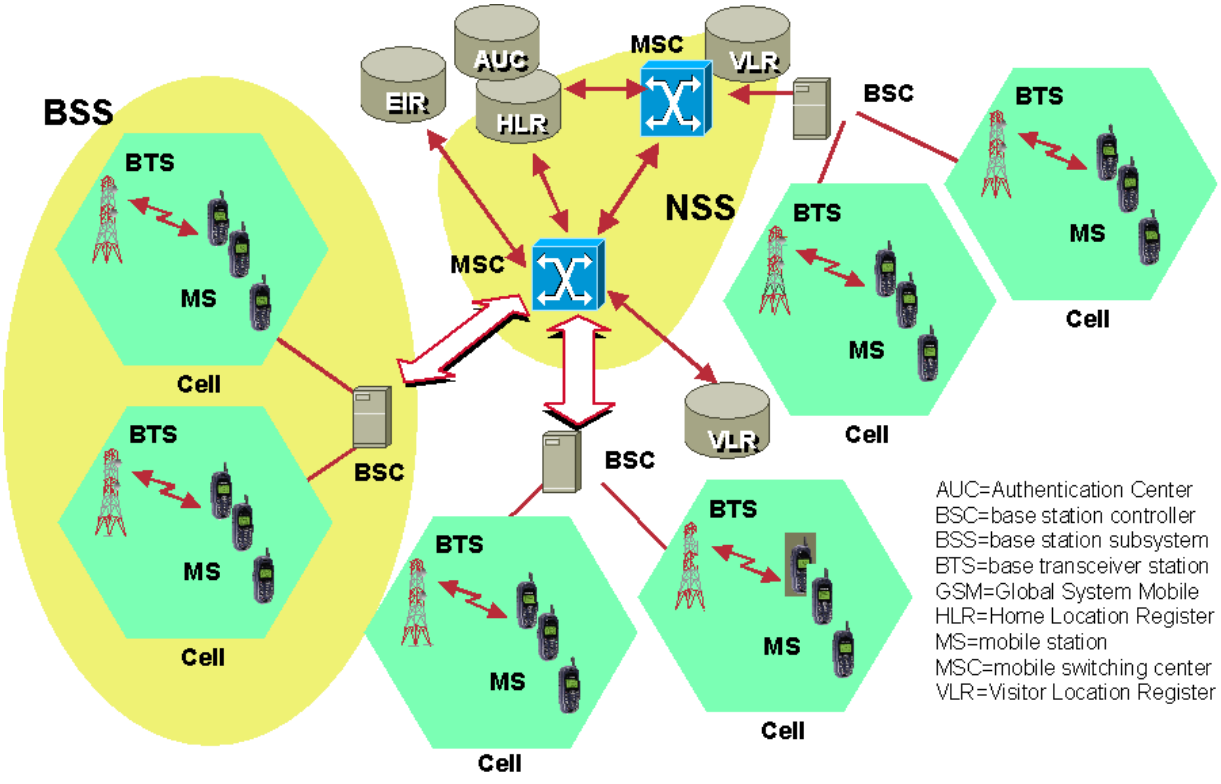
2.1 Cellular system operation



According to the diagram above, it can be understood simply by:

- Mobile device is connected to BTS (Antenna).
- BTS is connected to the Switching system called BSC.
- BSC is connected to the main switching system called MSC.
- MSC contains its own VLR (VLR: is a temporary database which stores the information of the visitors under its coverage area. VLR stands for Visitor Location register. When you roam in a different place VLR stores your user information.).
- MSC's are connected to GMSC which is connected to HLR. (HLR stands for Home location register, it is the main database where the documents or information of user is stored. all the documents that you give during purchase of a SIM card is stored in this HLR.
- VLR Takes your information from HLR when you Roam in other state or region.).

- HLR also provides authentication by AuC. AuC is connected with HLR. If you initiate a call HLR and AuC will see if you are a genuine Mobile user with valid IMEI number and Plan.and then the call is set up from source to the destination device.

Mobile Terminated Call

1: calling a GSM subscriber

2: forwarding call to GMSC

3: signal call setup to HLR

4, 5: request MSRN from VLR

6: forward responsible MSC to GMSC

7: forward call to current MSC

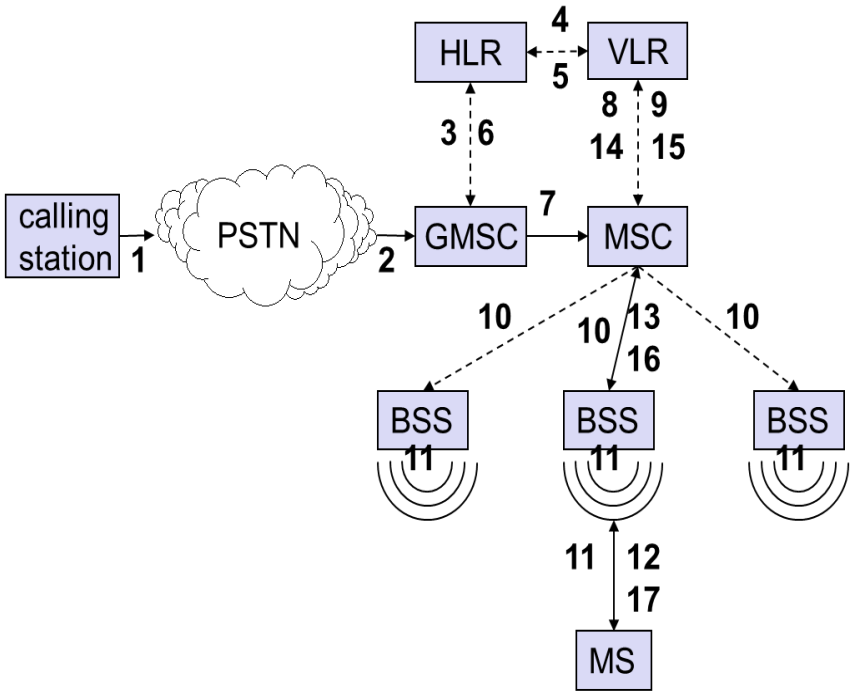
8, 9: get current status of MS

10, 11: paging of MS

12, 13: MS answers

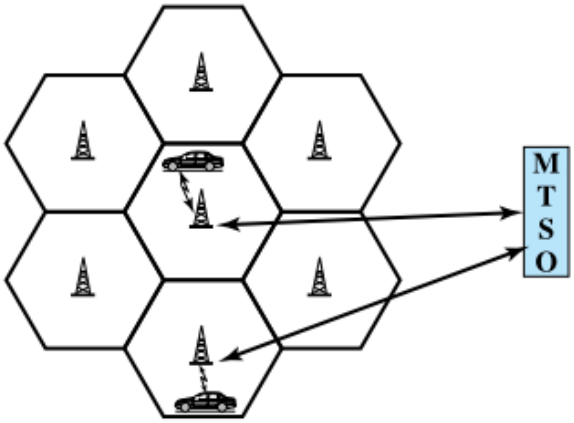
14, 15: security checks

16, 17: set up connection



Other functions performed by the system include the following:

- **Handoff (Handover):** If a mobile unit moves out of range of one cell and into the range of another during a connection, the traffic channel has to change to one assigned to the BS in the new cell. The system makes this change without either interrupting the call or alerting the user.



- **Call blocking:** During the mobile-initiated call stage, if all the traffic channels assigned to the nearest BS are busy, then the mobile unit makes a preconfigured number of repeated attempts. After a certain number of failed tries, a busy tone is returned to the user.
- **Call termination:** When one of the two users hangs up, the MTSO is informed and the traffic channels at the two BSs are released.
- **Call drop:** During a connection, because of interference or weak signal spots in certain areas, if the BS cannot maintain the minimum required signal strength for a certain period of time, the traffic channel to the user is dropped and the MTSO is informed.
- **Calls to/from fixed and remote mobile subscriber:** The MTSO connects to the public switched telephone network (PSTN). Thus, the MTSO can set up a connection between a mobile user in its area and a fixed subscriber via the telephone network.

2.3 RF Planning

RF Planning is the process of assigning frequencies, transmitter locations and parameters of a wireless communications system to provide sufficient coverage and capacity for the services required. The RF plan of a cellular communication system has two objectives: coverage and capacity.

a. Coverage relates to the geographical footprint within the system that has sufficient RF signal strength to provide for a call/data session.
b. Capacity relates to the capability of the system to sustain a given number of subscribers. Capacity and coverage are interrelated.

To improve coverage, capacity has to be sacrificed, while to improve capacity, coverage will have to be sacrificed. **It is necessary to restructure radiotelephone system to achieve high capacity with limited spectrum.**

1- **Increase the capacity of the system**: by using lower-power systems with shorter radius and to use numerous transmitters/receivers (Base stations). Thereby providing additional radio capacity with no additional increase in radio spectrum.

2- **Distributing the available channels throughout geographic region**: by systematically spacing base stations and their channel groups. The available channels can be reused as long as the interference between co-channel stations is kept below acceptable level.

2.4 Cell types

- Macro cell – their coverage is large (aprox. 6 miles in diameter); used in remote areas, high-power transmitters and receivers are used
- Micro cell – their coverage is small (half a mile in diameter) and are used in urban zones; low-powered transmitters and receivers are used to avoid interference with cells in another clusters

- Pico cell –is a small cellular system typically covering a small area, such as in-building (offices, shopping malls, train stations) . In cellular networks, picocells are typically used to extend coverage to indoor areas where outdoor signals do not reach well.

- Selective cells . located at the entrances of tunnels where a coverage of 360 degrees is not needed this case, a selective cell with a coverage of 120 degrees is used**.**

Decreasing the cell size gives:

- ❖ Increased user capacity
- ❖ Increased number of handovers per call
- ❖ Increased complexity in locating the subscriber
- ❖ Lower power consumption in mobile terminal: so it gives longer talk time, safer operation

2.5 Cellular Network Coverage

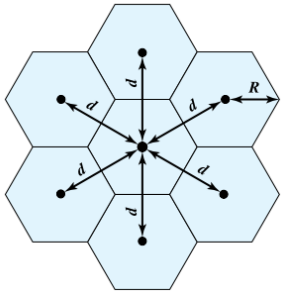
The essence of a cellular network is the use of multiple low-power transmitters, on the order of 100 W or less. Because the range of such a transmitter is small, an area can be divided into cells, each one served by its own antenna.

A- Each cell is allocated a band of frequencies and is served by a base station (consisting of transmitter, receiver, and control unit).

B- Adjacent cells are assigned different frequencies to avoid interference or crosstalk. However, cells sufficiently distant from each other can use the same frequency band.

While it might seem natural to choose a circle to represent the coverage area of a base station, adjacent circles cannot be overlaid upon a map without leaving gaps or creating overlapping regions.

The hexagon has:



- No gaps or overlapping
- The largest area compared with square and triangle.
- Fewest number of cells can cover a geographic region,

- Closely approximates a circular radiation pattern which would occur for an omnidirectional base station antenna and free space propagation.
- A hexagonal pattern provides for equidistant antennas.
- When using hexagons to model coverage areas, base station transmitters are depicted as either:
    - In the center of the cell (center-excited cells): omnidirectional antennas are used in center-excited cells.
    - On three of the six cell vertices (edge-excited cells): sectored directional antennas are used in corner-excited cells.

The radius of a hexagon is defined to be the radius of the circle that circumscribes it (equivalently, the distance from the center to each vertex; also equal to the length of a side of a hexagon).

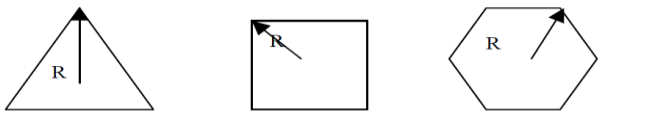
For a cell radius *R*, the distance between the cell center and each adjacent cell center is

$$d = \sqrt{3}R$$

Therefore the area of the hexagon is

$$Area = \frac{3\sqrt{3}}{2}R^2$$

- In practice, a precise hexagonal pattern is not used. Variations from the ideal are due to:
    - Topographical limitations.
    - Local signal propagation conditions.
    - Practical limitation on siting antennas.



$A_{tri} = 1.3R^2$ $A_{sq} = 2.0R^2$ $A_{hex} = 2.6R^2$