- It implements FDM. In pure FDMA, non overlapping frequency bands are assigned to users on a continuous time basis.
- FDMA is usually combined with TDMA (as in GSM); frequency allocation can now vary with time according to a certain pattern called the *hopping pattern*.
- In cellular networks, FDM is often used to provide the base station and the mobile station a simultaneous access to the medium. The two partners establish a duplex channel.
- The scheme itself is called as *Frequency Division Duplex (FDD)*. The mobile station communicates with the base station at one frequency whereas the base station communicates with the mobile host at another frequency.
- Thus, communication in two directions is now separated via two different frequencies.
- The frequency from the mobile station to the base station is called *uplink frequency* and the frequency from the base station to the mobile station is called *downlink frequency*.
- *Figure 3.5* shows the use of FDM in a GSM-900 MHz network.
  - All uplinks use the band 890.2 to 915 MHz.
  - All downlinks use the band 935.2 to 960 MHz.

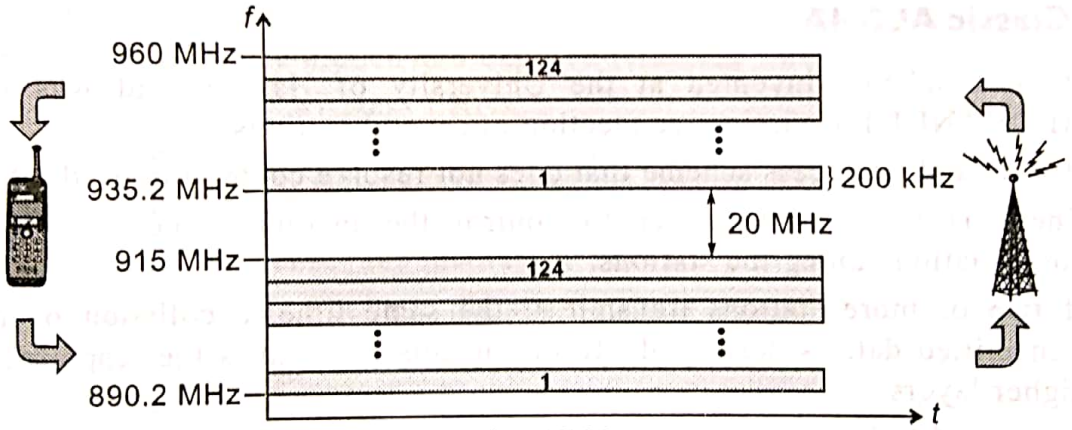



Fig. 3.5 : FDD in a GSM System

## 3.4 Time Division Multiple Access (TDMA) (V.IMP)

- It implements TDM. Different users can access the medium at different times.
- This is a more flexible scheme as compared to pure FDMA.
- In this mode, the receiver just has to tune in to the frequency at the right time.
- Almost all MAC schemes for wired networks like Ethernet, token ring, ATM, etc. work according to this principle.
- *Figure 3.4(b)* shows the basic idea of TDMA. Guard spaces of 3050 μs between time slots are commonly used in TDMA-based systems.
- The various types of TDM are discussed in following sections.

### 3.4.1 Fixed TDM (TDD) (IMP)

- *Figure 3.6* shows how fixed TDM patterns along with TDD can be used to implement multiple access in a DECT system.

Scanned by CamScanner

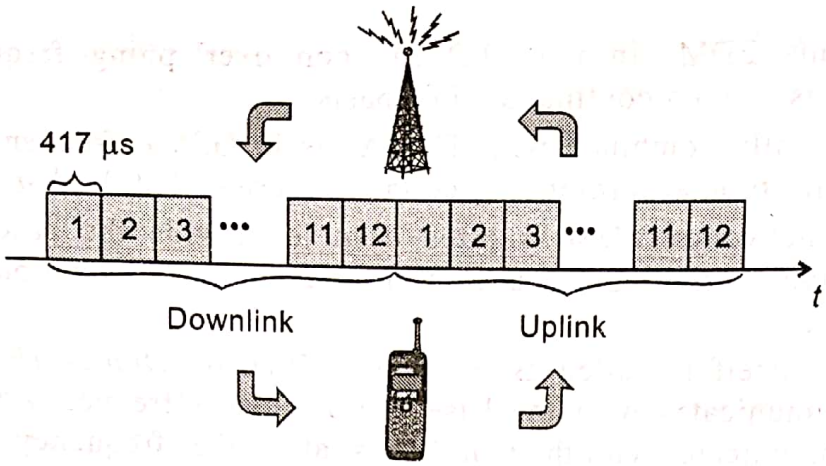



Fig. 3.6 : Fixed TDD Scheme Used in DECT

- In a *Time Division Duplex (TDD)*, different slots for uplink and downlink are assigned at the same frequency. Uplink and downlink are separated in time.
- As shown in *figure 3.6* the base station uses one of the 12 slots for uplink and the mobile station uses one of the 12 slots for downlink.
- This scheme however, wastes a lot of bandwidth and is not flexible.
- It is inefficient for asymmetric connections involving bursty traffic.

## 3.4.2 Classic ALOHA (IMP)

- It is a scheme invented at the University of Hawaii, and was used in the ALOHANET for wireless connection of several stations.
- It is a random access scheme that does not resolve contention on the MAC layer.
- There is no central arbiter to control the medium access and there is no coordination among the stations.
- If two or more stations transmit at the same time, a collision occurs and the transmitted data is destroyed. Resolving this problem is the responsibility of the higher layers.
- Classic ALOHA works fine for a light load, but the number of collisions increase drastically as the number of users increase.
- *Figure 3.7* shows the use of this scheme in case of three senders *A*, *B*, and *C*.

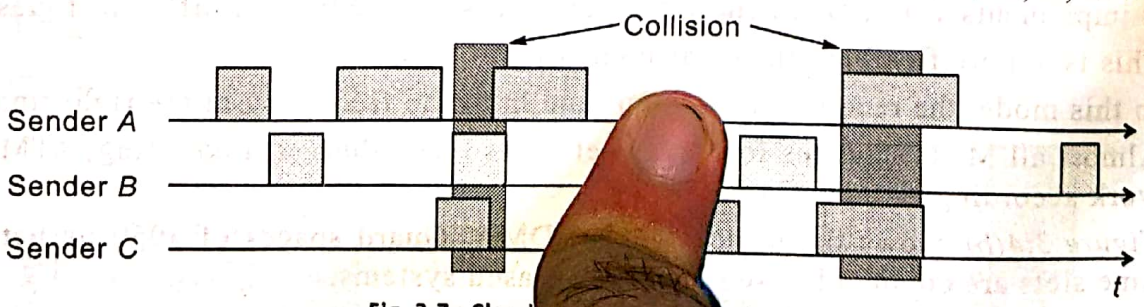



Fig. 3.7 : Classi Access

## 3.4.3 Slotted ALOHA

- This scheme is just a simple enh throughput of ALOHA from 18 %

Scanned by CamScanner

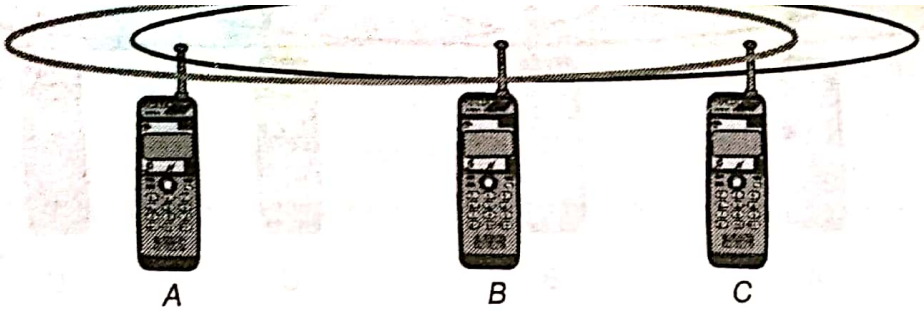



Fig. 3.3 : Near and Far Terminals

## 3.2 Space Division Multiple Access (SDMA) (IMP)

**Q.1. *What is SDMA ? How does it suit to mobile cellular systems ?*** **[Dec. 12] (5 M)**

**Note:** *Add points from section 3.6, table 3.1.*

Pg 78

- It implements SDM; it divides the available space into cells and further divides the cells into sectors. This allows for frequency reuse in different sectors by using directed antennas.
- Typically, SDMA is never used in isolation. It is always combined with some other scheme.
- New applications of SDMA use beam-forming antenna arrays, single users can be separated in space by focusing a single beam on them. This can improve the overall capacity of a cell tremendously.

## 3.3 Frequency Division Multiple Access (FDMA) (IMP)

- *Figure 3.4(a)* shows the basic idea of FDMA.

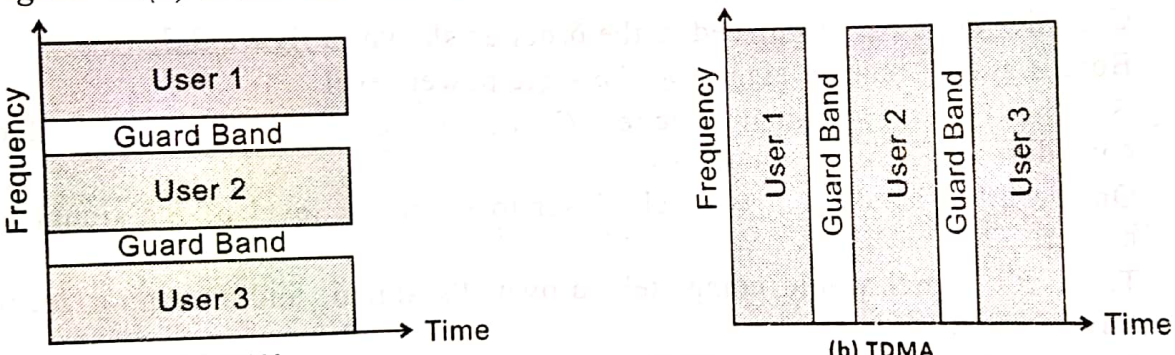



Fig. 3.4 : FDMA and TDMA

Scanned by CamScanner

- It implements FDM. In pure FDMA, non overlapping frequency bands are assigned to users on a continuous time basis.
- FDMA is usually combined with TDMA (as in GSM); frequency allocation can now vary with time according to a certain pattern called the *hopping pattern*.
- In cellular networks, FDM is often used to provide the base station and the mobile station a simultaneous access to the medium. The two partners establish a duplex channel.
- The scheme itself is called as *Frequency Division Duplex (FDD)*. The mobile station communicates with the base station at one frequency whereas the base station communicates with the mobile host at another frequency.
- Thus, communication in two directions is now separated via two different frequencies.
- The frequency from the mobile station to the base station is called *uplink frequency* and the frequency from the base station to the mobile station is called *downlink frequency*.
- *Figure 3.5* shows the use of FDM in a GSM-900 MHz network.
  - All uplinks use the band 890.2 to 915 MHz.
  - All downlinks use the band 935.2 to 960 MHz.

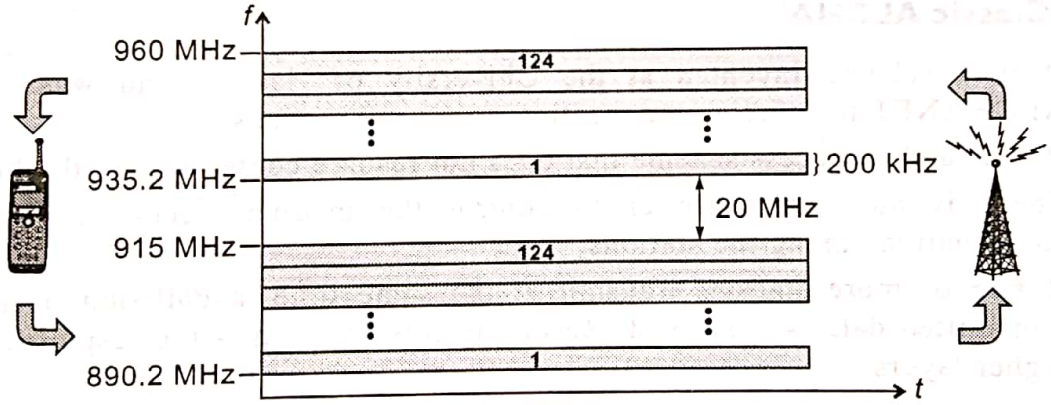



Fig. 3.5 : FDD in a GSM System

## 3.4 Time Division Multiple Access (TDMA) (V.IMP)

- It implements TDM. Different users can access the medium at different times.
- This is a more flexible scheme as compared to pure FDMA.
- In this mode, the receiver just has to tune in to the frequency at the right time.
- Almost all MAC schemes for wired networks like Ethernet, token ring, ATM, etc. work according to this principle.
- *Figure 3.4(b)* shows the basic idea of TDMA. Guard spaces of 3050 μs between time slots are commonly used in TDMA-based systems.
- The various types of TDM are discussed in following sections.

### 3.4.1 Fixed TDM (TDD) (IMP)

- *Figure 3.6* shows how fixed TDM patterns along with TDD can be used to implement multiple access in a DECT system.

Scanned by CamScanner

Fig. 3.8 : Slotted ALOHA Multiple Access

### 3.4.4 Carrier Sense Multiple Access (IMP)

- This is another improvement over the classic ALOHA.
- In this scheme, the senders sense the medium (carrier) before transmission. Transmission proceeds only if the medium is free. This reduces the probability of a collision.
- However, problems like hidden and exposed terminals still exist.
- CSMA is used in many wireless LANs.
- Some of the most common versions of CSMA are as follows :
  - **1- persistent CSMA**
    - A sender first senses the medium to check if it is free.
    - If the medium is free then the station starts transmission immediately.
    - If not, then the station continues to sense the medium and starts transmission AS SOON AS the medium becomes free. If a collision occurs then the station waits for a random amount of time and starts all over again.
    - The protocol is called *1-persistent because the host transmits with a probability of 1 whenever it finds the channel idle.*
  - **Non-persistent CSMA**
    - This scheme is typically, less greedy than the 1-persistent CSMA.
    - As in the above case, the sender first senses the medium to check if it is free.
    - If the medium is free then the station starts transmission immediately.
    - If the medium is not free, then it does not continue to sense the medium, instead, it waits for a random period of time and then senses the medium again.
    - The above step is repeated till the station finds the medium free.

Scanned by CamScanner

- **P-persistent CSMA**
  - It works as follows :

    **Step 1:** The station senses the medium.
    - If medium is idle then the station transmits a packet with probability $p$.
    - If a packet was transmitted then go to step 2.
    - If a packet was not transmitted or if the medium is busy wait for one time slot and repeat step 1.

    **Step 2:** In case a collision occurs, wait a random amount of time and then go to step 1.
- E.g. in a 0.5 persistent CSMA (i.e. $p = 0.5$), if the medium is idle then the station transmits only with a probability of 50%. If the packet is not sent then it tries again in the next time slot.
- **CSMA/CD**
  - Refer *section 3.1.*
- **CSMA/CA (CSMA with Collision Avoidance)**
  - The sender senses the medium. If medium is free then the sender transmits immediately.
  - If the medium is not free then a random back-off algorithm is used to decide when the sender should sense the medium again.

### 3.4.5 Demand Assigned Multiple Access (DAMA)

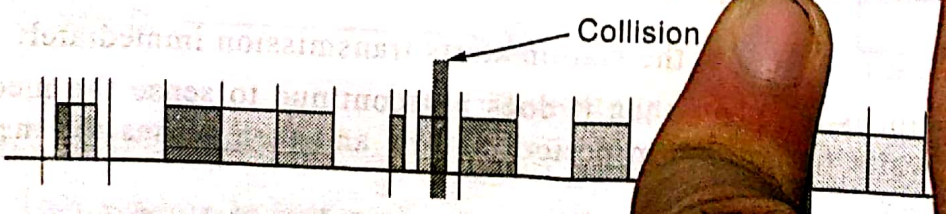
**(IMP)**

***Q.1. What are the benefits of reservation scheme ? How collisions are avoided during data transmission ? Explain DAMA scheme.***

**[May 08] (8 M)**

**Note:** *Refer section 3.4.6 and 3.4.7 also.*

- It is a scheme typically used in satellite systems. DAMA called as *Reservation ALOHA*.
- It is an explicit reservation scheme. During the contenti d ALOHA) phase, all the stations try to reserve the future time slots (re 0).
- During the transmission (reserved) phase, if a station has s time slot then no other station is allowed to transmit during
- It is important for all stations to keep the reservation list in time and, therefore, all stations must synchronize from t




Scanned by CamScanner

## 3.5 Code Division Multiple Access (CDMA) (VV.IMP)

**Q.1.** ***Write a shot note on CDMA.*** [Dec. 04, May 05, May 06, Dec. 06, May 07, Dec 07, May 10, May 12] (10 M)

**Q.2.** ***What are the advantages and disadvantages of using CDMA for a cellular network ?*** [May 08] (8 M)

**Note:** *Just pick the points pertaining CDMA from section 3.6. Also add points from chapter-2, section 2.5.5.*

- It implements CDM; this scheme uses different codes for different users allowing all the users to access the medium at the same time without interference.
- *Figure 3.15* illustrates the basic CDMA concept.
- The main issue in case of CDMA is to find the right codes to separate the users. A code used for any user should satisfy two conditions,

Scanned by CamScanner

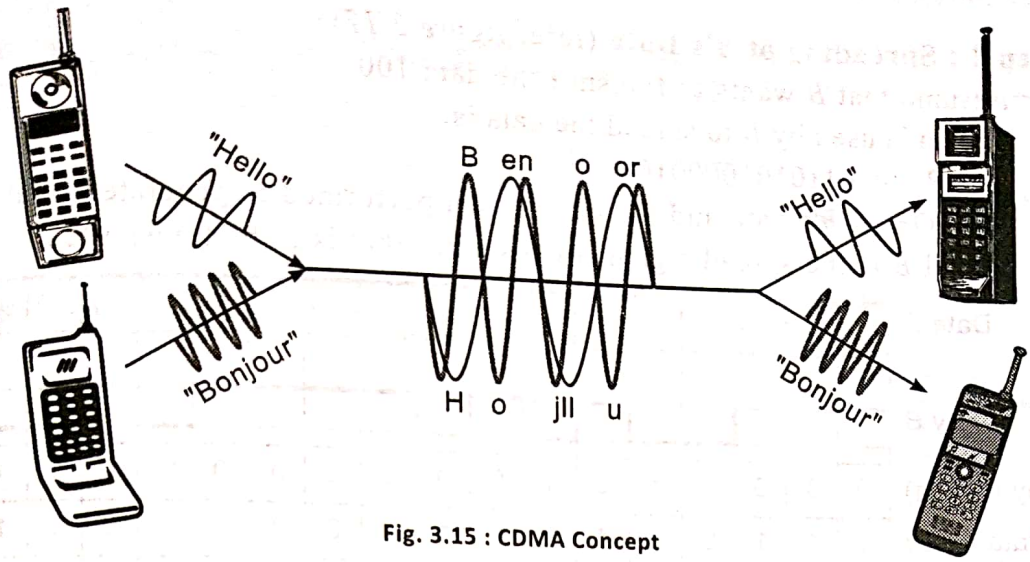



Fig. 3.15 : CDMA Concept

- It should have a good auto-correlation.
- It should be orthogonal to other codes i.e. its dot product with other codes should be zero (practically, as low as possible).

▸ Consider two senders *A* and *B*, sending their data using CDMA.

▸ The entire operation can be explained in five steps,

**Step 1 : Spreading of *A*'s Data** (refer *figure 3.16*)

- Assume that *A* wants to transmit the data 101.
- The code used by *A* to spread the data is,
  key *A* = 010100100010110011.
- An XOR of *A*'s data and *A*'s key is then performed to generate the signal *A*.
- Note that the result of an XOR operation is 1, if the inputs are different, and it is 0 if the inputs are same i.e., (1 XOR 0) = 1, (0 XOR 1) = 1, (0 XOR 0) = 0 and (1 XOR 1) = 0.
- Signal *A* is the spread signal (of *A*'s data) that is to be transmitted.

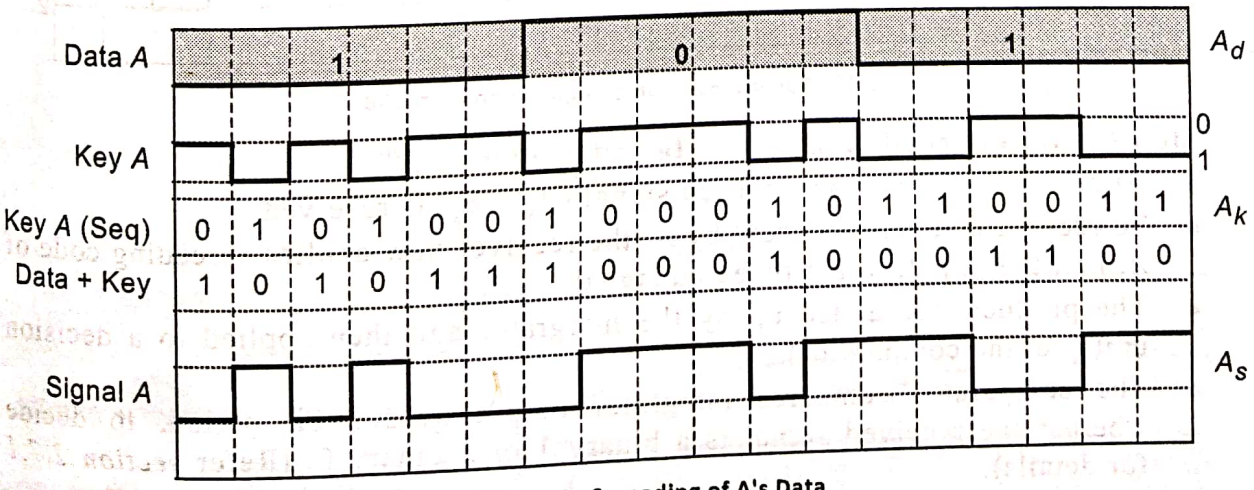



Fig. 3.16 : Spreading of A's Data

Scanned by CamScanner

**Step 2 : Spreading of *B*'s Data** (refer *figure 3.17*)

- Assume that *B* wants to transmit the data 100.
- The code used by *B* to spread the data is,
  Key *B* = 000110101000010111.
- An XOR of *B*'s data and *B*'s key is then performed to generate signal *B*.
- Signal *B* is the spread signal (of *B*'s data) that is to be transmitted.

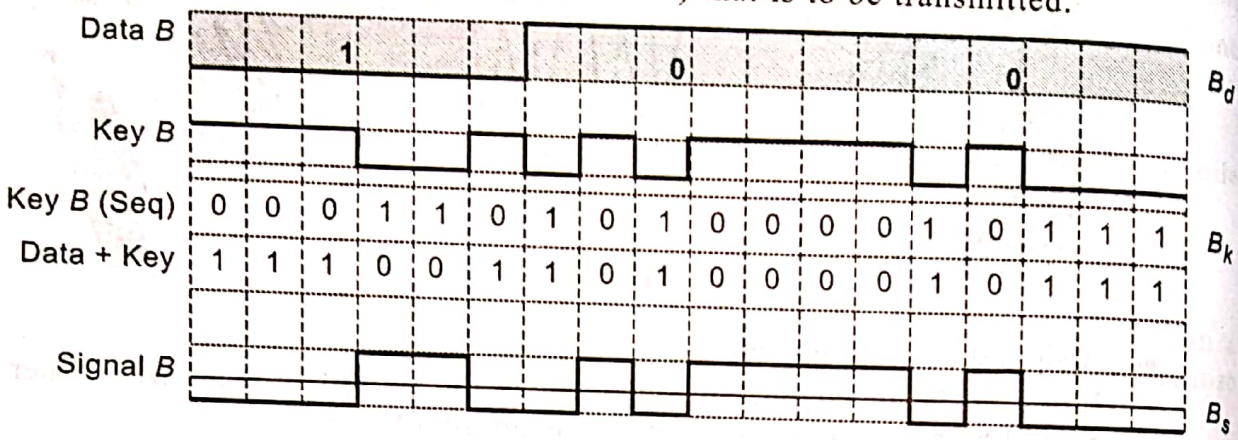



Fig. 3.17 : Spreading of B's Data

**Step 3 : Superimposition of Signal *A* and Signal *B*** (refer *figure 3.18*)

- As signal *A* and signal *B*, both, are transmitted at the same time at the same frequency they will get superimposed on each other.

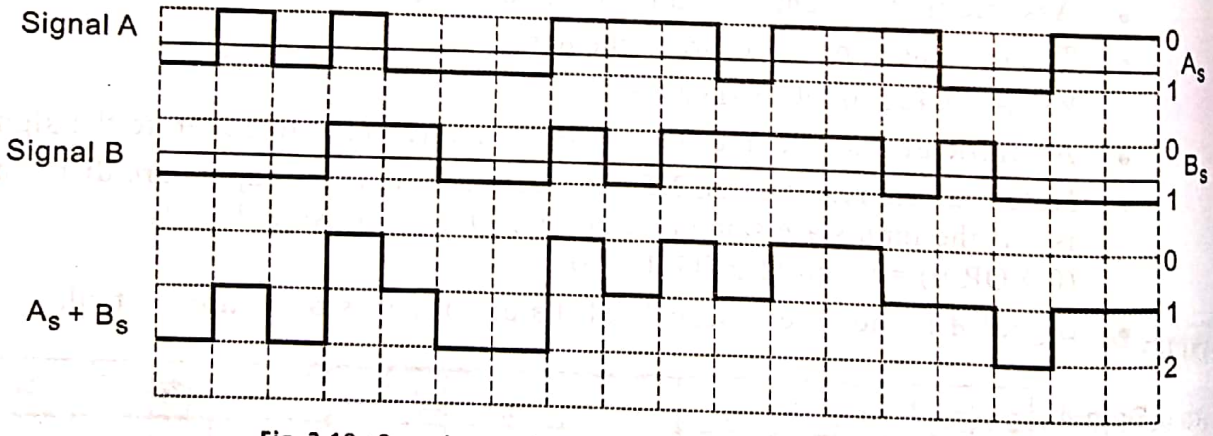



Fig. 3.18 : Superimposition of Signal A and Signal B

**Step 4 : Reconstruction of *A*'s Data** (refer *figure 3.19*)

- At receiver's side, superimposed signal ($A_s + B_s$) is received.
- To recover original data sent by *A*, the receiver now applies spreading code of *A*, i.e., the key *A*, to the received signal.
- The products are added up by the integrator and then applied to a decision unit (i.e. the comparator).
- The comparator compares integrator output over a bit period, to decide whether the received signal is a binary 1 or a binary 0. (Refer *section 2.7.1* for details).
- Thus, as we can see, comparator output is same as original data.

Scanned by CamScanner

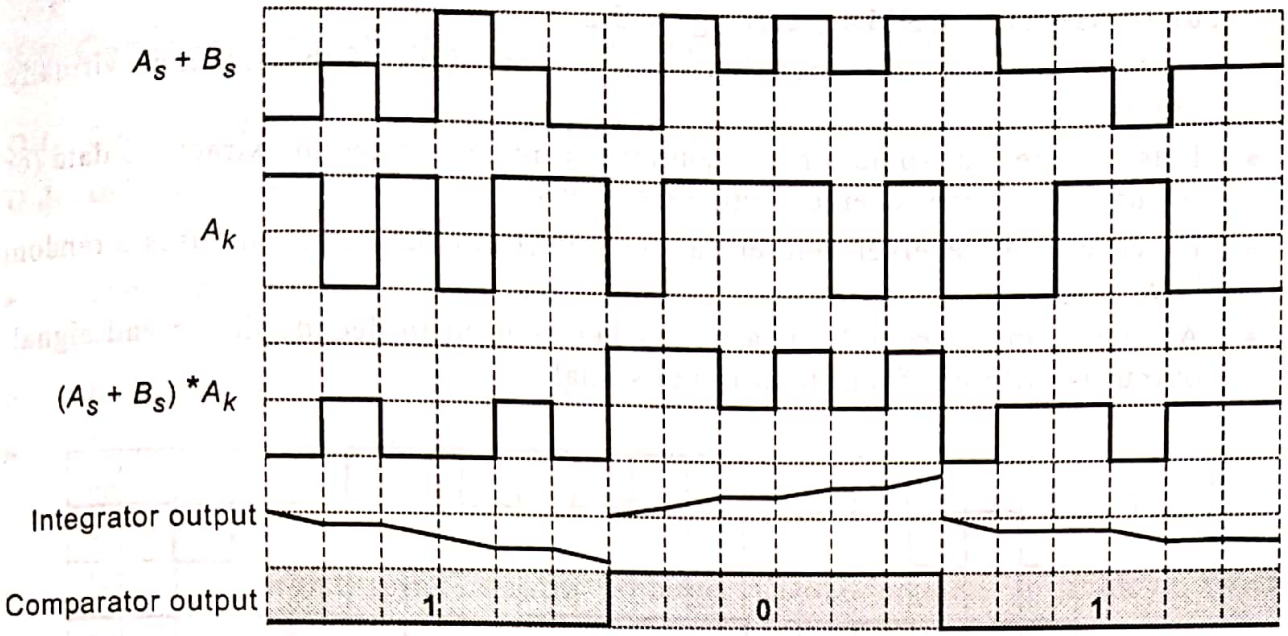



Fig. 3.19 : Reconstruction of A's Data

**Step 5 : Reconstruction of *B*'s Data** (refer *figure 3.20*)

- At receiver's side, superimposed signal $(A_s + B_s)$ is received.
- To recover original data sent by $B$, the receiver now applies spreading code of $B$, i.e., the key $B$, to the received signal.
- The products are added up by the integrator and then applied to a decision unit (i.e. the comparator).
- The comparator compares integrator output over a bit period, to decide whether the received signal is a binary 1 or a binary 0. (Refer *section 2.7.1* for details).
- Thus, as we can see, comparator output is same as original data.

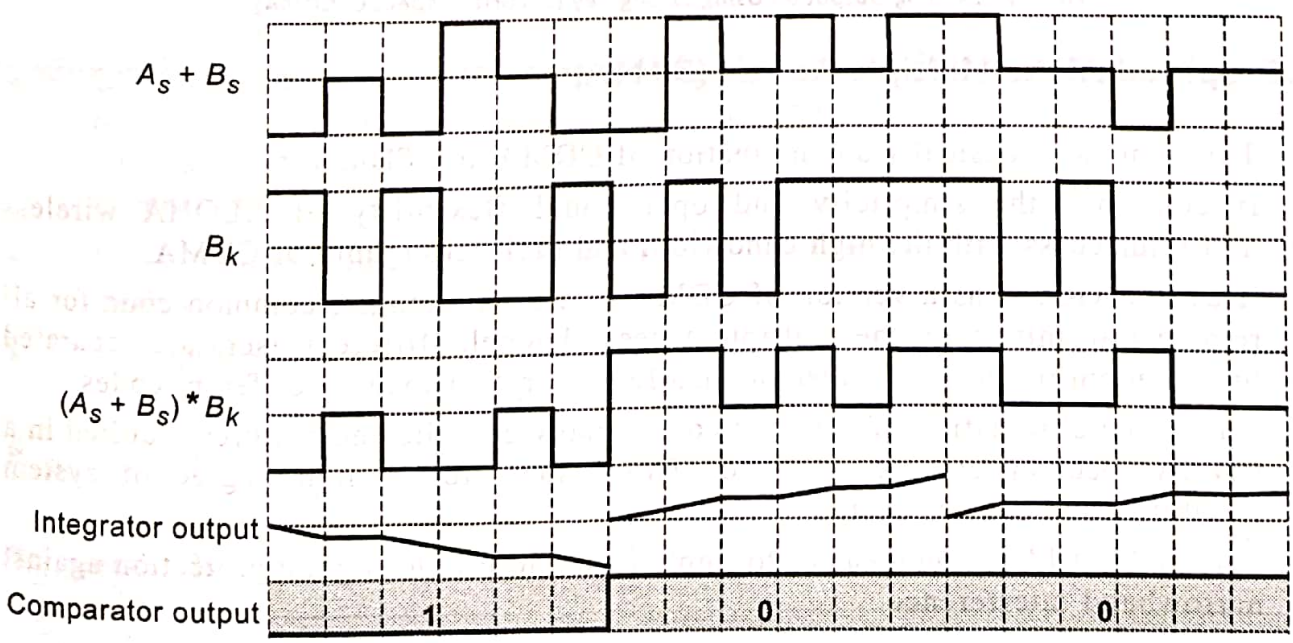



Fig. 3.20 : Reconstruction of B's Data

Scanned by CamScanner

- **Security Aspect of CDMA** (refer *figure 3.21*)
  - Without knowing the spreading code, Despreading of the signal is virtually impossible.
  - Lets assume that some other unauthorized receiver tries to extract *A*'s data (or *B*'s data) from the received signal ($A_s + B_s$).
  - However, this receiver neither has the key *A* nor the key *B* and uses a random key.
  - As shown in *figure 3.21*, if a wrong key is used to decode the spread signal, output is different from the original signal.

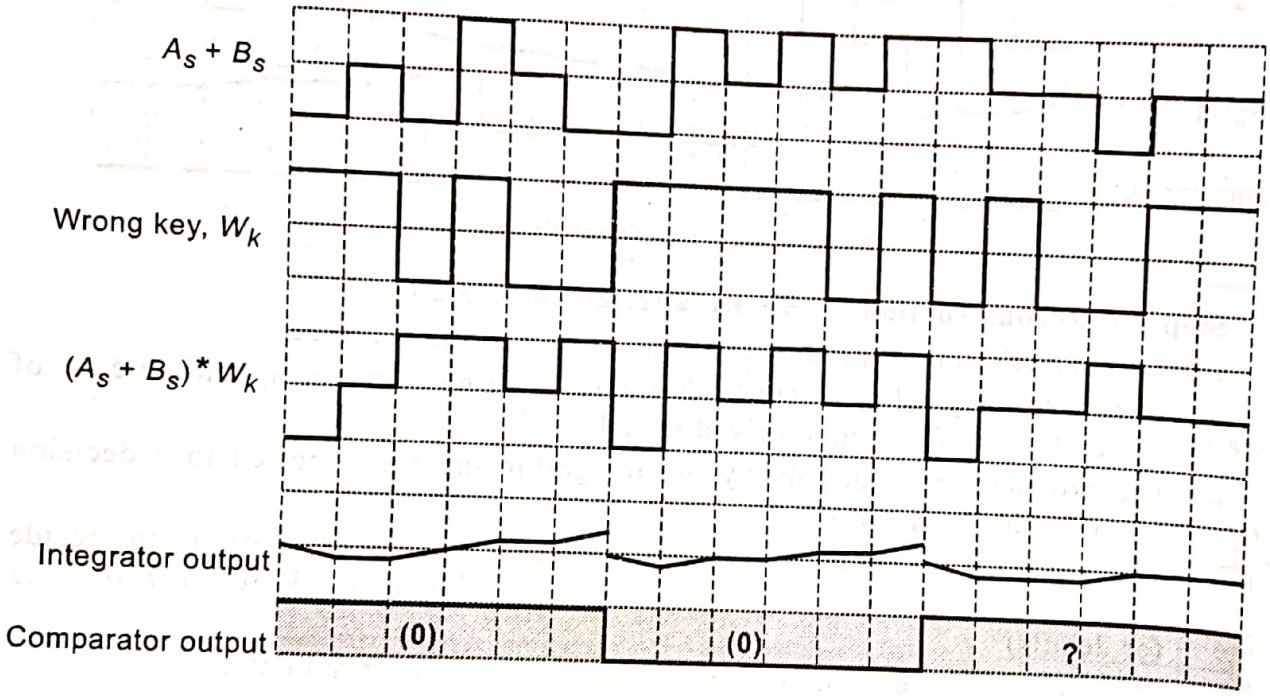



**Fig. 3.21 : Wrong Output on Using Wrong Key (Security Aspect of CDMA)**

## 3.5.1 Spread Aloha Multiple Access (SAMA)

- This scheme is basically a combination of CDMA and TDMA.
- It combines the simplicity and operational flexibility of ALOHA multiple access with the high bandwidth and high throughput of CDMA.
- It can be viewed as a version of CDMA that uses a single, common co remote transmitters in the multiple-access channel. Different users ar by a random timing mechanism as in ALOHA, rather than by different
- Due to the elimination of multiple codes, many complicated features r CDMA receiver can be removed. This allows for a high degree flexibility and ease of design.
- Spread ALOHA is much easier to implement and provides good protecti narrowband interference.

Scanned by CamScanner

- **Advantages**
  - Simple.
  - Ready to use.
  - Constant Quality.
  - Only software updates required.
- **Disadvantages of HSCSD**
  - Not suitable for computer data that is typically asymmetrical.
  - It still uses connection oriented mechanisms of GSM.
  - Once a channel has been reserved by a user, it is not available to other users.
  - This leads to blocking of the channels.

### 5.3.2 General Packet Radio Service (GPRS)

**Q.1.** ***What are the reasons for delay in GSM system for packet data traffic ? Draw and explain the protocol architecture of GPRS.*** **[May 05, Dec. 07] (10 M)**

**Q.2.** ***Explain GPRS architecture and show the protocol architecture of the transmission plane for GPRS.*** **[Dec. 08, May 09] (10 M)**

**Q.3.** ***Which components are new in GPRS as compared to GSM ? What is their purpose ?*** **[Dec. 10] (5 M)**

**Q.4.** ***How much of the original GSM network does GPRS need ? Which elements of the network perform the data transfer ?*** **[May 12] (5 M)**

**Q.5.** ***Write short note on GPRS.*** **[Dec. 12] (5 M)**

- GPRS allows mobile users to access value-added WAP services and other external packet switched networks such as the Internet or corporate intranets. (*Figure 5.23*)
- The GPRS network acts in parallel with the GSM network, GSM-BSS provides the radio interface whereas the GPRS core network handles mobility and access to external packet networks and services.

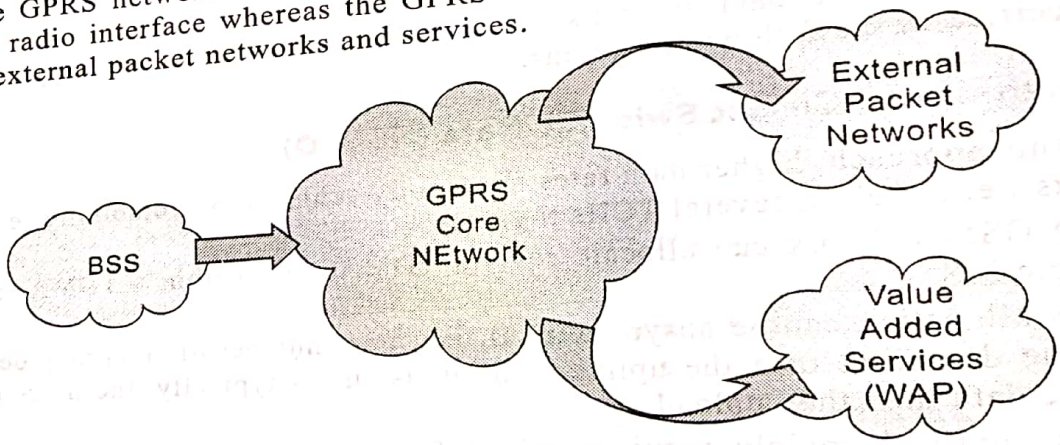



**Fig. 5.23 : GRPS System**

- Unlike GSM data services and HSCSD, charging in GPRS is based on the volume of data exchanged and not on the connection time itself.

Scanned by CamScanner

- Some features of a GPRS network are as follows:
  - The GPRS network must use as much of the existing GSM infrastructure with the smallest number of modifications to it.
  - GPRS should be able to support one or more packet-switched connections thus allowing users to have multiple data sessions.
  - GPRS must support different Quality of Service (QoS) as per user requirement.
  - GPRS network architecture has to be compatible with future 3rd and 4th generation mobile communication systems.
  - It should be able to support both point-to-point and point-to-multipoint data connections.
  - It should provide secure access to external networks.
- Delay in a GPRS network is mainly because of
  - Channel access delay
  - Coding mechanisms required for error correction.
  - Transfer delays in the fixed and wireless part of the GPRS network.
- However, GPRS does not cause additional delay by buffering packets for a long time. It tries to forward the packets as soon as possible.
- **Advantages of GPRS**
  - Very flexible.
  - Fully packet oriented and suitable for bursty internet traffic. Provides a much cheaper packet transfer service to the users.
  - Better quality of data services measured in terms of reliability, response time, and features available.
  - No connection needs to be set up prior to data transfer.
  - All GPRS services can be used in parallel to the conventional services provided by GSM.
- **Disadvantages of GPRS**
  - The real available data rates heavily depend on the network load as GPRS typically uses only the idle time slots.
  - Additional network elements are required to implement GPRS. This requires new software as well as hardware and thus increases the overall investment.
  - GPRS exhibits a large jitter (up to several 100 ms) as compared to fixed networks. This can degrade the performance of the interactive user applications used on top of GPRS.

### 5.3.2.1 GPRS System Architecture (V.IMP)

***Q.1. How much of the original GSM network does GPRS need ? Which elements of the network performs the data transfer ?*** **[Dec. 05, May 11] (5 M)**

***Q. [illegible] and explain architecture of GPRS system.*** **[Dec. 11, May 12] (10 M)**

Scanned by CamScanner

- *Figure 5.24* describes the architecture of GPRS. The various elements are discussed below:

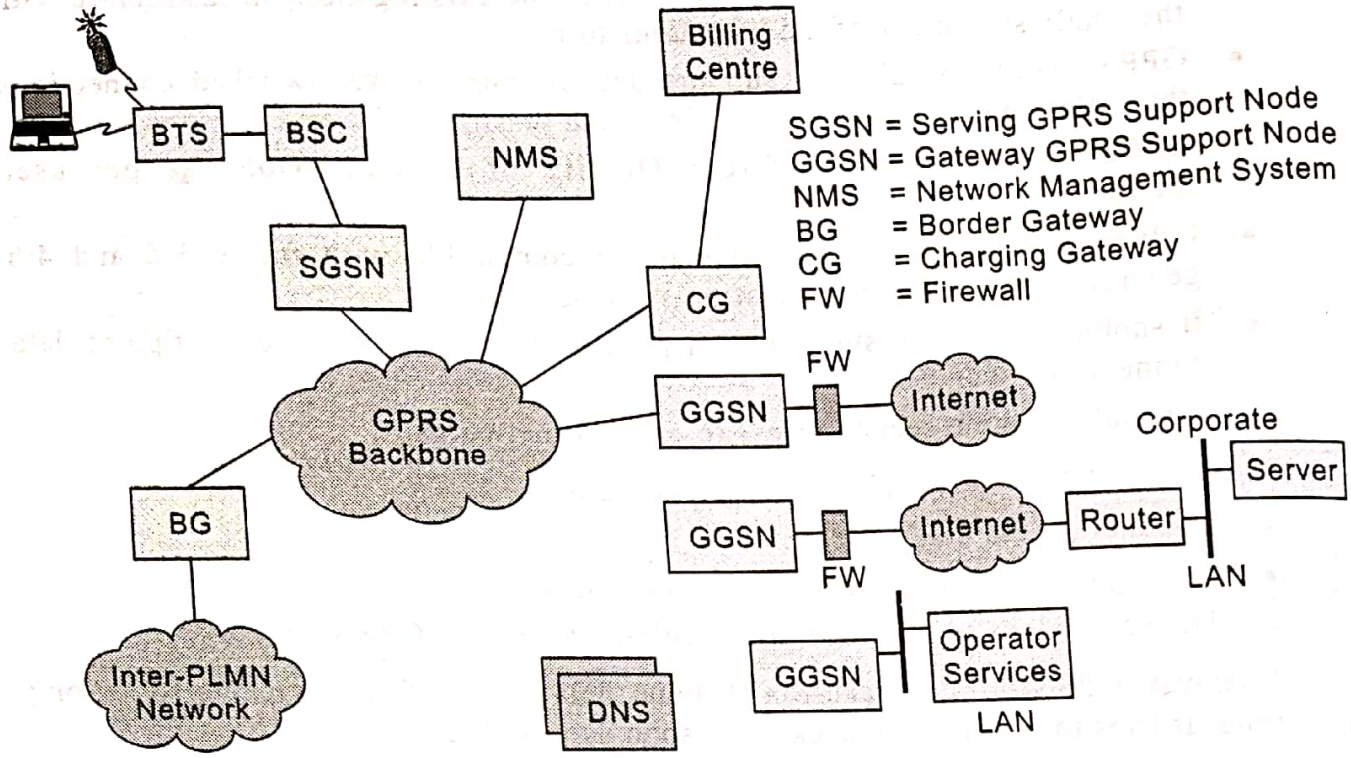



Fig. 5.24 : GPRS Architecture

- **Packet Control Unit (PCU)**
  - PCU separates the circuit switched and packet switched traffic from the user and correspondingly forwards them to the GSM and GPRS networks.
  - Frame Relay interconnects PCU to the GPRS core.
  - PCU performs most of the radio resource management functions of the GPRS network.
  - PCU can either be located in the BTS, BSC, or some other point between MS and MSC.

- **Serving GPRS Support Node (SGSN)**
  - SGSN is the most important element of the GPRS network and is equivalent to MSC of the GSM network. There must be at least one SGSN in a GPRS network.
  - SGSN has the following functions:
    - Protocol conversion (e.g. IP to FR)
    - Data compression
    - User Authentication
    - Mobility management
    - Routing of data to the relevant GGSN when a connection to an external network is required.
    - Collection of charging data pertaining to the use of GPRS users.

Scanned by CamScanner

**Gateway GPRS Support Node (GGSN)**

- GGSN is the gateway to external networks. From the external network's point of view, GGSN is simply a router to an IP sub-network.
- Each and every connection to a fixed external data network has to go through a GGSN.
- GGSN also acts as the anchor point when a subscriber moves to another SGSN during roaming.
- There are usually two or more GGSNs in a network for redundancy purposes, and they back up each other in case of failure.
- The functions of a GGSN are as follows :
  - Routing mobile-destined packets coming from external networks to the relevant SGSN and vice versa.
  - Interface with external IP networks and deal with security issues.
  - Allocates dynamic or static IP addresses to MS either by itself or with the help of a DHCP.
  - Involved in the establishment of tunnels with SGSN and with other external networks and VPN.
  - Collection of charging data pertaining to the use of GPRS users.

**Border Gateway (BG)**

- BG provides a direct GPRS tunnel between the GPRS networks of different operators.
- BG offers higher security by allowing data transfer between operators via the inter-PLMN data network instead of using the public intranet.
- It essentially allows a roaming subscriber to connect to home intranet through the home GGSN via the visiting PLMN network.

**Charging Gateway (CG)**

- As GPRS offers connectionless service to users, charging has to be based on the volume, destination, QoS, and other parameters of a connectionless data transfer.
- GPRS charging data referred as *Charging Data Records (CDRs)* are generated by all SGSNs and GGSNs in a network.
- Charging Gateway (CG) collects all of these records, sorts them, processes it, and passes it on to the Billing System.
- A protocol called *GTP prime (GTP')* is used for the transfer of data records between GSNs and the Charging Gateway.

### 5.3.2.2 GPRS Protocol Architecture

- A GPRS network introduces many new protocols to transfer user data in a reliable and secure way.

Scanned by CamScanner

### 5.3.3 Enhanced Data Rates for Global Evolution (EDGE)

- EDGE is a set of radio based high-speed mobile data standards. A technology that gives Global System for Mobile Communications (GSM) the capacity to handle services for the third generation of mobile network.
- EDGE was first proposed to *European Telecommunications Standards Institute* (ETSI) in Europe, as an evolution of GSM at the beginning of 1997.
- EDGE was initially developed for mobile network operators who failed to win *Universal Mobile Telephone System* (UMTS) spectrum. EDGE will allow these operators to stay competitive in wireless data markets by offering enhanced speeds.
- EDGE enables services like multimedia emailing, Web infotainment and video conferencing to be easily accessible from wireless terminals.
- EDGE uses the same TDMA (Time Division Multiple Access) frame structure, logic channel and 200 kHz carrier bandwidth as the GSM networks and hence it does not require new network elements, allowing existing cell plans to remain intact.
- EDGE uses high-level modulation in 200 kHz TDMA and is based on plug-in transceiver equipment.
- EDGE increases the HSCSD and GPRS data rates by up to three fold.
- Accordingly, these higher speed data services are referred to as EGPRS (Enhanced GPRS) and ECSD (Enhanced Circuit Switched Data).
- **Enhanced GPRS (EGPRS)**
  - (E)GPRS is an ideal bearer for any packet switched application such as an Internet connection.
  - From the end user's point of view, the EGPRS network is a wireless Internet sub-network.
  - Each user is allocated an IP address.

Scanned by CamScanner

- Typical EGPRS applications are:
  - E-mail
  - Web browsing
  - Enhanced short messages
  - Video services
  - Document and information sharing
  - VoIP

➤ **Enhanced Circuit Switched Data (ECSD)**

- Unlike e-mail and web that can run on non transparent services, some applications, such as fax and video, require a transparent service (constant bit rates).
- Typical ECSD applications are:
  - E-mail download and upload
  - File transfer
  - Real-time applications demanding a constant bit rate and transmission delay
  - Time-critical wireless imaging
  - Video on demand
  - Live video streaming.

➤ **Advantages of EDGE**

**(a) For the Operator**

- **Migration to Wireless Multimedia Services**
  - The operator can increase data revenues by offering attractive new types of applications to end users.
- **Improved Customer Satisfaction**
  - Increased data capacity and higher data throughput will decrease response times for all data services, thus keeping end users satisfied and connected.
  - Possibility of early market deployment of third generation type applications.
- **Quick Network Implementation**
  - EDGE will not require new network elements and EDGE capability can be introduced gradually to the network.

**(b) For the End User**

- Improved quality of service
- Personal multimedia services
- Potentially lower price per bit

## 5.4 Third Generation Systems

***Q.1. List the services offered by 3G mobile systems. Discuss the architecture of wireless local loop (WLL).*** **[Dec. 10] (10 M)**

**Note:** *Also refer section 5.5.*

Scanned by CamScanner

## 5.6.3 UMTS (V.IMP)

**Q.1.** ***Write short note on UMTS.*** **[Dec. 07, Dec. 09] (10 M)**

**Q.2.** ***Draw and explain the UMTS core network together with a 3G RNS and 2G BSS.*** **[May 11] (10 M)**

**Q.3.** ***Write short note on UMTS architecture and its domain.*** **[May 12] (5 M)**

- UMTS stands for *Universal Mobile Telecommunication System*. It is the European proposal for IMT-2000 and is standardized by ETSI.
- Initially proposed by ETSI, UMTS represents an evolution from the second generation GSM system to a third generation system.
- UMTS forum was then set up by a number of telecom operators, manufacturers, national governments, and other organizations.
- Its aim is to define a common strategy and policy for the development and implementation of UMTS and combining personal communications with multimedia services and applications built on existing fixed and mobile infrastructures.

Scanned by CamScanner

### 5.6.3.1 UMTS Architecture (V.IMP)

**Q.1. *Explain the system architecture of UMTS.*** **[Dec. 04] (10 M)**

**Q.2. *Explain UMTS architecture and its domains.*** **[Dec. 10] (10 M)**

- A very simplified UMTS reference architecture is shown in *figure 5.32*.

Fig. 5.32 : UMTS Reference Architecture

- The components of the UMTS architecture are explained as follows :

- **Core Network (CN)**
  - It communicates with UTRAN via the $I_u$ interface. This interface is similar to the *A* interface (between BSC and MSC) used in GSM.
  - It is responsible for the following functions:
    - Inter-system handover.
    - Gateways to other networks like ISDN or PSTN.
    - Location management.

- **Universal Terrestrial Radio Access Network (UTRAN)**
  - It handles cell level mobility and comprises of many *Radio Network Subsystems* (RNS).
  - It is connected to the *User Equipment* via the *Radio interface* $U_u$. This interface is comparable to the $U_m$ interface (between MS and BTS) used in GSM.
  - The function of RNS include -
    - Admission control.
    - Congestion control.
    - System information broadcasting.
    - Radio channel encryption and decryption.
    - Radio network configuration.
    - Channel quality measurements.
    - Radio carrier control.
    - Data transmission over the radio interface.
    - Channel coding.
    - Access control.
    - Handover control.
    - Radio resource management.

- **User Equipment (UE)**
  - This consists of the equipment that the subscriber uses to connect to the UMTS system.

Scanned by CamScanner

- The user equipment also contains SIM whose functions are similar to those in GSM.

➤ The simplified architecture of *figure 5.32* is further divided into a number of domains. *Figure 5.33* shows the various domains.

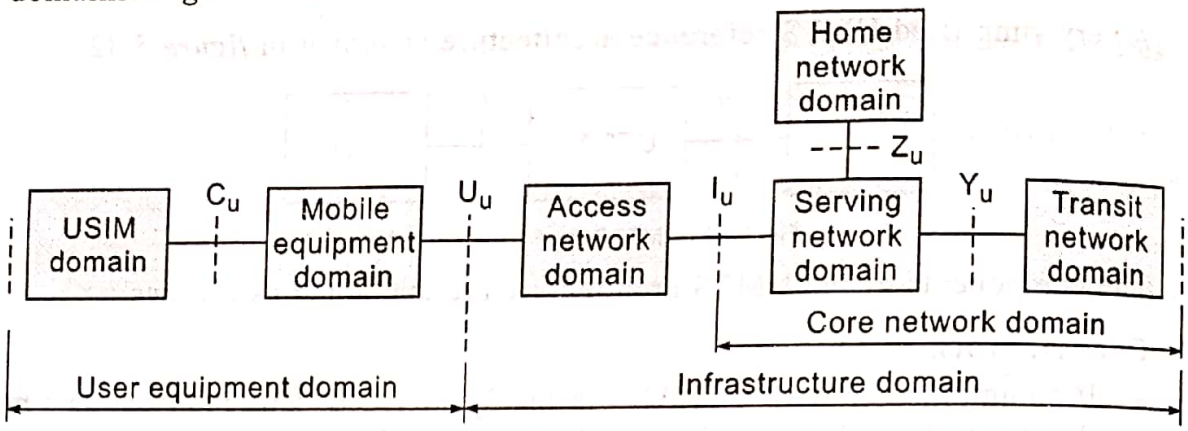



**Fig. 5.33 : UMTS Domains and Interfaces**

➤ **User Equipment Domain**

- It is assigned to a single user and is responsible for all the functions that are needed to access the UMTS services.
- It is further divided into,

➤ **USIM Domain**

- It consists of the *Subscriber Identity Module (SIM)* that performs authentication of the user and various other functions like encryption and decryption.
- USIM also stores all the user related data necessary for UMTS.
- USIM typically, belongs to a service provider.

➤ **Mobile Equipment Domain**

- The end device itself is in this domain.
- The mobile equipment contains the USIM.

➤ **Infrastructure Domain**

- This domain is shared among all users. It offers UMTS services to all the authenticated users. It consists of,

➤ **Access Network Domain**

- It contains all the Radio Access Networks (RANs).

➤ **Core Network Domain**

- It contains the access network independent functions.
- This domain can be separated into three domains, each of which performs a specific task.

➤ **Serving Network Domain**

- It comprises of all the functions that are currently used by the user to access the UMTS services.

Scanned by CamScanner

- **Home Network Domain**
  - It comprises of all the functions related to the home network of the user.
  - Also responsible for location management.
- **Transit Network Domain**
  - This is an optional domain.
  - It is necessary only when user cannot directly reach its home network.

Scanned by CamScanner