UNIT- 3

Introduction

Capacity expansion techniques include the splitting or sectoring of cells and the overlay of smaller cell clusters over larger clusters as demand and technology increases.

The cellular advantage

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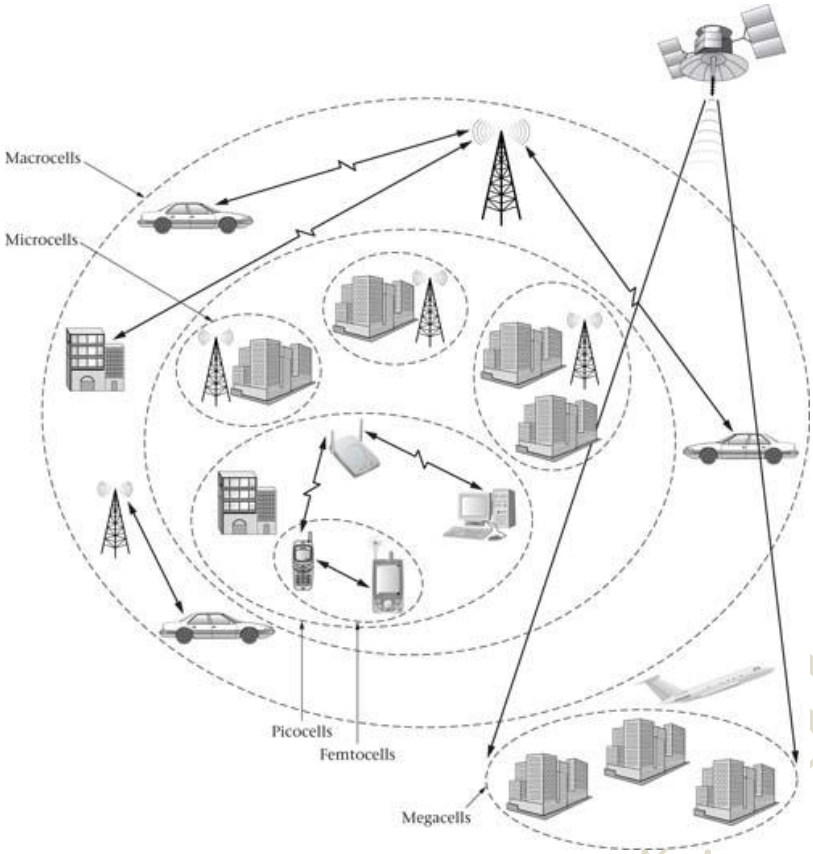
The cellular concept would provide a method by which frequency reuse could be maximized

The cellular concept provides a means of maximizing radio spectrum usage.

Another advantage of cellular radio system is that amount of mobile output power required is not as large as due to the smaller cells used , therefore the power requirements for the mobile are reduced, which allows for longer battery life.

Cellular hierarchy

- Picocells – Cells that are less than 100 meters in diameter
- Microcells – Cells with a a diameter between 100 meter & 1000 meter
- Marocells – Cells greater than 1000 meters in diameter
- Megacells – Cells with global coverage
- Femtocells – Very small cells

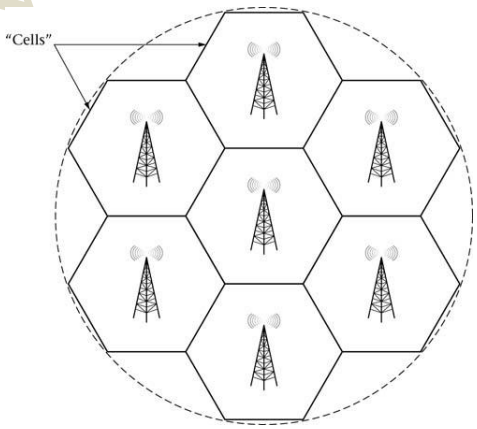


Cell Fundamentals

The use of hexagon allows for the complete theoretical coverage of an area with out any overlapping cells or gaps in the coverage area.

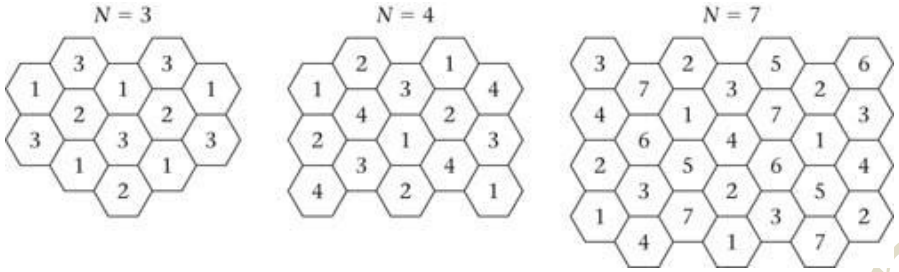
Reuse number

Cells are arranged in clusters, To determine minimum size cluster that can be used



Reuse distance

$$D = R(3N)^{1/2}$$



Cellular interference issues

Signal-to-interference ratio – It gives an indication of the quality of the received signal

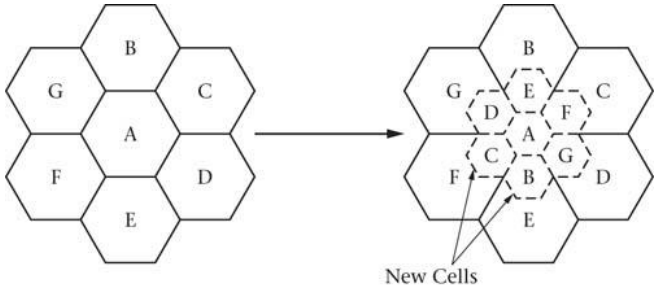
Cluster Size, N	*S/I Ratio*
3	11.3 dB
4	13.8 dB
7	18.7 dB
12	23.3 dB

Capacity Expansion Techniques

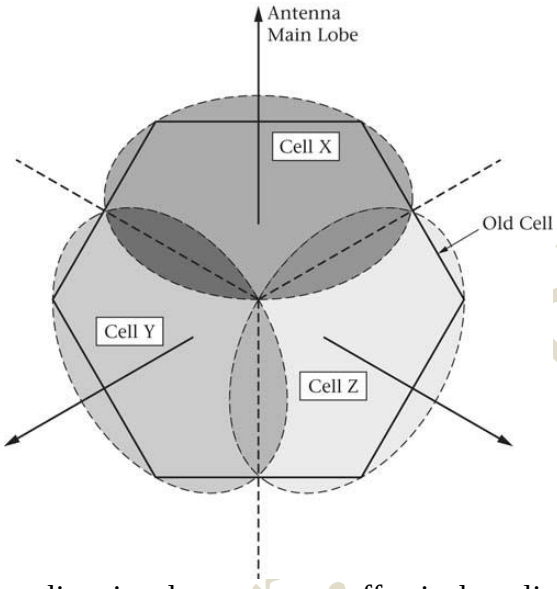
Cell splitting

Concept of splitting – It increases the capacity of the overburden areas.

Assume that cell a has become saturated and is unable to support its traffic load, Using cell splitting six new smaller cells with approximately one quarter of the area of the larger cells are inserted into the system in such a way as to be halfway between 2 cochannel cells. These smaller cells will use the same channels as the corresponding pair of larger cells. In order that the overall system frequency reuse plan be preserved.

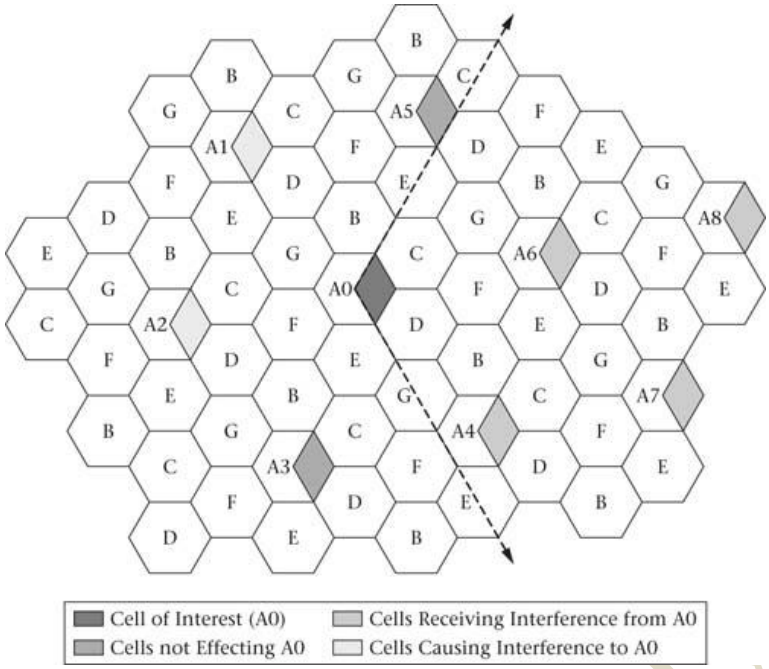


Cell sectoring

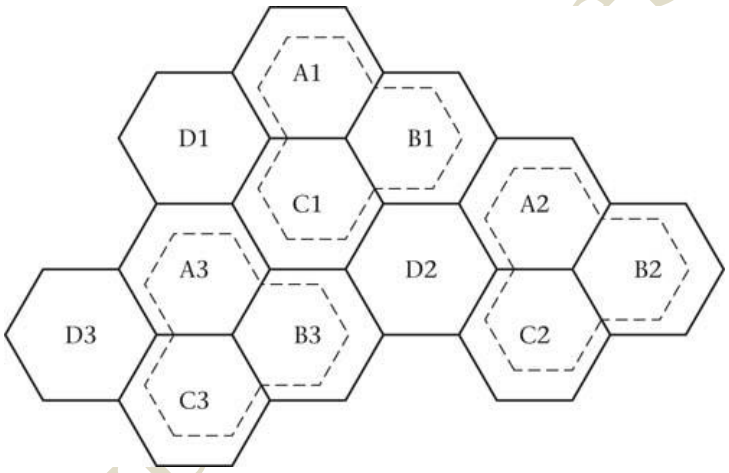


Cell sectoring uses directional antennas to effectively split a cell into three or sometimes 6 new cells, The new cell structure now uses three directional antennas with 120 ^{0} beam widths to illuminate the entire area previously serviced by a single omnidirectional antenna.

Sectoring of a cell results in a direction in the amount of interference that the sector experiences from its co-channel neighbors in adjacent clusters and conversely the amount of interference that the sector supplies to its co-channel neighbors.



Overlaid cells



Using overlaid cell operational wideband analog system could be upgraded to increase its capacity by overlaying another analog system with a narrow bandwidth requirement over it. In such a split band overlay system channels are divided between a larger macro cell and the overlaid micro cell that is contained in its entirely within a macro cell.

Channel allocation

The previously discussed methods relied on changes to cellular system architecture to gain additional system requirements

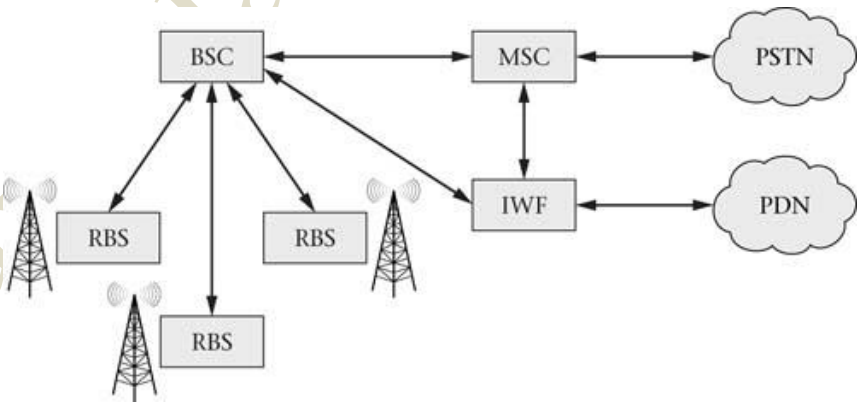
Three main methods

- Fixed channel allocation – Examines the traffic pattern over time and then fine tunes the system by allocating additional channels if needed.
- Channel borrowing – In this method high traffic channels can borrow channels from low traffic cells and keep them as needed
- Dynamic channel allocation- In this method available channels are placed in a channel pool. A channel is assigned to a new cell by S/I statistics.

Other capacity expansion schemes

- Lee's microcell technology
- Smart antenna technology
- Migration to digital technology

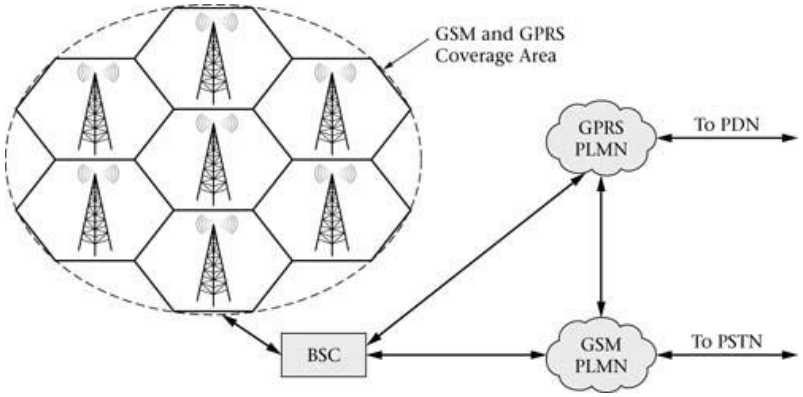
Cellular Backhaul Networks



Introduction

It describes both the infrastructure responsible for the process of carrying voice and data communications traffic from the cell sites to the core network.

PDSN is responsible for protocol conversion and mapping between wireless network to and the external packet network.



GSM cellular systems introduced packet switched data services through general packet radio services (GPRS).

Mobility Management

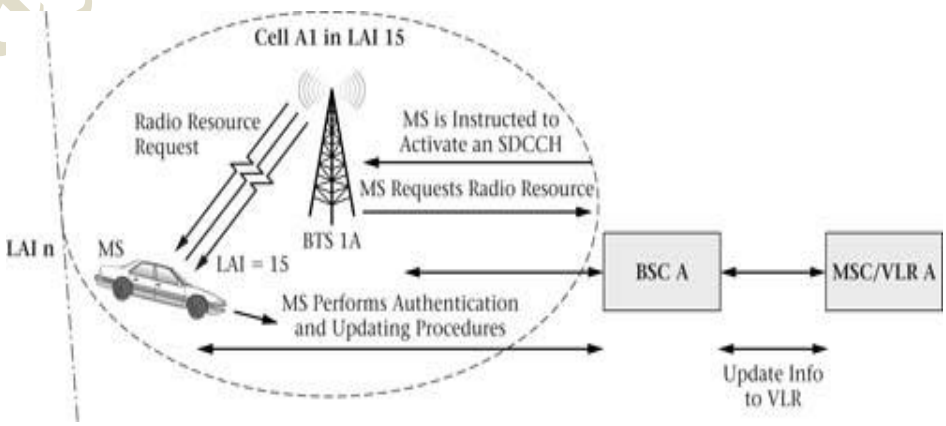
A wireless system does not know where the mobile subscriber is at all times and therefore it must incorporate a means to determine this information and subsequently infuse this data into the system.

Location management

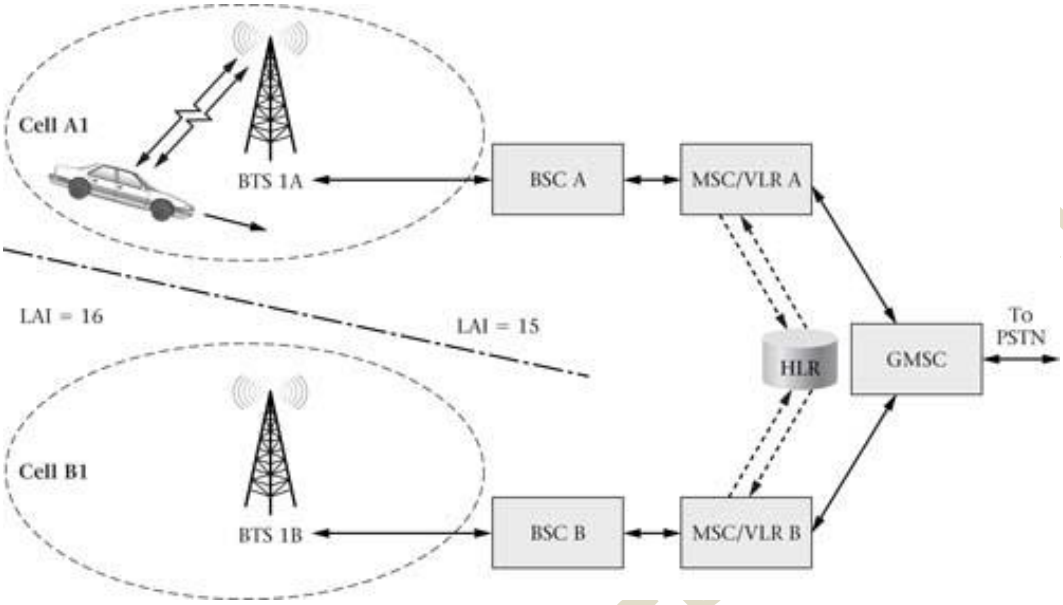
It is the process of keeping track of the present or the last known location of a mobile station and the delivery of both voice and data to it as it moves around.

There are three basic methods performed by location management.

- Location updating – Performed by mobile station. The system is designed such that the mobile station will send an update message everytime it changes its point of access to the fixed network.



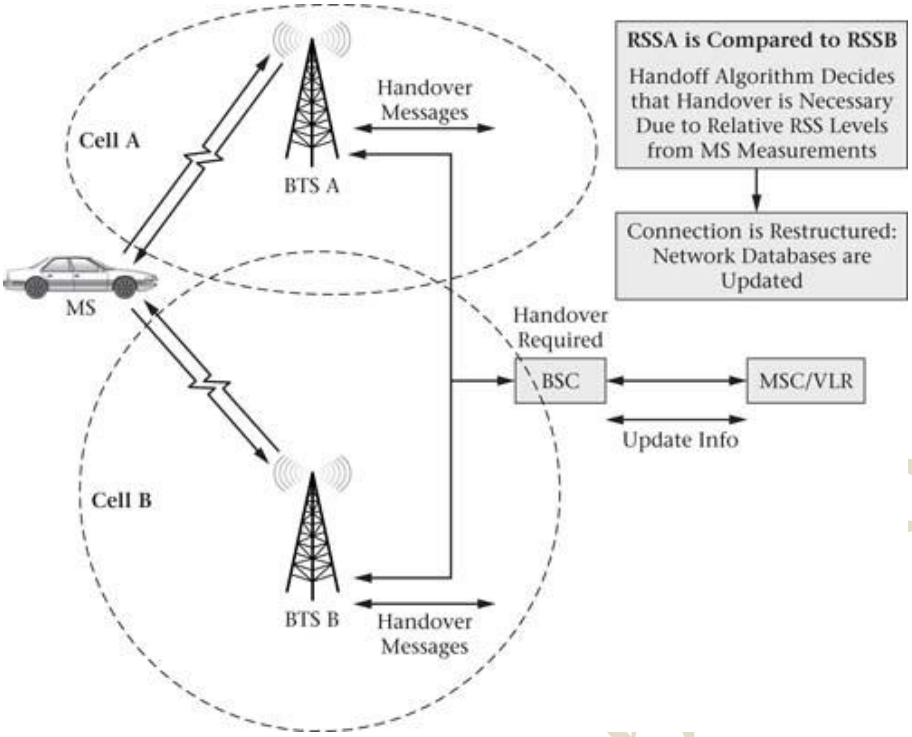
- Paging messages- Paging consists of the broadcasting of a message either to a cell or group of cells that is meant to bring a response from a single particular mobile.

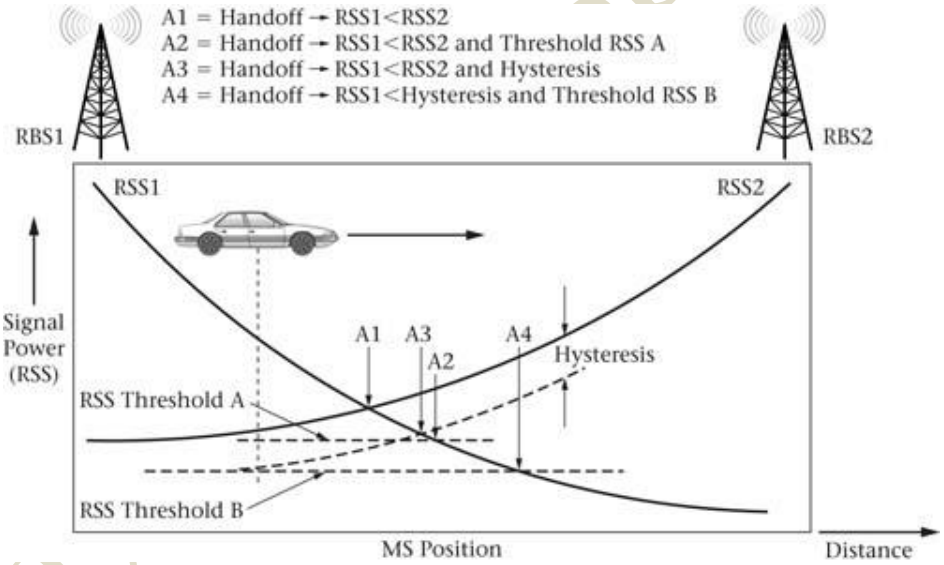


- Transmission of the location information between network elements – For location updating to work correctly there must exist several databases where mobile station information can be accessed by network.

Handoff management

If the subscriber moves from one cell to another cell, the cellular system must have the ability to reconfigure the connection to the mobile from the current B.S to the new B.S in the new cell . This process is called handoff.





Radio Resources and Power Management

- Power control
- Power saving schemes
  - Discontinuous transmission
  - Sleep modes
  - Energy efficient designs
- Radio resource management
  - Need
  - Schemes

Wireless Network Security

The security requirements of wireless network are very similar to the wire-line networks. The need for privacy in the transmission of a voice conversation is necessary.

Answers to Problems and Questions

Chapter 3

Section 3.1

1. The factors that determine frequency reuse distance are: the reuse number, N, and the cell radius. See Equation 4.1.

2. The use of a cellular architecture provides increased system capacity.

3. Cell size is limited by both geographic conditions and the system capacity. Too large of a cell size requires too much signal (transmitter) power and system capacity limitations might not allow a large cell the ability to be able to serve the potentially large number of users.

4. A cell tower located near an interstate highway would most likely provide a form of macrocell service with the potential for using a more focused antenna system pointing down the highway.

Section 3.2

5. The frequency reuse distance for a cell radius of 20 kilometers and a cluster size of 7 is given as follows:

Using equation 4.1:

$$D = R(3N)^{1/2} = 20(3\times 7)^{1/2} = 20(21)^{1/2} = 20(4.583) = 91.99\ km$$

6. The frequency reuse distance for a cell radius of 2 kilometers and a cluster size of 4.

$$D = R(3N)^{1/2} = 2(3\times 4)^{1/2} = 2(12)^{1/2} = 2(3.46) = 6.92\ km$$

7. The following chart shows one possible way to setup the channels in a cellular system with a cluster size of 4 that has 28 channels assigned to the system in such a manner as to maximize channel spacing.

Cell 1	**Cell 2**	**Cell 3**	**Cell 4**
Channe1 1	Channel 2	Channel 3	Channel 4
Channel 5	Channel 6	Channel 7	Channel 8
Channel 9	Channel 10	Channel 11	Channel 12
Channel 13	Channel 14	Channel 15	Channel 16
Channel 17	Channel 18	Channel 19	Channel 20
Channel 21	Channel 22	Channel 23	Channel 24
Channel 25	Channel 26	Channel 27	Channel 28

8. The minimum required cluster size for a particular radio transmission technology that requires a minimum S/I ratio of 15 dB is N=4 as shown in Table 4-1.

Section 3.3

9. Ideally, for a cell splitting scheme there will be an N times (where N is the frequency reuse number) increase in cellular system capacity.

10. Ideally, for a cell splitting scenario, if the cell transmit power is reduced to a sufficiently low enough level, co-channel interference levels will remain constant.

11. Cell splitting creates smaller cells as compared to cell sectoring that divides the cell into sectors. With cell splitting, N new cell sites are created. With cell sectoring, the same cell site is used by all the sectors. With cell splitting, omni-directional antennas are used, while with cell sectoring, directional antennas are used.

12. There are several possible limitations that would impose a practical limit on cell sectoring. Those limitations would be the need for a great number of base transmitter stations (RBSs) at a single location, expensive and elaborate antenna farms on a single tower, and the need for many handoffs for moving mobiles.

Section 3.4

13. The driving force for the adoption of microwave cellular backhaul networks is purely economic in nature.

14. The traditional method used to provide connectivity between the cellular network and the PSTN has been T-1 carrier lines.

15. When the all-IP core network becomes a reality, voice traffic will be carried to the cellular network as VoIP (packets).

Section 3.5

16. Mobility management consists of several basic functions: location management and location updating.

17. The location updating function occurs when the mobile detects a change in the location area ID.

18. The two basic operations that occur during the handoff process are the handoff management determination process that decides that a handoff should occur and the handoff process itself.

Section 3.6

19. Power management is important for cellular wireless systems due to the fact that the mobile is battery powered. The battery lifetime is dictated by the power draw on the battery.

20. Power control used by cellular systems may consist of several operations: One is the control of the output power of the mobile itself. The mobile's output power is adjusted for the

minimum level necessary for proper operation. Furthermore, when not in use, the mobile may automatically go into a sleep mode that will conserve battery power. Also, discontinuous transmission can be used to save battery power.

21. The term "discontinuous transmission" in the context of a wireless cellular system indicates the process by which the mobile only transmits when there is speech activity by the mobile user. This process also saves power.

22. The term "sleep mode" in the context of a wireless cellular system refers to times when the mobile will enter a state during which it only periodically listens for system pages. This type of mobile operation is used to save battery power.

Section 3.7

23. The GSM Association provides a form of security to its members by maintaining a global data base of all handsets that have been approved for use on GSM networks. Furthermore, lost or stolen handsets are "blacklisted" by the data base.

24. The basic form of security employed by cellular wireless systems is through the use of some form of encryption.

25. Secret-key encryption is a process by which both the sending and the receiving wireless devices share a secret key. This key is used for both the encryption and decryption of the transmitted data.