Introduction to Mobile Communication

Contents:

- History of Mobile Communication
- Advantages and Its Limitations
- Principles of Cellular MC

History of mobile communications

- Before 1946, half-duplex push-to-talk telephone system with 120 KHz RF bandwidth (per channel) was used
- In 1946, first public mobile telephone was introduced in 25 major American cities (a single high power Tx is used to cover 50 km)
- In 1950, FCC (Federal Communication Commission) double the number of channels per area with channel BW 60 KHz
- By the mid 1960 FM BW of voice transmission was cut to 30 KHz
- By 1976, the Bell Mobile phone service for NY city market (10,000,000 people) had only 12 channels and could serve 543 customers
- There was a waiting list of 3,700 people
- Service was poor due to call blocking and usage over the few channels

- During 1950 to 1960, AT&T Bell Laboratories and other telephone companies developed the theory and techniques of cellular radiotelephony
- The idea is a subscriber will carry a small-sized Tx-Rx with an assigned RF channel through which PSTN subscriber can call mobile subscriber and vice-versa
- In 1973 17th October, Dr. Martin Cooper patent to Motorola for radio telephone system. Today this cell phone is the enlarge version of this technology and he is the father of cell phone.
- In 1st May of 1974 FCC took a step to establish spectrum of 115 MHz wavelengths (2300 channels used for cellular phone service)

Following table can give clear conception on cellular Ph. Initialization:

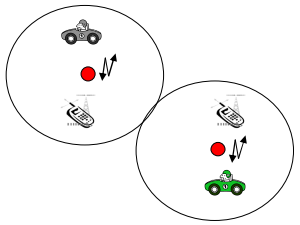
Year	Events
May 1978	First cellular phone was marketed in Bahrain
July 1978	Advanced Mobile Phone System (AMPS) start in NA by AT&T and Bell system joint venture
December, 1979	Started in Tokyo, Japan and within 5 years whole country
1983	Aurora 400 system introduced instead of AMPS . Next NMT (Nordic Mobile Telephone) tech. was introduced
Later	TACS (Total Access Comm. Sys.) C-Netz, Radicom-2000, RTMI, RTMS technologies were used for mobile comm. Now more sophisticated technology is used throughout the whole world.

Why cellular Communication

Limitation of conventional mobile system:

- Limited service capability
- Poor service performance
- Inefficient frequency spectrum utilization

Conventional mobile system



Principle of cellular system

Cellular systems have following principles:

- Frequency to provide a number of communication channels much greater than the number of frequency allocated to the system
- Automatic intercellular transfer to ensure continuity of communication
- Automatic location to mobiles within the network
- Continuous monitoring of communication from the mobile to verify quality and identity to need for cell change
- The functions required for all telecommunication network, operation, maintenance, invoicing etc.

Advantages of cellular mobile system

- Handling:System involving in operating cellular sets are very simple
- Portability: Very light and proper shape
- Economy:Cellular system becoming economic day by day due to the competition between various cellular vendors
- Reliability: As it is totally computer based system so it is more reliable
- Security: Since the system being radio based, it remains equally vulnerable like any other radio equipment
- Flexibility: It is integrated with public telephone network. So subscriber can talk a long distance from their apartment.
- Range:This system is having the scope of increasing the number of cell site within a particular area.
- Memory access: A number of phone numbers can be stored
- Application in rural area: In respect to BD where T & T can not make service, mobile communication can easily make communication

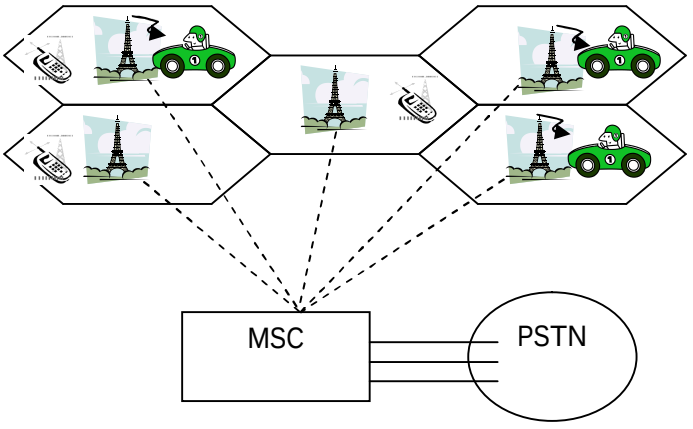
Disadvantages of mobile communication

- Radiation from antenna: Electromagnetic radiation from base station is harmful for human body
- Recharging:This is a disturbing job for the subscriber
- Traffic congestion: The allotment of channel is limited than the number of subscriber
- Limited range: AMPS system 25 km maximum. GSM system 10-15 km
- Lack of cell cites:The establishment of cell sites is limited

Basic components of cellular system

A basic cellular system consists of three parts:

- A mobile unit (mobile station)
- A cell cite (base station)
- A mobile switching center (MSC) or MTSO



Functions of cellular basic components

- Mobile unit: Contains a transceiver, an antenna, and control circuitry
- Base station: Consists of several Txs and Rxs and generally
- have towers having several transmitting and receiving antennas. It serves as a bridge between mobile users in the cell and

connects mobile calls via telephone lines or microwave links to the MSCMSC: Coordinates the activities of all of the base stations and connects entire cellular system to the PSTN. A typical MSC handle 1,00,000 cellular subscribers and 5,000 simultaneous conversation at a time and accommodates all billings and system maintenance functions, as well

Mobile communication channels

Communication between base station and mobile unit is established by four different channels

- Voice transmission channels:
  - Forward voice channels (voice transmission from base station to mobile)
  - Reverse voice channels (voice transmission from mobile to base station)
- Channels responsible for initiating mobile calls
  - Forward control channels
  - Reverse control channels

Setting up a call and moving it to unused voice channels. Call initiation and service requests. Channel changes and handoff instructions

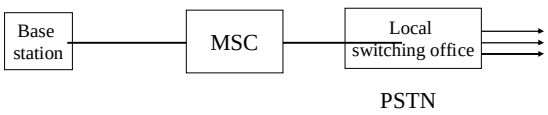
95% channels: voice and data

5% channels: for controls

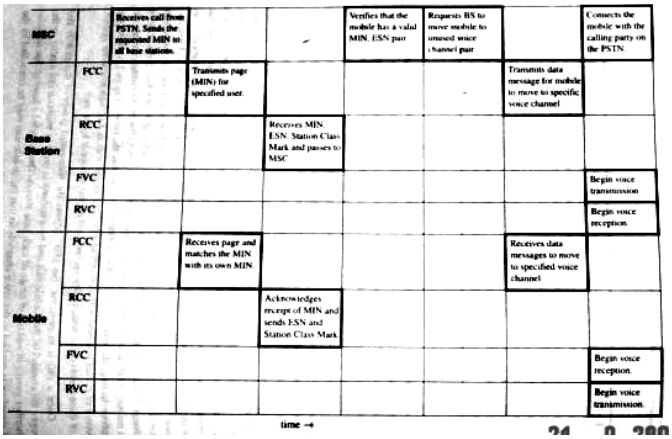
Type of calls provided by cellular phones

Mobile to mobile call

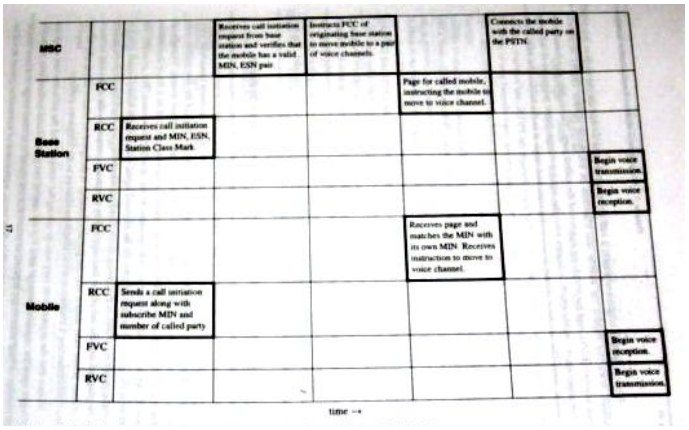
Mobile to fixed phone call



Schematic of call from a mobile user to a fixed subscriber



Schematic of call from a fixed subscriber to a mobile user



Mobile Systems and Standards

Contents:

- Standard mobile systems
- Why GSM system?
- GSM system architecture
- Function of GSM elements

Some mobile systems

- Advanced Mobile Phone System (AMPS)
- European Total Access Communication System
- United State Digital Cellular (USDC)

Parameter	AMPS specification	ETCS specification	USDC
Multiple access	FDMA	FDMA	TDMA
Duplixing	FDD	FDD	FDD
Channel bandwidth	30 kHz	25 kHz	30 KHz
Reverse channel freq.	824-849 MHz	890-915 MHz	824-849 MHz
Forward Channel freq.	869-894 MHz	935-960 MHz	869-849 MHz
Voice modulation	FM	FM	$\pi/4$ DPSK
Data rate	10 kpbs	8kpbs	48.6 kpbs
Spectral efficiency	0.33 bps/Hz	0.33 bps/Hz	1.62 bps/Hz
No. of channels	832	1000	3 user /channel

Why universal cellular systems are required?

Different cellular systems were undesirable due to following reasons:

- The equipment was limited to operate only within the boundaries of each country
- The market for each mobile equipments was limited

To overcome these problems the conference of European Posts and Telecommunications (CEPT) formed, in 1982, the group special mobile (GSM) for developing a pan-European mobile cellular radio system. The GSM later acronym Global System for Mobile communication

Standard mobile system

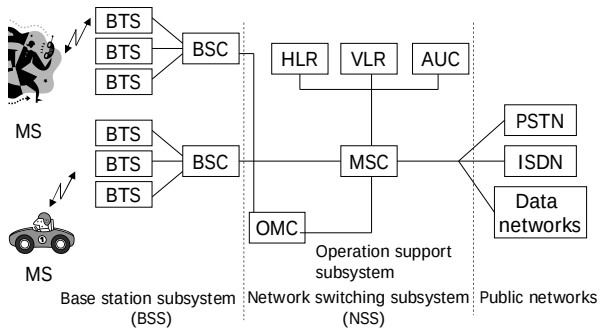
Standard mobile system should have the following criteria:

- Spectrum efficiency
- International roaming
- Low mobile and base station costs
- Good subjective voice quality
- Compatibility with other system such as ISDN
- Ability to support new services

Development stages of GSM

Year	Important events in the development of GSM
1982	A GSM group is established to develop the standards for a pan-European cellular mobile system
1985	Adoption of a list of recommendation to be gathered by the group
1986	Field tests were performed on different radio techniques for air interface
1987	TDMA is chosen as access method
1988	Validation of the GSM system
1989	The responsibility of the GSM specification is passed to the ETSI
1990	Appearance of the phas-1 of the GSM specifications
1991	Commercial launch of the GSM service
1993	GSM services starts outside Europe
1995	Phase-2 of the GSM specifications coverage of rural areas

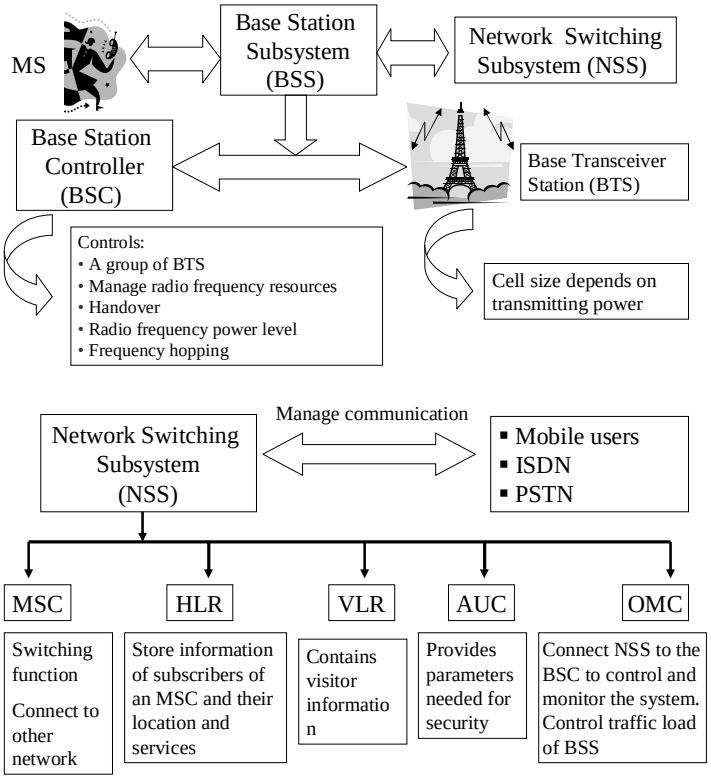
GSM system architecture



GSM system architecture

- Mobile Station (MS) consists of
  - Mobile equipment or terminal
    - Fixed terminals (~ 20 W)
    - GSM portable terminals (~ 8 W)
    - Handheld terminals (~ 2 W, 0.8 W)
- Subscriber Identity Module (SIM)
  - The SIM is a smart card that identifies the terminal. It is protected by a four digit PIN. To identify the subscriber to the system it contains some parameters of the users such as International Mobile Subscriber Identity (IMSI). The user can have access to its subscribed services in any terminal using SIM card

GSM system architecture



The GSM functions

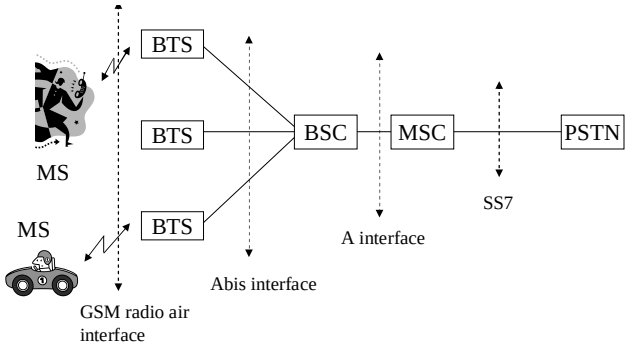
GSM functions are as follows:

- Transmission
- Mobility management
- Radio resources management
- Communication management
- Operation, administration and maintenance

The GSM functions

- Transmission
  - User information
  - Signaling information
- Radio resources management
  - Establish, maintain and release communication links between MS and MSC
- Mobility management
  - Location management, authentication and security
- Communication management
  - Call control
  - Supplementary services management
  - Short message services management
- Operation, Administration and maintenance
  - To monitor and control the system as well as to modify the configuration of the elements of the system

Various GSM interfaces



GSM radio interface

Interface between MS and fixed infrastructure

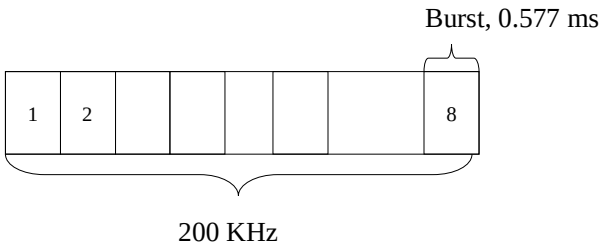
- Frequency allocation

- Uplink direction, MS-BTS (890-915 MHz)
- Downlink direction, BTS-MS (935-960 MHz)

- Multiple access
  - Mix of FDMA and TDMA

25 MHz divided by 124 channels each of 200 KHz frequency band

TDMA frame



A TDMA frame consists of 8 burst, 4.615 ms
Each of the 8 bursts is then assigned to a single user

Channel structure

In GSM there are two type of channels:

- Traffic channel (speech and data) 26 TDMA frame
  - 24 frame (traffic)
  - 1 for slow associated control channel
  - Last frame is unused
- Control channel (network management and maintenance)
  - Broadcast channel
  - Common control channel
  - Dedicated control channels
  - Associated control channels

Frequency hopping and modulation

- Frequencu hopping
  - To improve quality of channel frequency hopping is introduce in GSM system. Frequency hopping changes the frequency of every TDMA frame. It reduces co-channel interference
- Modulation
  - Gaussian minimum shift keying (GMSK) is a FM modulation
  - Binary 1 and 0 is modulated by shifting +-67.708 KHz

GSM is a very complex standard. It can be considered as a first serious attempts to fulfill the requirements for a universal mobile communication system

The Cellular Concepts-System Design Fundamentals

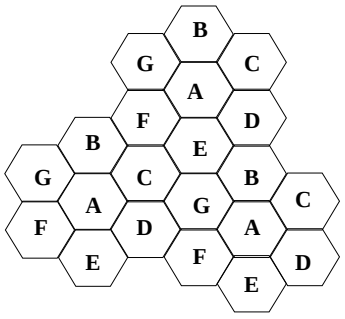
Contents:

- ❖ Concept of frequency reuse
- ❖ Channel assignment strategies
- ❖ Handoff technique

Definition of cell and frequency reuse

- ➢ Cell:
  Each cellular base station is allocated a group of radio channels to be used within a small geographical area called a cell
- ➢ Frequency reuse or frequency planning:
  The design process of selecting and allocating channel groups for all of the cellular base station within a system is called frequency reuse or frequency planning

Frequency reuse concepts



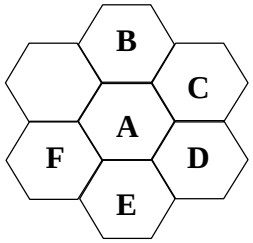
Frequency reuse capacity

S: Total no of channels available for use
K: A group of channels allocated for each cell
N: No. of cells in which S channels are divided

Total no. of available radio channels, S = KN

The N cells which collectively use the complete set of available frequencies is called a cluster. If a cluster is replicated M times within the system, the total no. of duplex channels C can be used as a measure of capacity and is given by
C = MKN = MS

A cluster ⇨



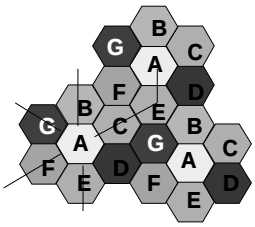
Method of location co-channel cell in a cellular system

The number of cell per cluster: $N = i^2 + ij + j^2$

To find the nearest co-channel neighbors of a particular cell, one must do the following:

1) Move *i* cells along any chain of hexagons and then
2) Turn 600 counter clockwise and move *j* cells

For i = 2, j = 2, Number of cell in a cluster, N = 7

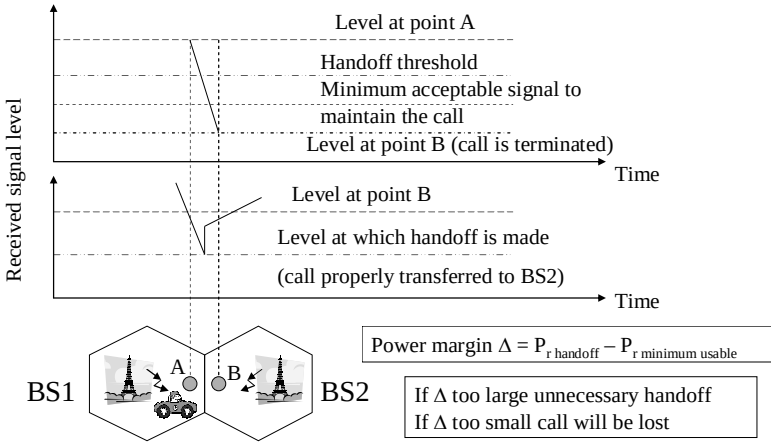


Channel assignment strategies

Channel assignment strategies:

- ❖ Fixed channel strategies:
  - unused channels are used
  - ▪ Problems
    - Call is blocked if there is no unused available channels
  - ▪ Solution
    - Channel borrowing strategies (from neighboring cell)
- ❖ Dynamic channel strategies:
  - ▪ Channels available under an MSC are used
  - ▪ The reuse distance of the channels is maintained

Handoff Scenario at cell boundary



Umbrella cell approach