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Infrastructure Support for Mobile Information Systems in Australia

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Executive Summary
Information systems (IS) are the core day-to-day applications of every major enterprise. With the proliferation of high speed workstations, portable computers, file servers, and high performance communication systems, major enterprises are taking advantage of advanced information systems technology to increase productivity, efficiency and flexibility. Typical information systems include electronic mail, inventory control, multimedia telecommunications, command and control systems, finance systems, executive decision systems, client/server applications, video conferences, non-stop business activity, ad hoc database queries and the list can go on and on. Today's competitive business climate demands tools that allow a working force to communicate at their own convenience and discretion. Mobile computing will enable current information systems to be carried with work force professionals where and when they are doing their jobs.

Advanced information systems need infrastructure support to realise their full potential, achieve efficiency, flexibility, openness, responsiveness and to operate in truly distributed computing environment. Current and forthcoming computing and communication technologies will affect the way information systems are designed and function. This paper provides a broad overview of existing communication technologies and various applications using them. Proliferation of mobile and wireless applications and technologies in Australia is discussed and analysed. Presented analysis of existing telecommunications networks in Australia will assist researchers and developers in planning future projects. Importance of communications infrastructure support for current and future information systems, including point-of-sale, goods delivery, road safety and many others, is outlined and demonstrated. It is argued and concluded that mobile information systems will be viable only through convergence of existing and future communications technologies like GSM, wireless LANs, packet-based data networks and satellite communications. Also, the need for a better designs of gateways and protocol converters to interconnect information systems scattered worldwide and communicate via diverse communication standards is highlighted.

1. Introduction and Background

High performance communication systems and recent advances in wireless technology have provided portable computers with wireless data interfaces and network communications even while users are mobile. The use of portable computers capable of wireless networking will revolutionise the way information technology (IT) professionals design and use information systems (Forman and Zahorjan 1994). Wireless communications will play a critical part in making the vision for mobile computing a reality.

Wireless data networks are a natural extension and enhancement to existing wireline information systems and services. Wireless data networks support users with mobility and computer communications in mind, and require remote access to their base computer networks (Motorola, "WDC: The choices..." 1995; Motorola, "WDC: An overview..." 1995). Wireless data services and systems represent a rapidly growing and increasingly important segment of the telecommunications industry (McGladdery and Clifford 1993). For example, the three telecommunication carriers in Australia are spending billions of dollars in building wireless networks infrastructures in a bid to attract the expected migration of wireline information systems to the wireless applications' arena. Wireless communications for Personal Digital Assistants (PDA)s are potentially huge new markets. Figure 1

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shows the future growth in worldwide mobile users numbers (Motorola 1996). When projected to Australia, the growth is even higher given large distances and a relative scarceness of populated centres.

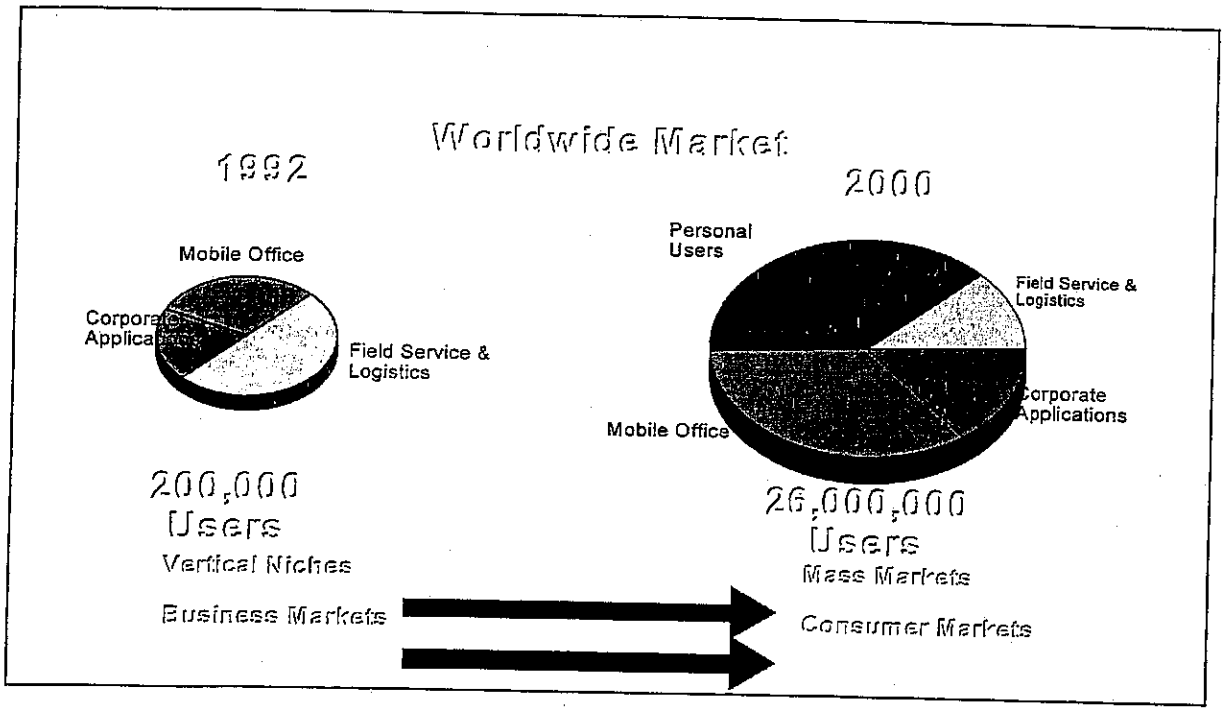

Fig. 1. Future growth in worldwide mobile users numbers

It is easy to notice that current information systems (IS) follow the rapid advancements in the telecommunications industry. Eventually, information systems will be influenced by the rapid evolution of the wireless segment of this industry (Satyanarayanan 1993). Despite the fact that mobility characteristics affect many assumptions upon which today's IS are based, information systems will have to move to where tomorrow's technology can support them. Wireless data technology will be a main platform for information systems which are naturally distributed, dynamic and require much flexibility and mobility.

The combination of networking and mobility will engender new types of information systems (Motorola, "WDC: An overview..." 1995; Motorola, "WDC: The choices..." 1995; Satyanarayanan 1993). These information systems can provide collaborative environment to support impromptu meetings, electronic bulletin boards whose contents adapt to the current viewers, lighting and heating that adjust to the needs of those present, Internet browsing, hotel and flight reservation, navigation software to guide users in unfamiliar places and tours, wireless security systems, wireless Electronic Fund Transfer Point Of Sale (EFTPOS) systems, remote E-mail, enhanced paging, wireless facsimile transmission, remote access to host computers and office LANs, information broadcast services, and law-enforcement agencies, to name few applications (Forman and Zahorjan 1994; Motorola, "WDC: An overview..." 1995).

1.1 The issues of Mobility and Portability

The volatility of information increases by the ability to change locations while connected to a computer network. Certain data considered static for stationary computing, becomes dynamic for mobile computing (Forman and Zahorjan 1994). As volatility increases, cost benefit trade-off points shift, requiring appropriate modifications in the design of information systems.

Mobility introduces several problems. For instance, a mobile computer network address changes dynamically, its current location affects configuration parameters as well as answers to user queries, and the communication path grows as it wanders away from a home server (Forman and Zahorjan 1994; Levesque and Pahlavan 1996). Traditionally, desktop computers are not meant to be mobile, so

designers take a liberal approach to space, power, cabling, and heat. In contrast, designers of hand-held mobile computers should strive for the properties of a wristwatch: small, light, durable, operational under environmental conditions, and requiring minimal power usage for long battery life. A battery, for example, is the heaviest part in a portable computer. While reducing battery weight may sound the fix to this problem, new problems will be introduced: a portable computer user needs to carry a spare battery, recharge the battery more frequently, and limit the use of a portable computer to reduce power consumption (McGladdery and Clifford 1993).

Portability also introduces several design pressures. For instance, power consumption, data loss risks, small user interface, and small storage capacity. For example, in order to conserve power consumption, applications need to reduce their power computation requirements, communications, memory swapping. Portable computers increase the risk of physical damage, security, loss and theft (Motorola, "WDC: The choices..." 1995; Levesque and Pahlavan 1996).

As a conclusion, for a wireline information system to become a wireless application it needs to adjust to portability and mobility factors. This will pressure the information technologists' traditional information system design approaches to change.

For example, let us take the scenario where a desktop IS client which relies on a stationary network address on a local area network (LAN) needs to become a mobile IS client. The stationary IS client which is usually connected to a LAN network Ethernet backbone now moves around the enterprise using a wireless LAN technology. As a consequence, the mobile IS client has a dynamically changing network address, new network interface, new network interface packet size, new network interface speed, and new Radio Frequency (RF) related factors, such as packets re-transmission. For the mobile IS client to be able to function with these new factors, the original desktop IS client design needs to change dramatically. Also, the power consumption factor must be taken into consideration. The same argument applies again when the mobile IS client needs to use another wireless communication with its host, say a wireless wide area network (WAN) or a GSM network.

On the other hand, the host application which serves the queries of the mobile IS client also needs a change to its design architecture despite the fact that it will still be stationary. This change is needed because new communication factors were created by the wireless LAN or the wireless WAN (or GSM). Usually, the host IS has to communicate with the new wireless network via a high speed wireline media, and then the wireless network communicates with the client via its RF base stations. This alters the direct communication between the IS host and the IS client that used to take place on the wireline Ethernet cable, for example. Hence, new communication milestones such as speed, packet size, re-transmission algorithms, just to name few, must be taken into consideration in the design of the IS host. Also, because of power consumption limitations, IS client will have to delegate more tasks to a current host computer. This will greatly affect wireless IS design too.

1.2 Applications Over Wireless Data Networks

Application services offered on public wireless data networks range from fleet management and dispatch for field service organisations, to E-mail and database access for mobile IT professionals. Other common applications include remote telemetry, alarm monitoring, electronic commerce and electronic funds transfer point of sale (EFTPOS), (see figure 2) (Motorola, "WDC: An overview..." 1995; Fist 1995).

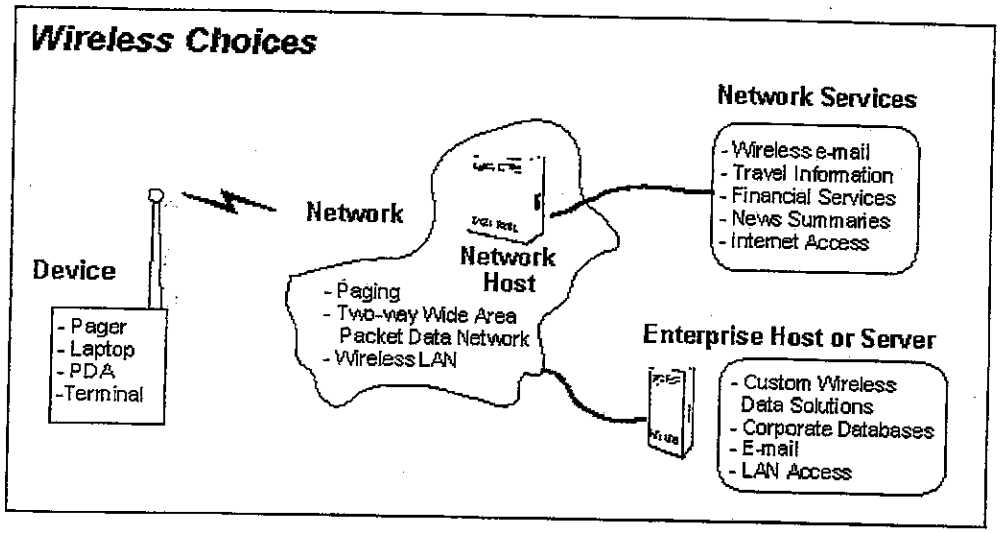

Fig.2. Wireless Data Choices (Motorola, "WDC: An overview..." 1995)

Four basic components are involved in sending wireless data: (Motorola, "WDC: An overview..." 1995; Satyanarayanan 1993)

- *The application*: The software application performs a particular task or set of tasks for the user. This can be a modified existing application for wireless communications or an application developed specifically for that purpose.
- *Connectivity*: Application software uses communication services provided by the wireless network and radio modem software. Thus, the application doesn't need to know the rules of the network, ie, the network protocol, in order to communicate successfully with other devices over the network.
- *The end-user device*: This can be, for example, a laptop computer, a terminal, or a personal digital assistant (PDA). A wireless network adapter, in the form of an internal or external wireless modem or a PCMCIA card, is used to allow the device to transmit over the wireless protocol.
- *The network*: A network carries information from one address to another and tracks its usage. A network also provides security and error detection, and resends messages when necessary. Data, such as E-mail, data files, and faxes, can be sent over cellular networks, public data networks, or private networks.

Host computers, with wired connections, can also be a part of the wireless data network. Hosts can be either a part of an enterprise networked system or a part of the public network. Enterprise hosts provide access to corporate applications (see figure 3) (Motorola, "WDC: An overview..." 1995; Motorola, "WDC: The choices..." 1995; Satyanarayanan 1993).

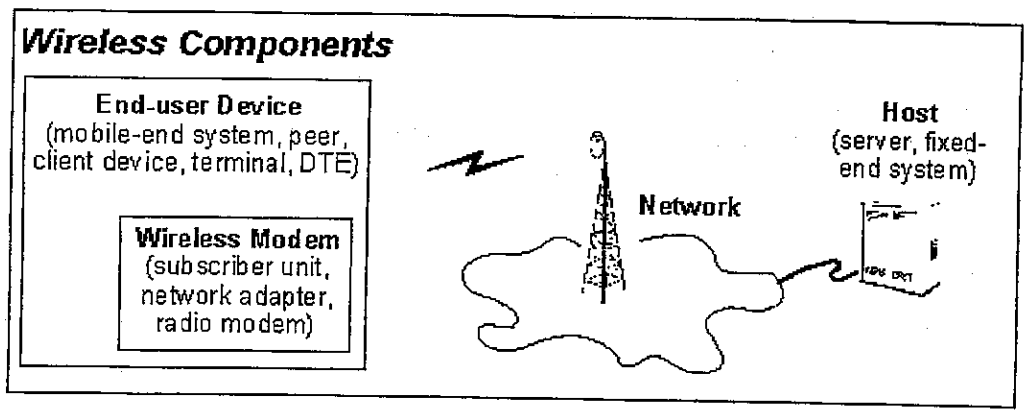

Fig.3. Wireless Components

As a conclusion, design approaches that were taken for granted to perform well in the design of a traditional IS need to be altered. They have to take into consideration wireless factors involved in the

mobile applications design. Traditional designers need to be educated about the mobility and portability factors in order to achieve suitable and realistic IS design approaches.

1.3 Wireless Communications Groups

Wireless communication services can be grouped into relatively distinct groups (Motorola, "WDC: An overview..." 1995; Motorola, "WDC: The choices..." 1995; McGladdery and Clifford 1993; Cox 1996). The grouping is generally done with respect to scale of mobility and communications applications or modes (as shown in figure 3). The grouping is summarised in Table 1 below.

Group	Categorised by;
Cordless Telephones	low mobility, low-power, two-way wireless voice communications, with low mobility applying both to the range and the user's speed.
Cellular Mobile Radio systems	providing high mobility, wide-ranging, two-way wireless communications, with high mobility applying to vehicular speeds and to widespread regional to national coverage.
Wide-Area Wireless Data Systems (Mobile Data Systems)	high mobility, wide-ranging , low-data-rate digital communications to both vehicles and pedestrians.
High-Speed Wireless Local-Area Networks (WLANs)	low-mobility high-data-rate data communications within a confined region, eg. a campus or a large building. An IEEE standards committee, 802.11, has been attempting to put some order into this topic.
Paging/Messaging systems	one-way messaging over wide areas
Satellite-Based Mobile Systems	provides two-way (or one-way) limited quality voice and/or very limited data or messaging to very wide-ranging vehicles (or fixed locations)

Table 1. Wireless communications groups

1.4 Wireless communications networks

Wireless networks modulate radio waves or pulsing infrared light to communicate. Stationary transceivers link the wireless communications to the wired network infrastructure. Wireless communications are affected by the surrounding environment. It interacts with the wireless signal, blocking signal paths and introducing noise and echoes (Forman and Zahorjan 1994). Wireless communications are characterised by limited bandwidth, high error rates, and more frequent spurious disconnections. These factors increase communication latency. This is a result of re-transmissions, re-transmission time-out delays, error control processing, and short disconnections.

Wireless data networks are in operation in most advanced countries and are increasingly becoming popular. To increase the confidence on the part of application vendors to develop wireless data applications, the current trend is towards open wireless data networks standards and protocols (McGladdery and Clifford 1993). The proprietary protocols are becoming open. For example, Motorola opened the RD-LAP protocol. Mobitex protocol (Ericsson, "Mobitex" 1996) which was developed by Swedish Telecom and Ericsson has always been open, and the Cellular Digital Packet Data (CDPD) is open to the public too.

The human attitude towards wireless networks depends on the type of the wireless network. In a wireless voice service, for example, the user usually appreciates the general characteristics and limitations of radio transmission and is tolerant of occasional signal fades and brief dropouts (Levesque and Pahlavan 1996). In contrast, it is interesting to notice that data services users are concerned with the accuracy of delivered messages and data, the time-delay, the ability to maintain service while travelling around, and the cost of the service.

This discussion adds a new factor to the design approach of a mobile and portable information system. Traditional IS designers long ago understood the human reaction to their IS designs. Now they have to consider the new human re-action factor to the performance of data services over

wireless networks in general. Time-delays usually create frustration among users. To avoid such frustration, a new user-friendly design approach is needed to mobile IS.

2. Available wireless data networks

Network technologies will continue to offer more services and greater flexibility at lower costs. Users will be able to choose from a wide range of technologies and mix and match wireless with wireline communications in an effort to meet their needs in the most cost-effective manner. A brief overview of the widely popular network technologies follows (Motorola, "WDC: An overview..." 1995; Motorola, "WDC: The choices..." 1995; Satyanarayanan 1993; Levesque and Pahlavan 1996; McGladdery and Clifford 1993; Ericsson, "GSM..." 1996; Ericsson, "Mobitex" 1996).

Public Packet Data Networks (PPDN) are provided to the public by service providers that offer wireless data communications. Private networks, used by fleet operators and support services such as emergency services, also use this type of network (Motorola, "WDC: An overview..." 1995; Motorola, "WDC: The choices..." 1995). Data transmissions are only provided on these types of networks and use infrastructures of base stations, network control centers, and switches to transmit the data. Enterprise systems and third-party service providers can connect host data systems to the network via wireline communications. Charges are based on the amount of data transmitted, not the connect time.

Packet-switched data networks are more economical to operate than similar circuit-switched networks. They allow many devices to share a small number of communication channels. Transmission speeds vary from 4800 bps to 19.2 kbps. However, the actual transmission time and throughput is determined by the network load and overhead and cannot be precisely specified. Packet data networks are well suited for short data transmissions where the overhead of setting up a circuit is not warranted for the transmission of data bursts lasting only seconds or less . Two widely used packet data network worldwide are the Motorola's DataTac and Ericsson's Mobitex (Motorola 1996; Ericsson, "Mobitex" 1996).

Cellular digital packet data (CDPD) is a new technology that transmits data packets over existing analog cellular networks. It is ideally suited for established voice cellular analog network operators who wish to add wireless data to their existing services. CDPD has the same in-building coverage as the current voice cellular analog networks (Motorola, "WDC: An overview..." 1995; Motorola, "WDC: The choices..." 1995).

2.1 Public Two-way Wireless Data Networks in Australia

There are only three telecommunication carriers in Australia: Telstra, Optus and Vodafone (provides GSM service only). The networks owned and operated by these carriers cover most of the available worldwide wireless telecommunication networks. Telstra is the major player in the telecommunications industry in Australia (AUSTEL 1996).

This paper will limit the discussion to publicly available two-way wireless data networks in Australia. Private wireless networks such as wireless LANs and cordless phones are beyond the scope of this paper. Also, one-way wireless data networks, such as paging, and trunked radio are not discussed. There are two types of wireless data networks in Australia: circuit-switched and packet-switched networks (AUSTEL 1996; Fairall 1996; Budde 1995). In circuit switched networks data is carried over a voice system such as AMPS, GSM, some Satellite Services or trunked mobile radio.

Australia uses Advanced Mobile Phone Service (AMPS) for its analogue network which uses the 800 MHz band. The AMPS network is solely operated by Telstra. However, under a certain agreement, Optus uses the same AMPS network for its customers (Budde 1995; AUSTEL 1996).

Under the Australian Telecommunications Authority (AUSTEL)'s guidelines, Australia will move completely to the new digital standard GSM (Global system for Mobiles), which uses the Time Division Multiple Access (TMDA) standard and operates using the 900 MHz band, by the year 2000 (AUSTEL 1996). This means that the AMPS network in Australia will not be available by the year 2000. As a consequence, the major carriers have no option but not to introduce CDPD in Australia to their customers. The Australian telecommunications market will be completely deregulated by 1/7/1997 (AUSTEL 1996).

There are currently three GSM networks in Australia. Telstra operates MobileNet GSM network supplied by Ericsson. Optus Communications operates a second GSM network supplied by Nokia. Vodafone, which only provides GSM services in Australia, operates the third GSM network supplied by Ericsson (Budde 1995). The Australian government has an agreement with the local wireless carriers, Optus and Vodafone to prohibit the CDMA as a rival cellular technology in Australia until the communication market is completely deregulated in 1997 (Budde 1995).

Australian government commissioned the Australian satellite system in 1983 when it formed Aussat to own and operate three satellites, of the A-series. This system started national communications in 1985. Second generation B-series are now replacing the old A-series (Fairall 1996). Optus Communications took over these systems in 1992 when it acquired the second telecommunications licence offered by the Australian government (Fairall 1996). Optus' MobileSat service is a domestic satellite voice/data service. It has been used in remote parts of Australia as a fixed service. A range of peripherals can be linked to MobileSat including fax, modem, printer at 2.4 kbps (Budde 1995). MobileSat provides mobile phone coverage across the entire Australian continent and up to 200km out to sea.

Telstra provides Inmarsat satellite services branded Satcom. Inmarsat satellites set up in 1979 provide international communications services for maritime, aviation, and land-based mobile users. Intelsat satellites was set up in 1964 to provide worldwide system which links almost any country to anywhere in the world (Satcom 1996). Telstra Mobile Satellite and Radio Services offer a number of different data services via their satellite products(Satcom 1996).

There are three major two-way packet-switched networks in Australia: MobileData operated by Telstra based on Motorola's DataTac 5000, Mobitex operated by United Wireless based on Ericsson's Mobitex, and the satellite service Inmarsat-C which is operated by Telstra (Motorola 1996; Ericsson, "Mobitex" 1996). In the following section, we highlight two packet-switched networks in Australia.

2.2 Available Packet-switched wireless networks in Australia:

Telstra MobileData network is based on Motorola's DataTac 5000. It uses the Motorola open protocol RD-LAP 19.2. The raw data rate is 19200 bps on 800MHz, 25kHz channel. Net data rate is estimated at 14,400bps. Wireless modem are half-duplex, ie, radio cannot receive packets while transmitting (Motorola 1996). Telstra MobileData claims to cover 70% of the Australian population.

Telstra MobileData supports fleet connectivity where one host application communicates with up to thousands of wireless modems (terminals). On Telstra MobileData there are three protocols involved: Standard Context routing (SCR), Native Control Language (NCL), and RD-LAP 19.2. MobileData users do not have to deal at all with the latter protocol. This protocol communicates between the wireless modem terminal and the MobileData base station. Figure 4 depicts the locations of the above mentioned protocols (Motorola 1996).

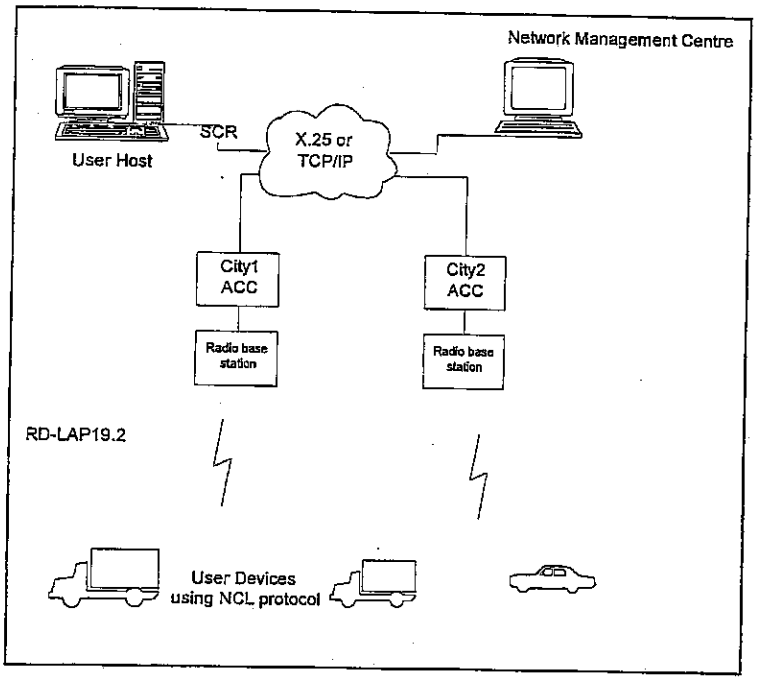

Fig.4. DataTac 5000 architecture (Motorola 1996)

Telstra Inmarsat C is a packet-switched data service which operates at 300bps. Inmarsat C terminals are the size of a car radio and connect via an RS232 port to a PC. By using this terminal customers can send and receive text and binary messages. Terrestrial users can send messages to or receive messages from an Inmarsat C mobile via telex, X.25, or the PSTN network using a V-series modem. Mobiles can also transmit text only faxes (Satcom 1996).

United Wireless Network is based on Mobitex network which is supplied by Ericsson. Mobitex uses packet switching to transfer information around the network. The network comprises of Base Stations (BAS), Area Exchange (MOX), Main Exchange (MHX) and a network control centre (NCC). The network infrastructure is hierarchical and capable of autonomous operation. The following diagram below shows the system architecture. The radio channel between the base station and a radio modem operates at 8kbps. The user data rate is 4.8kbps on 400MHz band (Ericsson, "Mobitex" 1996). Figure 5 depicts a Mobitex network.

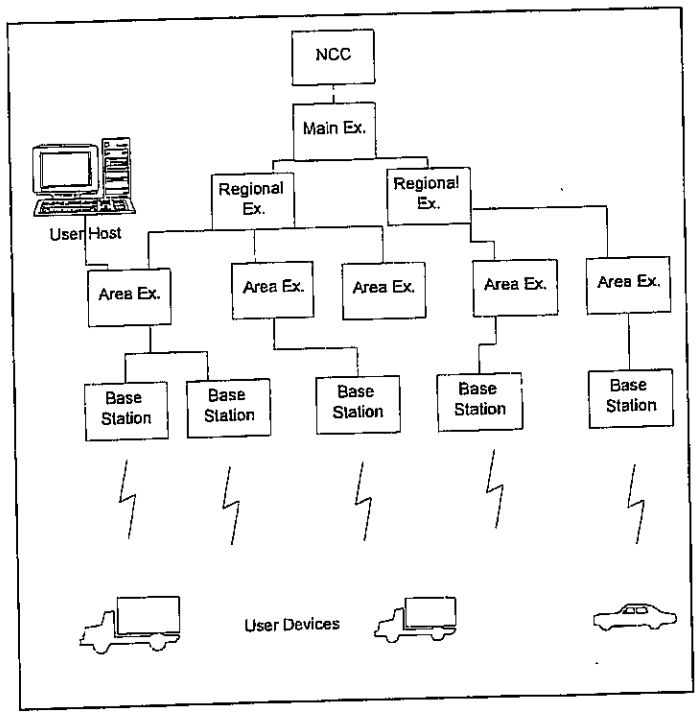

Fig.5. Mobitex network Architecture (Ericsson, "Mobitex" 1996)

As a conclusion, Australia like any other county in the world adopted more than one wireless network. The reasons behind this policy are many. Telecommunication providers have to answer the current and future demands of their customers. Australia has a special geographic nature which forces the need for more than one type of a network.

3. Analysis of future trends

This paper surveys a number of standards and technologies available in the wireless data networks worldwide. Australia adopted some of these standards. Some of these publicly available wireless data networks are analysed in this paper.

Currently, the GSM networks in Australia can transmit fax and data at 9600bps. Packets over GSM networks can be transmitted via the SMS service, with a limited packet size of 140 Octets or 160 characters. The future holds promising enhancements to the GSM network. A packet data service similar in functionality to CDPD is being designed for GSM networks, but will not likely be commercially available until 1999 at the earliest. GSM will be able to provide packet data capacity now being designed, known as General Packet Radio Services (GPRS). This is a packet radio network service which will provide higher-speed data services for mobile users up to 200 kbps(Ericsson, "Mobitex" 1996). GSM phones will soon be able to handle video-conferences, multi-media applications. A new part of the GSM standard is being developed. This is known as High Speed Circuit Switched Data (HSCSD) and will boost user capacity from 9600bps to 64 kbit/s and higher (Ericsson, "Mobitex" 1996).

These future enhancements to the GSM packet and voice/data services will put a lot of pressure on the existing two-way dedicated packet-switched data in Australia. In two years time, circuit-switched future GSM will make packet-switched DataTac and Mobitex obsolete in terms of speed, capacity, and efficiency. Wireless customers prefer to have only one handset for voice, data, fax, and packet-switching, which will be a GSM handset.

Australia is a vast continent and has different types of wireless customers. For instance, GSM suits customers in the GSM coverage area. Customers in rural areas of Australia need satellite coverage. Therefore, having too many standards in Australia proves to be a realistic assumption in the wireless networks industry. Also, different wireless networks carriers will have different coverage maps.

Telstra MobileNet, the GSM network operated by Telstra and Vodafone, uses Erricson supplied equipment while Optus uses Nokia for its GSM network. As the GSM will always be the standard, or at least until the digital wireless telecommunications industry is deregulated, carriers in Australia will adopt the GSM future enhancements. This means that the three carriers may introduce GPRS and HSCSD features in the future when they become a standard and available.

As a conclusion, there will be a need for more research in many different areas in the wireless industry. For instance, connecting different carriers' networks supplied by different vendors will prove to be very interesting research from a technical and marketing point of view. Inter-networking different packet networks such as DataTac and GPRS, by building multi-protocol gateways, is also another interesting research area. Although the forthcoming proposed 64kbps circuit-switched GSM network may not be enough for a real-time mobile multimedia application, it will prove to be the long-awaited seed to start research in this area. GPRS is expected to host fast packet-switched type of applications such as surfing the Internet.

Information systems which are designed on a wireline network, whether it is a LAN or a WAN, will soon be required to be wireless on the demand of their mobile users. Information systems will have to move with the technology that supports them. The wireless data networks have proven to be in great demand for traditional wireline information systems users. Mobile computing will be the rhythm of the 20th century.

Wide-area wireless networks (WANs) pose a series of limitations that most current information systems are not equipped to deal with. For example, the net data rate for wide-area wireless networks is limited to a maximum of 14,400 bps in the DataTAC RD-LAP 19.2 kbps. The proposed 200 kbps GPRS over GSM networks will also prove to be insufficient for efficient information systems.

The convergence of wireless LANs and wireline WANs may become an answer for efficient wireless information systems. Researchers should concentrate on this type of convergence as it means existing efficient information systems designed on wireline networks will need minimal modifications to become wireless. Converting wireline applications to wireless need to be transparent to end users. For instance, wireline TCP/IP applications proved to be very popular and efficient wireless applications in Australia as they require very little modifications to host and client programs. Wireline WANs with 100 Mbps fiber optic backbone combined with an efficient wireless LANs using data compression techniques will provide a real time wireless information system.

There will never be a certain one wireless network that suits every wireless information system. The type of information system will decide upon which network is most suitable. Circuit-switched networks will coexist with packet-switched networks to serve different types of information systems. Deciding which type of a wireless network, whether it is a circuit-switched or a packet-switched, suits a specific information system is an interesting area for research. Certain portability and mobility factors will affect such decisions. Also, the design of the wireline information system might affect the decision.

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