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WMT Repeated Questions with Solution

Note:

1. **Below mentioned questions are frequently asked question from university Question papers.**
2. **All of you are requested to refer complete syllabus for the exam, these questions are not sufficient for passing the external university exams.**
3. **Please refer reference books for complete syllabus.**
4. **Numerical problems are not included in this document**
5. **Questions may be asked beyond this document.**

Unit: 1

1. **Explain the impairments that affect the wireless communications.**
   OR
   Describe different types of noise that will affect the wireless signal.(Write only Noise Part)
   OR
   What is Free Space Loss? (Write only free space loss part)

Ans: Transmission Impairments refers to a condition that causes information to be lost in a signal. Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment.

This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received.

Various causes of impairment are Attenuation, Attenuation distortion, Free space loss, Atmospheric absorption, Multipath, Refraction and Noise.

Attenuation

The strength of a signal falls off with distance over any transmission medium. For guided media, this reduction in strength, or attenuation, is generally exponential and thus is typically expressed as a constant number of decibels per unit distance. For unguided media, attenuation is a more complex function of distance and the makeup of the atmosphere. Attenuation introduces three factors for the transmission engineer.

1. A received signal must have sufficient strength so that the electronic circuitry in the receiver can detect and interpret the signal.
2. The signal must maintain a level sufficiently higher than noise to be received without error.
3. Attenuation is greater at higher frequencies, causing distortion.

- Attenuation involves signals that loose power in time.
  - Strength of signal falls off with distance over transmission medium
  - Attenuation factors for unguided media
    - Suppose a signal travels through a transmission medium and its power is reduced to one-half.
      This means that P2 is (1/2) P1.

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In this case, the attenuation (loss of power) can be calculated as
A loss of 3 dB (–3 dB) is equivalent to losing one-half the power.

- Received signal must have sufficient strength so that circuitry in the receiver can interpret the signal

Free space loss

Free Space Loss (FSL) is the transmission loss between two isotropic antennas, separated by a distance D, assumed to be in a vaccum. FSL is the propagation loss solely due to spreading of the wave front and assumes no blockage of line of sight.

An antenna with a fixed area will receive less signal power the farther it is from the transmitting antenna. For satellite communication, this is the primary mode of signal loss. Even if no other sources of attenuation or impairment are assumed, a transmitted signal attenuates over distance because the signal is being spread over a larger and larger area. This form of attenuation is known as free space loss, which can be express in terms of the ratio of the radiated power "Pt to the power p, received by the antenna or, in decibels, by taking 10 times the log of that ratio. For the ideal isotropic antenna, free space loss is

$$\frac{P_t}{P_r} = \frac{(4\pi d)^2}{\lambda^2} = \frac{(4\pi f d)^2}{c^2}$$

Free-space path loss is proportional to the square of the distance between the transmitter and receiver, and also proportional to the square of the frequency of the radio signal.

where d and λ are in the same units (e.g., meters)

- P_t = signal power at transmitting antenna
- P_r = signal power at receiving antenna
- λ = carrier wavelength
- d = propagation distance between antennas
- c = speed of light (3×10^8 m/s)

For other antennas, we must take into account the gain of the antenna, which yields the following free space loss equation:

$$\frac{P_t}{P_r} = \frac{(4\pi)^2 (d)^2}{G_r G_t \lambda^2} = \frac{(\lambda d)^2}{A_r A_t} = \frac{(cd)^2}{f^2 A_r A_t}$$

where

- G_t = gain of transmitting antenna
- G_r = gain of receiving antenna
- A_t = effective area of transmitting antenna
- A_r = effective area of receiving antenna

$$= 20\log\left(\frac{4\pi f d}{c}\right) = 20\log(f) + 20\log(d) - 147.56 \text{ dB}$$

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Noise

- For any data transmission event, the received signal will consist of the transmitted signal, modified by the various distortions imposed by the transmission system, plus additional unwanted signals that are inserted somewhere between transmission and reception. These unwanted signals are referred to as noise. Noise is the major limiting factor in communications system performance. Noise may be divided into four categories:

- ✓ *Thermal noise*
  Thermal noise is due to thermal agitation of electrons. It is present in all electronic devices and transmission media and is a function of temperature. Thermal noise is uniformly distributed across the frequency spectrum and hence is often referred to as white noise. Thermal noise cannot be eliminated and therefore places an upper bound on communications system performance. Because of the weakness of the signal received by satellite earth stations, thermal noise is particularly significant for satellite communication.
- ✓ *Intermodulation noise*
  When signals at different frequencies share the same transmission medium, the result may be intermodulation noise. Intermodulation noise produces signals at a frequency that is the sum or difference of the two original frequencies or multiples of those frequencies. For example, the mixing of signals at frequencies fl and h might produce energy at the frequency $f_1 + f_2$. This derived signal could interfere with an intended signal at the frequency $f_1 + f_2$.
- ✓ *Crosstalk*
  Crosstalk has been experienced by anyone who, while using the telephone, has been able to hear another conversation; it is an unwanted coupling between signal paths. It can occur by electrical coupling between nearby twisted pairs or, rarely, coax cable lines carrying multiple signals.
- ✓ *Impulse noise*
  All of the types of noise discussed so far have reasonably predictable and relatively constant magnitudes. Thus it is possible to engineer a transmission system to cope with them. Impulse noise, however, is noncontinuous, consisting of irregular pulses or noise spikes of short duration and of relatively high amplitude. It is generated from a variety of causes, including external electromagnetic disturbances, such as lightning, and faults and flaws in the communications system

Diffraction

Diffraction occurs at the edge of an impenetrable body that is large compared to the wavelength of the radio wave. When a radio wave encounters such an edge, waves propagate in different directions with the edge as the source. Thus, signals can be received even when there is no unobstructed LOS from the transmitter.

Scattering

If the size of an obstacle is on the order of the wavelength of the signal or less, scattering occurs. An incoming signal is scattered into several weaker outgoing signals. At typical

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cellular microwave frequencies, there are numerous objects, such as lamp posts and traffic signs that can cause scattering.

Atmospheric Absorption

An additional loss between the transmitting and receiving antennas is atmospheric absorption. Water vapor and oxygen contribute most to attenuation. Peak attenuation occurs in the vicinity of 22 GHz due to water vapor. At frequencies below 15 GHz, the attenuation is less. The presence of oxygen results in an absorption peak in the vicinity of 60 GHz but contributes less at frequencies below 30 GHz. Rain and fog (suspended water droplets) cause scattering of radio waves that results in attenuation. This can be a major cause of signal loss. Thus, in areas of significant precipitation, either path lengths have to be kept short or lower-frequency bands should be used.

Multipath

For wireless facilities where there is a relatively free choice of where antennas are to be located, they can be placed so that if there are no nearby interfering obstacles, there is a direct line-of-sight path from transmitter to receiver. This is generally the case for many satellite facilities and for point-to-point microwave.In other cases, such as mobile telephony, there are obstacles in abundance. The signal can be reflected by such obstacles so that multiple copies of the signal with varying delays can be received. Obstacles reflect signals so that multiple copies with varying delays are received

Refraction

Refraction Radio waves are refracted (or bent) when they propagate through the atmosphere. The refraction is caused by changes in the speed of the signal with altitude or by other spatial changes in the atmospheric conditions. Normally, the speed of the signal increases with altitude, causing radio waves to bend downward. However, on occasion, weather conditions may lead to variations in speed with height that differ significantly from the typical variations. This may result in a situation in which only a fraction or no part of the line-of-sight wave reaches the receiving antenna.

2. How spreading of the spectrum in advantageous in wireless transmission? Explain the technique of frequency hopping?

OR

How is spread spectrum technique useful in Wireless Communication? Explain in detail FHSS and DSSS.

OR

Explain how spread spectrum technology is used for spreading and transmiting data in multiplexed wireless network. what are the advantages of using spread spectrum technology?

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Ans: Spread spectrum is a form of wireless communications in which the frequency of the transmitted signal is deliberately varied. This results in a much greater bandwidth than the signal would have if its frequency were not varied.The essential idea is to spread the signal over a wider bandwidth.

All technical modulation and demodulation strive for greater power and efficiency of bandwidth in aadditive stationary noise channel. Since bandwidth is a limited resource, one of the primary design goals of all the modulation schemes is to minimize the bandwidth required for transmission.

Spread-spectrum techniques are methods by which a signal generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth.

- These techniques are used for a variety of reasons, including the establishment of secure communications, increasing resistance to natural interference, noise and jamming, to prevent detection, and to limit power density.
- Immunity from multipath distortion
- Can be used for hiding and encrypting signals
- Several users can independently use the same higher bandwidth with very little interference

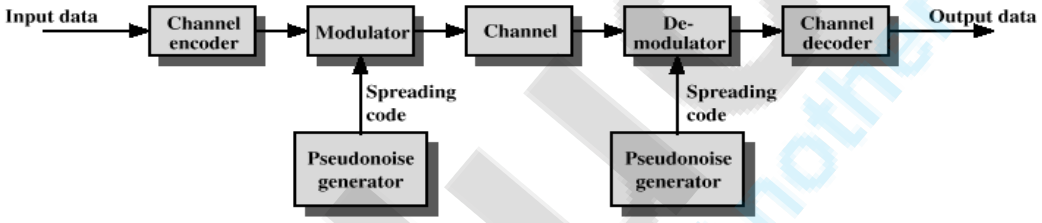

Figure 7.1 General Model of Spread Spectrum Digital Communication System

- Input is fed into a channel encoder
  - Produces analog signal with narrow bandwidth
- Signal is further modulated using sequence of digits
  - Spreading code or spreading sequence
  - Generated by pseudo noise, or pseudo-random number generator

Effect of modulation is to increase bandwidth of signal to be transmitted

Following are the two types of spread spectrum techniques −

- Direct Sequence and
- Frequency Hopping.

1. Direct Sequence Spread Spectrum(DSSS)-

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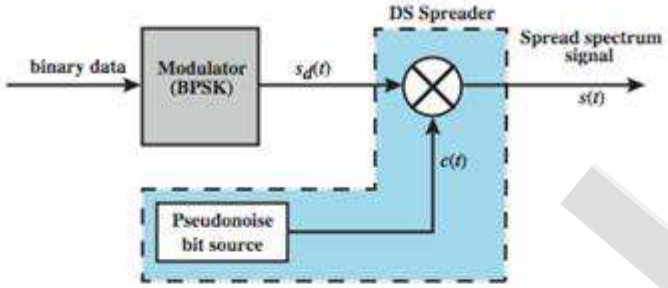
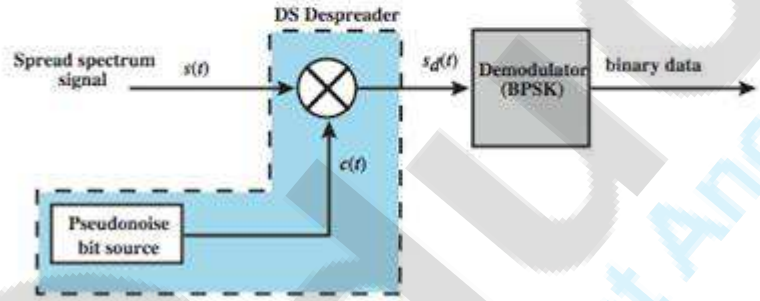
In direct sequence spread spectrum, the stream of information to be transmitted is divided into small pieces, each of which is allocated across to a frequency channel across the spectrum. A data signal at the point of transmission is combined with a higher data-rate bit sequence (also known as a *chipping code*) that divides the data according to a spreading ratio. The redundant chipping code helps the signal resist interference and also enables the original data to be recovered if data bits are damaged during transmission.

DSSS - Transmitter and Receiver



(a) Transmitter



(b) Receiver

- BPSK modulation on the data stream
- signal further modulated by the chipping sequence
- receiver using the same chipping sequence to demodulate signal

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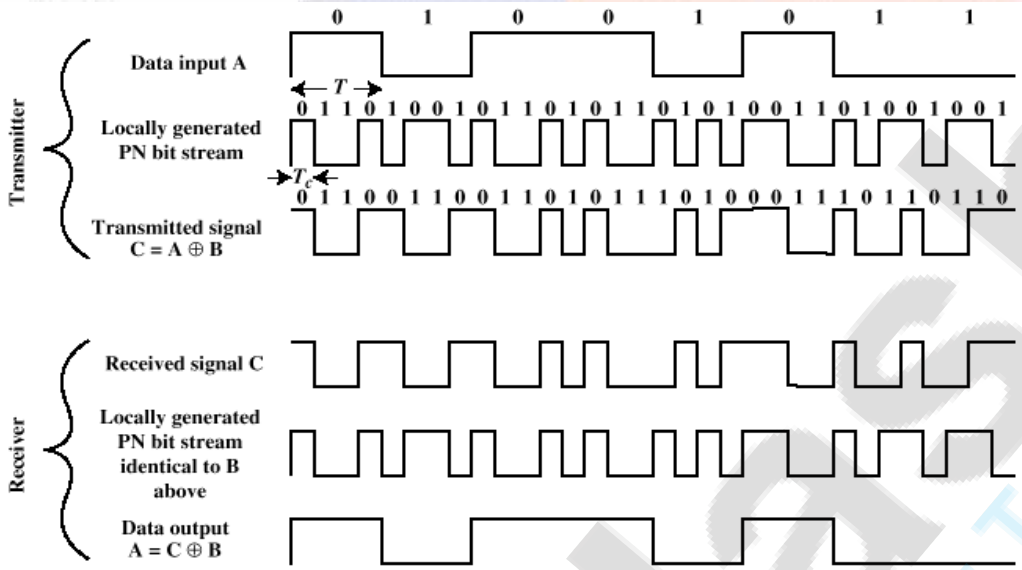

Figure 7.6 Example of Direct Sequence Spread Spectrum

2. Frequency Hopping Spread Spectrum(FHSS)

Signal is broadcast over random series of radio frequencies.A number of channels are allocated for the FH signal.Width of each channel corresponds to bandwidth of input signal

Signal hops from frequency to frequency at fixed intervals.Transmitter operates in one channel at a time.Bits are transmitted using some encoding scheme.At each successive interval, a new carrier frequency is selected.

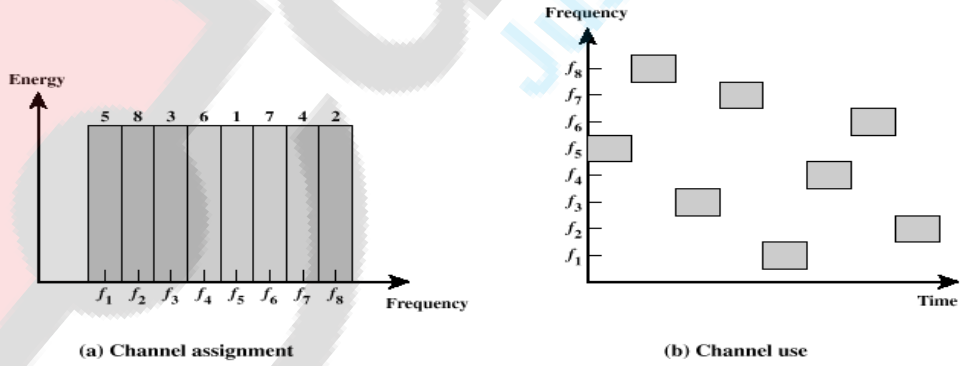

Figure 7.2 Frequency Hopping Example

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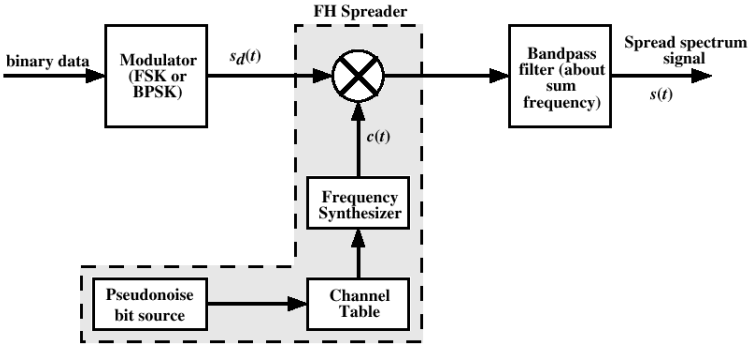
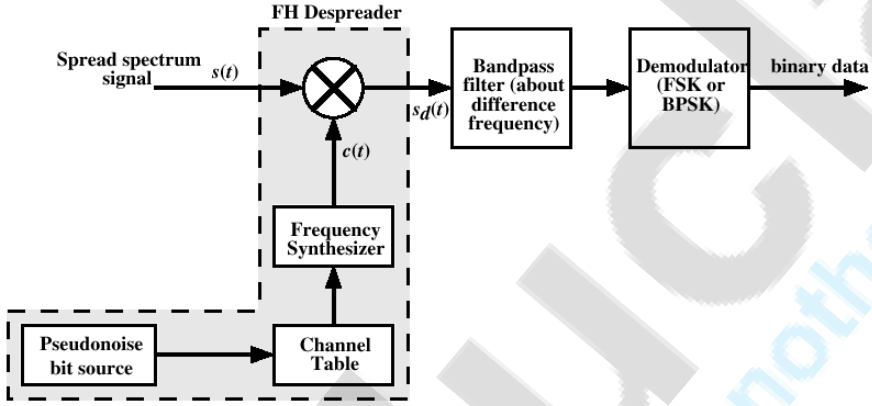


(a) Transmitter



(b) Receiver

Frequency hopping systems can be divided into fast-hop or slow-hop. A fast-hop FH system is the kind in which hopping rate is greater than the message bit rate and in the slow-hop system the hopping rate is smaller than the message bit rate.

Advantages of Spread Spectrum (SS) Techniques

a) Reduced interference: In SS systems, interference from undesired sources is considerably reduced due to the processing gain of the system.

b) Low susceptibility to multi-path fading: Because of its inherent frequency diversity properties, a spread spectrum system offers resistance to degradation in signal quality due to multi-path fading. This is particularly beneficial for designing mobile communication systems.

c) Co-existence of multiple systems: With proper design of pseudo-random sequences, multiple spread spectrum systems can co-exist.

d) Immunity to jamming: An important feature of spread spectrum is its ability to withstand strong interference, sometimes generated by an enemy to block the communication link. This is

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one reason for extensive use of the concepts of spectrum spreading in military communications.

Disadvantages of Spread Spectrum (SS) Techniques

a) Relatively high complexity of the coding mechanism is used in spread spectrum, which results in complex radio hardware designs and higher cost.
b) Bandwidth inefficiency.

3. Explain the importance of antenna in wireless communication. Discuss the different types of antenna.
Explain briefly antenna with example. Or Explain different types of Antenna.
Explain term Antenna Gain. Refer Slides..

Ans: Three functions of antennas

1. Acts as transmitter which radiates em signals in all directions.
2. Acts as receiver which collects em signals.
3. At transmitter's end, it converts electrical signals to electromagnetic waves & at receiver's end, it convert electromagnetic waves to radio frequency electrical signals.

Types of antennas

Omni-directional

1. Isotropic antenna

Directional

2. Half wave dipole antenna
3. Quarter wave dipole antenna
4. Parabolic antenna

4. What is fading? Explain the different types of fading.
OR
Explain the term fading in mobile environment. What are the different forms of fading?

Ans: In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. The fading may vary with time, geographical position or radio frequency, and is often modeled as a random process. A fading channel is a communication channel that experiences fading. In wireless systems, fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading.
Fading refers to the fluctuations in signal strength when received at the receiver and it is classified into two types as fast fading and slow fading. The multipath ropagation of the transmitted signal, which causes fast fading, is because of the three pr
opagation mechanisms described as reflection, diffraction and scattering.
The multiple signal paths may sometimes add constructively or sometimes destructively at the receiver, causing a variation in the power level of the received signal. The received signal envelope of a fast fading signal is said to follow a Rayleigh distribution if there is no line of

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sight between the transmitter and the receiver and a Ricean distribution if one such path is available.

The terms *slow* and *fast* fading refer to the rate at which the magnitude and phase change imposed by the channel on the signal changes. The coherence time is a measure of the minimum time required for the magnitude change or phase change of the channel to become uncorrelated from its previous value.

- **Slow fading** arises when the coherence time of the channel is large relative to the delay constraint of the channel. In this regime, the amplitude and phase change imposed by the channel can be considered roughly constant over the period of use. Slow fading can be caused by events such as shadowing, where a large obstruction such as a hill or large building obscures the main signal path between the transmitter and the receiver. The received power change caused by shadowing is often modeled using a log-normal distribution with a standard deviation according to the log-distance path loss model.

- **Fast fading** occurs when the coherence time of the channel is small relative to the delay constraint of the channel. In this case, the amplitude and phase change imposed by the channel varies considerably over the period of use.In a fast-fading channel, the transmitter may take advantage of the variations in the channel conditions using time diversity to help increase robustness of the communication to a temporary deep fade. Although a deep fade may temporarily erase some of the information transmitted, use of an error-correcting code coupled with successfully transmitted bits during other time instances (interleaving) can allow for the erased bits to be recovered. In a slow-fading channel, it is not possible to use time diversity because the transmitter sees only a single realization of the channel within its delay constraint. A deep fade therefore lasts the entire duration of transmission and cannot be mitigated using coding.
- **Block fading** is where the fading process is approximately constant for a number of symbol intervals. [2] A channel can be 'doubly block-fading' when it is block fading in both the time and frequency domains
- **flat fading:** the coherence bandwidth of the channel is larger than the bandwidth of the signal. Therefore, all frequency components of the signal will experience the same magnitude of fading.
- **frequency-selective fading:** the coherence bandwidth of the channel is smaller than the bandwidth of the signal. Different frequency components of the signal therefore experience uncorrelated fading.
- **Rician fading** is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself — the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others.
- **Rayleigh fading** is a statistical model for the effect of a propagation environment on a radio signal, such as that used by wireless devices. Rayleigh fading is most applicable

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when there is no dominant propagation along a line of sight between the transmitter and receiver. If there is a dominant line of sight, Rician fading may be more applicable.

5. **What are convolution codes?Draw an encode, shift register diagram for (2,1,3) encoder. Encode the bit sequence 1011000 using a (2,1,3) encoder.**

Ans; In telecommunication, a convolutional code is a type of error-correcting code that generates parity symbols via the sliding application of a boolean polynomial function to a data stream. The sliding application represents the 'convolution' of the encoder over the data, which gives rise to the term 'convolutional coding.'

Convolutional codes are often characterized by the base code rate and the depth (or memory) of the encoder [n,k,K]. The base code rate is typically given as n/k, where n is the input data rate and k is the output symbol rate. The depth is often called the "constraint length" 'K', where the output is a function of the previous K-1 inputs. The depth may also be given as the number of memory elements 'v' in the polynomial or the maximum possible number of states of the encoder (typically 2^v).
It Generates redundant bits continuously Error checking and correcting carried out continuously

(n, k, K) code
where

Input processes k bits at a time ,Output produces n bits for every k input bits, K = constraint factor,k and n generally very small,n-bit output of (n, k, K) code depends on:Current block of k input bits,Previous K-1 blocks of k input bits

Convolution encoding

To convolutionally encode data, start with k memory registers, each holding 1 input bit. Unless otherwise specified, all memory registers start with a value of 0. The encoder has n modulo-2 adders (a modulo 2 adder can be implemented with a single Boolean XOR gate, where the logic is: 0+0 = 0, 0+1 = 1, 1+0 = 1, 1+1 = 0), and n generator polynomials — one for each adder (see figure below). An input bit m_1 is fed into the leftmost register. Using the generator polynomials and the existing values in the remaining registers, the encoder outputs n symbols. These symbols may be transmitted or punctured depending on the desired code rate. Now bit shift all register values to the right (m_1 moves to m_0, m_0 moves to m_{-1}) and wait for the next input bit. If there are no remaining input bits, the encoder continues shifting until all registers have returned to the zero state (flush bit termination).

The figure below is a rate 1/3 (m/n) encoder with constraint length (k) of 3. Generator polynomials are G_1 = (1,1,1), G_2 = (0,1,1), and G_3 = (1,0,1). Therefore, output bits are calculated (modulo 2) as follows:

$n_1 = m_1 + m_0 + m_{-1}$
$n_2 = m_0 + m_{-1}$

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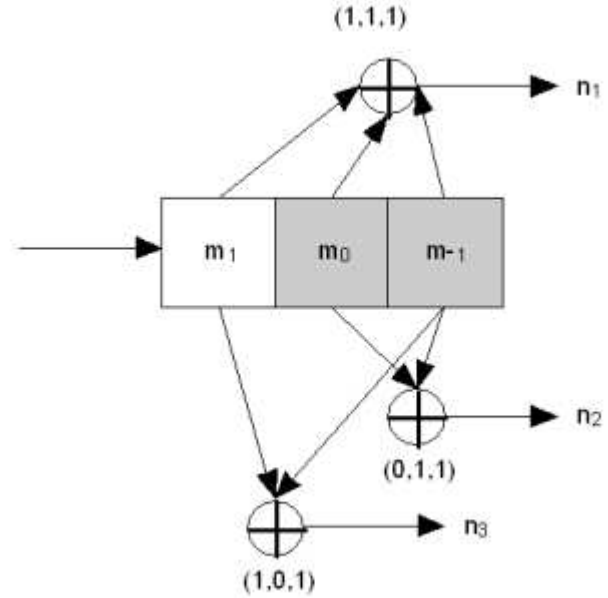
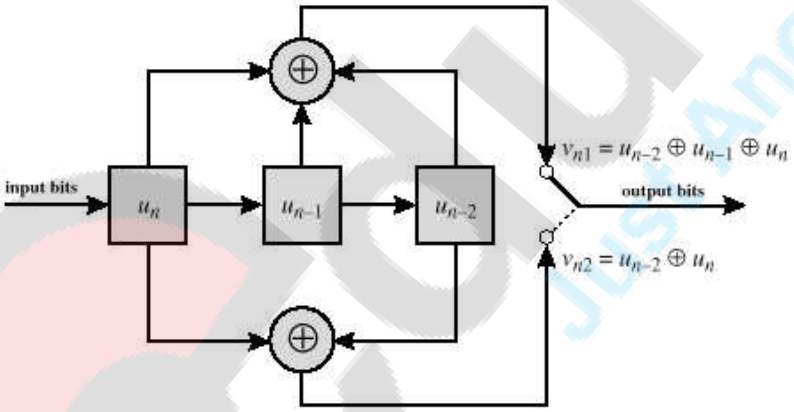
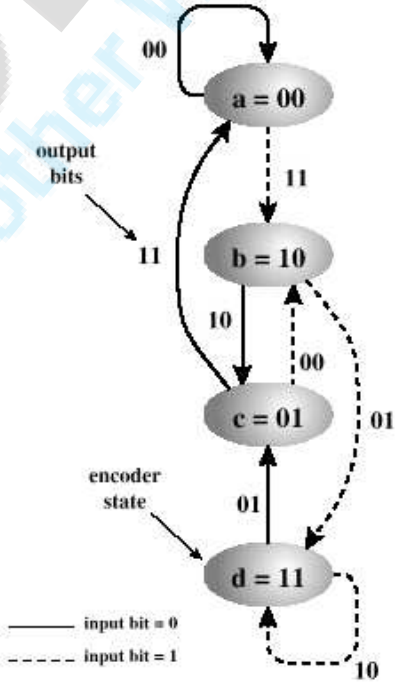
$n_3 = m_1 + m_{-1}$.





(a) Encoder shift register



(b) Encoder state diagram

Figure 8.9 Convolutional Encoder with $(n, k, K) = (2, 1, 3)$

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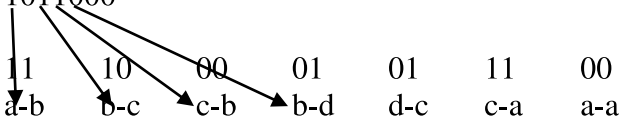
Convolution Code Table

u_n	u_{n-1}	u_{n-2}	v_{n1}	v_{n2}	
			On Edge		Next Stage
0	0	0	0	0	ns = 00
1	0	0	1	1	ns = 10
0	1	0	1	0	ns = 01
1	1	0	0	1	ns =11
0	0	1	1	1	ns = 00
1	0	1	0	0	ns = 10
0	1	1	0	1	ns = 01
1	1	1	1	0	ns = 11

Example:-
Input:-
1011000



Output:
11100001011100
a-b-c-b-d-c-a-a

Unit : 2

1. **Explain the term "Frequency reuse".**

Ans: Frequency reuse is the process of using the same radio frequencies on radio transmitter sites within a geographic area that are separated by sufficient distance to cause minimal interference with each other.

Frequency reuse allows for a dramatic increase in the number of customers that can be served (capacity) within a geographic area on a limited amount of radio spectrum (limited number of radio channels).

- Each cellular BS is allocated a group of radio channels to be used within a small geographic area called cell.
- BS in adjacent cells are assigned channel groups which contain completely different channels than neighboring cells.

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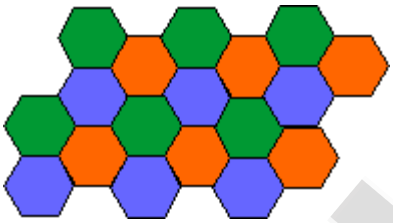
- By limiting the coverage area to within the boundaries of a cell, the same groups of channels may be used to cover different cells that are separated from one another by distances large enough to keep the interference levels within tolerable limits

- The design process of selecting and allocating channel groups for all of the cellular BSs is called frequency reuse or frequency planning.

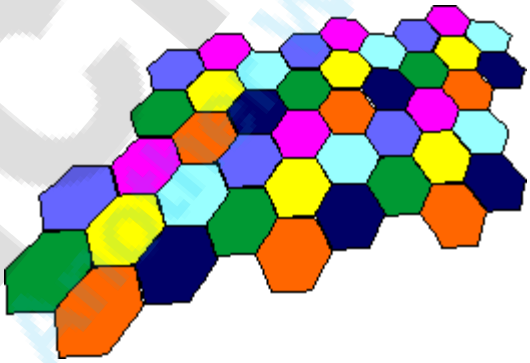
- Cells with the same letter use the same set of frequencies

Principles of cellular frequency reuse

- In the cellular concept, frequencies allocated to the service are re-used in a regular pattern of areas, called 'cells', each covered by one base station. In mobile-telephone nets these cells are usually hexagonal. In radio broadcasting, a similar concept has been developed based on rhombic cells.
- To ensure that the mutual interference between users remains below a harmful level, adjacent cells use different frequencies. In fact, a set of C different frequencies {f1, ..., fC} are used for each cluster of C adjacent cells. Cluster patterns and the corresponding frequencies are re-used in a regular pattern over the entire service area.



Frequency reuse plan for C = 3, with hexagonal cells. (i=1, j =1)

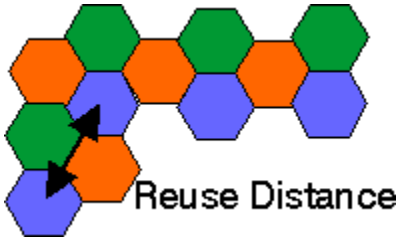


Frequency reuse plan for C = 7 (i=2, j =1).

The total bandwidth for the system is C times the bandwidth occupied by a single cell.

Reuse Distance

- The closest distance between the centres of two cells using the same frequency (in different clusters) is determined by the choice of the cluster size C and the lay-out of the cell cluster. This distance is called the frequency 're-use' distance.
- For hexagonal cells, i.e., with 'honeycomb' cell lay-outs commonly used in mobile radio, possible cluster sizes are C = i2 + ij + j2, with integer i and j (C = 1, 3, 4, 7, 9, ...). Integers i and jdetermine the relative location of co-channel cells.



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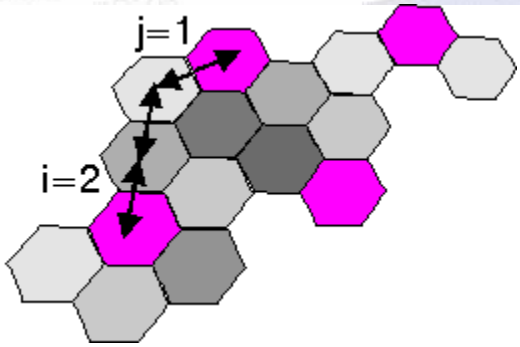
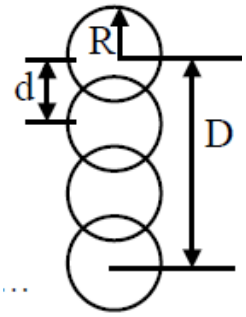


7-cell reuse with i = 2 and j =1.

Characterizing Frequency Reuse

- D = minimum distance between centers of cells that use the same band of
- frequencies (called co-channels)
- R = radius of a cell
- d = distance between centers of adjacent cells ($d = R\sqrt{3}$)
- N = number of cells in repetitious pattern (Cluster)
  - Reuse factor
  - Each cell in pattern uses unique band of frequencies
- Hexagonal cell pattern, following values of N possible
  $N = I2 + J2 + (I \times J)$, I, J = 0, 1, 2, 3, …
  Possible values of N are 1, 3, 4, 7, 9, 12, 13, 16, 19, 21, …
- $D/R=\sqrt{3N}$
- $D/d =\sqrt{N}$



2. What is the reason for a handoff in cellular networks? Explain the various types of handoffs and the strategies used for handoff.
OR
Explain cellular handoff in detail.

Ans: Mobility is the most important feature of a wireless cellular communication system. Usually,
continuous service is achieved by supporting handoff (or handover) from one cell to another.

Handoff is the process of changing the channel (frequency, time slot, spreading code, or combination of them) associated with the current connection while a call is in progress. It is the procedure of changing the assignment of a mobile unit from one BS to another as the mobile unit moves from one cell to another. It is often initiated either by crossing a cell boundary or by a deterioration in quality of the signal in the current channel.

Handoff is divided into two broad categories hard and soft handoffs. They are also characterized by “break before make” and “make before break.” In hard handoffs, current

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resources are released before new resources are used; in soft handoffs, both existing and new resources are used during the handoff process.

TYPES OF HANDOFFS

Handoffs are broadly classified into two categories—hard and soft handoffs. Usually, the hard handoff can be further divided into two different types—intra- and intercell handoffs. The soft handoff can also be divided into two different types—multiway soft handoffs and softer handoffs.

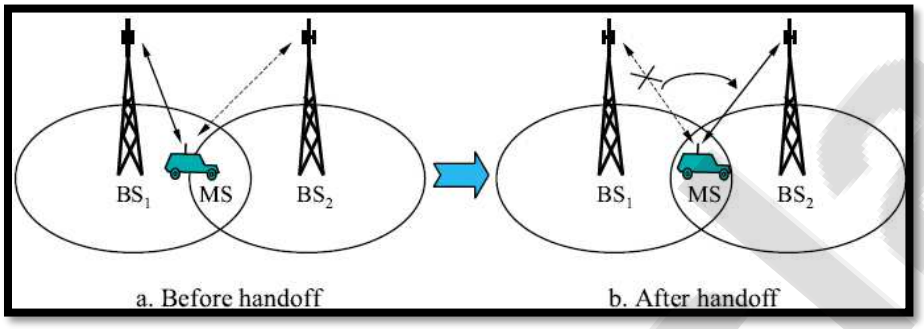

Figure 1.1 Hard handoff between the MS and BSs.

A hard handoff is essentially a "break before make" connection. Under the control of the MSC, the BS hands off the MS's call to another cell and then drops the call. In a hard handoff, the link to the prior BS is terminated before or as the user is transferred to the new cell's BS; the MS is linked to no more than one BS at any given time. Hard handoff is primarily used in FDMA (frequency division multiple access) and TDMA (time division multiple access), where different frequency ranges are used in adjacent channels in order to minimize channel interference. So when the MS moves from one BS to another BS, it becomes impossible for it to communicate with both BSs (since different frequencies are used). Figure1.1 illustrates hard handoff between the MS and the BSs.

Soft handoffs are well known from traditional CDMA networks as they use macro diversity, a basic property of CDMA. In a soft hand-off, a mobile station communicates with two base stations at the same time.

HANDOFF DECISION

The decision-making process of handoff may be centralized or decentralized (i.e., the handoff decision may be made at the MS or network).From the decision process point of view, one can find at least three different kinds of handoff decisions.

Network-Controlled Handoff

In a network-controlled handoff protocol, the network makes a handoff decision based on the measurements of the MSs at a number of BSs. In general, the handoff process (including data transmission, channel switching, and network switching) takes 100–200 ms. Information about the signal quality for all users is available at a single point in the network that facilitates

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appropriate resource allocation. Network-controlled handoff is used in first-generation analog systems such as AMPS (advanced mobile phone system), TACS (total access communication system), and NMT (advanced mobile phone system).

Mobile-Assisted Handoff

In a mobile-assisted handoff process, the MS makes measurements and the network makes the decision. In the circuit-switched GSM (global system mobile), the BS controller (BSC) is in charge of the radio interface management. This mainly means allocation and release of radio channels and handoff management. The handoff time between handoff decision and execution in such a circuit-switched GSM is approximately 1 second.

Mobile-Controlled Handoff

In mobile-controlled handoff, each MS is completely in control of the handoff process. This type of handoff has a short reaction time (on the order of 0.1 second). MS measures the signal strengths from surrounding BSs and interference levels on all channels. A handoff can be initiated if the signal strength of the serving BS is lower than that of another BS by a certain threshold.

Note: For handoff strategies refer Ans 2(Roaming Scenarios)

3. **Discuss CDMA architecture and List benefits of CDMA in wireless data transmission**.

Ans: CDMA (Code-Division Multiple Access) is a channel access method used by various radio communication technologies.

- It is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth.
- The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands.
- It utilizes a spread spectrum technique in which a spreading signal (which is uncorrelated to the signal and has a large bandwidth) is used to spread the narrow band message signal.
- In this, the same bandwidth is occupied by all the users, however they are all assigned separate codes, which di_erentiates them from each other.
- Direct Sequence Spread Spectrum (DS-SS) is the most commonly used technology for CDMA.
- In DS-SS, the message signal is multiplied by a Pseudo Random Noise Code. Each user is given his own codeword which is orthogonal to the codes of other users and in order to detect the user, the receiver must know the codeword used by the transmitter.

Basic concepts of CDMA

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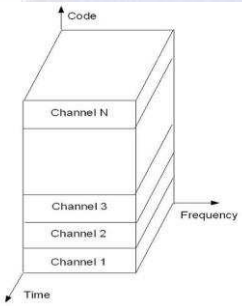

- However,there is two problems are arise in CDMA Technique.
    1. Self-interference Problem
    2. Near-Far Problem
- **Self-interference Problem** arises from the presence of delayed replicas of signal due to multipath. The delays cause the spreading sequences of the di_erent users to lose their orthogonality, as by design they are orthogonal only at zero phase o_set. Hence in despreading a given user's waveform, nonzero contributions to that user's signal arise from the transmissions of the other users in the network.
- **Near-Far Problem** arises from the fact that signals closer to the receiver of interest are received with smaller attenuation than are signals located further away. Therefore the strong signal from the nearby transmitter will mask the weak signal from the remote transmitter.

In CDMA, codes with certain characteristics can be applied to the transmission to enable the use of code division multiplexing (CDM). A code for a certain user should have a good **autocorre-lation** and should be **orthogonal** to other codes. This example explains the basic function of CDMA before it is applied to signals:

- Two senders, A and B, want to send data. CDMA assigns the following unique and orthogonal key sequences: key Ak = 010011 for sender A, key BK = 110101 for sender B. Sender A wants to send the bit Ad = 1, sender B sends Bd = 0. To illustrate this example, let us assume that we code a binary 0 as –1, a binary 1 as +1. We can then apply the standard addition and multiplication rules.
- Both senders spread their signal using their key as chipping. Sender A then sends the signal As = Ad*Ak = +1*(–1, +1, –1, –1, +1, +1) = (–1, +1, –1, –1, +1, +1). Sender B does the same with its data to spread the signal with the code: Bs = Bd*Bk = –1*(+1, +1, –1, +1, –1, +1) = (–1, –1, +1, –1, +1, –1).
- Both signals are then transmitted at the same time using the same frequency, the following signal C is received at a receiver: C = As + Bs = (–2, 0, 0, –2, +2, 0).
- The receiver now wants to receive data from sender A and, therefore, tunes in to the code of A, i.e., applies A's code for despreading: C*Ak = (–2, 0, 0, –2, +2, 0)*(–1, +1, –1, –1, +1, +1) = 2 + 0 + 0 + 2 + 2 + 0 = 6. As the result is much larger than 0, the receiver detects a binary 1. Tuning in to sender B, i.e., applying B's code gives C*Bk =

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(–2, 0, 0, –2, +2, 0)* (+1, +1, –1, +1, –1, +1) = –2 + 0 + 0 – 2 – 2 + 0 = –6. The result is negative, so a 0 has been detected.

Compare CDMA with TDMA and FDMA techniques.

Approach	TDMA	FDMA	CDMA
Allocated Bandwidth	12.5 MHz	12.5 MHz	12.5 MHz
Frequency reuse	7	7	1
Required channel BandWidth	0.03 MHz	0.03 MHz	1.25 MHz
Idea	Segment sending time into disjoint time-slots, demand driven or fixed patterns	Segment the frequency band into disjoint sub-bands	Spread the spectrum using orthogonal codes
Terminals	All terminals are active for short period of time on the same frequency	Every terminal has its own frequency, uninterrupted	All terminals can be active at the same place at the same moment,uninterrupted
Signal separation	Synchronization in the time domain	Filtering in the frequency domain	Code plus special receivers
Handoff used	Hard handoff	Hard handoff	Soft handoff
Advantages	Established, fully digital,very flexible	Simple,established, robust	Flexible, less planning needed, soft handover
Disadvantages	Guard space needed(multi-path propagation), synchronization difficult	Inflexible,frequencies are a scarce resources	Complex receivers, needs more complicated power control for senders
Comment	Standard in fixed networks,together with FDMA/SDMA used in many mobile networks	Typically combined with TDMA(frequency hopping patterns) and SDMA(frequency reuse)	Used in many 3G systems, higher complexity,lowered expectations, integrated with TDMA/FDMA

4. Briefly explain generations of Cellular Networks 1G,2G,2.5G,3G and 4G

Ans: A cellular network is distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station.

In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell.

When joined together these cells provide radio coverage over a wide geographic area.

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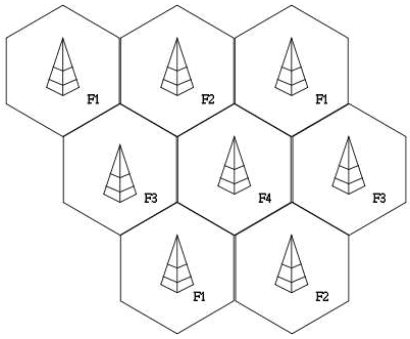
This enables a large number of portable transceivers (e.g., mobile phones, pagers, etc.) to communicate with each other .



Generations of Network: 1G, 2G, 3G, 4G, 5G

1. First Generation (1G) – Analog System:

- 1G refers to the first-generation of wireless telephone technology, mobile telecommunications.
- These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications.
- The main difference between two succeeding mobile telephone systems, 1G and 2G, is that the radio signals that 1G networks use are analog, while 2G networks are digital.
- Although both systems use digital signaling to connect the radio towers (which listen to the handsets) to the rest of the telephone system, the voice itself during a call is encoded to digital signals in 2G whereas 1G is only modulated to higher frequency, typically 150 MHz and up.

Security Issues with 1G:

- Analog cellular phones are insecure.
- Anyone with an all-band radio receiver can listen in to the conversation. Many scandals have been reported in this area

2. Second Generation (2G) Network – Digital System:

- Second Generation (2G) cellular networks, introduced in the late 1980s, are based on digital transmission.
- Digital transmissions offer several benefits over analog.
- Second generation 2G cellular telecom networks were commercially launched on the GSM standard in Finland by Radiolinja in 1991.
- Three primary benefits of 2G networks over their predecessors were that phone conversations were digitally encrypted; 2G systems were significantly more efficient on the

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spectrum allowing for far greater mobile phone penetration levels; and 2G introduced data services for mobile, starting with SMS text messages.

Advantages:

- Going all-digital allowed for the introduction of digital data services, such as SMS and email.
- Greatly reduced fraud: With analog systems it was possible to have two or more "cloned" handsets that had the same phone number.
- Enhanced privacy: A key digital advantage not often mentioned is that digital cellular calls are much harder to eavesdrop on by use of radio scanners. While the security algorithms used have proved not to be as secure as initially advertised, 2G phones are immensely more private than 1G phones, which have no protection against eavesdropping.

3. Third Generation Network (3G) – Internet System:

- 3G or 3rd generation mobile telecommunications is a generation of standards for mobile phones and mobile telecommunication services fulfilling the International Mobile Telecommunications-2000 (IMT-2000) specifications by the International Telecommunication Union.
- Application services include wide-area wireless voice telephone, mobile Internet access , video calls and mobile TV, all in a mobile environment.
- The first pre-commercial 3G network was launched by NTT DoCoMo in Japan on 1998, branded as FOMA. It was first available in May 2001 as a pre-release (test) of W-CDMA technology.
- 11 December 2008, India entered the 3G arena with the launch of 3G enabled Mobile and Data services by Government owned Mahanagar Telephone Nigam Ltd MTNL in Delhi and later in Mumbai
- The goal of 3G systems is to enable wireless service providers to offer services found on today's wireline networks.
- The goal of 3G wireless systems was to provide wireless data service with data rates of 144kbps to 384kbps in wide coverage areas, and 2Mbps in local coverage areas.

4. 4G Networks – Integration System:

- In telecommunications, 4G is the fourth generation of cellular wireless standards. It is a successor to the 3G and 2G families of standards. In 2009, the ITU-R organization specified the IMT-Advanced(International Mobile Telecommunications Advanced) requirements for 4G standards, setting peak speed requirements for 4G service at 100 Mbit/sec for high mobility communication (such as from trains and cars) and 1 Gbit/sec for low mobility communication (such as pedestrians and stationary users).

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- A 4G system is expected to provide a comprehensive and secure all-IP based mobile broadband solution to laptop computer wireless modems, smartphones, and other mobile devices.

Items	3G	4G
Speed	Up to 2Mbps	Full-mobility: up to 100Mbps Low-mobility: up to 1Gbps
Services	Difficulty of global roaming	Roaming smoothly
Core Network	Wide-area concept Circuit and packet switching	Broadband, Entirely IP-based packet switching
Technologies	WCDM, CDMA2000, TD-SCDMA	All access convergence including: OFDM, MC-CDMA, LAS-CDMA, Network-LMPS

5. 5G Networks - Real Wireless World System:

- 5G (5th generation mobile networks or 5th generation wireless systems) is a name used in some research papers and projects to denote the next major phase of mobile telecommunications standards beyond the 4G/IMT-Advanced standards effective since 2011.
- At present, 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardization bodies such as 3GPP, WiMAX Forum, or ITU-R.
- New mobile generations are typically assigned new frequency bands and wider spectral bandwidth per frequency channel (1G up to 30 kHz, 2G up to 200 kHz, 3G up to 5 MHz, and 4G up to 40 MHz), but sceptics argue that there is little room for new frequency bands or larger channel bandwidths

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Unit :4

1. Explain GSM architecture.

Ans:There are mainly 3 Components that are:-

GSM

- **Mobile Station (MS)**
- **Base station Subsystem(BSSS)**
- **Network Switching Subsytem(NSS)**

Diagramatic Representation :-

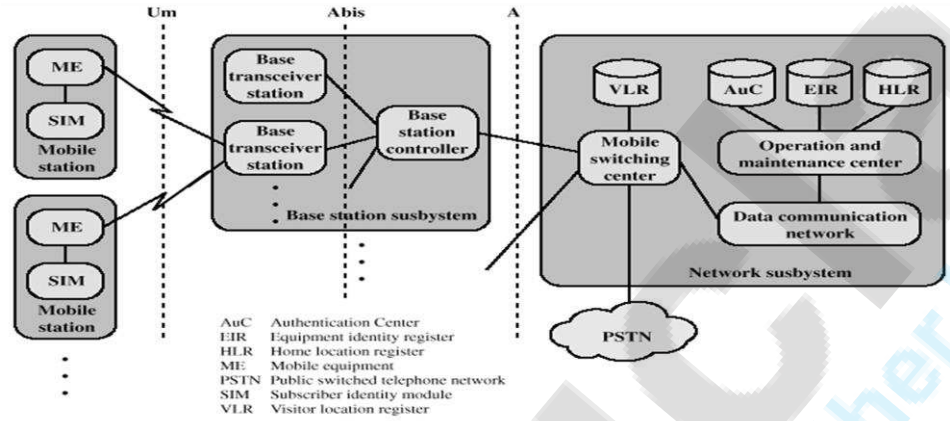

Figure 10.14 Overall GSM Architecture

A) Mobile station:- Mobile station communicates across Um interface (air interface) with base station transceiver in same cell as mobile unit. It Further divided into two parts:-

1) **Mobile equipment (ME)** – physical terminal, such as a telephone ,radio transceiver, digital signal processors and subscriber identity module (SIM)
   - **Addresses and Identifiers**:- Smart card containing the International Mobile Subscriber Identity (IMSI) Carries all the subscriber specific information used by an MS.
2) **Subscriber Identity Module (SIM)**:- SIM allows user to send and receive calls and receive other subscribed services. Major functions are to identify the current user of an MS and to take part in security and confidentiality procedures.It Can be moved from phone to phone – contains key information to activate the phone.

B) Base Station Subsytem(BSS):-

- Base Station Subsystem is composed of two parts that communicate across the standardized Abis interface allowing operation between components made by different suppliers.
- It consists of base station controller and one or more base transceiver stations (BTS)

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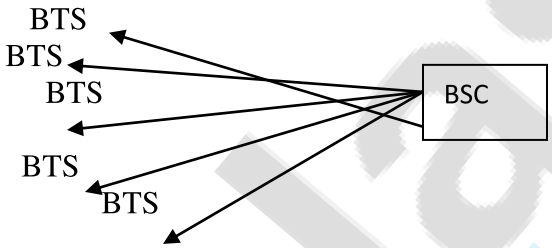
- Each BTS defines a single cell which includes radio antenna, radio transceiver and a link to a base station controller (BSC)
- BSC reserves radio frequencies, manages handoff of mobile unit from one cell to another within BSS, and controls paging

BSS Further divided into 3 parts:-

1) **Base Transceiver Station (BTS):-** A BTS usually placed on center of the cell
   - Each BTS has between 1 to 16 transceiver depending on density of the user in the cell.
2) **Base Station Controller (BSC):-** It manages resources for BTS. It also Handles call set up and updation of location.



C) Network & Switching Subsystem (NSS):- NSS provides link between cellular network and public switched telecommunications networks.

Services provided by NSS are

1) Controls handoffs between cells in different BSSs
2) Authenticates users and validates accounts
3) Enables worldwide roaming of mobile users

It consist of :-

->Mobile Switching Center (MSC)
->Home Location Register (HLR)
->Visitor Location Register (VLR)
->Equipment Identify Register (EIR)
->Authentication Centre (AuC)

1) **Mobile Switching Center (MSC) :-** It is the Central element of NS.

- It Switch speech and data connections between:Base Station Controllers, Mobile Switching Centers,GSM-networks and Other external networks –Public Switched Telephone Network (PSTN) and Public Land Mobile Network (PLMN) .
- One MSC can handles multiple BSCs and also interfaces with other MSC's (Using E-Interface).
- It also handles inter-BSC handoffs as well as coordinates with other MSC's for inter-MSC handoffs.

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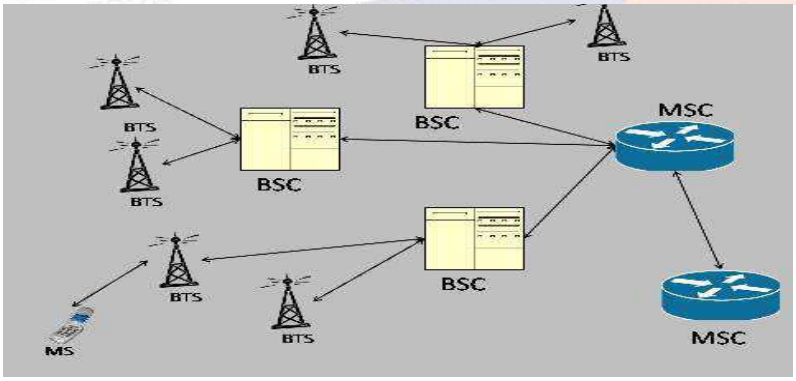
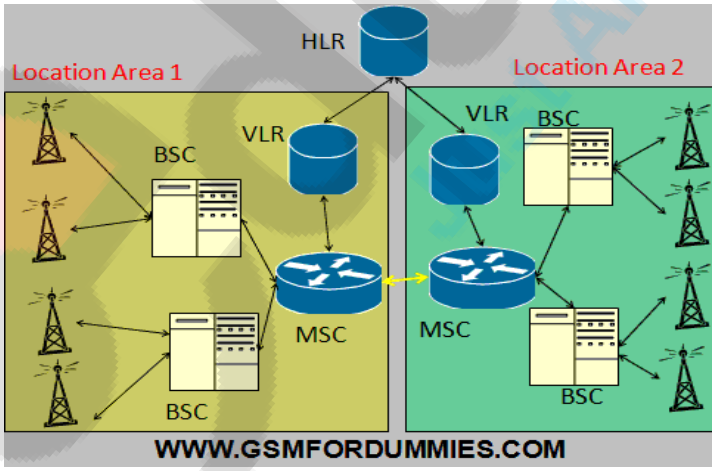


2) **Home location register (HLR)**:-
   - HLR is a central database that contains details of each mobile phone subscriber that is authorized to use the GSM core network.
   - The HLRs store details of every *SIM card* issued by the mobile phone operator.
   - Each SIM has a unique identifier called an **IMSI** which is the *primary key* to each HLR record.
   - HLR may be implemented as a distributed database means logically one HLR per GSM Network
3) **Visitor Location Register (VLR):-**
   - The VLR keeps track of all subscribers roaming in the VLR service area.
   - The VLR temporarily stores subscription information for the visiting subscribers so that the corresponding MSC can provide service like call handling and mobility management.
   - VLR provide dynamic data management (HLR static data management)



4) **Equipment Identity Register (EIR) :-**

   - The EIR is a database that keeps tracks of handsets on the network using the IMEI.

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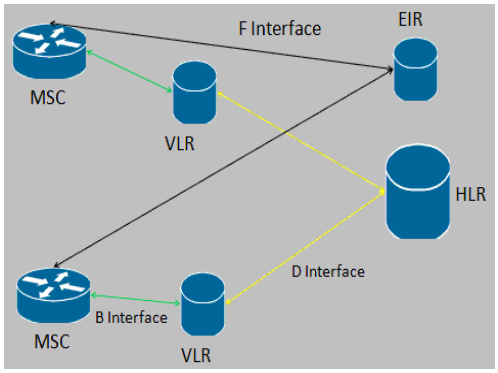
- The EIR was introduced to identify, track and bar such equipment from being used in the network
- There is only one EIR per network.
  ->Composed of three lists.
- The White List
- The Gray List
- The Black List



5) Authentication Cemter(AuC):-

- AUC is always integrated with HLR for the purpose of the authentication.
- The Subscriber Authentication Key (Ki) is allocated to the subscriber, together with the IMSI. The Ki is stored in the AUC and used to provide the triplets, same Ki is also stored in the SIM.

➔ AUC stores the following information for each subscriber

- The IMSI number,
- The individual authentication key Ki

2. What is the role of Mobile Switching Centre in roaming? Or Describe the GSM architecture and its concept of physical channel.

Ans: **Definition**

A mobile switching center (MSC) is the centerpiece of a network switching subsystem (NSS). The MSC is mostly associated with communications switching functions, such as call set-up, release, and routing. However, it also performs a host of other duties, including routing SMS messages, conference calls, fax, and service billing as well as interfacing with other networks, such as the public switched telephone network (PSTN).

The MSC is structured so that base stations connect to it, while it connects to the PSTN. Because cellphones connect to these base stations, all forms of communication, whether between two cell phones or between a cell phone and a landline telephone, travel through the MSC

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From technical perspective

A small network operator may employ only one MSC, while a large operator requires multiple MSCs. The MSC plays a significant role in handovers, particularly handovers involving multiple base station controllers - known as inter-BSC or intra-MSC handovers - as well as those involving multiple MSCs, known as inter-MSC handovers.

In an inter-BSC handover and upon detecting that a mobile device is approaching the edge of its cell, a BSC requests handover assistance from its MSC. The MSC then scans a list of adjacent cells and their corresponding BSCs and facilitates the handover to the appropriate BSC.

As mobile phones move, it is important for the MSC to determine each phone's location to effectively facilitate routing communications between them. For this task, the MSC works with a large database known as the home location register (HLR), which stores relevant location and other information for each mobile phone.

Function performed by an MSC

- Processing of signals
- Establishing and terminating the connection between various mobile stations via BSCs
- The mobile stations to be connected may fall in a given MSCs own area or in the area assigned to another MSC, in which case the communication path has to be via the other MSC
- Establishing and terminating the connection between an MS and a fixed line phone via a GMSC or IWF
- Monitoring of calls made to and from an MS
- Call charging, multi-way calling, call forwarding, and other supplementary Services

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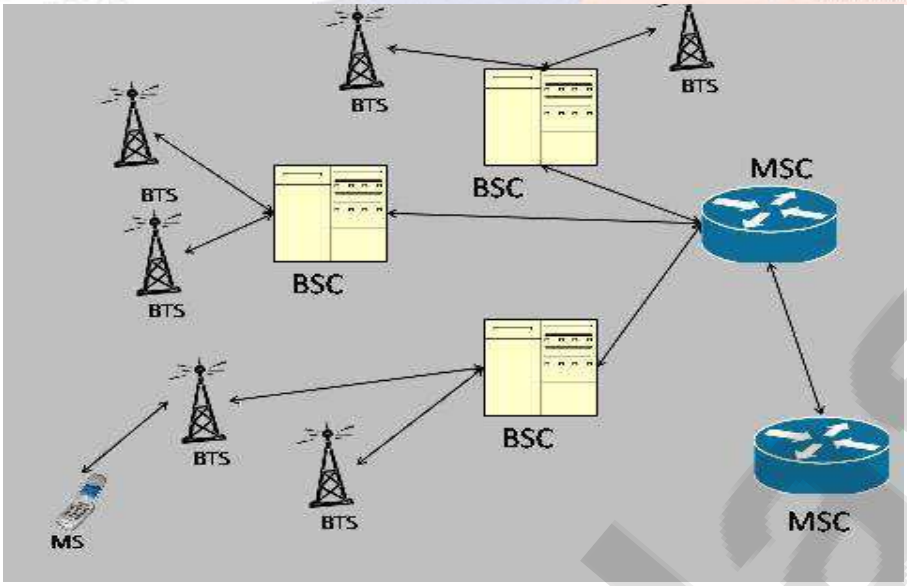

Gateway mobile service switching centre

- A special node which handles connections to other fixed networks
- These other networks may be ISDN, PSTN, PSPDN, or other PLMN networks
- Special IWFs may be used by a GMSC to connect to public data networks such as the X.25

Visitor location register at each MSC

- A dynamic real-time database that stores both permanent and temporary subscriber data which is required for communication between the MSs in the coverage area of the MSC associated with that VLR. The VLR is an integral part of the MSC

HLR (Home location register)

- Has the MT databases
- Stores all the relevant subscriber data including mobile subscriber ISDN number (MSISDN), details of subscription permissions such as call forwarding, roaming, etc., subscriber's ISMI, user's location area, user's current VLR and MSC status
- Each mobile user has only one HLR record worldwide, which is updated constantly on a real-time basis
- Each MS must register at a specific HLR of a specific MSC
- The HLR contacts AuC in the OSS for authentication

VLR (Visitor Location Register)

- When the mobile user visits a network other than the home system, a temporary record for the mobile user is created in the visitor location register (VLR) of the visited system.
- The VLR keeps track of all subscribers roaming in the VLR service area.
- The VLR temporarily stores subscription information for the visiting subscribers so that the corresponding MSC can provide service like call handling and mobility management.VLR provide dynamic data management (HLR static data management

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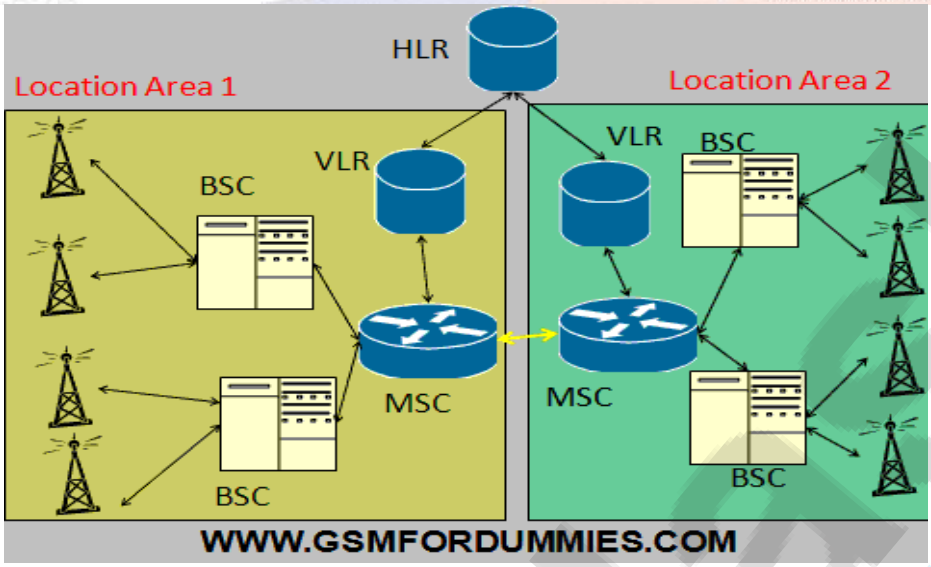
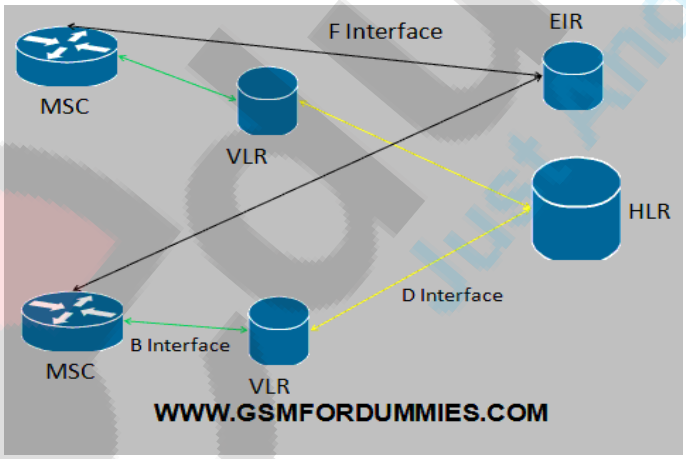


EIR (Equipment Identity Register)

- The EIR is a database that keeps tracks of handsets on the network using the IMEI.
- The EIR was introduced to identify, track and bar such equipment from being used in the network
- There is only one EIR per network.
- Composed of three lists.
  - The White List
  - The Gray List

  The Black List



AuC (Authentication Centre)

- AUC is always integrated with HLR for the purpose of the authentication.
- The Subscriber Authentication Key (Ki) is allocated to the subscriber, together with the IMSI. The Ki is stored in the AUC and used to provide the triplets, same Ki is also stored in the SIM.
- AUC stores the following information for each subscriber
  - The IMSI number,

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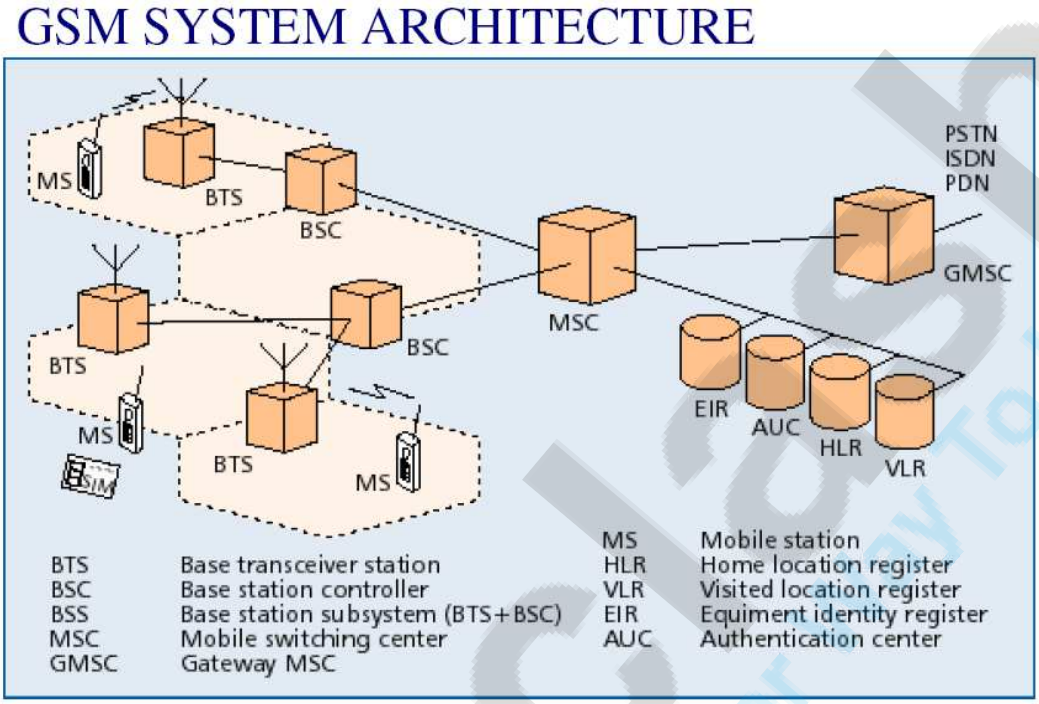
› The individual authentication key Ki

GSM System Architecture



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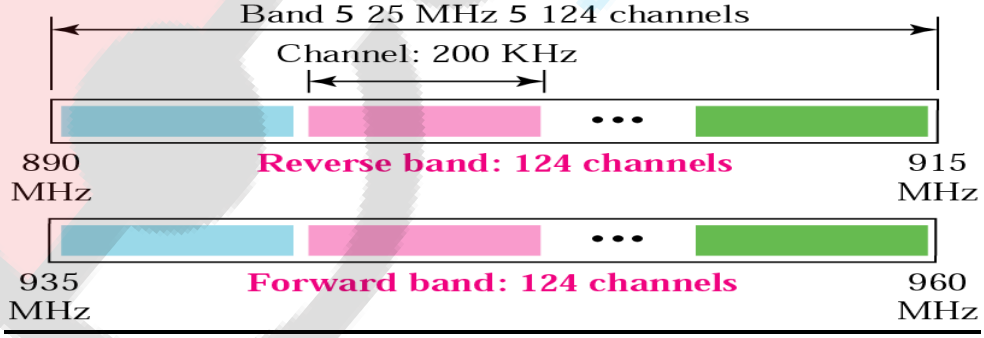
GSM concept of physical channel

Radio link used by GSM are:

- 25 MHz for base transmission(935-960 MHz)
- 25 MHz for mobile transmission(890-915 MHz)
- Network access: FDMA and TDMA
- Channels are modulated at a data rate 270.833 kbps
- There are radio frequency carries every 200KHz which proved for 124 full duplex channels.



TDMA Format of GSM

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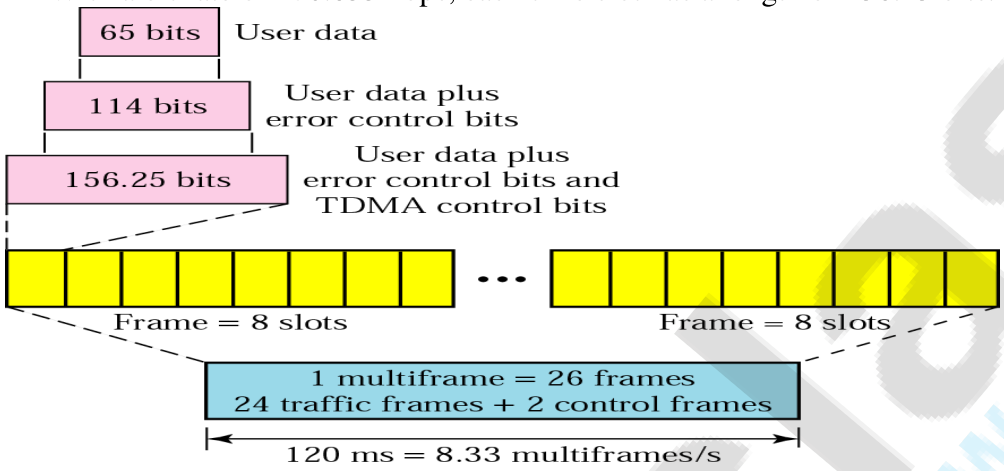
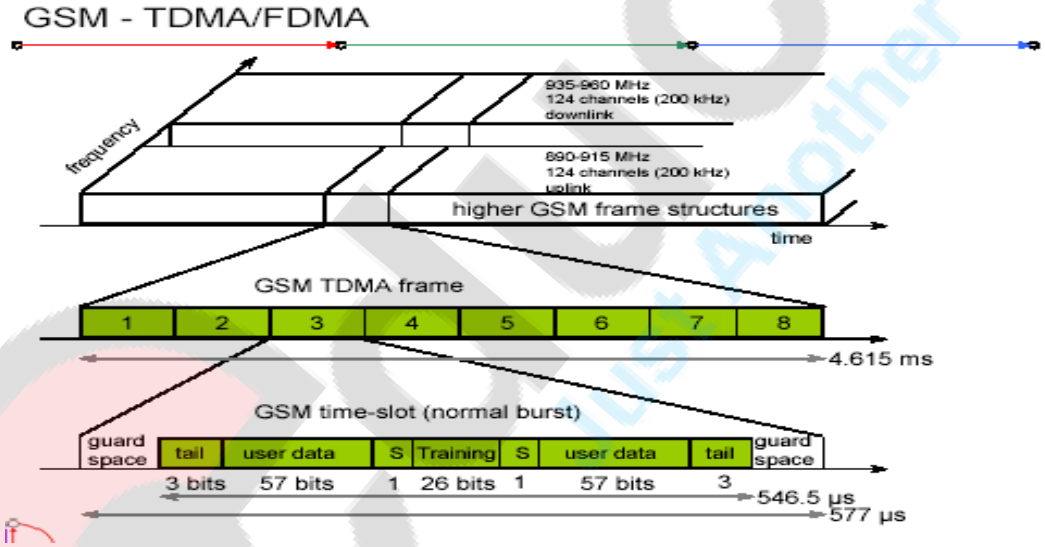
- GSM uses complex hierarchy of TDMA frames to define logical channels.
- Each 200 KHz frequency band is divided into 8 logical channels defined by repetitive occurrence of time slots.
- At the lowest level is the time slot , also called a burst period, which has a duration of 0.577 ms.
- With a bit rate of 270.833 kbps, each time slot has a length of 156.25 bits.



GSM Frame Structure



Frame Structure Fields:

- Trail bits – allow synchronization of transmissions from mobile units
- Encrypted bits – encrypted user data
- Stealing bit - indicates whether block contains data or is "stolen"
- Training sequence – used to adapt parameters of receiver to the current path propagation characteristics
    - Strongest signal selected in case of multipath propagation

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  - By determining how the known training sequence is modified by multipath fading, the rest of the signal is processed to compensate for these effects.
- Guard bits – used to avoid overlapping with other bursts

3. How is localization, location update, roaming done in GSM and reflected in the databases? What are typical roaming scenarios?

Ans: For the localization and location update two important registers maintained by GSM i) HLR ii) VLR

Home location register (HLR):-

- HLR is a central database that contains details of each mobile phone subscriber that is authorized to use the GSM core network.
- The HLRs store details of every *SIM card* issued by the mobile phone operator.
- Each SIM has a unique identifier called an **IMSI** which is the *primary key* to each HLR record.
- HLR may be implemented as a distributed database means logically one HLR per GSM Network

Visitor Location Register (VLR):-

- The VLR keeps track of all subscribers roaming in the VLR service area.
- The VLR temporarily stores subscription information for the visiting subscribers so that the corresponding MSC can provide service like call handling and mobility management.
- VLR provide dynamic data management (HLR static data management)

The GSM system only stores the current location area for a user in the VLR. Each time a user changes the location area this change is reflected in the VLR. Additionally, periodic updates are possible. Roaming includes changing the network operator. This can happen within the same country (national roaming) or when going to another country (international roaming). The latter is the most common scenario as national roaming typically involves direct competitors. Prerequisite are roaming agreements between the different operators. The HLR always stores the current VLR for the user, no matter if inside the own or inside a foreign network. Precise localisation of users is performed during call setup only (paging within the location area).

Different Roaming Scenario of GSM

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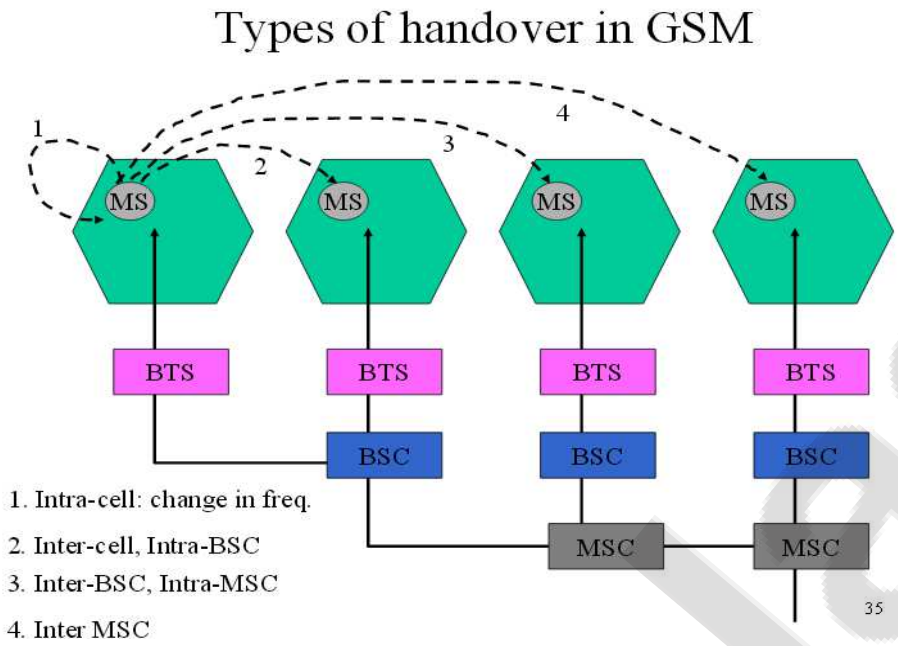

- Intra-cell handover: Within a cell, narrow-band interference could make transmission at a certain frequency impossible. The BSC could then decide to change the carrier frequency (scenario 1).
- Inter-cell, intra-BSC handover: This is a typical handover scenario. The mobile station moves from one cell to another, but stays within the control of the same BSC. The BSC then performs a handover, assigns a new radio channel in the new cell and releases the old one (scenario 2).
- Inter-BSC, intra-MSC handover: As a BSC only controls a limited number of cells; GSM also has to perform handovers between cells controlled by different BSCs. This handover then has to be controlled by the MSC (scenario 3). This situation is also shown in Figure
- Inter MSC handover: A handover could be required between two cells belonging to different MSCs. Now both MSCs perform the handover together (scenario 4).

4. Discuss GPRS technology and its features and its physical architecture.

Ans: General Packet Radio Services (GPRS) is a packet-based wireless communication service that

promises data rates from 56 up to 171.2 Kbps and continuous connection to the Internet for mobile phone and computer users. It provides packet mode transfer for applications that exhibit traffic patterns such as frequent transmission of small volumes (e.g., typical web requests) or infrequent transmissions of small or medium volumes (e.g., typical web responses)according to the requirement specification

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Compared to existing data transfer services, GPRS should use the existing network resources more efficiently for packet mode applications, and should provide a selection of QoS parameters for the service requesters.
The overall goal in this context is the provision of a more efficient and, thus, cheaper packet transfer service for typical internet applications that usually rely solely on packet transfer.
The main benefit for users of GPRS is the 'always on' characteristic – no connection has to be set up prior to data transfer.

Features :

- Immediacy: GPRS facilitates instant connections whereby information can be sent or
  received immediately as the need arises. No dial-up modem connection is necessary. This is why GPRS users are sometimes referred to be as being "always connected". Immediacy is one of the advantages of GPRS (and SMS) when compared to Circuit Switched Data.

- Speed: Theoretical maximum speeds of up to 171.2 kilobits per second (kbps) are
  achievable with GPRS using all eight timeslots at the same time. This is about three times as fast as the data transmission speeds possible over today's fixed telecommunications networks and ten times as fast as current Circuit Switched Data services on GSM networks.

- New applications, better applications :
  GPRS facilitates several new applications that have not previously been available over GSM networks due to the limitations in speed of Circuit Switched Data

- Service Access :To use GPRS, users specifically need:
  - mobile phone or terminal that supports GPRS
  - subscription to a mobile telephone network that supports GPRS
  - use of GPRS must be enabled for that use
  - knowledge of how to send and/ or receive GPRS information
  - destination to send or receive information through GPRS

Physical Model

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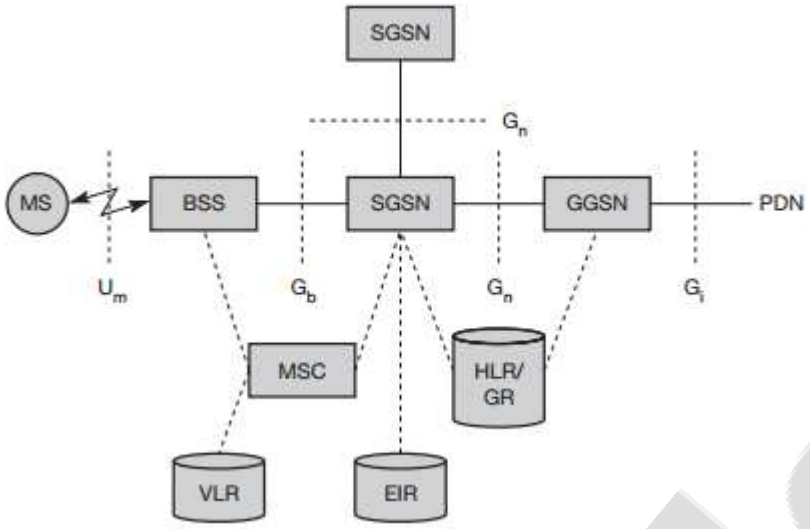

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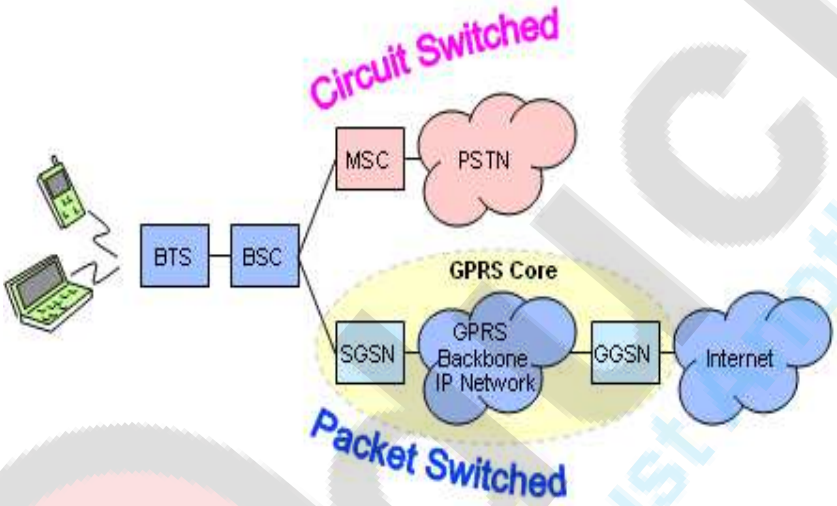

GPRS Network Architecture
The GPRS architecture introduces two new network elements , which are called GPRS support nodes.

GPRS support nodes are responsible for the delivery and routing of packets between mobile stations and the external packet data networks (PDN).

- There are two types of support nodes:
  - SGSN (Serving GSN)
  - GGSN (Gateway GSN)

(GSN)are in fact routers and the gateway GPRS support node (GGSN) is the interworking unit between the GPRS network and external packet data networks (PDN) it contains routing

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information for GPRS users, performs address conversion, and tunnels data to a user via encapsulation.

The other new element is the serving GPRS support node (SGSN) which supports the MS before sending any data over the GPRS network, an MS must attach to it,The attachment procedure includes assigning a temporal identifier, called a temporary logical link identity (TLLI), and a ciphering key sequence number (CKSN) for data encryption.

Serving GPRS Node (SGSN)

- A Serving GPRS Support Node (SGSN) is responsible for the delivery of data packets from and to the mobile stations within its geographical service area.
- Whatever MSC does for voice ,SGSN does the same function for packet data.
- Its tasks include packet routing and transfer, mobility management (attach/detach and location management), logical link management, and authentication and charging functions.
- The location register of the SGSN stores location information (e.g., current cell, current VLR) and user profiles of all GPRS users registered with this SGSN.
- The SGSN is connected to the base station system with Frame Relay.

Gateway GPRS Support Node(GGSN)

- The GGSN is responsible for the internetworking between the GPRS network and external packet switched networks like the Internet and X.25 networks .
- GGSN's function is similar to that of a router in a LAN.
- GGSN maintains routing information that is necessary to tunnel the PDUs to the SGSN s that service particular mobile stations.
- It converts the GPRS packets coming from the SGSN into appropriate packet data protocol (PDP) format for the data networks like Internet and X.25. PDP sends these packets out on the corresponding packet data network.
- On the other side PDP receives incoming data from data networks and converts them to the GSM address of the destination user.
- The readdressed packets are sent to the responsible SGSN.
- GGSN also performs authentication and charging functions related to data transfer.

In idle mode an MS is not reachable and all context is deleted. In the standby state only movement across routing areas is updated to the SGSN but not changes of the cell
Only in the ready state every movement of the MS is indicated to the SGSN.

5. Different processes in GPRS network.

Ans: Following Processes required for GPRS communication:

- This section describes the following basic processes used in GPRS networks:
- **Attach process**—Process by which the MS attaches (i.e, connects) to the SGSN in a GPRS network

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- **Authentication process**—Process by which the SGSN authenticates the mobile subscriber
- **PDP activation process**—Process by which a user session is established between the MS and the destination network
- **Detach process**—Process by which the MS detaches (i.e., disconnects) from the SGSN in the GPRS network
- **Network-initiated PDP request for static IP address**—Process by which a call from the packet data network reaches the MS using a static IP address
- **Network-initiated PDP request for dynamic IP address**—Process by which a call from the packet data network reaches the MS using a dynamic IP address

Attach process:

■ When a mobile subscriber turns on their handset, the following actions occur:

1. A handset attach request is sent to the new SGSN.
2. The new SGSN queries the old SGSN for the identity of this handset. The old SGSN responds with the identity of the handset.
3. The new SGSN requests more information from the MS. This information is used to authenticate the MS to the new SGSN.
4. The authentication process continues to the HLR. Authentication based on IMSI and similar to the CHAP authentication process in PPP.
5. A check of the equipment ID with the EIR is initiated.
6. If the equipment ID is valid, the new SGSN sends a location update to the HLR indicating the change of location to a new SGSN. The HLR notifies the old SGSN to cancel the location process for this MS. The HLR sends an insert subscriber data request and other information associated with this mobile system and notifies the new SGSN that the update location has been performed.
7. The new SGSN initiates a location update request to the VLR.
8. The new SGSN sends the Attach Accept message to the MS.
9. The MS sends the Attach Complete message to the new SGSN.
10. The new SGSN notifies the new VLR that the relocation process is complete

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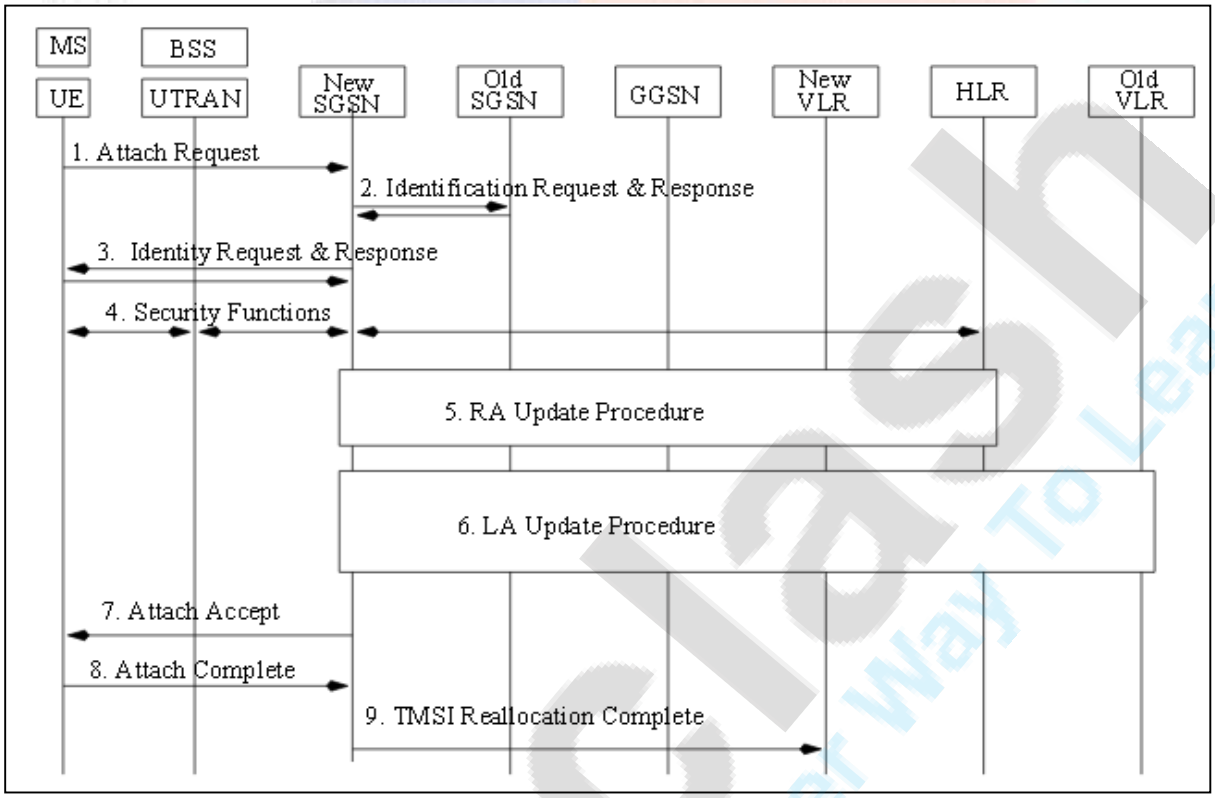

Detach Process:

- GPRS detach can be initiated by MS, SGSN, or HLR.The different types of detach are:
  - IMSI detach
  - GPRS detach
  - Combined GPRS/IMSI detach (MS-initiated only)
- Detach Process Initiated by MS When a mobile subscriber turns off their handset, the detach process initiates. The detach process is described below.
- The MS sends a Detach Request to the SGSN.
- The SGSN sends a Delete PDP Context Request message to the serving GGSN.
- The SGSN sends an IMSI Detach Indication message to the MSC/VLR indicating the MS request to disconnect.
- The SGSN sends a GPRS Detach Indication message to the MSC/VLR.
- The SGSN sends the Detach Accept message to the MS

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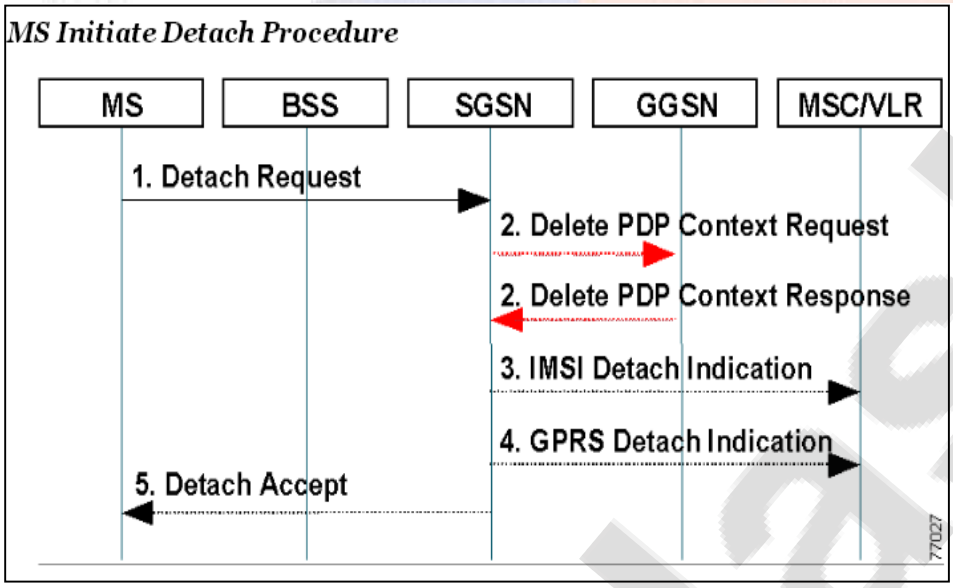


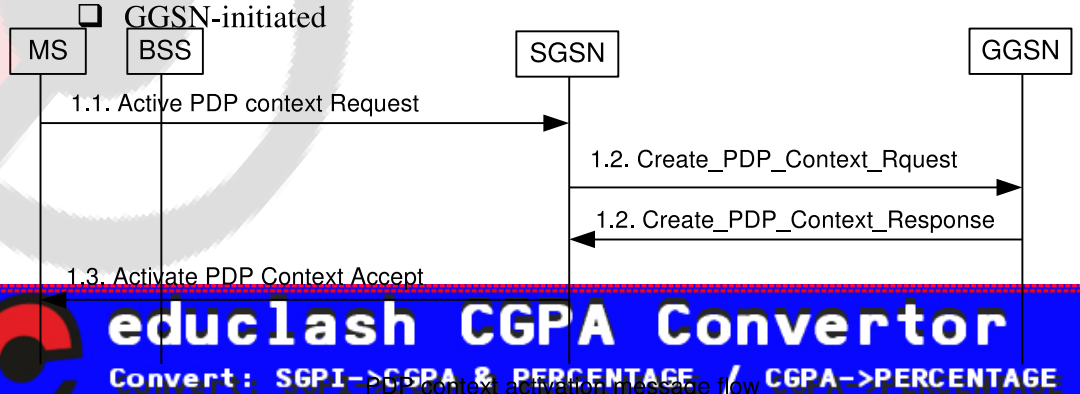
PDP process for Session Management:

After Successful attach a MS gets one or more Packet Data Protocol(PDP) address. This address is unique only for a particular session. For each session a PDP context is created. It consists of,

- PDP type
- PDP address assigned to MS
- Requested QoS (priority, reliability, delay, user data throughput, scheduled repeated transmission)
- Address of the corresponding GGSN
- This context is stored in the MS, the SGSN and the GGSN.With an active PDP context, the MS is visible to the external PDN.

PDP context procedures are:

- PDP Context Activation
  - MS-initiated
  - Network-requested
- PDP Context Modification
- PDP Context Deactivation
  - SGSN-initiated
  - MS-initiated
  - GGSN-initiated



PDP context activation message flow

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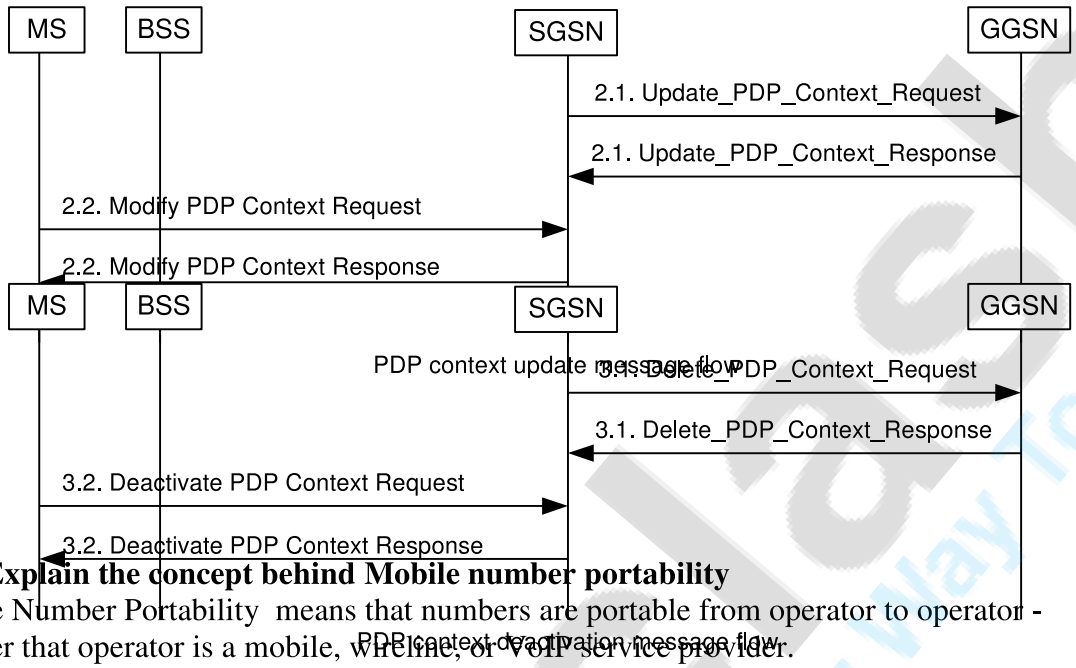

6. Explain the concept behind Mobile number portability

Mobile Number Portability means that numbers are portable from operator to operator - whether that operator is a mobile, wireline, or VoIP service provider.

Number Portability is a network function that allows a subscriber to keep a "*Unique*" telephone number.NP is one of the three important mechanisms to enhance fair competition among telecommunications operators and to improve customer service. The other two mechanisms for fair competition are equal access and network unbundling.

Three types of number portability have been discussed:

1.Location portability :

With location portability, a subscriber may move from one location to another without changing his/her telephone number. This type of portability is already implied in mobile phone service.

2.Service portability :

With service portability, a subscriber may keep the same telephone number when changing telecommunications services. In the U.S., service portability between fixed telephone service and mobile phone service is implementable because both services follow the "NPA-NXXXXXX'' telephone number format.

3.Operator portability :

With operator portability, a subscriber may switch telecommunications operators without changing his/her telephone number.

Basic of MNP:

An MS is associated with two numbers: the directory number and the identification number. In a UMTS circuit-switched domain, the Mobile Station ISDN Number (MSISDN) is the directory number, which is dialed to reach the MS. In other words, the MSISDN is the telephone number of the MS. The International Mobile Subscriber Identity (IMSI) is the identification number that uniquely identifies an MS in the mobile network. The IMSI is used

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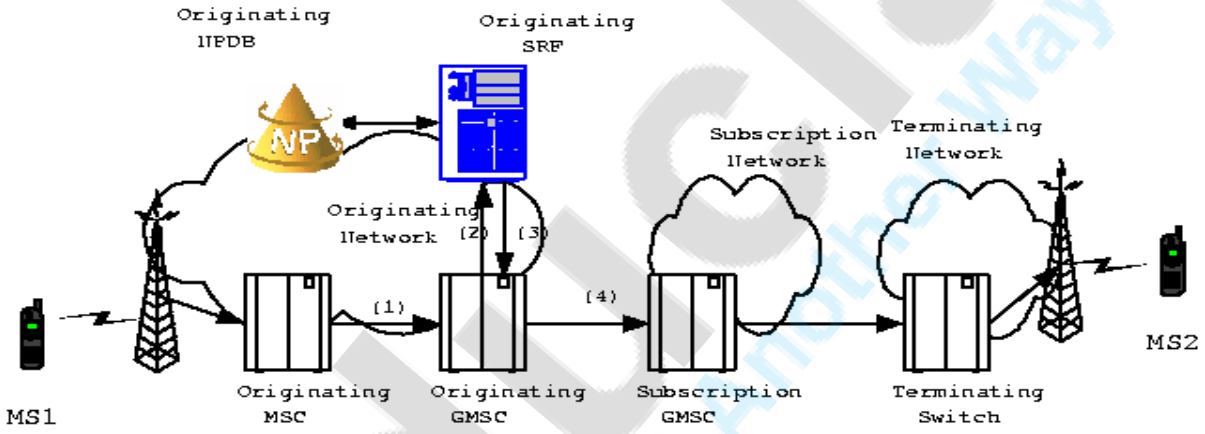
to authenticate/identify the MS during mobile network access such as location update and call origination, which is hidden from the mobile user. When a mobile user switches operators, a new MSISDN and IMSI pair is assigned to the user. When mobile number portability is introduced, a porting mobile user would keep the MSISDN (the ported number) while being issued a new IMSI. In other words, IMSI shall not be ported. When the ported number is no longer used, the number is returned to the NRH network. Note that lawful interception will be possible on a ported MSISDN.

Call Setup Scenario using NP :

Step 1: After calling party dials the MSISDN of MS2, the call is routed to the GMSC of the originating network.
Step 2: The GMSC queries SRF for the subscription network information of MS2.
Step 3: By consulting the NPDB, the SRF (Signal Relay Function)obtains the subscription network information, and forwards it to the originating GMSC.
Step 4: The originating GMSC routes the call to the subscription GMSC (i.e., GMSC of MS2). The call is then set up following the standard GSM procedure.



(a) The Originating Network is NOT the Subscription Network

The impact of number portability on mobile network is considered in three aspects:
Location Update, Mobile Call Origination, Mobile Call Termination.

Number Portability benefits :

- It gives subscribers the freedom to choose operators based on criteria like services, price, and customer service. Their freedom of movement is not influenced by the inconveniences and costs that come with changing numbers.
- It also makes it easier for operators to compete for customers, precisely because it eliminates a major barrier to churn - that is, reluctance to change numbers.
- Number portability has been a huge success around the world, because it helps to level the playing field, giving all operators more opportunities to grow their subscriber bases and revenues.

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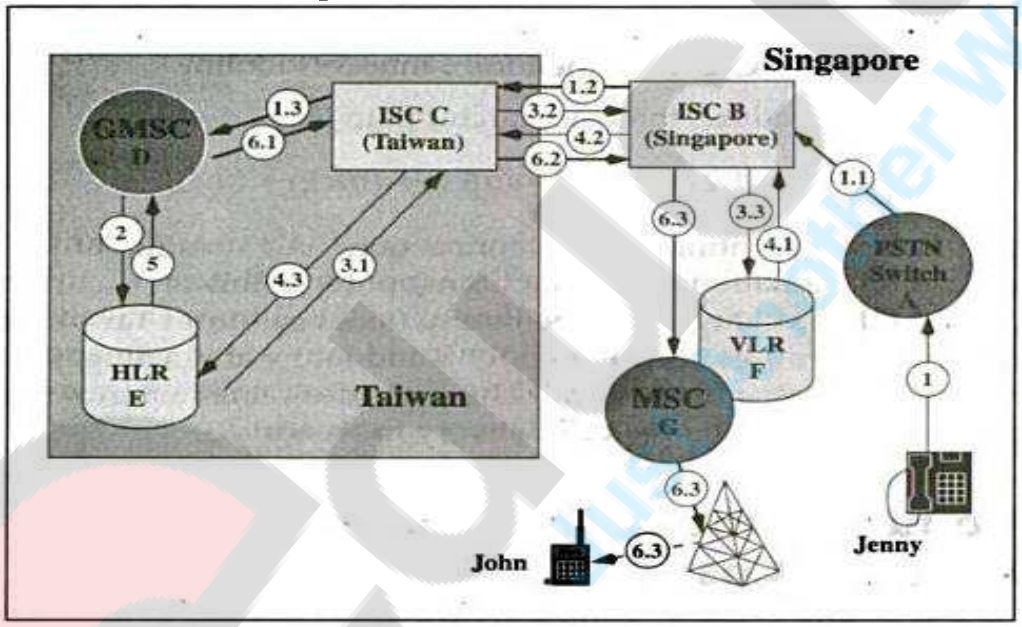
7. Short notes on International Roaming scenario

Ans:Roaming helps to ensure that a traveling wireless device is kept connected to a network without breaking the connection. GSM supports roaming services that allows a subscriber in a GSM network to receive telephony service when the user visits a different GSM network.
In current GSM international roaming implementations, call delivery to a GSM roamer results in one or call delivery to John:
Scenario 1: If a person in Taiwan calls John, the result is a local call and an international call. The caller is charged for an international call from Taiwan to Singapore.
Scenario 2: If the caller is from a third country (Hong Kong), the call delivery to John results in 2 international calls. The caller is charged for an international call from Hong Kong to Taiwan, and John is charged for an international call from Taiwan to Singapore.
Scenario 3: If the caller is in Singapore the call delivery results in 2 international calls, even though both Jenny and John are in Singapore! This scenario is in fact a special case of Scenario 2, and is referred as **tromboning**.
The tromboning effect in scenario 3 discourages call terminations to a GSM roamer.
International Call Set up Procedure



Consider the previous example where Jenny places a call to John, who has roamed from Taiwan to Singapore. The call setup message flow involves following steps:

1. John's GSM home system is in Taiwan, so Jenny first dials the international switch center access code (ISCA), then the country code (CC). Then she dials John's MSISDN. When switch A intercepts ISCA, the first portion of the dialed digits, it identifies the call as an international call, then sets up the call using the IAM message to Singapore's International Switch Center (ISC B). Based on the country code, ISC B

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routes the call to Taiwan's International Switch Center (ISC C). ISC C interprets the prefix of the remaining digits and sets up the voice trunk to GMSC D.

2. GMSC D queries HLR E to obtain the MSRN.
3. HLR E queries VLR F. The message travels between Taiwan and Singapore (3.1, 3.2, 3.3, 4.1, 4.2, and 4.3).
4. The MSRN is returned to GMSC D.
5. Based on the MSRN, GMSC D uses the IAM message to set up the trunk to MSC G, and therefore connects John.

In this call setup procedure, the voice circuit path is:
(1)-> (1.1) -> (1.2) -> (1.3) -> (6.1) -> (6.2) -> (6.3) which requires 2 international trunk connections. As a result, Jenny is charged for the international call from Singapore to Taiwan and John is charged for the international call from Taiwan to Singapore.

8. Short Notes on VoIP

Ans: Voice over Internet Protocol (VoIP) is a methodology and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet.

VoIP, is a technology that allows you to make voice calls using a broadband Internet connection instead of a regular (or analog) phone line.

Working

VoIP services convert your voice into a digital signal that travels over the Internet. If you are calling a regular phone number, the signal is converted to a regular telephone signal before it reaches the destination. VoIP can allow you to make a call directly from a computer, or a traditional phone connected to a special adapter. In addition, wireless "hot spots" in locations such as airports, parks, and cafes allow you to connect to the Internet and may enable you to use VoIP service wirelessly.

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A broadband (high speed Internet) connection is required. This can be through a cable modem, or high speed services such as DSL or a local area network. **A computer, adaptor, is required.** Some VoIP services only work over your computer or a special VoIP phone, while other services allow you to use a traditional phone connected to a VoIP adapter.

VoIP Components

The four most important VoIP components are:

- Signaling Gateway Controller
- Media Gateway
- Media Server
- Application Server

1. **Signaling Gateway Controller :**

As you might remember from my VoIP Essentials article, the Signaling Gateway Controller (SGC) is known as a "called agent" because of its call control function and is also commonly referred to as a "Media Gateway Controller" because of its Media Gateway control function.The SGC entity has multiple roles. It is the heart of VoIP platform; its main role is to connect the PSTN (public switched telephone network) world with the IP world.

2. **Media Gateway :**

The Media Gateway's main role is the transmission of voice packets using the RTP transmission protocol. When the media gateway is used in a converged PSTN/IP network it has extra functions to perform such as packetization, since it uses TDM trunks from the one side and IP trunks on the other.

3. **Media Server :**

A Media Server is used where added features are needed such as voicemail or video conferencing. Moreover, a media server is used when special tones or announcements need to be transmitted. Therefore, the media server has an important role within the VoIP architecture

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4. Application Server :

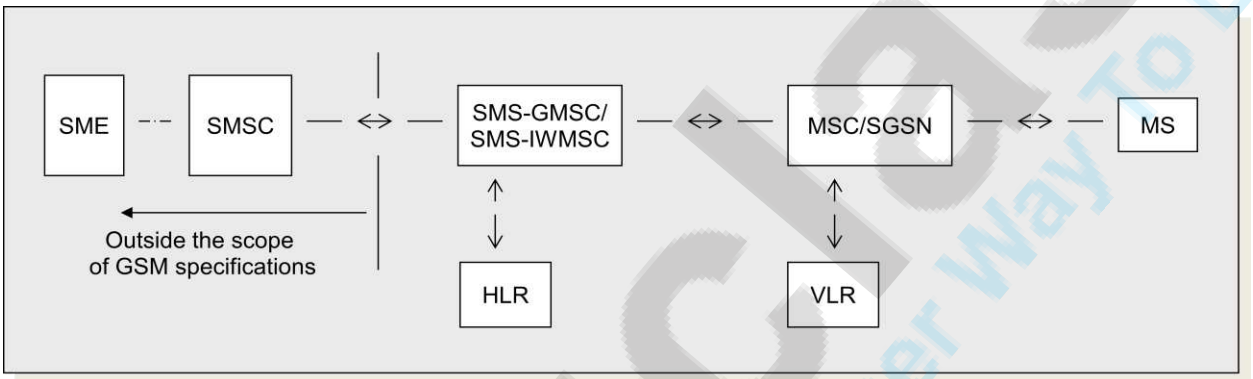
The major responsibility of an Application Server is to provide value-added services to the IP network. Global and customer specific services are provisioned here. Call characteristics and session specifications are influenced by the application server.

9. Explain the SMS architecture and how and SMS travels in case of mobile originating and mobile terminating Messaging

OR

SMS architecture in detail

Ans: SMS Network Architecture



Components:

Short Message Entity (SME) – sends or receives short messages

Short Message Service Centre (SC) – stores-and-forwards messages between the SME and the MS

Gateway MSC For Short Message Service (SMS-GMSC) - receives messages from the SC, interrogates the HLR for routing information and forward the messages to the MSC or SGSN

Home Location Register (HLR) - a database used for permanent storage and management of user/subscriber profiles

Inter-Working MSC For Short Message Service (SMS-IWMSC) - receives messages from the MSC or SGSN and forwards them to the SC

Mobile Service Centre (MSC) – From technical perspective MSC is just an ordinary Integrated Services Digital Network (ISDN) exchangeOne MSC can handles multiple BSCs and also interfaces with other MSC's (Using E-Interface). It also handles inter-BSC handoffs as well as coordinates with other MSC's for inter-MSC handoffs.

Visitor Location Register (VLR) - a database that contains temporary information about roaming subscribers. The MSC and the VLR are always on the same platform.

Serving GPRS Support Node (SGSN) – performs packet switching functions for mobile stations in a geographical area. The SGSN is used instead of the MSC when SMS info is transferred over GPRS.

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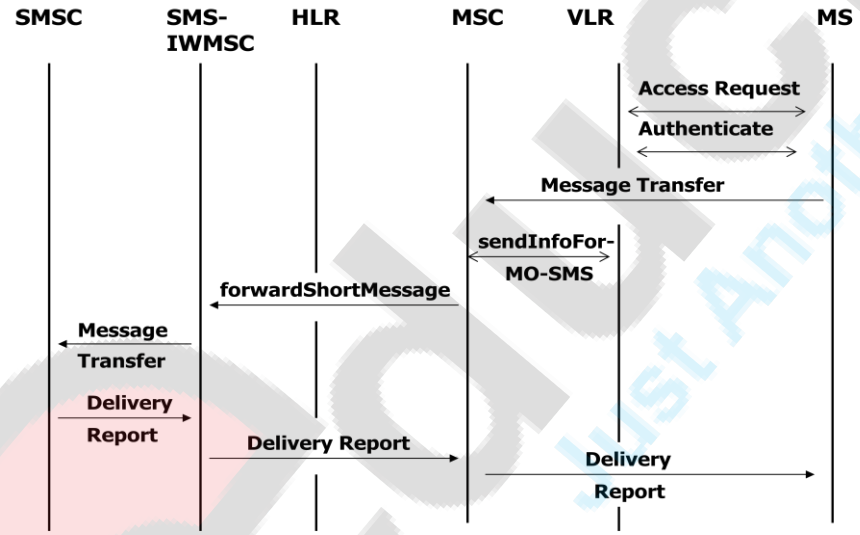
Mobile Station (MS) – a device on the mobile network capable of receiving and sending short messages

Working:

If a user sends a SMS to another user,the SMS first deliver from the MS which is know as Mobile Station A to SM-SC(Short Message Service Center) Via the Base Station System (BSS), and then it catch up to the Mobile Station center(MSC) and finally combine with InterworkingMSC(IW-MSC). If a recipient is not reachable, the SMSC queues the message for later retry.[45] Some SMSCs also provide a "forward and forget" option where transmission is tried only once. The use of Short Message Service Center (SM-SC) to carry ahead the SMS message to the GSM network through a definite GSM-MSC called the Short Message Service gateway MSC (SMS-GMSC). The SM-SC is allowed to link with several GSM networks and to several SM-GMSCs in a GSM network. The SMS-GMSC come across the contemporary MSC of the message acceptor and then step ahead the SMS message to that Mobile Station center, pursue the Global System for Mobile Communication (GSM) roaming protocol.The MSC then Publish the SMS through the Base Station System (BSS) to the destination MSB.

Mobile Originated



1. The mobile station transfers the short message to the MSC.

2. The MSC queries the VLR to verify that the message transfer does not violate the supplementary services invoked or the restrictions imposed on the subscriber.

3. The MSC sends the short message to the SMSC using the *forwardShortMessage* operation.

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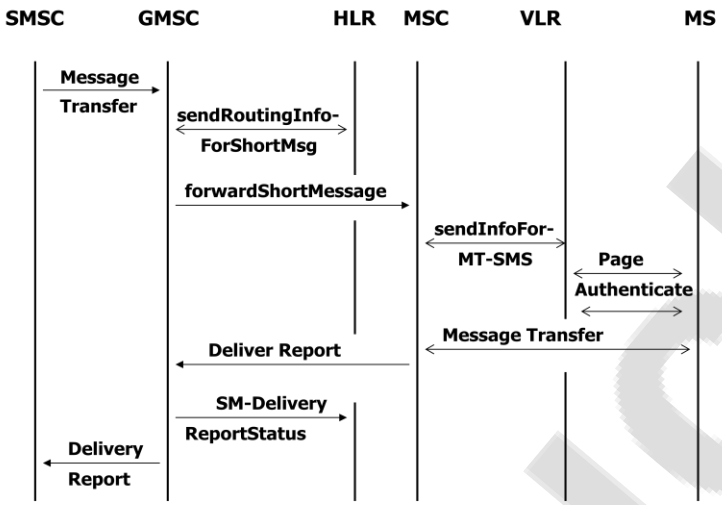
4. The SMSC delivers the short message to the SMC.

5. The SMSC acknowledges the successful outcome of the *forwardShortMessage* operation to the MSC.

6. The MSC returns the outcome of the short message operation to the mobile station.

Mobile Terminating



1..The Short message is transferred from SC to SMS-GMSC
2.SMS-GMSC queries the HLR(SRI) and receives the routing information for the mobile subscriber (SRI-ACK).
3. The SMS-GMSC sends the short message to the MSC using the forwardShortMessage operation(FSM).
4. The MSC retrieves the subscriber information from the VLR. This operation may include an authentication procedure.
5. The MSC transfers the short message to the mobile station.`
6. The MSC returns the outcome of the forwardShortMessage operation to the SMS-GMSC(FSM-ACK).
7. If requested by the SMC, the SMSC returns a status report indicating delivery of the short message

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