Topic 3 Notes

3.1 Introduction

Mobile Computing: A technology that allows transmission of data, via a computer, without having to be connected to a fixed physical link. Mobile voice communication is widely established throughout the world and has had a very rapid increase in the number of subscribers to the various cellular networks over the last few years. An extension of this technology is the ability to send and receive data across these cellular networks. This is the principle of mobile computing. Mobile data communication has become a very important and rapidly evolving technology as it allows users to transmit data from remote locations to other remote or fixed locations. This proves to be the solution to the biggest problem of business people on the move - mobility.

3.2 Public switched telephone network

The public switched telephone network (PSTN) is the network of the world's public circuit switched telephone networks. It consists of telephone lines, fiber optic cables, microwave transmission links, cellular networks, communications satellites, and undersea telephone cables, all inter-connected by switching centers, thus allowing any telephone in the world to communicate with any other. Originally a network of fixed-line analog telephone systems, the PSTN is now almost entirely digital in its core and includes mobile as well as fixed telephones.

The technical operation of the PSTN utilizes standards created by the ITU-T. These standards allow different networks in different countries to interconnect seamlessly. There is also a single global address space for telephone numbers based on the E.163 and E.164 standards. The combination of the interconnected networks and the single numbering plan make it possible for any phone in the world to dial any other phone.

3.3 Cellular Network Architecture

Mobile telephony took off with the introduction of cellular technology which allowed the efficient utilization of frequencies enabling the connection of a large number of users. During the 1980's analogue technology was used. Among the most well-known systems were the NMT900 and 450 (Nordic Mobile Telephone) and the AMPS (Advanced Mobile Phone Service). In the 1990's the digital cellular technology was introduced with GSM (Global System Mobile) being the most widely accepted system around the world. Other such systems are the DCS1800 (Digital Communication System) and the PCS1900 (Personal Communication System).

A cellular network consists of mobile units linked together to switching equipment, which interconnect the different parts of the network and allow access to the fixed Public Switched Telephone Network (PSTN). The technology is hidden from view; it's incorporated in a number of transceivers called Base Stations (BS). Every BS is located at a strategically selected place and covers a given area or cell - hence the name cellular communications. A number of adjacent cells grouped together form an area and the corresponding BSs communicate through a so-called Mobile Switching Centre (MSC). The MSC is the heart of a cellular radio system. It is responsible for routing, or switching, calls from the originator to the destination. It can be thought of managing the cell, being responsible for set-up, routing control and termination of the call, for management of inter-MSC hand over and supplementary services, and for collecting charging and accounting information. The MSC may be connected to other MSCs on the same network or to the PSTN.

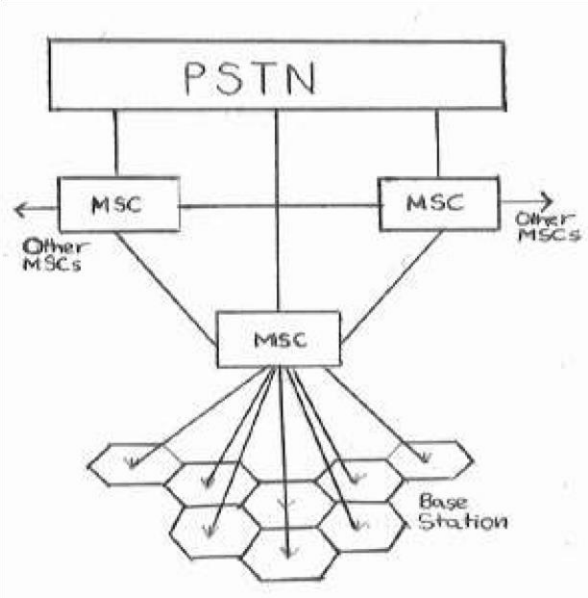

Fig 3.1: Mobile Switching Centre

The frequencies used vary according to the cellular network technology implemented. For GSM, 890 - 915 MHz range is used for transmission and 935 -960 MHz for reception. The DCS technology uses frequencies in the 1800MHz range while PCS in the 1900MHz range.
Each cell has a number of channels associated with it. These are assigned to subscribers on demand. When a Mobile Station (MS) becomes 'active' it registers with the nearest BS. The corresponding MSC stores the information about that MS and its position. This information is used to direct incoming calls to the MS.
If during a call the MS moves to an adjacent cell then a change of frequency will necessarily occur - since adjacent cells never use the same channels. This procedure is called hand over and is the key to Mobile communications. As the MS is approaching the edge of a cell, the BS monitors the decrease in signal power. The strength of the signal is compared with adjacent cells and the call is handed over to the cell with the strongest signal.
During the switch, the line is lost for about 400ms. When the MS is going from one area to another it registers itself to the new MSC. Its location information is updated, thus allowing MSs to be used outside their 'home' areas.

3.4 Data Communications
Data Communications is the exchange of data using existing communication networks. The term data covers a wide range of applications including File Transfer (FT), interconnection between Wide-Area-Networks (WAN), facsimile (fax), electronic mail, access to the internet and the World Wide Web (WWW).

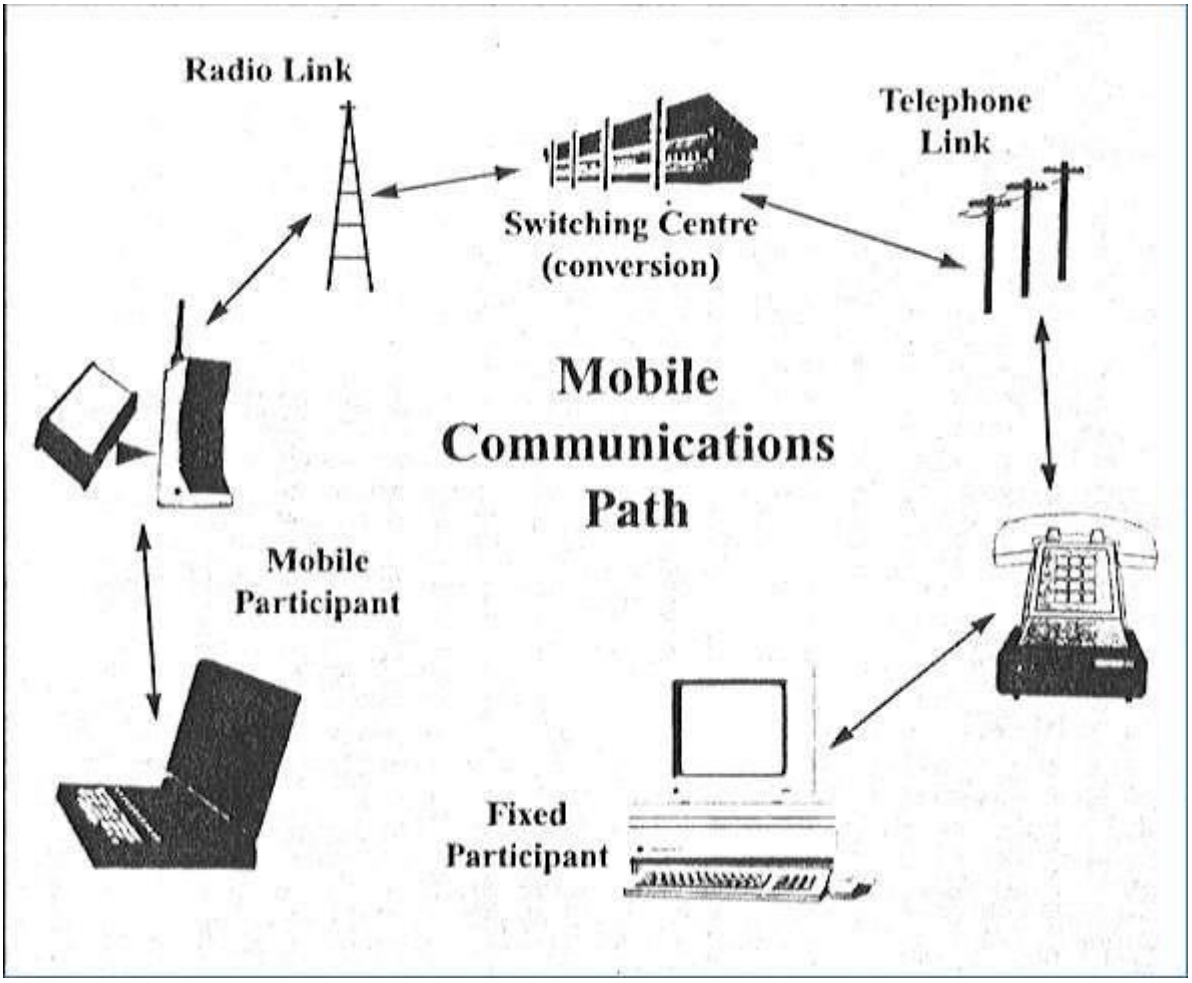

Fig 3.2: Mobile Communications Overview

Data Communications have been achieved using a variety of networks such as PSTN, leased lines and ISDN (Integrated Services Data Network) and ATM (Asynchronous Transfer Mode)/Frame Relay. These networks are partly or totally analogue or digital using technologies such as circuit - switching, packet - switching etc.

Circuit switching implies that data from one user (sender) to another (receiver) has to follow a prespecified path. If a link to be used is busy, the message cannot be redirected , a property which causes many delays.

Packet switching is an attempt to make better utilization of the existing network by splitting the message to be sent into packets. Each packet contains information about the sender, the receiver, the position of the packet in the message as well as part of the actual message. There are many protocols defining the way packets can be send from the sender to the receiver. The most widely used are the Virtual Circuit-Switching system, which implies that packets have to be sent through the same path, and the Datagram system which allows packets to be sent at various paths depending on the network availability. Packet switching requires more equipment at the receiver, where reconstruction of the message will have to be done.

The introduction of mobility in data communications required a move from the Public Switched Data Network (PSDN) to other networks like the ones used by mobile phones. PCSI has come up

with an idea called CDPD (Cellular Digital Packet Data) technology which uses the existing mobile network (frequencies used for mobile telephony).
Mobility implemented in data communications has a significant difference compared to voice communications. Mobile phones allow the user to move around and talk at the same time; the loss of the connection for 400ms during the hand over is undetectable by the user. When it comes to data, 400ms is not only detectable but causes huge distortion to the message. Therefore data can be transmitted from a mobile station under the assumption that it remains stable or within the same cell.

3.4.1 Cellular Digital Packet Data (CDPD) Technology

Today, the mobile data communications market is becoming dominated by a technology called CDPD. There are other alternatives to this technology namely Circuit Switched Cellular, Specialised Mobile Radio and Wireless Data Networks.
CDPD's principle lies in the usage of the idle time in between existing voice signals that are being sent across the cellular networks. The major advantage of this system is the fact that the idle time is not chargeable and so the cost of data transmission is very low. This may be regarded as the most important consideration by business individuals.
CDPD networks allow fixed or mobile users to connect to the network across a fixed link and a packet switched system respectively. Fixed users have a fixed physical link to the CDPD network. In the case of a mobile end user, the user can, if CDPD network facilities are nonexistent, connect to existing circuit switched networks and transmit data via these networks. This is known as Circuit Switched CDPD (CS-CDPD).

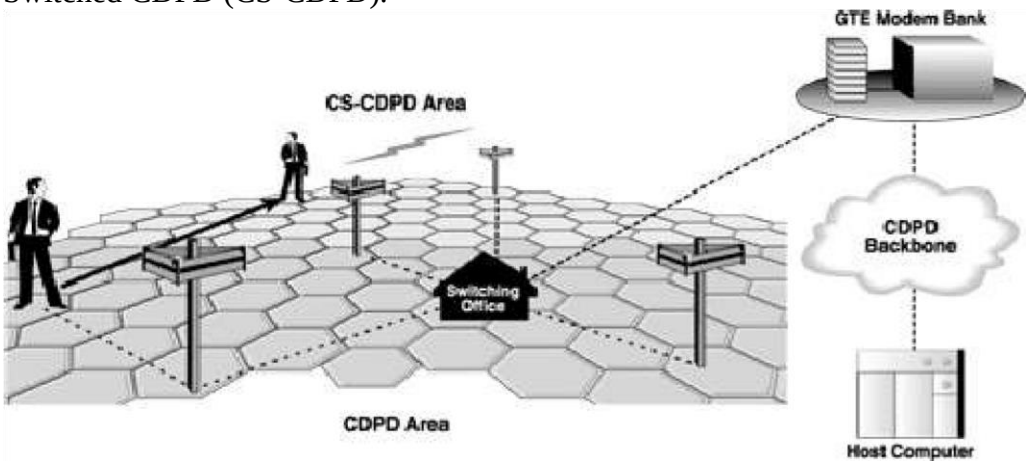

Fig 3.3: Circuit Switched CDPD

Service coverage is a fundamental element of providing effective wireless solutions to users and using this method achieves this objective. Where CDPD is available data is split into packets and a packet switched network protocol is used to transport the packets across the network. This may be of either Datagram or Virtual Circuit Switching form.
The data packets are inserted on momentarily unoccupied voice frequencies during the idle time on the voice signals. CDPD networks have a network hierarchy with each level of the hierarchy doing its own specified tasks.
The hierarchy consists of the following levels:

Mobile End User Interface- Using a single device such as a Personal Digital Assistant or personal computer which have been connected to a Radio Frequency (RF) Modem which

is specially adapted with the antennae required to transmit data on the cellular network, the mobile end user can transmit both data and voice signals. Voice signals are transmitted via a mobile phone connected to the RF Modem Unit. RF Modems transfer data in both forward and reverse channels using Gaussian Minimum Shift Keying (MSK) modulation , a modified form of Frequency Shift Keying (FSK) at modulation index of 0.5 .

Mobile Data Base Station (MDBS)- In each cell of the cellular reception area, there is a Mobile Data Base Station (MDBS) which is responsible for detection of idle time in voice channels, for relaying data between the mobile units and the Mobile Data Intermediate Systems (MDIS), sending of packets of data onto the appropriate unoccupied frequencies as well as receiving data packets and passing them to the appropriate Mobile end user within its domain.

- Detection of idle time -This is achieved using a scanning receiver(also known as sniffer) housed in the MDBS. The sniffer detects voice traffic by measuring the signal strength on a specific frequency, hence detecting an idle channel.
- Relaying data packets between mobile units and networks - If the sniffer detects two idle channels then the MDBS establishes two RF air-links between the end user unit and itself. Two channels are required to achieve bidirectional communications. One channel is for forward communication from the MDBS to the mobile units. This channel is unique to each mobile unit and hence contention less. The reverse channels are shared between a number of Mobile units and as a result, two mobile units sharing a reverse link cannot communicate to each other. Reverse channels are accessed using a Digital Sense Multiple Access with Collision Detection (DSMA - CD) protocol which is similar to the protocol used in Ethernet communication which utilises Carrier Sense Multiple Access with Collision Detection (CSMA - CD). This protocol allows the collision of two data packets on a common channel to be detected so that the Mobile unit can be alerted by the MDBS to retry transmission at a later time.

Once a link is established, the MDBS can quickly detect if and when a voice signal is ramping up (requesting) this link and within the 40ms it takes for the voice signal to ramp up and get a link, the MDBS disconnects from the current air-link and finds another idle channel establishing a new link. This is known as channel hopping. The speed at which the MDBS hops channels ensures that the CDPD network is completely invisible to the existing cellular networks and it doesn't interfere with transmission of existing voice channels.

When the situation occurs that all voice channels are at capacity, then extra frequencies specifically set aside for CDPD data can be utilized. Although this scenario is very unlikely as each cell within the reception area has typically 57 channels, each of which has an average of 25 - 30% of idle time.

Mobile Data Intermediate Systems (MDIS) - Groups of MDBS that control each cell in the cellular network reception area are connected to a higher-level entity in the network hierarchy, the Mobile Data Intermediate Systems. Connection is made via a wideband trunk cable. Data packets are then relayed by MDBS to and from mobile end users and MDIS. These MDIS use a Mobile Network Location Protocol (MNLP) to exchange location information about Mobile end users within their domain. The MDIS maintains a

database for each of the M-ES in its serving area. Each mobile unit has a fixed home area but may be located in any area where reception is available. So, if a MDIS unit recieves a data packet addressed to a mobile unit that resides in its domain, it sends the data packet to the appropriate MDBS in its domain which will forward it as required. If the data packet is addressed to a mobile unit in another group of cells, then the MDIS forwards the data packet to the appropriate MDIS using the forward channel. The MDIS units hide all mobility issues from systems in higher levels of the network hierarchy. In the reverse direction, where messages are from the Mobile end user, packets are routed directly to their destination and not necessarily through the mobile end users home MDIS.

Intermediate Systems (IS) - MDIS are interconnected to these ISs which form the backbone of the CDPD system. These systems are unaware of mobility of end-users, as this is hidden by lower levels of the network hierarchy. The ISs are the systems that provide the CDPD interface to the various computer and phone networks. The IS's relay data between MDIS's and other IS's throughout the network. They can be connected to routers that support Internet and Open Systems Interconnection Connectionless Network Services (OSI-CLNS), to allow access to other cellular carriers and external land- based networks.

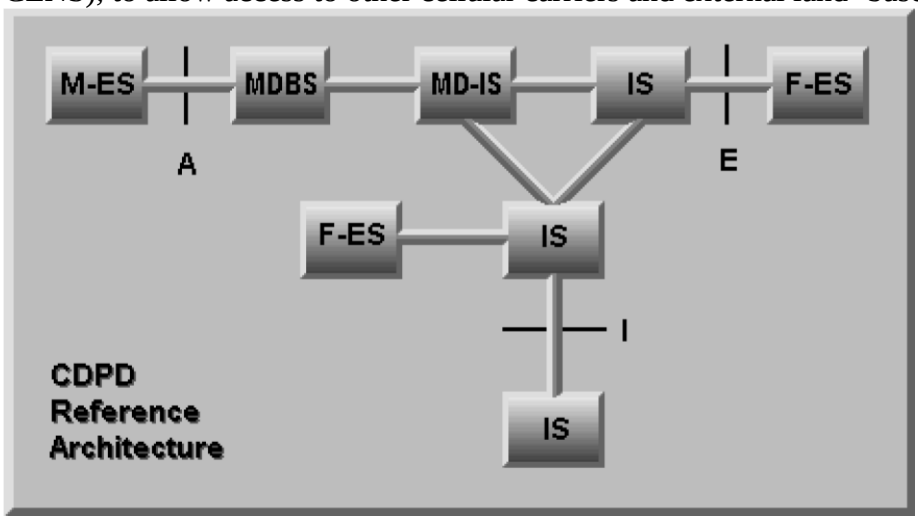

Fig 3.4: CDPD Network

3.4.2 CDPD Network Reliability

There are some actions that are necessary in order to obtain reliability over a network.

- User Authentication - The procedure which checks if the identity of the subscriber transferred over the radio path corresponds with the details held in the network.
- User Anonymity - Instead of the actual directory telephone number, the International Mobile Subscriber Identity (IMSI) number is used within the network to uniquely identify a mobile subscriber.
- Fraud Prevention - Protection against impersonation of authorized users and fraudulent use of the network is required.
- Protection of user data - All the signals within the network are encrypted and the identification key is never transmitted through the air. This ensures maximum network and data security.

The information needed for the above actions are stored in **data bases**. The **Home Location Register (HLR)** stores information relating the **Mobile Station** (MS) to its network. This includes information for each MS on subscription levels, supplementary services and the current or most recently used network and location area. The **Authentication Centre (AUC)** provides the information to authenticate MSs using the network, in order to guard against possible fraud, stolen subscriber cards, or unpaid bills. **The Visitor Location Register** (VLR) stores information about subscription levels, supplementary services and location for a subscriber who is currently in, or has very recently been, in that area. It may also record whether a subscriber is currently active, thus avoiding delay and unnecessary use of the network in trying to call a switched off terminal.
The data packets are transmitted at speeds of typically 19.2 Kilobits/second to the MDBS, but actual throughput may be as low as 9.6 Kilobits/second due to the extra redundant data that is added to transmitted packets. This information includes sender address, receiver address and in the case of Datagram Switching, a packet ordering number. Check data is also added to allow error correction if bits are incorrectly received. Each data packet is encoded with the check data using a Reed-Solomon forward error correction code. The encoded sequence is then logically OR'ed with a pseudo-random sequence, to assist the MDBS and mobile units in synchronization of bits. The transmitted data is also encrypted to maintain system security.
CDPD follows the OSI standard model for packet switched data communications. The CDPD architecture extends across layers one, two and three of the OSI layer model. The mobile end users handle the layer 4 functions (transport) and higher layers of the OSI model such as user interface.

Revision questions

1. Describe the architecture of a mobile system
2. Explain how PSTN supports mobile communication
3. What is CDPD technology?
4. What are the levels in a CDPD network?
5. How is network reliability ensured in cellular communication?