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Mobile Compting and Communication Past, Present and Future

Jayanta Loha is an Assistant Professor in the Department of Computer Science and Application at St. Joseph's College, Darjeeling. He is pursing Ph. D from North Bengal University.

Pravin Titumus Mukhia is an Assistant Professor in the Department of Computer Science and Application at St. Joseph's College, Darjeeling.

Abstract

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. In this article an overview of existing cellular networks has been given and describes in detail the CDPD technology which allows data communications across these networks. Finally, we look at the applications of Mobile Computing in the real world.

Keywords: Mobile computing, Data communication, Technology, Communication network

Introduction

Mobile Computing is 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.

A key requirement of mobile computing systems will be the ability to access critical data regardless of location. Data from shared file systems and databases must be made available to programs running on mobile computers: for example, a technician servicing a jet engine on a parked aircraft needs access to engineering details of that model of engine as well as past repair records of that specific engine. Similarly a businessman who is continuing his work on the train from MUMBAI needs access

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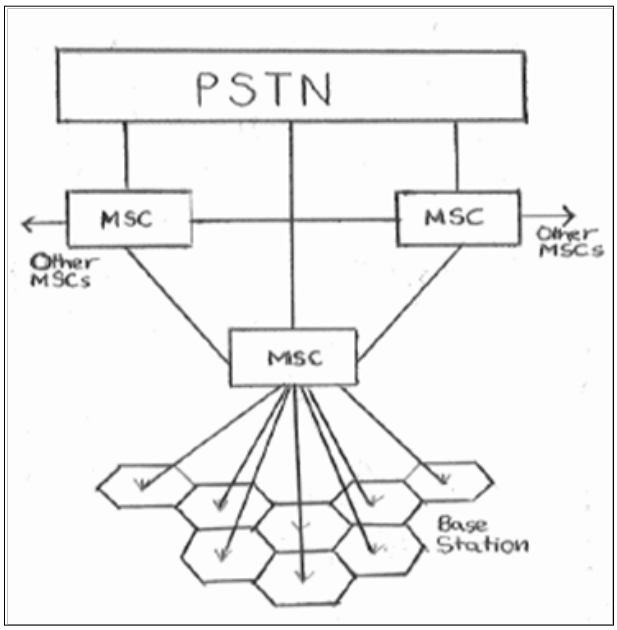
to his business records. Yet another example involves emergency medical response to a case of poisoning: the responding personnel will need rapid access to medical databases describes poison symptoms and antidotes; as well as access to the specific patients medical records to determine drug sensitivity.

Existing cellular network architecture[1]

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



Mobile Switching Centre

1 Simon Haykin, *Communication Systems* (Third edition), New York, John Wiley & Sons Inc., 1994, pp. 511-540.

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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.

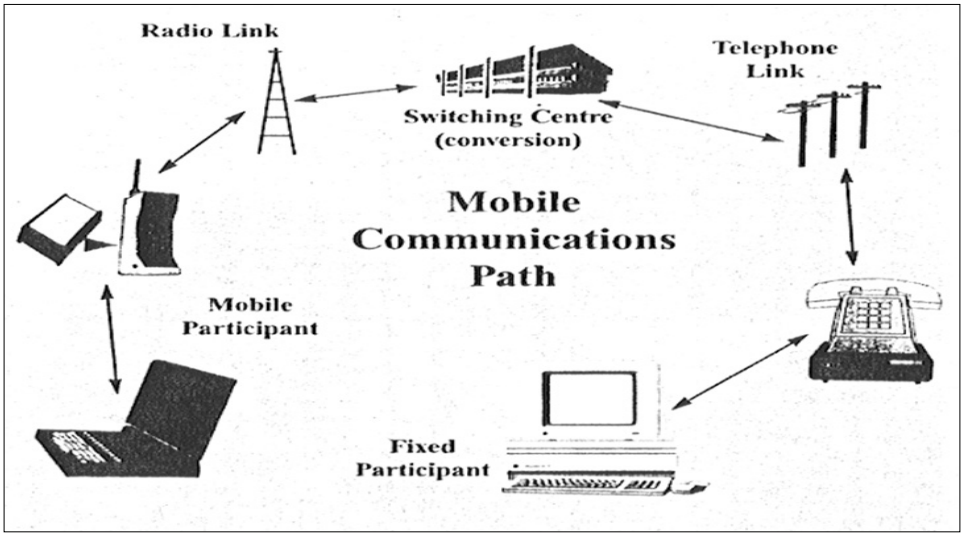
The frequencies used vary according to the cellular network technology implemented. For GSM, 890 - 915 MHz range is used for transmission and 935 -960 MHz for reception. The DCS technology uses frequencies in the 1800MHz range while PCS in the 1900MHz range.

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.

Data communications[2]



Mobile Communications Overview

2 Fred Halsall, "Network Switching Techniques-Circuit, Packet and Datagram" in *Data Communications, Computer Networks and Open Systems*, 4th edition, Boston, Addison-Wesley, 1996, pp. 424-459.

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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).

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 etc.

Circuit switching implies that data from one user (sender) to another (receiver) has to follow a pre-specified 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)[3] 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 John Gallant, "The CDPD Network", PCSI.

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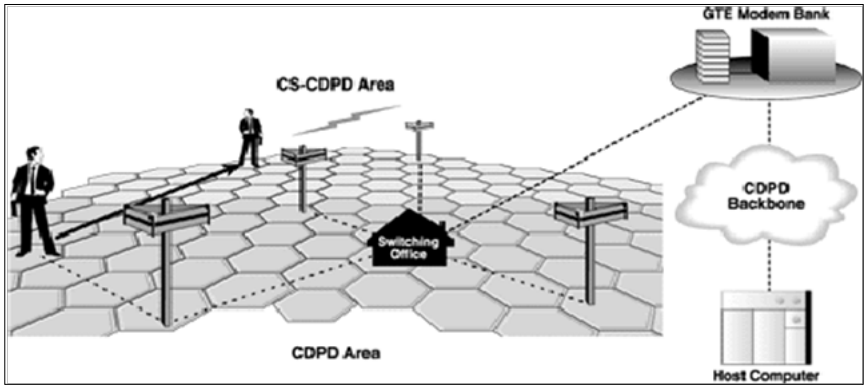
CDPD Technology: the hot cookie[4]

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, Specialized Mobile Radio and Wireless Data Networks. As can be seen from the table[5] below the CDPD technology is much more advantageous than the others.

	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).



CDPD Overview

4 Omar Iqbal, "CDPD: The answer to all mobile business individuals' problems?", 1996. See also, "CDPD - Advanced mobile phone standard network bandwidth contention", *IEEE Conference*, New Orleans, LA, USA, 13-15 Dec 1995.

5 URL: http://www.cdpd.org/library/report_card/table1.html (accessed on 28/Jan/2013).

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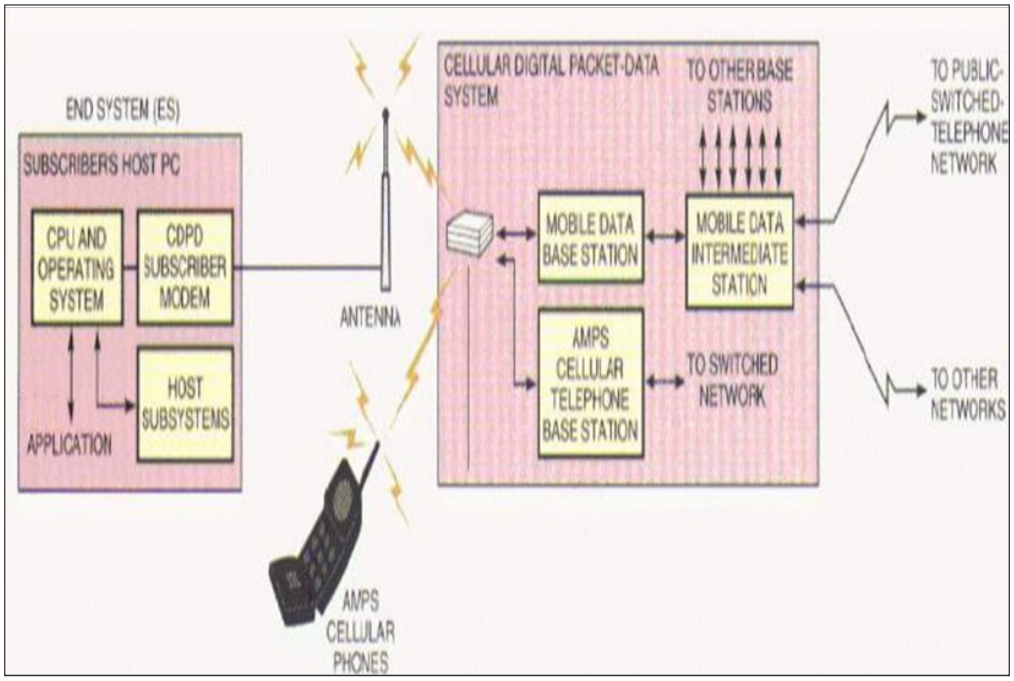

Circuit Switched CDPD

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 has 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 different types of shift keying modulation.

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

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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 numbers 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 utilizes 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.

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

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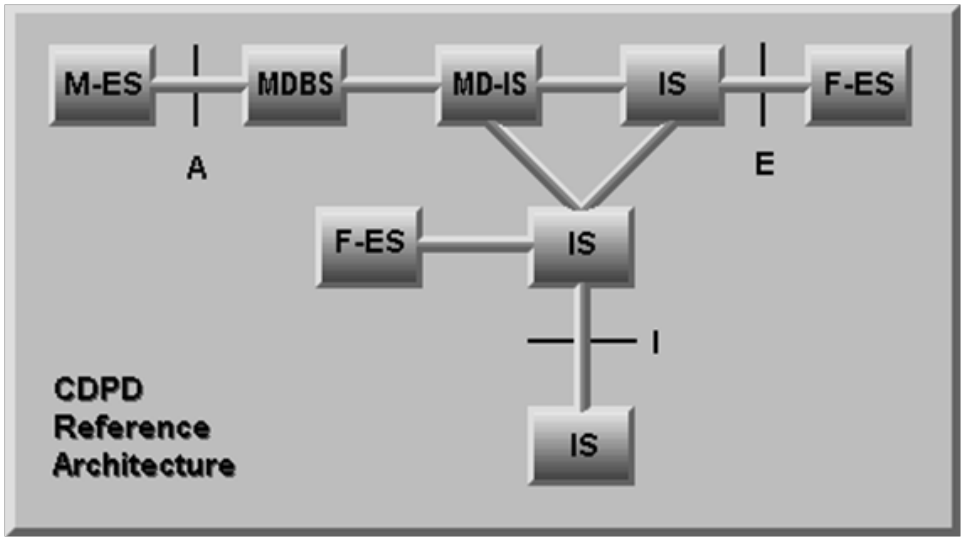
receives a data packet addressed to a mobile unit that resides in its domain, it sends the data packet to the appropriate MDBS in its domain which will forward it as required. If the data packet is addressed to a mobile unit in another group of cells, then the MDIS forwards the data packet to the appropriate MDIS using the forward channel. The MDIS units hide all mobility issues from systems in higher levels of the network hierarchy.

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.



CDPD Network

CDPD Network Reliability[6]

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.

6 Vasilis Koudounas, "Cellular Digital Packet Data (CDPD): What makes it Reliable?", 1996. URL: http://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol2/vk5/article2.html (accessed on 25/Jan/2013).

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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.

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.

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.

Applications of Mobile Computing[7]

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 utilize time efficiently. Efficient utilization of resources (i.e.: staff) can mean substantial savings in transportation costs and other non quantifiable costs such as increased customer attention, impact of onsite maintenance and improved intercommunication within the business. Many types of mobile computers have been introduced since the 1990s, such as the smart phone, computer, and now wearable computers. Mobile Computing Applications gathers together informative mobile computing articles, educational mobile computing videos, and lively chatter and conversation about mobile computing and mobile computing applications.

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

7 *Ibid.*

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.

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.

In companies

Managers can use mobile computers in, say, and 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.

Stock Information Collation/Control

In environments where access to stock is very limited i.e.: 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.

Emergency Services

Ability to receive 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.

Here the reliability and security implemented in the CDPD system would be of great advantage.

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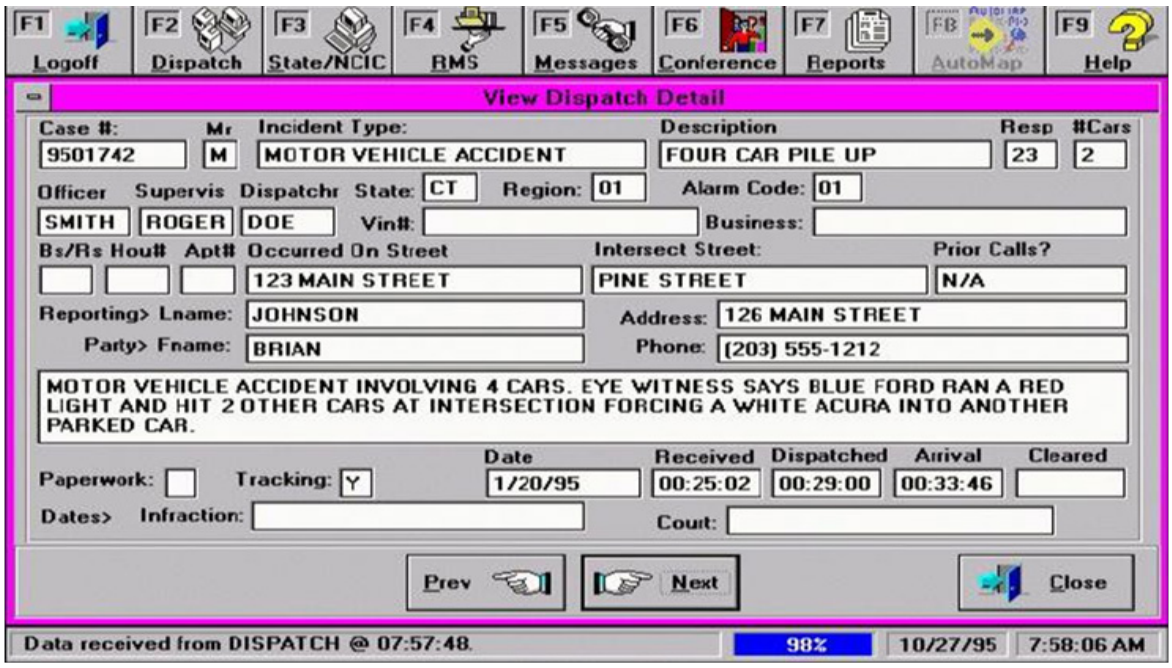
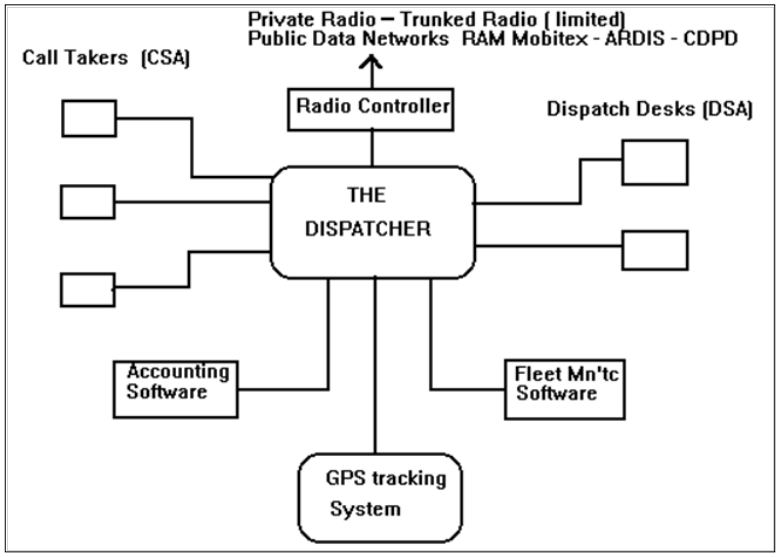


PIIS(Police Incident Information Screen)

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.

Taxi/Truck Dispatch



Taxi Dispatch Network

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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 i.e.: Securicor. This allows a central computer to be able to track and receive status information from all of its mobile secure delivery vans. Again, the security and reliability properties of the CDPD system shine through.

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.

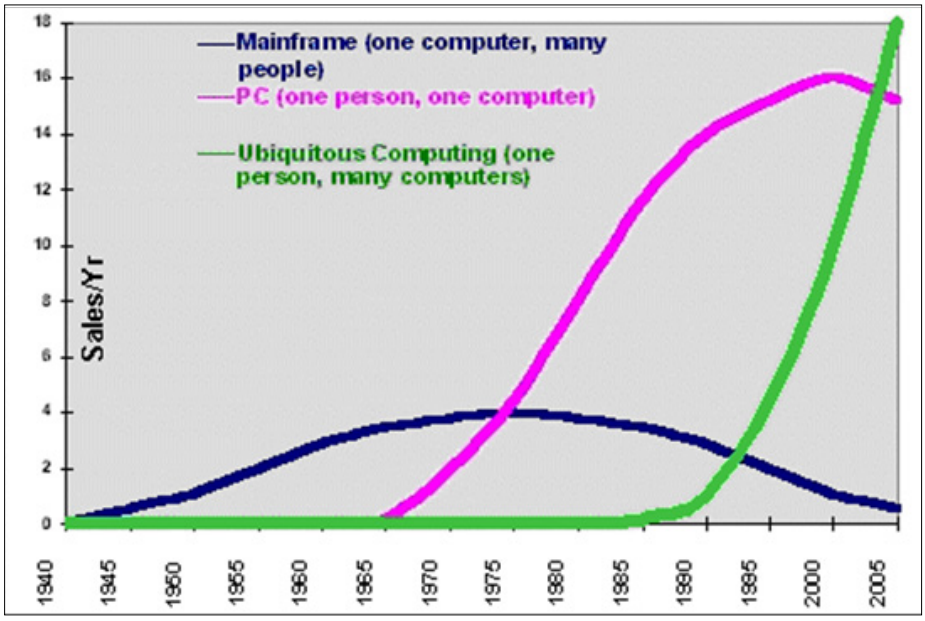
The future

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.[8]

Use of Artificial Intelligence may allow mobile units to be the ultimate in personal secretaries, which can receive emails, understand what they are about, and change the individual's 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.

8 Thiry X and R. Mittra, "Modeling of hand-held receiving antennas in the presence of a human head", *IEEE Antennas and Propagation Society International Symposium*, 2(1995), 1116-1119.



Major Trends in Computing

Indeed, technologies such as Interactive television and Video Image Compression already imply a certain degree of mobility in the home, i.e., home shopping etc. Using the mobile data communication technologies discussed, this mobility may be pushed to extreme.

The future of Mobile Computing is very promising indeed, although technology may go too far, causing detriment to society.[9]

9 M. A. Stuchly, "Health Effects of exposure to electromagnetic fields", Conference paper, IEEE Aerospace Applications Conference, Aspen, Colorado, (1995) 351-68.