The New Age of Mobile Technology

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Abstract **- Mobile communication has become a very vital and fast evolving technology as it allows users to transmit data from distant locations to other distant or fixed locations. This proves to be the key to the main problem of business people on the move - mobility. In this paper we give an overview of existing cellular networks and explain the feature of CDPD technology principle lies in the practice of the idle time in between existing voice signals that are being sent across the networks. The major advantage of the system is that the idle time is not chargeable and so the cost of data transmission is very low. This scarcy concept of a world full of inanimate zombies sitting, locked to their mobile stations, accessing every sphere of their lives via the computer screen becomes ever more real as technology. It has the chance of influencing almost every facet of our life and has opened up new horizons to investigate in the area such as security and medicine. People have to be educated about this upcoming technology in order to avoid mistreatment. Also safety strategy, research and manufacturing policies are needed to be provided on this technology. In this paper, we present a discussion on the concept behind "THE MOBILE COMPUTING" and the legal implications of mobile computing, as relevant to the new age of mobile Technologies**

I. Existing Cellular Network Architecture

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 tranceivers 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).

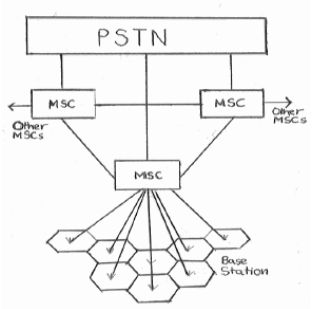

Fig.1 Mobile switching centre

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 techology 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.

II. 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).

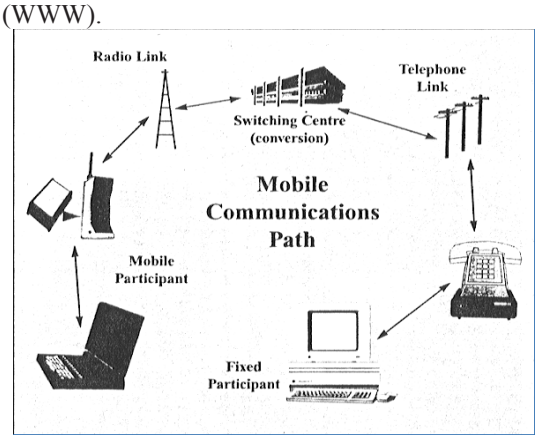

Fig.2 Mobile communications overview

Data Communications have been achieved using a variety of networks such as PSTN, leased-lines and more recently 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 e.t.c.

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 can not be redirected , a property which causes many delays.

Packet switching is an attempt to make better utilisation 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.

III. CDPD Technology : The Hot Cookie

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. As can be seen from the table below the CDPD technology is much more advantageous than the others.

Table I CDPD Technology

	Cellular Digital Packet Data (CDPD)	Circuit Switched Cellular	Specialized Mobile Radio (Extended)	Proprietary Wireless Data Networks
Speed	best	best	good	good
Security	best	better	good	better
Ubiquity	best	best	good	better
Cost of Service	best	better	better	good
Cost of Deployment	best	best	better	good
Mobility	best	good	better	good
Interoperability	best	good	good	better

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 non-existent, connect to existing circuit switched networks and transmit data via these networks. This is known as Circuit Switched CDPD (CS-CDPD).

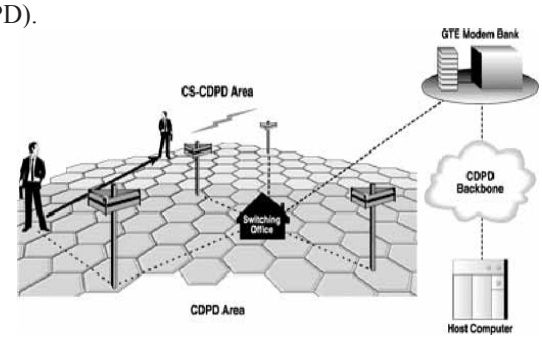

Fig.3 Circuit Switched CDPD

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.

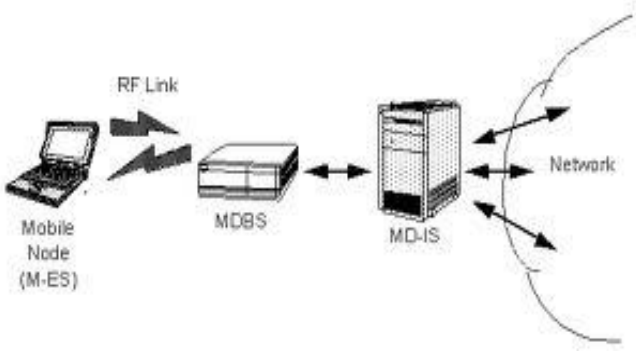

Fig.4 CDPD network

The hierarchy consists of the following levels :

A. 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 .

B. 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.

1) 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.

2) 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 contentionless. 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 utilised. 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.

3) 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.

4) Intermediate Systems (IS)

MDIS are interconnected to these IS 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.

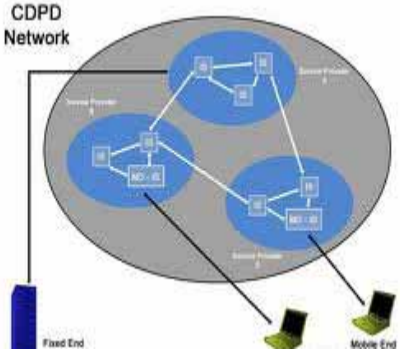

Fig.5 CDPD Network

IV. CDPD Network Reliability

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

1) 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.

2) 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.

3) Fraud Prevention

Protection against impersonation of authorised users and fraudulent use of the network is required.

4) 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 subsciber 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, reciever 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 recieved. 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 synchronisation 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.

V. Applications Of Mobile Computing

The question that always arises when a business is thinking of buying a mobile computer is "Will it be worth it?"

In many fields of work, the ability to keep on the move is vital in order to utilise time efficiently. Efficient utilisation of resources (ie: staff) can mean substantial savings in transportation costs and other non quantifyable costs such as increased customer attention, impact of on site maintenance and improved intercommunication within the business.

The importance of Mobile Computers has been highlighted in many fields of which a few are described below:

A. For Estate Agents

Estate agents can work either at home or out in the field. With mobile computers they can be more productive. They can obtain current real estate information by accessing multiple listing services, which they can do from home, office or car when out with clients. They can provide clients with immediate feedback regarding specific homes or neighborhoods, and with faster loan approvals, since applications can be submitted on the spot. Therefore, mobile computers allow them to devote more time to clients.

B. Emergency Services

Ability to recieve information on the move is vital where the emergency services are involved. Information regarding the address, type and other details of an incident can be dispatched quickly, via a CDPD system using mobile computers, to one or several appropriate mobile units which are in the vicinity of the incident.

C. In courts

Defense counsels can take mobile computers in court. When the opposing counsel references a case which they are not familiar, they can use the computer to get direct, real-time access to on-line legal database services, where they can gather information on the case and related precedents. Therefore mobile computers allow immediate access to a wealth of information, making people better informed and prepared.

D. In companies

Managers can use mobile computers in, say, critical

presentations to major customers. They can access the latest market share information. At a small recess, they can revise the presentation to take advantage of this information. They can communicate with the office about possible new offers and call meetings for discussing responds to the new proposals. Therefore, mobile computers can leverage competitive advantages.

E. Stock Information Collation/Control

In environments where access to stock is very limited ie: factory warehouses. The use of small portable electronic databases accessed via a mobile computer would be ideal.

Data collated could be directly written to a central database, via a CDPD network, which holds all stock information hence the need for transfer of data to the central computer at a later date is not necessary. This ensures that from the time that a stock count is completed, there is no inconsistency between the data input on the portable computers and the central database.

F. Credit Card Verification

At Point of Sale (POS) terminals in shops and supermarkets, when customers use credit cards for transactions, the intercommunication required between the bank central computer and the POS terminal, in order to effect verification of the card usage, can take place quickly and securely over cellular channels using a mobile computer unit. This can speed up the transaction process and relieve congestion at the POS terminals.

G. Taxi/Truck Dispatch

Using the idea of a centrally controlled dispatcher with several mobile units (taxis), mobile computing allows the taxis to be given full details of the dispatched job as well as allowing the taxis to communicate information about their whereabouts back to the central dispatch office. This system is also extremely useful in secure deliveries ie: Securicor. This allows a central computer to be able to track and recieve status information from all of its mobile secure delivery vans. Again, the security and reliabilty properties of the CDPD system shine through.

H. Electronic Mail/Paging

Usage of a mobile unit to send and read emails is a very useful asset for any business individual, as it allows him/her to keep in touch with any colleagues as well as any urgent developments that may affect their work. Access to the Internet, using mobile computing technology, allows the individual to have vast arrays of knowledge at his/her fingertips. Paging is also achievable here, giving even more intercommunication capability between individuals, using a single mobile computer device.

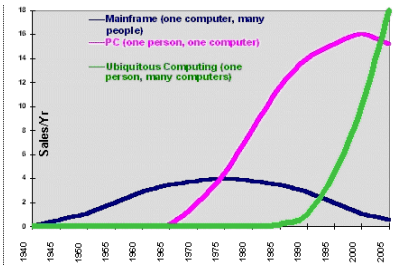

Fig.6 Major Trends in Computing

Wireless data connections used in mobile computing take three universal forms. Cellular data service uses technologies such as GSM, CDMA or GPRS, and more recently 3G networks such as W-CDMA, EDGE or CDMA2000. These networks are generally available within range of commercial cell towers. Wi-Fi connections offer advanced performance, may be either on a private business network or accessed through public hotspots, and have a typical range of 100 feet indoors and up to 1000 feet outdoors. Satellite Internet access covers areas where cellular and Wi-Fi are not available and may be set up wherever the user has a line of sight to the satellite's location, which for satellites in geostationary orbit means having an unclear view of the southern sky. Some project deployments combine networks from multiple cellular networks or use a mix of cellular, Wi-Fi and satellite. When using a mix of networks, a mobile virtual private network (mobile VPN) not only handles the security concerns, but also performs the several network logins automatically and keeps the application connections alive to prevent crashes or data loss during network transitions or coverage loss.

VI. Conclusion and Future

With the rapid technological advancements in Artificial Intelligence, Integrated Circuitry and increases in Computer Processor speeds, the future of mobile computing looks increasingly exciting.

With the emphasis increasingly on compact, small mobile computers, it may also be possible to have all the practicality of a mobile computer in the size of a hand held organizer or even smaller.

Use of Artificial Intelligence may allow mobile units to be the ultimate in personal secretaries, which can receive emails and paging messages, understand what they are about, and change the individuals personal schedule according to the message. This can then be checked by the individual to plan his/her day.

The working lifestyle will change, with the majority of people working from home, rather than commuting. This may be beneficial to the environment as less transportation will be utilised. This mobility aspect may be carried further in that, even in social spheres, people will interact via mobile stations, eliminating the need to venture outside of the house.

This scary concept of a world full of inanimate zombies sitting, locked to their mobile stations, accessing every sphere of their lives via the computer screen becomes ever more real as technology, especially in the field of mobile data communications, rapidly improves and, as shown below, trends are very much towards ubiquitous or mobile computing.

References

[1] Third Generation of Mobile Systems in Europe, Special issue of the IEEE, April 1998.

[2] P. Agrawal and C. J. Sreenan, "Going Wireless: Key Technologies for Mobile Computing," to appear in IEEE ITPro magazine, 1999.

[3] P. Lettieri and M. B. Srivastava, "Advances in wireless terminals," I*EEE Personal Communications,* Vol. 6, No. 1, February 1999, pp. 6-l 8.

[4] MH Repacholi, "health risks from the use of mobile phones", *Toxicology Letters,* 2001 - Elsevier

[5] "Video Over IP: An Example Reconfigurable Computing Application for a Handheld Device", Elina Kamenetskaya, M.Eng. Thesis, Massachusetts Institute of Technology, May 2003.

[6] Roth, J. "Mobile Computing - Grundlagen, Technik, Konzepte", 2005, dpunkt.verlag, Germany