

Mobile Wireless

Release November 2002

4th Infocomm Technology Roadmap Report 2002 - 2007

iDA INFOCOMM
DEVELOPMENT
AUTHORITY OF
SINGAPORE

Dear Reader,

Welcome to the newest revision of our Infocomm Technology Roadmap Reports.

The "Infocomm Technology Roadmap" programme serves to anticipate the macro infocomm technology trends globally and identify potential strategic technologies for adoption in Singapore. Facilitated by IDA, each "Infocomm Technology Roadmap" report is conceived and written via a collaborative effort between many parties, namely from the industry, research & academic community, as well as from government agencies.

It has been slightly over two years since we inaugurated the "Infocomm Technology Roadmap" programme via the first report on "Broadband Access and Mobile Wireless". To date, we have together travelled through four cycles of technology roadmap exercises with the support from our participants on different but strategic technology areas to Singapore.

In embarking on this intimate journey with the local infocomm community, the Technology Group in IDA is guided by the motto 'to bring technologies to better our lives' to build up Singapore's competitiveness via the infocomm cluster.

We hope that you will find our published reports useful and take your time to enjoy reading this latest version. You too can be part of the local infocomm community, if not already, just by being part of the knowledge, even as an informed user with a sophisticated demand.



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The roadmap process entails a continual updating exercise. This ITR4 Release November 2002 has combined, revised, added new emerging interests and will supersede the following:

- ITR1 Release July 2000 (*"Broadband Access and Mobile Wireless"*);
- ITR2 Release March 2001 (*"Broadband Access and Mobile Wireless Updates"*, *"The Connected Home"*, *"Infocomm Security in e-commerce"*);

ITR3 Release February 2002 (*"Next Generation Optical Networks and Photonics"*, *"Next Generation Internet Applications"*) remains valid and current.

Objective of Roadmap Reports

Summary of Worldwide Technologies, Standards and Applications. A key objective of this roadmap report is to provide a good overview of past and future developments worldwide, the efforts of key standardisation bodies and industrial forums for interoperability. The report also aims to promote a good understanding of the market and technology undercurrents which are constantly evolving.

Collective Vision for Alignment of Resources. The fast changing landscapes, the multidisciplinary nature of emerging technologies, competing and converging technology standards, and heightened user expectations call for a more collaborative and managed approach to technology development. For this, the report aims to derive a common vision and directions for future work, reflective of the joint work effort between the industry, government, research community and academia. Where possible and appropriate, we would include strategic gaps and opportunities for collaborative exploitation. The roadmap exercise aims to identify synergies and complementary expertise so that we can pool our resources, leverage on each other's strengths to seize technology opportunities.

Your Feedback

Lastly and very importantly, your feedback will be deeply appreciated on either the report itself, or on collaborative proposals for technology development via the survey form attached at the end of this report. We thank you in advance for your time and effort in doing so and this will help us produce better future roadmap reports.

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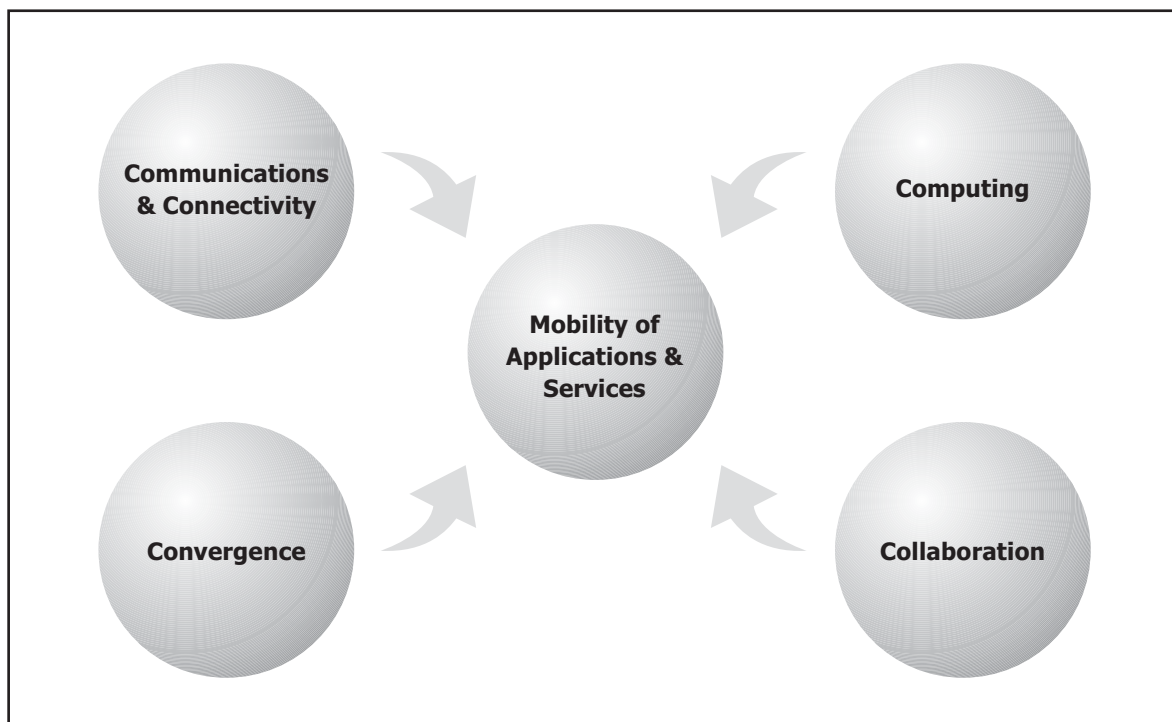
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Vision for Infocomm Technology Roadmap

Forward

In moving towards 2007 and beyond, this ITR4 report weaves through emerging modern communication technologies for an integrated broadband infrastructure. An integrated broadband infrastructure is a multi-pronged combination of heterogeneous networks (last-mile access, mobile wireless or in-home networks), technologies and end devices closely integrated to allow the key concept of *application mobility and access* anytime, anywhere. Secured payment and authentication mechanisms, non-repudiation of services, communication between trusted parties and access management to information and services will also be an enabler of this integrated infrastructure.



The global trend towards an integrated infrastructure will facilitate three basic human needs for “communication and connectivity”, “computing” and “collaboration”. The “convergence” of technologies, open standards & platforms, and contents will lend to the ease of mobility of applications and services encapsulated in this infrastructure. Ultimately, working towards the mobility of applications and services regardless of the technology, network and platform used is to enable a convenient and consistent user experience. It is all about users, both consumer and corporate.

We shall now elaborate more on what we see today and the milestones ahead. Some of the technologies or applications to be described below can satisfy more than one of the three basic human needs mentioned above, hence some overlapping is to be understood.

Communication and Connectivity. Communication is a human basic need to contact each other anywhere, anytime and via various platforms and devices, and a means to stay connected. In the area of mobile wireless, we will see new varieties of services apart from simple voice calls such as rich multi-party multimedia communications, instant messaging and presence services, location based services, as well as one-to-many multimedia broadcast and mobile webcasting. This will enhance individual communication features but also open up enterprise opportunities such as in the areas of mobile e-learning, mobile seminars, corporate teleworking and marketing. Emerging 3G mobile networks could offer in Singapore average data rates of around 100 to 200Kbps while in the longer term, 4G networks could reach peak rates of 100Mbps targeting average data rates of 20Mbps at least. In fact, certain 3G standards such as HSDPA (high speed downlink packet access) for WCDMA in 3GPP Release 5 today is exploring downlink rates of up to 10Mbps, with up to 20Mbps downlink for Release 6 (but deployments are expected around 2005). This development coupled with the decreasing computational power differences between hand-held devices and desktops would facilitate the mobility of applications from wireline to wireless domain.

In the area of Broadband Access, it is about creating the necessary connectivity for communication, computing and collaboration. In our vision of 2007, we expect ADSL and cable to replace dial-up as the dominant means for accessing Internet. However, these two access technologies may no longer be considered "broadband". We believe that the access speeds offered by VDSL and fibre will set the stage for the new definition of "broadband". Lifestyle changes like teleworking will become common, resulting in increase use of applications like video-conferencing, workgroup collaboration, and productivity tools. "Always-on" broadband access characteristic is not sufficient and needs to be enhanced by QoS and symmetric downstream/upstream access speed.

Bandwidth for home area networks will even be less of an issue compared to access networks. By 2007, we could expect a home network to support applications with data rate in excess of 100Mbps, made possible by a wide choice of networking technologies, such as Ethernet, Phoneline networking and Ultra-Wideband. The preference for mobility and "no new wire" advantage will make WLAN (802.11a and beyond) and UWB the dominant choices in most homes, enabling applications with speed of 54Mbps or more. Wireline technologies such as structured wiring will be increasingly used as the high-speed backbone for in-home wireless networks. Powerline communication technology may find its niche in smart home kitchen appliances. However, for home technologies to take off, these technologies must become embedded into devices to the point that they become transparent to the users, and that the deployment of IPv6 is critical to meet the demand for addresses, QoS and security. At the same time, the plug and play ease of use is to be enabled by efforts in automatic service deployment and discovery of enabled appliances.

Vision for Infocomm Technology Roadmap

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Security will take precedent to address a myriad of issues in diverse communication paths occurring between one-to-one, one-to-many and many-to-many in an open dynamic network. Adding to the complexity is the variety of participants in this network, from humans to machines and software agents. At the base of secured communication channels is encryption. By 2007, DES will be completely phased out and AES will be dominant over Triple-DES.

Computing. Pervasive or anywhere computing advances communications and its success pivots on the creation of more sophisticated user demand. In mobile wireless, computing applications will migrate from simplistic mobile games, rudimentary calculator functions to mobile web services, multi-party role play coloured gaming, Java enabled applications, packet based multimedia applications and mobile VPN solutions. The introduction and more widespread use of feature-rich handsets and smartphones will facilitate this migration. In addition, the development of open specifications (e.g. OSA/Parlay APIs) and IP Multimedia Subsystem specifications will work towards the vision of interoperable roaming of these services across both CDMA and GSM networks across the world.

Computing applications like web services are predicted to change the nature of computing to service based models. But regardless of the setting, in working towards end-to-end security for open and heterogeneous web services, the industry targets by 2007 to have a rather complete stack of security standards to support for dynamic and federated networks of web services. This will be the layer of security infrastructure bridging silo-computing systems.

For computing inside the Connected Home, we see today the first wave of development under the guise of data networking for sharing of resources. A second wave of development will revolve around home information and entertainment space. Towards 2007, many entertainment equipment will transit from analogue to smart digital network-ready appliances, examples are multi-services residential gateway, advanced set-top box, digital/interactive television, home media servers, and to a lesser extent, smart kitchen appliances. Most of these appliances will be integrated with one or more in-home networking technologies and adopting open standard device connectivity, with features such as easy plug and play, zero administration, automatic service delivery and discovery, quality of service and device discovery. Security and a flexible billing mechanism will be built-in to support a variety of home applications.

Collaboration. Collaboration extends communication, connectivity and computing to group interaction and team sharing. It widens the interaction scope to groups of individuals in proximity or geographically disparate around the globe. Ad-hoc networking is an important feature to allow the impromptu set up of local networking for collaborative work or resource sharing in meetings or even for multi-party entertainment and gaming.

Collaboration can also be between trusted or non-trusted parties. To enable more sophisticated user demand by 2007, we need to move towards using appropriate security mechanisms to allow communication and collaboration between trusted parties. As such, in addition to PIN and passwords, we will see the emergence of related security authentication and non repudiation technologies and services such as trust service providers, 3D Secure, PKI, biometrics and smart random tokens and chip cards.

Convergence. Convergence can occur at several levels. At the industry cluster level, it can mean working towards integrating contents across different clusters such as the media, arts and entertainment, home automation, finance, IT & communication, broadcasting, telematics, telemedicine, education or e-learning, and e-government.

At the network level, we already see the convergence of voice, text, data, multimedia video that can be delivered with a single IP based network. At the technology and standards level, convergence can mean the confluence of hardware packaging techniques (e.g. BGA, CSP, stacked packaging), movement towards globally standardised architecture, platforms, open APIs (e.g. OMA, OSA). In services, convergence can happen with aggregated contents with 3G portals, or with IP based bundled multimedia services. At home, the OSGI residential gateway represents a tool for convergence towards a multi-service model and whereby service providers can enter to make headway into the smart home via remote provisioning of new services.

Similarly, at the security level, we see efforts towards identity management, federations and single sign on. If we converge under a federated umbrella model, each partner then agrees to trust user identities issued or authenticated by other organisations, while maintaining control of the identity and preference information of its own users. This will not be easily achieved. Sharing session and authentication information across networks and across disparate application is not only difficult, but resource-intensive as well. The level of trust placed over a given client request might vary across different services. By 2007, management console to talk to any security server or client regardless of device type, brand, OS, application or location will however lend itself to support this convergence.

Mobility of Applications and Services. There can be many different networks, access devices, technology platforms but we should have only one convenient, consistent and connected lifestyle. By this, we mean that we should not need to worry about which network we are connected to, how to access different networks or be preoccupied with end to end security of applications. Increasing online applications from fixed sites mainly confined to environments such as corporate LANs or PC internet access networks (in-home or at public internet access sites) are now ported to mobile devices, leading to ubiquitous connectivity.

Vision for Infocomm Technology Roadmap

Forward

Security will also need to interoperate over heterogeneous environments from LAN to public, from wireline to wireless to provide the user with uninterrupted connection to the various forms of services. By 2007, single sign on solutions and portable security such as biometrics (key ones being fingerprint, iris and facial) and smart cards will gain momentum.

The above spells our vision for this report. In gearing up to this vision, the many network and enabling technologies covered in this timeframe of 2002-2007 should take a backseat when compared to the more critical issue of understanding and creating sophisticated user demand, as well as to factor in business perspectives and operational challenges. However, it is a highly volatile task for anyone to anticipate accurately trends in market factors like future user demand and business sentiments. Hence, we can at best provide a technical roadmap of technology vision and trends, and a best-effort attempt to position technology milestones in this timeframe as we collectively judged with the help of industry participants, which the reader should moderate according to prevailing market sentiments.

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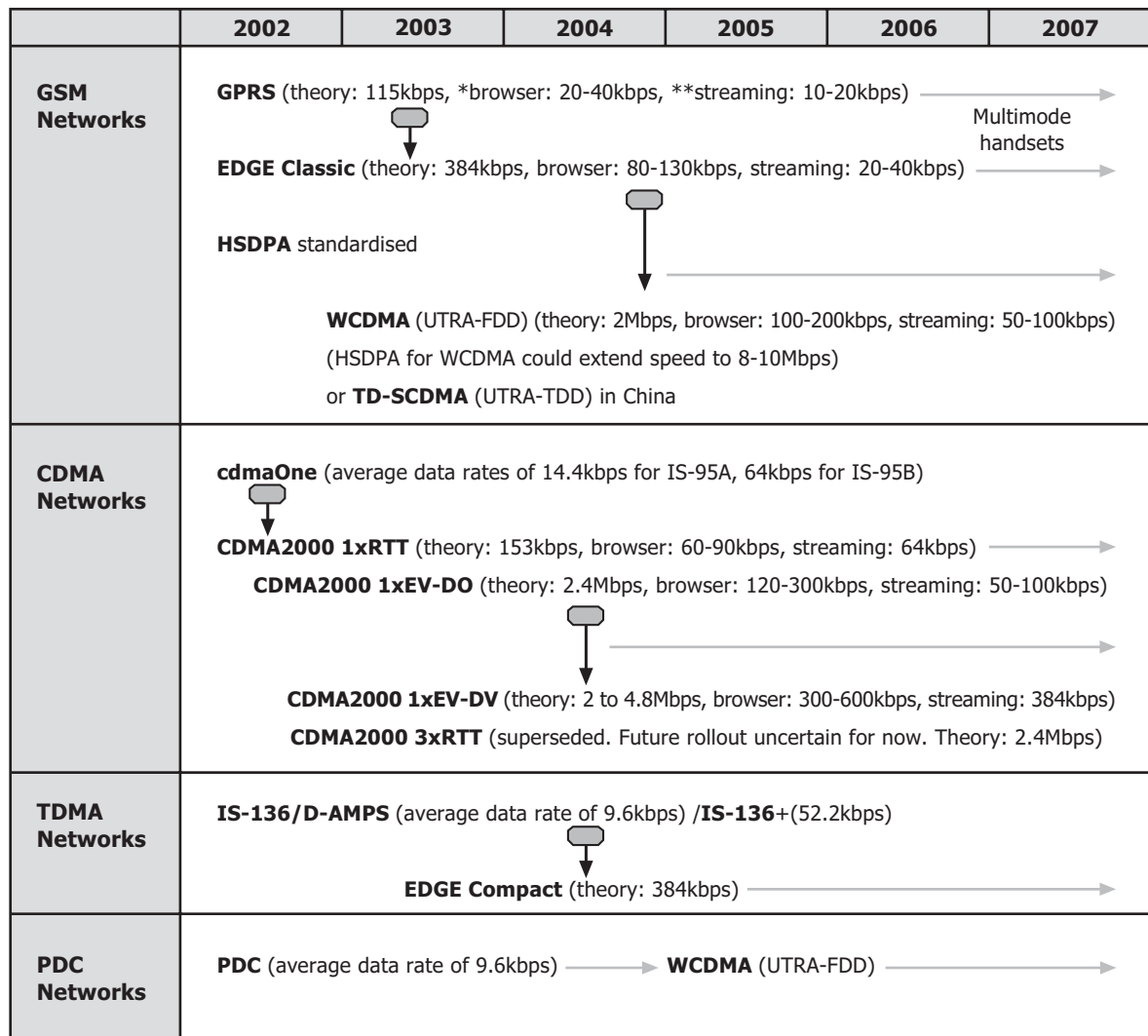
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We summarise the salient points in this report according to their chapters.

Mobile Networks



*Browser: average PC browser speed (loaded network)

**Streaming: average streaming media speed (loaded network)

Figure 1. Summary of 3G Migration Paths

- There is a trend gravitating towards all-IP in core networks as well as to the edge, end-to-end IP. Roaming is enabled by Mobile IP and the report also discussed issues on WLAN/WWAN and 4G issues. The playing field for 4G is still open with various candidate technologies proposed. Both GSM and WCDMA were commercially launched about a decade

after research and standardisation work initially started on them, hence this shows that if 4G networks and services were to be expected around 2010, it would not be too early to discuss or begin work in 4G today.

Enabling Technologies

Wireless Payment and Billing. Billing can be done via many options such as based on volume, airtime, transaction, content or URL access. 3GPP has defined contents-based charging APIs to facilitate an open standard environment for billing. By 2005, we could also see handsets embedded with a contactless interface for proximity, transport, fixed POS (point-of-sale) micropayments. There are other electronic payment standards in progress taken by parallel industries such as EMV (Europay MasterCard Visa) for credit/debit applications. In particular, EMV migration will be completed in Europe by 1 January 2005 and in Asia by 1 January 2006. Key initiatives like "Verified by Visa" and 3D Secure will facilitate authentication for mobile macropayment. Commercial products for this is already available in 2002 for WAP and will be available using SMS in 2003. At present, the Mobile Payment Forum and PayCircle Consortium seems to be more prominent than other payment forums. Ultimately, some collaboration would be needed to drive a common end to end standard amongst the diverse payment forums and be aligned to more established global organisations such as ITU/3GPP/3GPP2.

Handheld Devices & Features. In 2007, GSM-based technology will be dominant accounting for 80.5% of handsets, while CDMA-based technologies will occupy 15%, the rest of 4.5% will be 2G PDC and TDMA handsets (source: derived from ARC Group market figures). Many of these handsets are segmented and personalised for different target user groups. The market nature, and correspondingly differing product and service strategies needed, ranges from dominantly handset replacement in advanced countries to dominantly new handset sales in less developed countries with lower mobile penetration rates.

- **Power.** Power or battery technologies will progress beyond Li-ion and Li-polymer to disposable fuel cell technologies with higher performance and duration.
- **Display.** Displays will be mainly coloured screens (except in low end devices) and advance to organic polymer technologies.
- **Storage.** Portable storage will be commonplace with various media cards currently at 512Mbytes capacity going into Gbytes, whereas USIM cards will offer higher security/authentication and storage capacities from Kbytes to Mbytes range.
- **Imaging & Video.** Imaging and video applications will gain market ground as 200 million

out of the total 880 million handsets in 2007 will be sold with integrated cameras (source: ARC Group). Not only can handsets send multimedia data to online portals, but the opposite flow is also true where PC-based online services and applications can be directed at mobile users. MPEG-4 is chosen by 3GPP as the open multimedia standard for mobile devices. MPEG-4 part 10 is known to ITU as H.264, whose version 1 is scheduled for release in 2003, promises a compression improvement (hence usage cost savings) of 50% at the same visual quality compared with other video standards, albeit much more computational complexity.

- **Human-Machine Interface.** Human-Machine interfaces are emerging with innovative gadgets such as proprietary gaming handset covers as mobile devices converge with gaming handheld consoles. Speech recognition technologies are in general still lacking in accuracy, natural language understanding and speed. New products such as Tablet PC are improving handwriting recognition capabilities.
- **Machine-Machine Interface.** Machine-Machine interfaces would greatly improve in the future with two key trends namely ad hoc networking and autonomic computing, along with flexibility, inter-roaming and bandwidth improvements in physical local connectivity technologies such as Bluetooth, USB, WLAN etc.
- **Digital Radio, Multicast/Broadcast.** Convergence is indeed common today, and is true for digital radio, multicast and broadcast integration with mobile wireless networks in the long term. In particular, this may require higher data rates than 3G could support. Important efforts in future 3GPP Release 6 will include multimedia broadcast/multicast (MBM). This also opens up new world of opportunities for infotainment, e-learning or corporate applications.
- **Chipset Hardware.** Mobile processors in 200-400MHz range are now emerging, and will evolve to beyond 1GHz by 2007. In packaging, convergence is also felt with the amalgam of ball grid array, chip scale packaging and stacked interconnections for mobile ICs.

Middleware. Middleware platforms will revolve dominantly around Sun Microsystem's J2ME and Qualcomm's BREW. MExE, standardised by 3GPP for mobile application environment has incorporated Java J2ME as classmark, while Qualcomm is proposing BREW as new classmark to MExE. MExE is seen to lose momentum and the work is likely to move to Open Mobile Alliance. Due to the strong GSM base, and that majority of handsets are Java enabled by 2007 (source: ARC Group), J2ME is likely to dominate.

Architecture and Platforms. The various trends are depicted below:

- **Operating Systems.** Operating systems involve dominant platforms from players like Microsoft's Windows CE/Smartphone2002/Pocket PC 2002, Symbian OS (formerly EPOC), Palm OS but also emerging Linux based platform like embedded Configurable OS (eCOS). For the handset market, Symbian OS is expected to remain dominant platform in 2007. While in the PDA segment, Pocket PC will overtake market leadership from Palm OS by 2007.
- **Microbrowsers.** Microbrowsers will increasingly support XHTML and J2ME and the market leader OpenWave Mobile Browser will continue its market dominance over handheld devices, with possibly only significant threat from Microsoft's Mobile Explorer.
- **Wireless Application Protocol.** WAP specifications has embraced XHTML Basic as markup language, that is also supported by others like NTT DoCoMo, which signifies compared to the past a tremendous improvement towards a single unified mobile data standard. Backward compatibility with earlier WAP versions is still maintained via WML version 2. Meanwhile, new evolution in the XHTML series by W3C has introduced and will complete XHTML 2.0 around Q3 2004. XHTML 2.0, whose working draft is currently available includes in particular XForms, could be the markup language that developers will use to develop the next generation multi-channel and multi-modal mobile applications.
- **Open Application Programming Interfaces.** Open APIs needed for multi-vendor interoperability in 3G services are proposed by Open Service Access/Parlay and adopted by 3GPP. JAIN (Java API for Integrated Network) Java API binding is expected with OSA/Parlay APIs. Hence these will be the dominant APIs for applications supported by telco operators.
- **IP Multimedia Services and Virtual Home Environment.** Combined with OSA/Parlay APIs, IP Multimedia Subsystem standard supported by MWIF, OHG, 3GPP and 3GPP2 will be a significant reference model for developing interoperable and ubiquitous IP multimedia services over mobile networks and Virtual Home Environments.
- **Web Services.** Web Services will see main competition between Microsoft's .NET Compact Framework and Sun Microsystems' J2ME web services. In terms of beta version rollouts, Microsoft has a slight lead over Sun Microsystem, but J2ME is supported by many handset vendors including Nokia and others like IBM. Hence, J2ME web services may dominate in mobile handsets.
- **3G Portals.** 3G portals are important delivery platforms for services. Amongst the technologies recommended by UMTS for portals, XHTML and HTML markup languages, open

compression formats such as JPEG 2000, MP3, MP3 Pro and MPEG-4 are preferred. Ultimately, we will see convergence into integrated multimedia standards consisting of MPEG-7, MPEG-21, RTFD1.0 and Windows Media Player.

Synchronisation. For synchronisation in Personal Information Management applications, SyncML is the undisputed dominant standard.

Security. USIM card standards by 3GPP will be the dominant specification. JavaCard is likely to emerge as leader in multi-application operating system for SIM cards over MULTOS operating platform, but we also see now that many smart card solutions offer flexibility to include various multi-application Oses onto one single chip. Hence there will not be a critical need to force SIM applications to one platform. USIM cards will reinforce their role in service personalisation and configuration, and provide security means for efficient digital rights management and a variety of digital transactions.

Applications and Services

Revenues for 3G services are expected to hit US\$322 billion by 2010 with the average user spending US\$30 monthly on 3G data services (source: UMTS Forum). Rich content provision via 3G portals, multimedia messaging, location based services are as important as billing and payment mechanisms. New emerging areas that 3G may not be sufficient (or in a limited manner) to provide are personalised consumer and corporate webcasting (multicast) applications, video applications and converged services with broadcasting applications. These are better provided by 4G.

- **Messaging.** Ultimately, streaming and video conferencing would be natural extensions to multimedia messaging. While 3G can possibly support streaming, resource heavy video applications may have to wait for 4G. Videophone real time conversations for example require stringent QoS with delays below 150ms and a frame error rate of less than 1%, and a data rate up of 32 to 384kbps, according to UMTS Forum.
- **Location Based Services, LBS.** LBS as one of the next dominant applications is facilitated by the Location Interoperability Forum's (moving on to OMA) work on interoperability protocols. For LBS to flourish, what is needed still is the work on user privacy issues that probably differ from country to country. Singapore has already embarked on privacy work via Singapore's IT Federation's Wireless Chapter.
- **Instant Messaging and Presence Services, IMPS.** IMPS facilitated mainly by Wireless Village will pave the way for new mobile applications that will amount to US\$9.2 billion in revenues by 2006 (source: Baskerville). Many of the work under Wireless Village, WAP Forum and LIF had or will be migrated to Open Mobile Alliance, the future key dominant alliance.

- **Infotainment.** Amongst the many infotainment services, wireless gaming or multi-party wireless gaming could be an interesting application for many users. Datamonitor expects the Asia Pacific region including Japan to attain US\$10 billion in revenues by 2006 for the wireless gaming market amounting to 220 million gamers by then, growing from just US\$827 million in 2001.
- **Personalised Services.** Amongst the many variants of personalised services, mobile webcasting especially with 4G networks would be an excellent tool for consumer entertainment, e-learning as well as corporate applications.
- **Mobile Commerce.** Closely linked to advancement in payment tools, mobile commerce may be rekindled with multimedia capabilities of handsets for more interesting mobile Internet surfing experience. Interestingly, ARC Group ranks adult entertainment as the third most popular mobile picture application. This may pose certain social challenges.
- **Corporate Applications.** With the advent of mobile VPN solutions based on IPv6, wireless intranets/extranets could extend work resources to employees on the move. This will also be enabled by the integration of wireless LAN (WLAN) with mobile wireless networks.

To conclude, the reader may refer to the roadmap chart completed with this report so as to have a snap overview of key developments in the timeline 2002-2007 for planning purposes.

1 Introduction

Target Audience. The report strives to benefit the following readership: decision and policy makers, operators & industry players, and end users (individuals or organisations).

Report Taxonomy. In chapter 1, we define key driving forces behind next generation mobile wireless. In chapter 2, we describe the various 2.5G and 3G network trends including GSM and CDMA. We also look at the convergence towards all-IP, roaming with Mobile IP and 4G. In chapter 3, we depict trends in enabling technologies in hardware, middleware, software, architectures, industry alliances, market applications and services. In chapter 4, we examine the local Singapore landscape. Chapter 5 concludes this report. The mobile wireless roadmap chart produced is a succinct milestone representation of this report.

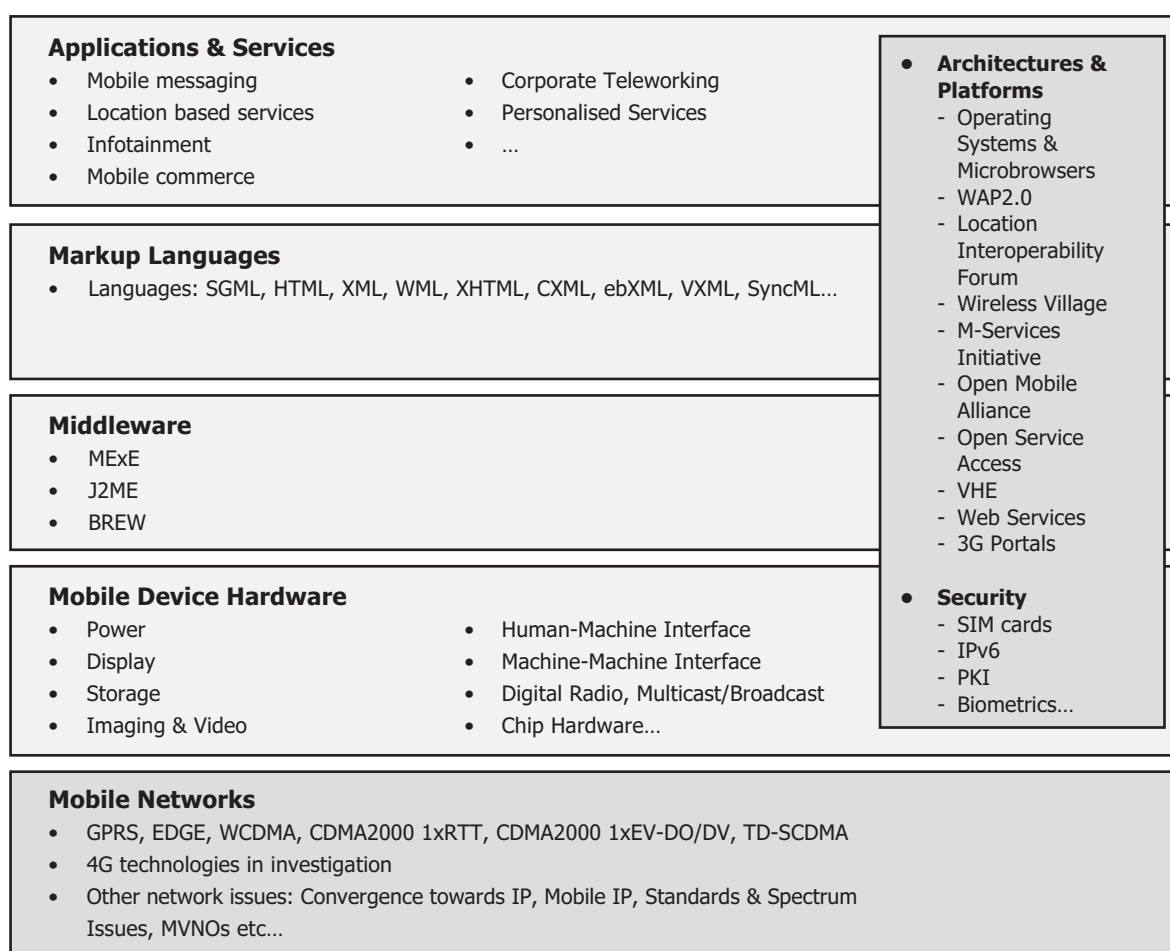


Figure 2. Overall Report Organisation

Drivers for Next Generation Mobile Wireless. The undercurrents shaping the development of mobile wireless technologies & services may be classified under social, technological, economic, environmental and political forces that pivot on the interaction of four essential group of key players: consumers, industry, researchers and government. These relationships introduce critical uncertainties that can make or break a mobile wireless technology or service in conception.

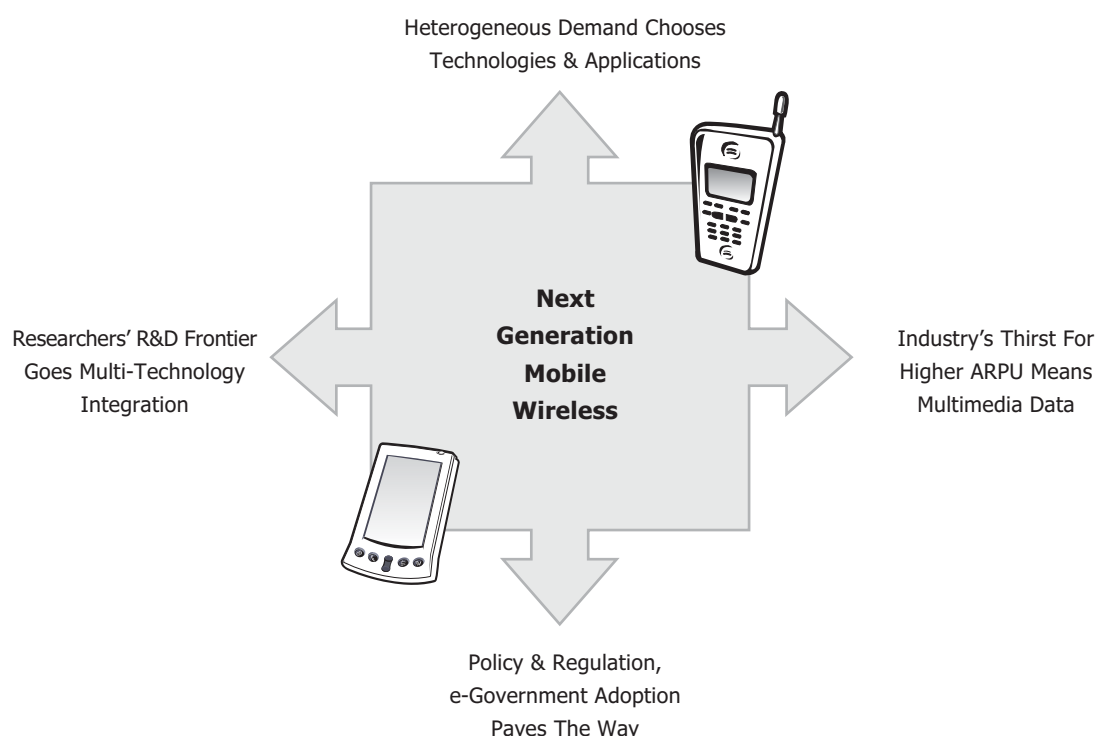


Figure 3. Key Driving Forces Shaping Mobile Wireless Evolution

Driver 1: Very Strong But Heterogeneous Mobile Demand. There can be many interesting characteristics and segmentations of consumer and corporate demand. Let us first look at the general global trends in mobile demand.

	2002	2003	2004	2005	2006	2007
Global Mobile Handset Unit Sales (in millions)	429.9	488	557	646	752	880

Table 1. Global Mobile Handset Sales to End Users
(Source: ARC Group)

Worldwide statistics show that more people now own a mobile phone than a PC, & the trend is expected to escalate exponentially. In fact, even when compared to fixed phone lines and TV penetration, mobile subscription has outperformed these technologies in a much shorter time frame. This explosive popularity will be a long-term sustaining driver because it correctly addresses the basic human need for communication and interaction anywhere and anytime. Hence, the mass users in both developed and developing countries constitute the bedrock of guarantee for the sustainability and investment in next generation mobile wireless.

Within the adopters, there are also the early users or the mobile jet setters, who usher the market entry of new devices, technologies and services. These users can generate a critical mass of users (typically at 25% rate of adoption by market) but they can also generate a destructive publicity to the detriment of the industry. Mobile users are also segmented according to age groups, gender, habits, professions, income groups, or corporate users and handsets are increasingly being customised for specific target groups in terms of both hardware and software features.

An increasingly important and key demand is from enterprise mobile users. Those enterprises who have a growing mobile workforce require mobile enterprise solutions to allow them to fully connect with the enterprise infrastructure and business applications while they are on the road. The enterprise mobile demand will bring the mobile solution providers profitability.

The market evolution in different countries or regions in the same country differs greatly depending on the saturation and penetration rate of mobile subscribers. On the one hand, in saturated markets such as Singapore, the demand for mobile handsets primarily originates from replacement or upgrading of existing ones. This is the same trend witnessed in many mature markets usually found in advanced countries such as Japan, South Korea, North America and Western Europe. Several of these markets show a penetration rate of above 70%.

The market differentiation also varies widely depending on many attributes including technological factors of device availability and functionalities, content richness and accessibility, social & economic factors of lifestyle priorities, purchasing power, rising social status consciousness, to political & regulatory considerations affecting technology deployment.

As such, typical handset replacement rates could vary from about 9 months in Singapore to possibly 18 months in Japan. In China, mobile development in the rural regions compared to coastal cities is different. To the Chinese, a mobile handset jacket made of rare skins could potentially be higher priced than the device itself as it reflects a higher social status of the owner. Yet many Chinese are also buying second-hand handsets according to consultancy firm BDA China Ltd. Branding power, often cited as critical as the market is seen dominated by a few major brands, has surprisingly produced widely diverse results on markets like Singapore

when compared to China. Nokia has captured the majority market share in Singapore while the same brand in China has only managed to capture about a quarter of market share.

Dataquest saw global shipments of handheld computers in 2001 to be only 13.1 million units. The PDA market is generally less saturated and hence depending primarily on higher penetration rates for growth. This applies also to unsaturated mobile handset markets found typically in developing countries. According to ARC Group, the China market with its fast subscriber growth would mature to become a replacement market by as early as 2007. Eastern Europe in the survey by Mobile Communications magazine saw more than 50% increase in annual new subscribers up to June 2002. At this rate, it seems that the worldwide mobile market will transform itself into almost a replacement market over the next five to ten years.

To conclude, we believe although in general the mobile demand is poised to grow over 2002-2007, there are these consequences:

- The demand is heterogeneous and segmented, resulting in growing device diversification, more localised and customisable application rollouts, more dependence on open technologies (open platforms & OSes, XML-based languages, Java, etc) that are preferably post-issuance friendly (with over the air provisioning of services) and thus remote loading of applications will demand increasing end-to-end security all the more so when the mobile environment assimilates richer online multimedia and connectivity capabilities;
- In saturated and mature markets like Singapore, growth is about replacing handsets. Hence it is more important to have more enticing new handset models and features. It is also wise to synchronise the contractual period for subsidised handset hardware in a timely manner with vendor, application and network roadmaps for new technology features and value add services. This may allow better success for 3G uptake. In the unique case of Japan, it is in fact the operators that dictate the handset functionalities and place orders to the Japanese handset vendors, but this is possible because of the operators' strong position backed by a large domestic market.
- Growth is also to focus more on enterprise mobile demand that will bring the mobile solution providers profitability.
- There could be a widening gap between the have's and have-not's intra- and inter-country, with the introduction of multimedia mobile services & devices via 2.5G/3G/4G. Heightened aspirations, the myth or fact that owning a handset is a basic necessity and increasing dependence of Personal Information Management via mobile devices may produce social discomfort, psychological dependence and unbalanced lifestyles if individual wealth does not progress on par.

Driver 2: Strong Industry Base. The breadth and depth of the global mobile industry itself and its supporting bandwagon of industries are testimony and drivers to the development of next generation wireless technologies, besides providing the livelihood for many. Telecommunication infrastructure is key to any developing or developed country. Within the industry itself, there are many competing activities and alliances driving the development technology standards and the deployment of applications. There are also innovators and quick movers that can sometimes rise to become disruptive technology players.

In matured mobile markets like Singapore, the focus of telecom operators is to increase the Average Revenue Per User or ARPU. This will lead the rise of new data-intensive services such as multimedia messaging, instant messaging, location based services, etc, which we will elaborate more further in this report. The industry will hence drive the development of next generation mobile wireless such as 3G and even 4G, as it is currently doing so, to meet even more data intensive and real time broadband-on-the-move requirements of applications such as video broadcast/multicast.

Driver 3: Strong Research Impetus & Innovation. There are abundant laboratories worldwide involved in wireless research. The mobile industry benefits from its ability to leverage from this long existing research community as well as from increasingly cross disciplinary research activities. Research activities are currently pushing the envelope of possibilities of 3G and especially 4G technologies. This driving force is particularly important in determining the critical uncertainties of the later years in mobile wireless such as for 4G networks and the convergence towards IP-based multimedia services.

There is also the increasing role of contents and services in the mobile value ecosystem. The convergence within the media, entertainment, arts, IT, Internet, broadcasting and communication clusters can be tapped to create further innovation and mutual benefits for economic growth and lifestyle enhancements. We can consider this as soft infrastructure research and innovation, as it involves a lot of human synergies and collaboration, regulatory collaboration and creative ideas for contents and applications.

Driver 4: Strong Government Thrust. The government in many countries plays a key role in mobile wireless, be it as a key anchor customer in for example e-government computerisation, or policy maker and regulator, or as an industry & e-lifestyle promoter. As such, it is certainly a key driving force that will help contribute to the long-term growth of mobile wireless. In its particular role as regulator, mobile wireless development can be facilitated via policies in the areas of fair competition, interoperability (e.g. SMS, EMS, MMS, LBS, number portability etc), privacy and data protection, as well as roaming issues.

2 Next Generation Mobile Wireless Networks

In this chapter, we begin with an overview of the evolution of mobile wireless networks, followed by individual analysis on the different 2.5G and 3G networks. After which, we will examine prominent topics like All-IP and Mobile IP, standards and interoperability issues, as well as what is looming beyond 3G – the technologies for 4G.

2.1 The Route to 3G Mobile Wireless

Background. First generation RF cellular communications systems were deployed in industrialised countries in the early to mid 1980's. These cellular systems had air interfaces comprising of analogue technology and among them were AMPS (Advanced Mobile Phone System), NMT (Nordic Mobile Telephone), TACS (Total Access Communications System) and JTAC (Japanese Total Access Communications). Most were designed for use in a specific geographic area and not intended to be deployed in other areas. There was not much commonality beyond using the same air interface technology, Frequency Division Multiple Access (FDMA), and the same modulation, analogue FM. The frequency bands ranging from 800MHz to 900MHz, air interface protocols, number of channels, and data rates ranging from 6.8kbps to 14.4kbps were all different. These systems provided national and at best regional coverage.

As subscriber growth increased, the need for second generation systems with added capacity was evident. In addition, some areas desired communication systems across countries, as in Europe. The deployment of GSM (Global System for Mobile communications) Phase I in 1992 marked the beginning of digital second-generation (2G) systems. NADC (North American Digital Cellular) and PDC (Personal Digital Cellular) followed in North America and Japan, respectively. Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) air interface technologies were combined and used to provide more efficient usage of the frequency spectrum and hence additional capacity. The frequency bands, air interface protocols, number of channels, data rates and, in this case, modulation were different. These systems provided digital speech, privacy, and additional capacity.

Around 1995, enhanced second-generation systems (2G+) were introduced. These systems primarily centred on up-banding the existing systems to the 2GHz PCS frequencies as well as the deployment of *cdmaOne* systems. *cdmaOne* systems introduced Code Division Multiple Access (CDMA), a completely different air interface technology which promised even more capacity over the TDMA systems. With the increasing desire for systems with data transmission services these enhanced second-generation systems such as GSM Phase 2 offered additional services such as short messaging service, and improved the digital speech. GSM Phase 2+ offered service customisation such as SIM Toolkit and increased data rates to 64kbps maximum.

Unlike the first generation systems that were designed for a specific geographic area, these second and enhanced second-generation systems were intended to be deployed internationally with global roaming capabilities.

With the massive popularity of Internet in the mid 1990's, Internet Protocol (IP) technologies and packet switching networks became the focal point of development. The majority of previous mobile networks were mainly based on circuit switching, which is highly suitable for voice communication but less for data communication. High Speed Circuit Switched Data (HSCSD) network was one of the attempts to provide better data services using circuit switched technologies. These interim deployments did not prove to be popular. To become more data friendly while still supporting voice communication, many GSM wireless networks today migrated to 2.5G networks such as General Packet Radio Service (GPRS). Sometimes, HSCSD is considered 2.5G. However since HSCSD is not as widely deployed as GPRS, we would focus on GPRS. Attempts were also made in the US to overlay IP over analogue AMPS networks via the specification developed in 1993 on Cellular Digital Packet Data (CDPD), to boost data rates to 19.2kbps. However, such attempts did not prove widespread and had reliability challenges.

The world is now in a bid to provide even better and quicker data cum voice services via third generation (3G) mobile communication systems. IMT-2000 is ITU's vision of global wireless access in the 21st century. IMT is the acronym for International Mobile Telecommunications. Deployment of these systems was then expected to start around the year 2000 and the frequency of operation approximately 2000MHz. Hence, the name IMT-2000.

Third Generation networks could offer up to 144kbps (high mobility in fast moving vehicle), up to 384kbps (walking pedestrian) and up to 2Mbps (stationary). IMT-2000 has been designed from the outset as a global system, linking both terrestrial and satellite components. A number of different radio environments are defined covering very small indoor cells with high capacity all the way through large outdoor terrestrial cells to satellite coverage. Subscribers will be able to roam between networks, for example from a private network, into a public network then into a wide area network and to a satellite network - with minimum break in communication.

By the end of 2000, the world has witnessed the arrival of WAP (Wireless Application Protocol), HSCSD and GPRS, and seen the majority of 3G licences awarded. However, the transition to 3G will be nothing like the move from analogue to digital GSM. The discrepancy among standards, readiness of handsets and contents are just some issues causing setbacks in 3G development. Initial 3G deployments will not see full capabilities being made available from the start and hence there is a need to manage consumer expectations.

2.1.1 GPRS - General Packet Radio Service

The route to 3G is not always easy to understand. New and existing operators can choose between developing today's system or building a completely new type of radio network based on WCDMA technology. Many operators will probably opt for both. It is vital to understand the available interim technologies and select the correct path to build the network of today that can accommodate the needs of tomorrow.

The First Step – Packet Data. Some American operators who use the TDMA and cdmaOne systems, and the Japanese PDC operators have already supplemented their systems with packet data technologies. Meanwhile, GSM operators have begun installing GPRS system in their networks. GPRS is a packet-switched 2.5G protocol with theoretical transmission speed of 171.2kbps. GPRS supports both GSM and TDMA technologies.

GPRS operates by overlaying a packet based air interface over an existing GSM network. It offers high data speeds and provides an 'always on' connection to the Internet. GPRS requires network resources only when a subscriber sends or receives data. The 'best effort' mode of operation also smoothens out the traffic peaks. With GPRS, voice communications are still circuit switched, while data is packeted in small packets and sent wherever there is available capacity in the network.

GPRS data rate in deployment is limited by the terminal's capability and coding schemes being used. Coding Schemes 1 to 4 (CS-1 to CS-4) defined by ETSI are related to the error correction overheads, the higher the error correction overhead the lower the throughput. The theoretical speed of 171.2kbps corresponds to the highest coding scheme of CS-4 (meaning least level of error correction) and when all 8 timeslots are dedicated to that single user. Actual rollouts would typically offer around 40.2kbps downstream and 14.4kbps upstream.

A GPRS handset can also be classified according to various speed classes such as Class 2 (1Tx, 2Rx), Class 4 (1Tx, 3Rx), Class 8 (1Tx, 4Rx), Class 10 (2Tx, 4Rx), Class 12 (4Tx, 4Rx) and Class 18 (8Tx, 8Rx). While first generation appearance of GPRS handsets did not really create much excitement for data applications but had rather been exploited for branding and market differentiation purposes, second generation GPRS handsets offering MMS capability and E-OTD (Enhanced Observed Time Difference) location technology are of Class 8. Third generation GPRS handsets will be of Class 10 and supports E-OTD, J2ME, MExE and MMS. From these terminals, we see that it is unlikely that actual GPRS speeds will improve much to cater for advanced broadband applications. CS-3/CS-4 will not be employed soon as current GPRS terminals have stability issues with CS-1 and CS-2. Using more timeslots to increase GPRS data rates will demand more power consumption as well as cause the handset to radiate stronger, both not desirable for users. However, in the longer term, we may see CS-3/4 enabled handsets as technology matures.



GPRS Roaming. One of the key factors behind the success of GSM was seamless roaming across borders. If GPRS is to realise its full revenue potential, roaming that approaches the ubiquity users expect with voice services must be replicated for GPRS as soon as possible.

Unfortunately, GPRS roaming is not just a matter of expanding the voice-roaming deals that were struck for GSM. Instead, new technical and commercial challenges must be overcome. From a technical point of view, there are three roaming models available for inter-connection.

- The first model involves direct connections between two mobile networks using direct leased lines. This method of inter-connection may give the GPRS operator control over QoS and is highly secure, but it is the most expensive option.
- A second model is to use a public IP network such as Internet. This model may be attractive from cost perspective, but in terms of QoS and security, very few operators would opt for this method of inter-connection as a long-term solution.
- The third model, GPRS roaming exchange, or GRX¹ in short, is effectively a company that provides inter-connection services to GPRS carriers for the carriage of IP traffic between two or more GPRS network operators. The advantage of using a GRX as a hub for routing GPRS data along private IP connections is that the operator only has to manage the connection to the GRX and not the several connections to all roaming partners.

For inter-operator exchange billing settlement, a Transfer Account Procedure TAP3 protocol has been developed. Besides, this option has the capability of offering the QoS and high security along with a realistic cost structure. Operators are already addressing many of the commercial issues as they establish roaming contracts, settlement agreements and peering arrangements. Several early deals have been agreed on a trial-and-error basis. For example, in March Deutsche Telekom's T-Mobile announced that it would offer international GPRS roaming. And Vodafone and mmO2 have agreed to allow operators within the T-Mobile group to roam over their GPRS networks.

Commercial GPRS services have been launched by more than 100 mobile operators in Western Europe, as well as in the USA, and by several Asia Pacific operators in countries including Australia, China, Philippines, and Singapore. However, roaming for GPRS has been implemented between relatively few of these operators. Many operators have been distracted from implementing GPRS roaming services because they have been grappling with delays in the

1 GRX (GPRS Roaming Exchange) is specified in the IR.34 recommendations laid down by the International Roaming Expert Group (IREG) of the GSM Association.

introduction of large quantities of GPRS handsets, and with the need to devise appropriate pricing policies and offer enticing applications for GPRS.

With the introduction of GPRS data services, mobile operators have taken the initiative since 2000 to strive to ensure seamless cross-border roaming for GPRS data services. The world's first full-service, scalable GRX peering exchange, the Amsterdam GRX Peering Exchange², for the interconnection of GPRS roaming was announced in 19 July 2001. The GRX peering refers to the interconnection of separate GRXs. The GRX peering will facilitate global roaming for mobile end users and is a core component in enabling a truly global mobile Internet.

But the technical limitations of today's GPRS networks make it difficult for operators to share services and subscriber-profile information even within their own service areas, much less with other operators. To tackle this problem, the mobile operators, equipment vendors and companies that build mobile-data-service systems are working together on the emerging Customised Application of Mobile Enhanced Logic (CAMEL) standard³. CAMEL III is geared towards providing intelligent network services over wireless networks, and promises the extensive metering and monitoring that are required for GPRS roaming. CAMEL IV standard is in place in 3GPP Release 5, and eventually it will enable standards-based roaming across multiple networks, with the ultimate goal of "home-based roaming" in which profiles remain on the subscriber's home network but are shared across multiple networks. Solutions like CAMEL are needed because today's GPRS systems lack the granular visibility and control required for robust GPRS roaming, and the power and flexibility for identity portability across boundaries. CAMEL has however not made very significant progress in general. So far, CAMEL is deployed in multi-vendor networks involving prepaid, and also used for voice/GPRS roaming scenarios involving prepaid.

2.1.2 EDGE - Enhanced Data Rates for Global Evolution

Enhanced Data Rates for Global Evolution (EDGE) offers speeds of up to 384kbps. The speed of 384kbps is not a random number but rather judged to be a minimum requirement for a satisfactory bandwidth for video streaming applications. EDGE was developed by Ericsson. In comparison, EDGE will provide 7 times more capacity than TDMA systems and up to 3 times more than that of GPRS. To achieve this, it uses 8-PSK (eight-phase-shift keying) instead of

2 The founding membership of the Amsterdam GRX Peering Exchange represents 80% of all current providers of international GPRS roaming data backbones for mobile operators, with signatures from 17 of the 22 currently listed GRX.

3 CAMEL 3GPP TS 22.078 v5.7.0 (2002-06) – method to speed up the introduction of network functions into future mobile phone networks. Before, to introduce new network functions, it was necessary to update the software in all base station and exchange involved. With CAMEL, the local exchanges are instructed to refer unknown network functions to a central computer.

GSM's GMSK (Gaussian minimum-shift keying) modulation technique, tripling the user's bit rate in the 200kHz channels. Actual data rates to the user still depend on terminal compatibility and coding scheme used like for GPRS handsets.

From GSM and TDMA (IS-136) to EDGE. As EDGE is implemented in the existing frequency spectrum, it requires no additional spectrum investment to enable operators to offer a wide range of new revenue-generating services. From the convergence of TDMA and GSM technologies using EDGE, there will be the benefit of economy of scale, since the same core and radio access technology will be shared. Operators can also capitalise on many of their previous investments and reuse portions of their infrastructure. EDGE also provides the unique ability for operators to offer single terminal roaming between TDMA and GSM networks in all frequency bands world-wide. With EDGE, operators can realise their full revenue potential through incorporating international roaming more conveniently and cost effectively.

When the EDGE control channel reuses the normal GSM broadcast channel, this is referred to as EDGE Classic. For TDMA systems, the evolution to EDGE may face more stringent spectrum availability. Hence the EDGE control channel needs to leverage on a modified broadcast channel that could fit into the limited spectrum bandwidth, this is called EDGE Compact.

Growth for EDGE would most probably begin in North America and Europe as early as 2003. In North America, the availability of GAIT (GSM ANSI Interoperability Team) handsets in the first half of 2002 to allow roaming between TDMA and GSM signifies a first step in the actualisation of migration from TDMA to GSM networks. GAIT vendors (Nokia, Siemens, Sony Ericsson) are contractually obliged to supply EDGE enabled handsets to the US TDMA operators (such as AT&T) for EDGE migration. Nokia announced that its EDGE enabled handsets for North America would see the light by end 2002 and offer EDGE on 850MHz, followed by 900MHz. We are likely to see more EDGE handsets in commercial deployment in 2003/2004. By 2004, Nokia claims that all its GPRS and WCDMA handsets will work with EDGE. In Europe, WCDMA handsets are likely to incorporate EDGE functionality.

EDGE networks could persist in 2007 or migrate to WCDMA. With the many issues that have delayed WCDMA, in contrast to past predictions, we are more likely to see more operators choosing EDGE while preferring to adopt a more cautious approach to WCDMA for it to stabilise. Several telcos including AT&T indicated their migration from GPRS to EDGE instead of directly to WCDMA. Some operators deem EDGE networks sufficient for most initial advanced applications, as such to them, it is less urgent to invest directly in WCDMA.

On the standardisation front, GSM and EDGE will evolve with enhancements that will align them to WCDMA. These enhancements are now being specified as part of the GSM/EDGE radio access network (GERAN) standard in upcoming releases of the 3GPP standard. The GERAN

standard will support the same quality of service classes, such as conversational multimedia and streaming video, similar to those defined for WCDMA. Also, GERAN is adopting the WCDMA architecture, which will provide the same functional split between the core network and the radio access network for GERAN as that defined for WCDMA.

2.1.3 WCDMA - Wideband Code Division Multiple Access

New Radio Network with WCDMA. The 3G standard that Europe and Japan have agreed to adopt is known as UMTS. UMTS is an upgrade from GSM. The standardisation work for UMTS is being carried out by the Third Generation Partnership Project (3GPP). The terrestrial part of UMTS is known as UTRA (UMTS Terrestrial Radio Access). The FDD (Frequency Division Duplex) component of UTRA is based on WCDMA standard (UTRA-FDD) that can offer very high data rates of up to 2Mbps (likely average rates of 100-200kbps). The TDD component of UTRA is called TD-CDMA (UTRA-TDD).

Finland was first to allocate its 3G licences as early as May 2000. NTT DoCoMo has launched the world's first WCDMA services in October 2001. During the launch, the consumer is presented with a choice of two phones: the standard NEC N2001 and the more expensive P2101V videophone. FOMA phones can operate at much higher speed than CDMA2000 1xRTT. However, there are still significant coverage, handset and service issues encountered in the Japanese WCDMA deployment.

There were, in fact, a number of 3G handsets made available by leading Japanese telecomm manufacturers such as Matsushita. But, they will operate on the Japanese version of WCDMA, which is pre-R99 version, different from the European version of WCDMA (UMTS). There are small but significant differences between the two standards, which means the Japanese phones are unlikely to work on European networks. However, these pre-R99 networks will be upgraded to full 3GPP standard compliance improving on interoperability issues.

Some more WCDMA networks in Europe are likely to be launched in 2003. We are likely to see more widespread WCDMA deployments in Asia and North America starting 2004. The period of 2004 to 2006 will see the wider deployment worldwide of WCDMA by GSM operators.

One key development in the WCDMA camp is HSDPA (High Speed Downlink Packet Access). The 3GPP Release 5 specifications include HSDPA to support packet-based multimedia services at downlink rates of up to 8 to 10Mbps over a 5MHz bandwidth, and Release 6 targets to include up to 20Mbps for MIMO (multiple input multiple output) systems in CDMA downlink. However, HSDPA deployments are unlikely before 2005.

We would also likely see an increase in the number of GSM camp operators who could possibly evaluate the option of CDMA2000 1xEV instead of WCDMA as the former is more stable currently and that WCDMA has encountered setbacks and delays. Nevertheless, the majority of GSM operators would choose WCDMA over CDMA2000 1xEV.

Migration to 3G and IP-Centric Networks. A general view in the industry is that the demand for data service in the future will create a whole new revenue stream for operators and hence, it will drive the deployment of future networks. This is based on the huge volume of data traffic generated by the Internet on fixed networks and, to a lesser extent, the rise in the use of SMS on mobile networks. In Japan, the demand for the much publicised i-Mode service is primarily driven by the fact that the vast majority of Japanese people do not have Internet access.

There will not be enough public IPv4 addresses available for all the mobile terminals to connect to the Internet and the use of IPv4 addresses and address translators would greatly complicate the network infrastructure. To deal with these problems, IPv6 has been adopted as a functional and durable solution. When moving towards IPv6 in mobile networks, the biggest changes are needed in the Gateway GPRS Support Node (GGSN) elements in the mobile core network and in the mobile terminals. The transition from IPv4 to IPv6 requires special care and attention. As a matter of fact, IPv4 networks and services will continue to exist for quite some time, making efficient inter-working between IPv4 and IPv6 very important.

2.1.4 CDMA2000 - Code Division Multiple Access 2000

The chief competitor to WCDMA is Qualcomm's CDMA2000. The standardisation work for the CDMA2000 is carried out by the Third Generation Partnership Project 2 (3GPP2).

CDMA2000 has two phases: phase one is 1xRTT (sometimes 1X in short), which can be upgraded to phase two, the 3xRTT (3X in short). CDMA2000 1xRTT can offer on a single 1.25MHz carrier in new or existing spectrum peak rates of 307.2kbps with Release A, while most deployed are on earlier Release 0 version with peak rate of 153.6kbps. CDMA2000 3xRTT promises up to 2Mbps on three 1.25 (total of 3.75MHz) carriers. CDMA2000 1xRTT has been commercially available since October 2000 (launched by South Korea's SK Telecom) and followed by LG Telecom and KT Freetel.

In the United States, Verizon Wireless' CDMA2000 1xRTT network named Express Network provides for full Internet access, intranet access, and e-mail functionality via a laptop. The data rate expected for users is average between 40 to 60kbps. These figures are indeed very close to GPRS speeds, hence the reason why some say that CDMA2000 1xRTT is not 3G but 2.5G.

For migration, CDMA operators would possibly adopt a different approach from GSM operators. Due to the characteristics of high speed data applications, the migration path from 2G IS-95A technology to 2.5G IS-95B (also known as cdmaOne) and then to CDMA2000 1xRTT version was not found to be a viable technical and business proposition by service providers, because it would be easier and cheaper to just skip IS-95B. In view of this, several CDMA operators would prefer going directly to CDMA2000 1xRTT version from 2G IS-95A technology. However, there were others, mainly in Japan and South Korea, who went past IS-95B such as SK Telecom, Hansol, DDI and IDO.

While the GSM world is stuck in 3G delays, the CDMA camp has benefited and forged ahead with roughly a dozen of CDMA2000 1xRTT deployments, mainly driven by the South Korean and American markets (Sprint PCS, Verizon Wireless, and even TDMA operators like US Cellular), as well as support from China (China United Telecommunications Corporation) and Japan (KDDI). However, there is reluctance from many operators and vendors to adopt a technology such as CDMA2000 because of its proprietary nature when compared to open standards based on GSM. Nevertheless, Qualcomm has launched a GSM friendly solution called GSM1x (mix of GSM and CDMA2000 1xRTT benefits) to entice GSM operators to switch to CDMA networks. Much remains to be seen.

Handsets using CDMA2000 1xRTT technology is backward compatible to the existing cdmaOne networks. Operators who deploy CDMA2000 1xRTT can enjoy roaming into CDMA operators on their cdmaOne networks worldwide. Handset vendors for CDMA2000 1xRTT include for example AirPrime, GTRAN, Hyundai CURITEL, Kyocera, LG Electronics, Motorola, Nokia, Novatel Wireless, Samsung, Sanyo, Sierra Wireless, SK TeleTech and Sony Ericsson.

After CDMA2000 1xRTT, the CDMA market is migrating to CDMA2000 1xEV-(DO & DV). Previously, the industry was focused on a wider band approach to high data rates, commonly referred to as CDMA2000 3xRTT. The 3X standard has now been superseded by a two-phase strategy called CDMA2000 1xEV using 1.25MHz carrier. Thus, CDMA2000 3xRTT has now been put on the wayside until market demands make it necessary to migrate to a wider band carrier (3.75MHz). It is also questionable whether CDMA2000 3xRTT will ever materialise due to spectrum requirement and technology change-out costs.

Advances in the industry and engineering prowess contributed to new proposals for higher data throughput and more capacity while maintaining the 1.25MHz bandwidth. Operators and manufacturers soon realized that there were inherent cost, backward compatibility and timing advantages in keeping with the 1.25MHz bandwidth for evolution. Hence, the next evolution step towards the two CDMA2000 1xEV (EV=Evolution) standards.

To provide higher speed for data services, a data-optimised version of CDMA2000 called CDMA 1xEV-DO (DO = Data Only) provides a peak data rate of 2.4Mbps, with average data throughput rates at over 700kbps. CDMA2000 1X EV-DO uses a separate 1.25MHz carrier for data. To implement 1X EV-DO, operators will have to install a separate carrier that is dedicated to data-only use at each cell location where high-speed services are demanded. The beauty of this technology is that, the users will be able to handoff seamlessly from a 1X EV-DO to 1X carrier.

Most CDMA carriers will roll out CDMA2000 1xEV-DO from 2003, mainly with South Korean and Japanese carriers currently in trials and pre-commercialisation stage. South Korea's SK Telecom is also collaborating with handset manufacturers such as Samsung and SK Teletech to develop the PCMCIA-based terminals. In Japan, CDMA2000 1xEV-DO is intended for pre-commercial service in Kanto area in April 2003, while commercial service is planned for in October 2003 by KDDI.

CDMA2000 1X EV-DV (Data & Voice) integrates voice and data on the same carrier. This technology promises of data speeds ranging from 2Mbps to 4.8Mbps. There are as many as eight proposals that have been submitted to standards committee 3GPP2 for the design of EV-DV. In June 2002, CDMA2000 1xEV-DV has been approved by both the 3GPP2 and Telecommunications Industry Association (TIA) for publication, and has been submitted to the ITU for formal approval as an IMT-2000 3G global standard.

2.1.5 TD-SCDMA - Time Division Synchronous Code Division Multiple Access

Time Division Synchronous Code Division Multiple Access, TD-SCDMA (www.tdscdma-forum.org). Since 2001, China has more mobile phone users than any other country in the world. A TDD standard namely TD-SCDMA was developed by the China Academy of Telecommunications Technology (CATT) in collaboration with Siemens. Together with local vendors like Datang, the technology was tested since October 2001 and can deliver data rates up to 384kbps. TD-SCDMA stands alongside WCDMA and CDMA2000 as an official IMT-2000 standard. TD-SCDMA uses a spectrum bandwidth of 1.6MHz and is relevant for migration to 3G for GSM/GPRS networks, without the need to build a new infrastructure.

The Chinese mobile wireless market is dominated by GSM technology with operators like China Mobile (the largest), China Unicom (second largest) and others like China Telecom and China Netcom. In China, mobile services are still mainly focused on 2G voice services and prepaid users, while SMS interoperability was only seen since January 2002 between the two largest operators. There are of course more advanced GPRS deployments started off by China Mobile together with WAP services, especially in the richer coastal cities. China Unicom's subsidiary

Unicom Horizon has also launched CDMA based networks in January 2002, and currently piloting CDMA2000 1xRTT. The uptake on CDMA networks was also encouraging and there is a possibility of Unicom Horizon being spun off as full-fledged CDMA operator in China. Recently, Huawei has also developed a CDMA450 solution that provides data rates of up to 154kbps at frequency of 450MHz. It is backward compatible with IS-95 and can smoothly evolve to CDMA2000 1xEV.

It would probably be in 2003 for TD-SCDMA handsets to be ready. The local ownership of the network technology and regulatory controls will allow the Chinese handset and equipment vendors to dominate the local market. Already in China, there are 11 GSM licensed Chinese manufacturers and 19 for CDMA, while there are fewer foreign makers such as Motorola, Samsung and Siemens. Local handset manufacturers already occupy 15% of the market share in 2001 and are expected to expand their share to 20% in 2002, according to BDA China Ltd (a consultancy firm focused on China mobile market).

There is currently no clear indication of which operator or operators will be running a TD-SCDMA network. China Mobile has conducted WCDMA trials while China Unicom has a GSM network and its subsidiary Unicom Horizon has adopted a CDMA path. There are left China Telecom and China Netcom. There are plans to split China Telecom into two separate entities, one of which could merge with China Netcom. Amidst this restructuring process is the possible grant of a 3G licence to allow the adoption of TD-SCDMA. But whatever the commercial and regulatory decisions are, we would see in China probably a mix of various 3G network technologies and China certainly has the market size to sustain these different networks.

2.1.6 Summary on 3G Migration

Deployment Scenarios of 3G Networks. Four different development scenarios are foreseen:

- **Slow Growth:** Slow take-up rate of mobile data services, combined with complex and expensive network and terminal equipment limit the rollout of 3G services.
- **2.5G Substitution:** The demand for data services is frustrated by the expense and complexity of the 3G hardware, resulting in an alternative take up of 2.5G services such as GPRS and restricting the migration to 3G to the business community.
- **3G Upgrade:** Low demand for data services, 3G networks are used to meet operational improvements and for delivering multimedia services to business.
- **Rapid Growth:** High demand for data service is met by 3G technology, with the cost to both the operator and the subscriber reduced by economics of scale.

WCDMA is unfortunately incompatible with CDMA2000. Besides a few relatively small experimental networks, no WCDMA systems are yet up and running outside Japan. This is

largely because WCDMA is new – unlike CDMA2000, which is an evolution of a mature standard. The WCDMA camp is also much larger than its rival, which means it takes longer time to get everyone to agree, and to get their equipment to work together. The huge debts amassed by European operators to pay for their 3G licenses may have slowed things down too.

Despite all these issues, WCDMA ensures that subscribers can use the handsets in many other countries due to large number of countries has adopted GSM. This is because WCDMA is designed as an upgrade path for GSM operation and it is envisaged most operators will offer dual mode WCDMA/GSM operations. An operator that switched to CDMA2000 would restrict its subscriber ability to roam as a result of lacking of global coverage of cdmaOne network – CDMA2000 users can roam with cdmaOne but not GSM networks. The likely outcome is that WCDMA will end up as the dominant 3G standard with major market share; CDMA2000 will have a smaller share, but is rolled out sooner.

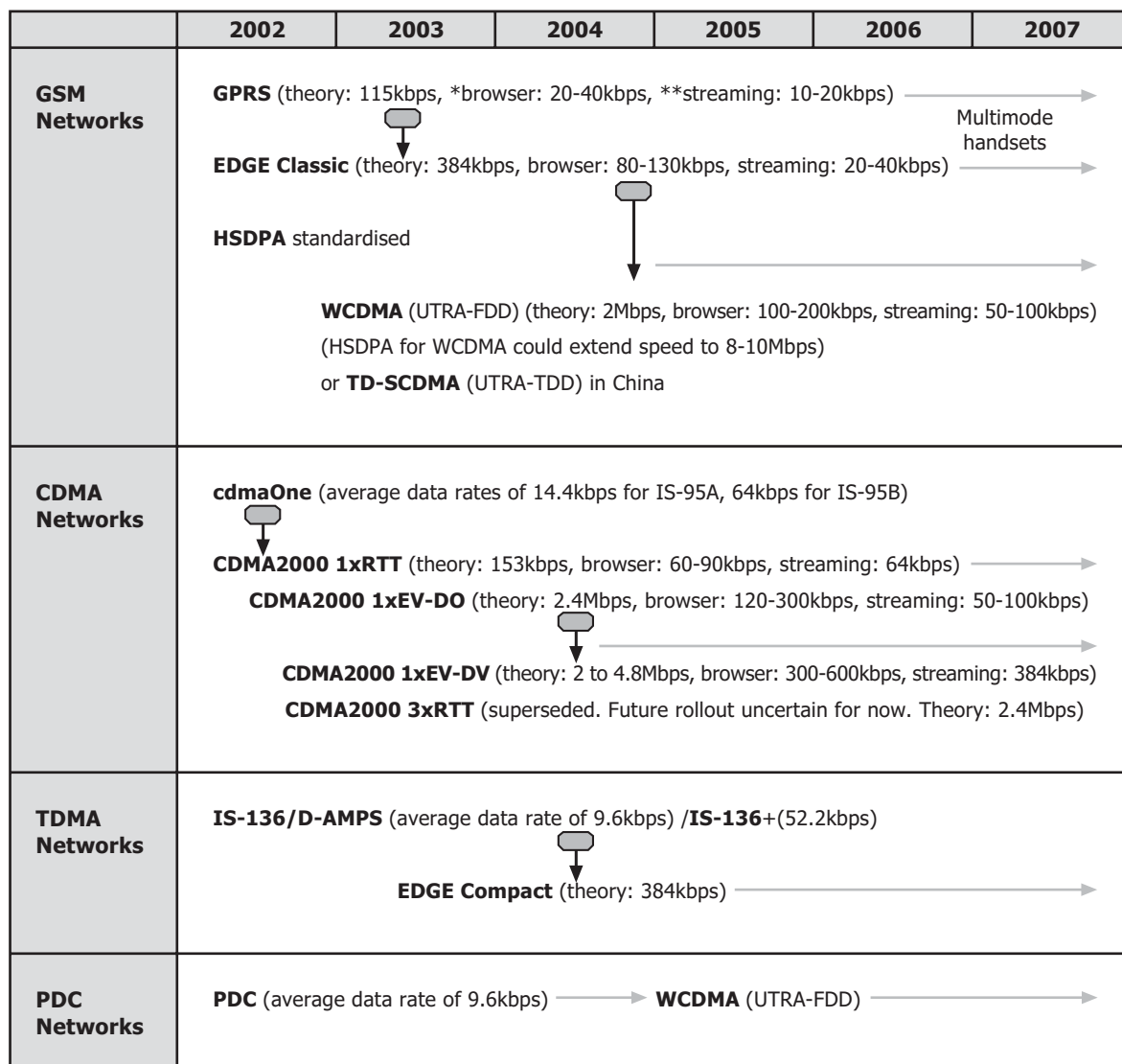
South Korea has issued three 3G licenses, requiring one operator to roll out services using CDMA2000, but forcing two operators to adopt WCDMA. The government has also told Samsung that it must supply phones that work on both standards. America will probably end up with both kinds of 3G too. Qualcomm has claimed in January 2002 to make available technology for mobile phones that can work with both CDMA2000 and WCDMA wireless standards. Yet, still the technology is unlikely to be available to the initial users of 3G phones.

Figure 4 depicts a summary of the various migration options towards 3G.

Technical Challenges Ahead. Today's customers enjoy the ability to "roam" anywhere a GSM network is in place. But it will takes years for operators to complete their new 3G networks, in early days, therefore, there will be islands of new 3G services in a sea of old GSM. Few customers will be prepared to buy 3G handsets if they can only enjoy limited coverage.

Combining old GSM and WCDMA systems in the same phone, however, is far from easy. Building a dual-mode phone is a challenge because of the need to 'hand-off' or transfer calls between GSM and the 3G parts of the phone. It involved building another radio into the handset. From a technology perspective, narrow-band, time-domain GSM is very different from the wideband, CDMA technology that 3G uses, thus there is not much circuitry that can be shared to reduce cost, size or power consumption. It will be some time before dual-mode handsets can fully compete with single mode handsets.

The lack of a single global 3G standard is a headache for the entire industry. A cellular phone that offers high-speed Internet access and works anywhere is still some way off. Still, there is always the next generation. Already, those in the industry are discussing about 4G.



*Browser: average PC browser speed (loaded network)

**Streaming: average streaming media speed (loaded network)

Figure 4. Summary of 3G Migration Paths

2.1.7 Key Concepts in All-IP and Mobile IP

All-IP Networks. The concept of “All-IP networks” entails mobile network architectures that will enable fully IP based service delivery; i.e. data, voice and multimedia services to be provisioned over an IP bearer. This has been the goal of the different standardisation bodies

(IETF, 3GPP, 3GPP2, ITU). Their efforts reinforce that the core network of the next generation mobile network will be pure IP-based (already in 3GPP Release 5). The All-IP-networks concept will allow the deployment of a unified backbone, federating different access technologies e.g. narrow/broad-band, fixed/wireless, and public/private access networks. Furthermore, we are also moving IP to the edge and ultimately trying to achieve end-to-end IP.

The primary purpose for All-IP networks is to provide user with an always-on access to IP-based services from any suitable access point, regardless of the types of fixed or mobile networks or the terminal used. Besides a common call and session control mechanism, where the Session Initiation Protocol (SIP) and H.323 are two potential candidates, the major requirement remains the provision of a mobility management scheme enabling a seamless roaming between various access technologies to the IP core network.

Roaming with Mobile IP. The IP mobility provided by the Mobile IP protocol (defined in IETF) is potentially a key solution. Handling the terminal mobility at the IP layer, Mobile IP has actually two fundamental intrinsic properties in an IP environment. Firstly, it is transparent to applications running over IP, which are generally based on the assumption that the terminal is fixed. Secondly, Mobile IP can be deployed in any network where the IP connectivity is available, whatever the underlying protocols and technologies used. Hence, Mobile IP based core network can be either wired (PSTN, ISDN, xDSL, Ethernet LAN, etc.) or wireless (WLAN, GSM, GPRS, UMTS etc.) allowing heterogeneous access by user.

Overview of Mobile IP. In IP networks, the IP address denotes the location of the IP node in the network topology, in addition of being the endpoint identifier. This introduces a major conflict between these two functions in the context of mobility: as the same mobile node changes its points of attachment to the Internet, the uniqueness between location and identity is lost. When a new IP address is assigned to the node at each point of attachment, this would imply that the over layer connections (e.g. TCP connections) maintained by the node would be broken after each change of location, as data traffic are delivered based on IP address.

To enable IP mobility, the IETF Mobile IP solution (RFC 3220) proposes using two IP addresses. Firstly, it requires a permanent address, the Home Address, to be assigned to the IP node, acting as the endpoint identifier. Secondly, it requires a temporary address – the Care-of Address (CoA) giving the location of the node in the current network. The approach here is to allow the terminal to maintain the same IP address, i.e. Home Address, wherever it is located, so that it will always have a unique identifier. The Mobile IP protocol is capable of tracking the location of the mobile terminal in a meaningful way (topologically significant) in order to deliver any packets to it wherever it moves.

When a mobile node (MN) stays connected in its home network, it is reachable by its invariant home address. Each time the MN connects to a foreign network, it obtains a temporary address, called the care-of-address (CoA), which is only valid for the time the MN will stay connected to this foreign network. The MN will then be reachable via both its home address and the CoA. There are two mobility agents that accommodate the MN: the foreign agent (FA) in the visited network and the home agent (HA) in the home network. Whenever the MN obtains the CoA from the FA, it must inform its HA of the obtained CoA; this is the registration process. After this registration, the HA can forward the packets (originally sent to the MN's home address) to the FA by tunnelling. This CoA can be either determined by a Foreign Agent present in the sub-network (Foreign Agent care-of-address – FCoA), or by an alternative mechanism such as the Dynamic Host Configuration Protocol (DHCP), referred then as a co-located care-of address (CoCoA).

Data sent by a correspondent node to the mobile node's home address are intercepted by the mobile node's HA and tunnelled to the current mobile node's CoA. The tunnel endpoint is either the FA (in case of FCoA) or the MN itself (for a CoCoA). In the reverse path, data sent by the mobile node are usually delivered using standard IP routing mechanisms, with the mobile node's home address as IP source address.

Mobility Support for Voice Over IP. H.323 Recommendation and SIP protocol are the de-facto standards for providing signalling in VoIP implementations. Currently, there exist two basic approaches to support mobility in the VoIP services. The first one seeks to solve the mobility in the network layer by using Mobile IP and related proposals. Although Mobile IP is not directly related to VoIP applications, the mobility support for the VoIP service can be realised via Mobile IP. The other approach is to solve the mobility problem in the application layer by augmenting the existing VoIP protocols such as H.323 and SIP.

H.323 Mobility with Mobile IP. H.323 mobility is essential in a VoIP communication where different access networks are involved, as is the case of GPRS and WLAN. GPRS is suitable for bridging the gaps between non-overlapped WLAN coverage. For example, a mobile distributed corporation (WLAN Intranet) would have several separated sites across a certain area (covered by GPRS infrastructure). Mobile IP enables transparent handover between these heterogeneous networks.

H.323 does not have inherent IP mobility capability, thus having to rely on external mobile IP mechanisms such as Mobile IP. However, the latter would introduce overheads to VoIP communication. These overheads include the Mobile IP administration and maintenance of data tunnels, triangular routing, etc. and Mobile IP architectures (FA-CoA and Co-CoA). These are likely to have impact on the performance of the most important phases in a VoIP session, namely the initial set-up phase (H.225 and H.245 signalling exchanged for establishing a call),

the establishment of the audio-visual communication and the call termination phase (H.225 and H.245) for different VoIP signalling scenarios (direct or gatekeeper-routed signalling exchange).

Quality of Service, QoS. Additionally, QoS parameters such as delay, jitter and packet loss need to be taken into account during the audio-visual exchange phase for both signalling scenarios. Regarding QoS parameters, ETSI has established TIPHON (Telecommunications and Internet Protocol Harmonisation over Networks) to ensure standardisation to support the market for IP telephony. Subjectively, people can tolerate delays of no more than about 200 ms to 250 ms before the conversation gets annoying. Jitter describes the variations in latency of a VoIP transmission. Network components compensate for jitter with buffers, which smooth the delivery of packets to produce a more even flow of voice data. A typical jitter buffer delay is 20 ms, but often reaches 80 ms. As packet loss is concerned, if a packet is lost every 20th packet (5%), voice is still recognisable. That is not as bad as losing 1 sec of audio followed by 19 sec with no lost packets. One full second of lost audio will certainly annoy users.

SIP Mobility. The SIP is an application layer protocol used for establishing and tearing down multimedia sessions, both unicast and multicast. In SIP, callers and callees are identified by SIP address and/or E.164 numbers (the numbering system of the telephone system). The bearer system (GPRS or 3G) will manage micro-mobility, i.e. the movement of the mobile user from one base station to another. Macro-mobility, the movement of the mobile user from one domain to another, will be handled by SIP.

Current version of SIP supports user mobility by proxying and redirecting requests to the user's current location. A callee may move between a number of different end systems over time. These locations can be dynamically registered with the SIP server. Users can register their current location by using registration services. The REGISTER request allows a client to let a proxy or redirect server know at which address(es) it can be reached.

When making a SIP call, a caller first locates the appropriate server and then sends a SIP request. Instead of directly reaching the intended callee, a SIP request may be redirected or may trigger a chain of new SIP requests by proxies. SIP servers can operate in two different modes – as proxy servers or as redirect servers. SIP proxy servers forward requests to the next hop, SIP server, or user-agent within an IP cloud. Redirect servers inform their clients of the address of the requested server and allow for the client to contact that server directly.

The SIP user agent that resides in the client terminal performs two basic functions: (1) listening to the incoming SIP messages, and (2) sending SIP messages upon user actions or incoming messages. The SIP proxy server relays SIP messages, so that it is possible to use a domain name to find a user, rather than knowing the IP address or name of the host. A SIP proxy can thereby also be used to hide the location of the user. On the other hand, the SIP redirect

server returns the location of the host rather than relaying the SIP messages. This makes it possible to build highly scalable servers, since it only has to send back a response with the correct location. The SIP redirect server has properties resembling those of the home agent in Mobile IP with Route Optimisation, in that it tells the caller where to send the invitation.

SIP supports personal mobility; i.e., a user can be found independent of location and network device (PC, laptop, IP phone, etc.) and was originally designed only for roaming. However, recent efforts have been made to enable maintenance of on-line connectivity during the SIP session while handoff takes place. One potential solution is to re-invite the correspondent host by sending INVITE message. SIP makes use of RTP translator to achieve fast handoff, during which the proxy server can re-write the media destination in the outgoing INVITE message with the address of the proxy server or the affiliated RTP translator, so that the MN hands off in the same domain (more precisely, under the same RTP translator) without re-establishing the channel with the correspondent host. This mechanism resembles the micro-mobility solution approach.

IPv6. The insufficiency of IPv4 address space for new machines to identify to the Internet has resulted in the evolution towards IPv6 (Internet Protocol Version 6). Developed by IETF, IPv6 has widespread support from many industry players, Internet service providers and mobile operators, from Cisco, Microsoft, Nokia to carriers like BT, SingTel and NTT. IPv6 also makes changes to IPv4 in routing and network auto-configuration. There is however a period of transition whereby we would see the two protocol versions co-existing before we fully migrate to IPv6. In its suite of solutions for mobile applications, Microsoft has also launched Mobile Information 2001 Server (Enterprise edition and Carrier edition) with security features for VPN such as with IPSec, WTLS (for WAP, Wireless Transport Layer Security), passport for .NET web service authentication and PKI.

The design of Mobile IP support in IPv6 (Mobile IPv6) represents a natural combination of the experiences gained from the development of Mobile IP support in IPv4 (Mobile IPv4), together with the opportunities provided by IPv6. Mobile IPv6 thus shares many features with Mobile IPv4, but is integrated into IP and provides many improvements. The improvements include auto-configuration to eliminate foreign agent, route optimisation, support for multicast routing, bi-directional identity confirmation, routing header to elimination IP encapsulation, more robust and efficient message handling.

Future Work Areas for Mobile IP. Mobile IP, in a general form, is essential in providing seamless IP roaming in a global mobility system. It links heterogeneous networks at the IP layer to form a widespread environment of IP mobility. It also allows an always-on access to ISP services (VoIP, VPN, mobile Internet, etc.) and to Intranet networks.

However, current Mobile IP implementations and standards are still inadequate in terms of providing efficient handling fast handovers between various access networks. This is due to the extra hop to Home Agent before going to the destination, sometimes causing notable disruption in real-time services. The concept of route optimisation to solve this is being explored in IETF. Further work is also considering interoperability between IP and non-IP native network in order to optimise IP signalling transport such as ICMP messages transfer (e.g. for Router Advertisement). The Security and QoS management aspect of Mobile IP are also areas for further research.

Despite the unresolved issues, standardisation groups and research organisations are relentlessly working on these track as they believe Mobile IP still remains the promising fundamental building block to provide universal mobility in the next generation IP based telecommunication systems.

2.2 Standards & Interoperability

2.2.1 Harmonisation of Standards

Industry Associations. There are many mobile wireless associations around the world. A few key industry promotion and/or standardisation bodies are for example ITU, 3GPP, 3GPP2, TD-SCDMA Forum, UMTS Forum and GSM Association. Many of these bodies have a website that provides an excellent source of technical and business information on mobile wireless.

International Telecommunications Union, ITU (www.itu.int). The ITU is the world's oldest international organisation established in 1865 to manage the first international telegraph networks, now with members from almost every country and over 500 private members from the telecommunication, broadcasting and information technology sectors. Since 1865, the ITU has covered voice telephony, radio-communications, satellite communications, and is the leading association for this telecommunications-based information era.

Within the ITU, the **Third Generation Partnership Project (3GPP, www.3gpp.org)** was formed in Dec 1998 to harmonise the various proposals based on WCDMA for GSM evolution. Subsequently, a CDMA2000-centric group, the **3GPP2 (www.3gpp2.org)**, was also formed for IS-95 evolution.

In June 1999, the **Operator Harmonisation Group (OHG)**, formed by international operators, proposed a harmonisation between the 3GPP and 3GPP2 technologies. The single unified standard, accepted by both 3GPP and 3GPP2, to be known as G3G (Global Third

Generation), allows interoperability and interworking of UTRA (UMTS Terrestrial Radio Access) and CDMA2000. In Nov 1999, the number of original proposals to IMT-2000 was reduced to six, that can be categorised into five main operating modes with the following three dominant modes:

- CDMA-DS (CDMA-Direct Spread), based on UTRA FDD (Frequency Division Duplex) for WCDMA by 3GPP;
- CDMA-MC (CDMA-Multi Carrier), based on CDMA2000 using FDD by 3GPP2;
- TDD (CDMA TDD –Time Division Duplex), based on TDD for TD-SCDMA by 3GPP.

TD-SCDMA Forum (www.tdscdma-forum.org). In order to promote the development of China's TD-SCDMA technologies, the China Mobile Association Committee (CMAC) initiated the TD-SCDMA Forum in September 2000. Amongst the founding members are China Mobile, China Telecom, China Unicom, Datang Group, Huawei Corporation, Motorola, Nortel and Siemens. The forum now has over 300 members.

UMTS Forum (www.ums-forum.org). The UMTS Forum is an open, international body for promoting the global uptake of third generation (3G) mobile systems and services. UMTS Forum generates many reports, position papers, and presentation slides available on its website covering the technical and business aspects of 3G. Its objectives are to:

- To promote global success for UMTS/3G services delivered on all third generation system technologies recognised by the ITU;
- To forge high-level dialogue between operators and other market players that can ensure commercial success for all;
- To present market knowledge that aids the rapid development and uptake of new services and applications.

GSM Association, GSMA (www.gsmworld.com). Founded in 1987, the GSMA has played a pivotal role in the development of the GSM platform and of the global wireless industry. It has now over 600 organisations as members, including the world's leading network operators who together provide service to more than 71% of global mobile phone users. The M-Services Initiative which we would elaborate in the second half of this report is one of the major programmes from GSMA. The GSMA focuses on GSM technologies, platforms and services.

2.2.2 IMT-2000 Spectrum Issues

The harmonisation of spectrum use is a necessary step and a key element in reducing the cost and complexity of 3G implementations. Bands harmonised globally would provide end-users with the same services at a minimum cost, irrespective of the terminal used or the user's location.

Radio Spectrum Required for WCDMA. Radio spectrum is often organised (and sold) as paired – often specified in a form like 2 x 15MHz. The technique of two users talking to each other on two separate frequencies is called Frequency Division Duplex, or FDD, WCDMA is an FDD technique whereas TD-SCDMA is a TDD technique that can use unpaired spectrum.

WCDMA is designed to operate in paired frequency bands, with uplink in the 1920-1980MHz band, and downlink in the 2110-2170MHz band. TDD is left with the unpaired frequency bands 1900-1920MHz, and 2010-2025MHz. The satellite services use the bands 1980-2010MHz (uplink) and 2170-2200MHz (downlink). Future expansion bands were also identified during the World Radio Conference 2000 (WRC-2000).

In Europe and Asia the choice of frequency bands for implementing UMTS was clear. However, these frequency bands were not available in U.S., so at WRC-2000, three frequency bands were suggested for implementing UMTS in the U.S.

- 806-890MHz (used for cellular and other mobile services),
- 1710-1885MHz (used by the U.S. department of Defence),
- 2500-2690MHz band (used for instructional TV and wireless data)

Unfortunately, none of the above bands can be made available in short term as the NTIA (National Communications and Information Administration) has reported that the existing users have refused to move their communications to another frequency bands. The NTIA has proposed legislation to delay the 3G auction until 30 September 2004.

CDMA2000 is very flexible in its spectrum requirements being designed to operate on all existing allocated spectra for wireless communications. CDMA2000 is not constrained to only the IMT-2000 band, thereby maximising flexibility for operators. These bands includes:

- 450/700/800/900 MHz
- 1700/1800/1900/2100 MHz

In Singapore, the 824-842.5/869-887.5MHz band was recovered in January 2000 and have not been reassigned. This band has been reserved for digital cellular system operation. Taking note that the adjacent spectrum is all used by Private Mobile Radio (PMR) and GSM 900 services.

Such bands are occupied for CDMA (2G, IS-95) systems in South Korea and US. On the other hand, European countries are using these bands for 2G extended GSM services, which could be refarmed progressively and integrated into the IMT-2000 allocation in the longer term as a result of market forces (880-915/925-960MHz).

2.2.2.1 Spectrum Bands for IMT-2000 Extension

The amount of available spectrum is another key issue. If 3G data services take off the way we hope they do, additional or incremental spectrum will be required. In the longer term, UMTS forum has considered the current market forecasts to justify a claim for the full 160MHz identified for terrestrial mobile communications by WARC-92 to be available by the year 2005, with a further 185MHz required for terrestrial services by the year 2010.

The bands 470-806MHz and 806-960MHz may also be attractive because of propagation conditions. At these lower frequencies, a greater range is possible for a given transmitter power, providing a wider area coverage. Signals transmitted at these frequencies penetrate more easily through vegetation and into buildings.

2.2.2.2 Future Re-use of Second Generation Bands

Spectrum currently used for second generation mobile services may be re-used for IMT-2000 only in a longer term when such use has significantly decreased. However, some forward planning for this re-use is undertaken by WRC-2000 to identify these bands for future IMT-2000 use.

2.2.3 Mobile Virtual Network Operator

In setting the framework to allocate scarce 3G spectrum, it was generally believed that the best way to achieve the best possible deal for the consumers in terms of quality, choice and value for money is through the competitive supply of services.

MVNOs and What They Might Offer. The concept of an MVNO (Mobile Virtual Network Operator) has generated significant interest. An MVNO is an organisation that offers mobile subscription and call services to customers but it does not have an allocation of spectrum. MVNOs (Mobile Network Operators) would therefore pay MNO(s) to gain access to the radio networks of one or more of the operators. A range of fixed and mobile integrated services may be developed which centre on a single handset with superior coverage, enabling tracking services such as 'one number' to be developed. This was seen as being achievable by bundling together different elements of fixed and mobile voice, data and content services. The common vision was that such services would be accompanied by a 'one-stop-shop' for billing and customer services.

Facilities a MVNO May Require from the MNO. There are several ways in which MVNOs may be implemented, and that may require different levels of the use of the mobile network

operator's infrastructure. Obviously, the most likely form of MVNO to be developed is one, which requires the minimum amount of facilities from the MNO, with the use of the radio interface only. This would maximise the MVNO's control over its customers and their calls. At the other extreme, the maximum use by the MVNO of the MNO's facilities, and all the MVNO would directly control the SIM card and the Mobile Network Code. It is likely that MVNOs who intend to minimise their risks would also want to control their own Home Location Register (HLR) and Authentication Centre (AUC) functions.

Legal Consideration. In order for MVNOs to offer services to customer, they will need to conclude commercial agreements with at least one mobile operator to gain access to that network. Under the licensing framework of the 3G auction released by IDA, the wholesale arrangement for access to 3G networks will be left to commercial negotiations between MVNOs (Mobile Virtual Network Operators) and 3G licensees. IDA will intervene in cases of undue restrictive or anti-competitive practices in accordance with the relevant provisions in the Telecom Competition Code of Practice.

2.3 Beyond 3G: Vision, Technologies and Opportunities In 4G

It has become apparent over the past months that 3G systems, while maintaining the possible 2Mbps data rate in the standards specification, will deliver rates of up to 384kbps. The goal of higher broadband cellular service has given impetus to 4G (Fourth Generation) with a target improvement over 3G capacities by an order of magnitude. Figures ranging from 20Mbps (average) to 100Mbps (peak rate) have been cited for 4G, with also more than 1Gbps rates in isolated cells such as hotspots and indoor offices.

There are also efforts to develop concepts for digital broadband millimetre wave systems (up to 200GHz) to deliver speeds of 155Mbps by Japanese based Mobile IT Forum (MITF). In particular, MITF sees 4G as more user-focused and has a stronger authentication and security focus than 3G for advanced applications. MITF also sees the migration from aggressive users (3G) to universally popularised users (4G). The social role for 3G functions is also seen as dispensable while 4G will accomplish indispensable functions in our society. Autonomous seamless connectivity will also be an important target for 4G systems.

Some operators such as NTT DoCoMo has expressed the possibility of launching 4G as early as 2006 while the general opinion is that 4G is slated for mass deployment only around 2010. From now to 2007, there is huge industry and research interest in 4G, and the 4G Mobile Forum forecasted that the industry investment in 4G would have attained US\$30 billion by end 2002.

There is really no fixed definition yet of 4G, but 4G is currently merely a framework under which researchers and the industry (both GSM and CDMA players) gather to piece together the various advanced technologies to allow seamless integration of wireless and wireline broadband technologies. The vision of a seamless integrated global broadband infrastructure is still a faraway target with many issues to be resolved and technologies to be developed too.

Local connectivity technologies such as Bluetooth will also be seamlessly integrated in 4G. It is likely that 4G networks will use higher frequency bands such as 3GHz to 8GHz. Higher frequencies will also allow smaller chip designs. 4G could possibly bring about more power efficient handsets, such as with UWB technologies that consume little power and can yet provide between 50Mbps to 1Gbps data rates. 4G would also provide for roaming with 3G networks, and multimedia services that can rival the quality of fixed wireline broadband networks.

The prevailing consensus in the industry and research laboratories also has it that 4G networks will be completely packet-based, if not also entirely IP-based, to achieve infrastructure cost savings. This constitutes a significant shift from current cellular networks (up to and including 3G), which contain both circuit- and packet-switched components. The move towards all-IP networks will also facilitate linkages to wireless LAN (WLAN) and other IP-based networks widely available today, thereby increasing the benefits from economies of scale. Security, QoS, wider terminal addressing capacity would be enabled by IPv6. Furthermore, whereas today's networks are combinations of both existing and evolved equipment, some of which are analogue, 4G systems have been envisioned to be completely digital.

Research & Development in 4G. The below takes a quick look at some global interests in 4G:

- In the US, AT&T and Nortel Networks had outlined their initial plans for 4G back in September 2000, aiming to deliver cellular data rates of 20Mbps and beyond. The companies pointed to some key technologies that would need to be harnessed to this end, including software-defined radio (or SDR), wideband transceivers and power amplifiers. Lucent Technologies has since also created a research programme on 4G design and network development, under their Wireless Research Laboratory.
- In Japan, NTT DoCoMo has started building an experimental 4G system, consisting of both base station and mobile station equipment. They have designed this system with the target transmission speeds of more than 100Mbps for downlinks and 20Mbps for uplinks. NTT DoCoMo will conduct practical evaluations of the experimental system in summer 2002, and hopes to commercialise the system by 2010.
- NTT DoCoMo had earlier announced a joint 4G R&D effort with Hewlett-Packard Company, in December 2000. Termed "MOTO-Media," the joint research on basic 4G technology is

targeted for completion by 2003, with commercial release by 2007. As the first collaborative effort between the two companies, this programme will combine NTT DoCoMo's expertise in WCDMA and i-mode services with HP's research in network and server technologies.

- China has been preparing for 4G as well, seeking to leverage on the clout bestowed by its large market. While China may be a latecomer to the 2G and 3G scenes, the 2010 timeframe for 4G presents a window of opportunity that is still open. Chinese players in this space include Huazhong University of Science and Technology, Shanghai Jiaotong University and Wuhan Hanwang Technologies Inc., under the auspices of the Ministry of Science and Technology.

Standardisation in 4G (www.itu.int). Within the ITU Radiocommunication Sector (ITU-R), who oversees current 3G air interface technologies, there is an industry body called **WP8F (Working Party 8F)** who is the working group responsible for the development of 4G radio access technologies. At its sixth WP8F (Working Party 8F) conference meeting in October 2001, the ITU-R arrived at a basic consensus on 4G mobile systems. The ITU-R agreed on the starting premise that 4G mobile telecommunication systems would be combined with other systems such as WLANs, and achieve data transmission speeds of up to 100Mbps by 2010.

Earlier, in March 2001, the **Wireless World Research Forum (WWRF)** was formed by Alcatel, Ericsson, Nokia and Siemens, with the aim to "secure momentum, strategic orientation, and impact for the research on wireless communications beyond 3G." They and other members are using the forum to formulate and define their ideas on 4G networks, technologies and services. Amongst the key technology areas for WWRF are augmented reality, semantics aware services, end to end security and privacy, co-operative networks and terminals, ad hoc networks.

IMT2000 and Beyond Working Group. This is a ITU-T (ITU-Telecommunication) Special Study Group responsible for studies relating to network aspects of IMT2000 and beyond, including wireless Internet, convergence of mobile and fixed networks, mobility management, mobile multimedia functions, internetworking, interoperability and enhancements to existing ITU-T Recommendations on IMT-2000.

2.3.1 Technology Enablers

Multi-carrier Modulation (MCM) Technologies. To achieve the very high data speeds of 4G networks, one promising underlying technology is MCM, which is a baseband process that uses parallel equal bandwidth sub-channels to transmit information. MCM is not a new technology; forms of multi-carrier systems are currently used in DSL modems and digital audio/video broadcast (DAB/DVB).

MCM technologies are mainly OFDM or CDMA based, differing in the type of modulation used in each sub-carrier. There are for example, W-OFDM (Wideband Orthogonal Frequency Division Multiplex), MC-CDMA (Multi-Carrier CDMA), and VSF-OFCDM (Variable Spreading Factor Orthogonal Frequency and Code Division Multiplexing) which is a variation of MC-CDMA technology used in WLAN at 5GHz. CDMA methods use typically quadrature phase shift keying (QPSK) while OFDM methods use more high level modulations, such as m-QAM ($m = 4, 8, 16$ to 256). These 4G candidates offer efficient schemes for better spectrum usage, higher capacity support for users and higher quality air interface.

Coding Technologies. Error correction coding for 4G has not yet been proposed. Nevertheless, 4G will provide different level of QoS, including data rates and bit error rates. It is likely that a form of concatenated coding will also be used, and this could be the turbo code used in 3G, or a combination of a block code and a convolutional code. This increases the complexity of the baseband processing in the receiver design.

Frequency Re-use. For 4G transmitters to perform at data rates as high as 100Mbps, the need for a clean signal also increases. To increase capacity, one can increase frequency re-use. As the cell size gets smaller to accommodate more frequency re-use, smaller base stations are required. Smaller cell sizes need less transmit power to reach the edge of the cell, though better system engineering is required to reduce cell interference. A critical issue to consider is spurious noise – the regulatory agencies need to impose stringent requirements on the amount of unwanted noise that can be sent out of the range of the spectrum allocated.

Smart Antenna. Examples of base station smart antenna systems are ultrawide bandwidth systems, angle diversity antenna systems where several narrow beam antennas and a wide angle antenna are used to provide an optimal output and adaptive multi-beam phased array antennas with digital beamforming. High data rate systems for 2.5G and 3G networks would require more power for base stations and pencil beam phased array antennas could provide higher gains. MEMS (Micro-electromechanical system) technology is also used in smart antenna systems. GaAs Heterojunction Bipolar Transistors (HBTs), power HEMTs (High Electron Mobility Transistor) implemented on substrate technologies such as Gallium Nitride (GaN), Indium Phosphide (InP) or Silicon Carbide (SiC) would enable power transistors for compact base station transmitters.

Ericsson predicted that future multi-standard, multi-carrier, wideband radios would demand 20dB more dynamic range over current GSM systems. 50% of the cost of base stations would go into multi-carrier power amplifiers. Fujitsu Laboratories are developing interference cancellation techniques for 3G/4G networks using multi-user detection and adaptive array antennas for WCDMA base stations.

Software Defined Radio, SDR. The SDR Forum has been working closely with other global standard bodies like 3GPP and ANSI to develop standards for bringing SDR to full commercial viability. SDR makes the main characteristics of a cellular phone reconfigurable with software. SDR presents a versatile broadband, multiple access scheme, and bandwidth efficient transceiver. It is hence possible to reprogram a cellular phone to operate on different radio interface standards. Besides, a SDR can cope with the unpredictable dynamic characteristics of highly variable wireless links.

SDR also simplifies the hardware design in a cellular phone. To do this, SDR aims to transfer more radio frequency (RF) analogue hardware into digital processing that can thus be done via advanced software and DSP chips. This means that ultimately, what analogue is left over in the cellular phone is only just the RF input/output interface to receive incoming or send outgoing signals from and to the air interface respectively.

We see that then reconfigurable SDR is closely linked to evolution in Digital Signal Processing (DSP), and Analogue-Digital/Digital-Analogue Converters (ADCs/DACs). Given the state of technology development in these critical enabling technologies to SDR, we do not expect widespread commercialisation in our timeframe of consideration. SDR calls for high-resolution and high speed ADC/DACs. According to Philips Research Laboratories, there would be about 3 orders of magnitude of improvement compared to current technology status for A/D converters in the next 6 to 10 years. Commercial SDR products are only likely in the very long term.

2.3.2 Competing/Complementary Technologies to UTRA in Non Public Environment

Non public environment 3G spectrum refers to licence-exempt spectrum, which are unpaired bands within the spectrum identified for UMTS meant for domestic or corporate users. This is useful for example for Virtual Home Environment (VHE) applications and typically indoor applications within the home or office. There are other competing or complementary technologies such as Wireless Local Area Networks (WLAN) 802.1x, HiperLAN 2, HomeRF, DECT, Bluetooth, Infrared and Ultrawide Band (UWB). These technologies including UWB and WLAN are found in the Connected Home Roadmap and the Broadband Access Roadmap. The reader should cross reference to these reports for more details.

WLAN & Wireless Wide Area Networks (WWAN). There is convergence today between WLAN services and 2.5G/3G mobile services (WWAN services). Some wireless ISPs, incumbent carriers and mobile operators have launched WLAN hotspots such as in Singapore, South Korea and United States. While there are pros and cons of WLAN networks compared to 3G

mobile wireless networks in terms of data speed, roaming capability and cost of implementation, we see these technologies as complementary rather than competing due to the different value propositions. These technologies will co-exist and this brings us to our next topic on WLAN and WWAN roaming.

WLAN/WWAN Roaming. WWANs provide nation-wide coverage, mobility, roaming and QoS, therefore users are guaranteed bandwidth on demand. This means that new classes of applications such as video conferencing, streaming video may be delivered while the user is on the move.

WLAN deployed today, on the other hand, provides high-speed last-mile access up to a maximum of 11Mbps (802.11b), and is designed to cover small areas. WLAN cells have a 30 to 50m radius, whereas a WWAN cell could have a radius of 300m to 30km. This makes WLAN suitable for hot spot locations and WWAN for broad and high speed umbrella coverage.

From user point of view, they may want to use WLAN and GPRS/3G services seamlessly and receive one bill. From an operator's point of view, they are able to offer an integrated set of services, providing more freedom for users and enabling them to access their services using whichever network makes sense at the time. This provides greater flexibility and freedom for both the operator and user.

3GPP is actively involved in developing standards combining UMTS with WLAN. The first set of standards for WLAN-UMTS interworking is expected in the June 2003 Release 6 from 3GPP. End user devices like PDAs and laptop PCs have just begun to offer integrated solutions incorporating WLAN and GPRS access. As more manufacturers release products providing integrated support, we will most likely see a corresponding increase in subscribers demanding seamless integration of WLAN/WWAN. Besides 3GPP, WLAN-UMTS interworking is also standardised by various bodies such as IETF, IEEE, ETSI and MMAC (Multimedia Mobile Access Communication, in Japan).

In the near future, we will begin to see Multi-Mode Devices entering the market. These devices will be capable of accessing WLAN, GPRS/3G and Bluetooth networks from the one device. Such devices will be integrated into mobile phones, PDAs and laptop PCs. Software within these devices will enable users to configure rules that will determine the best choice of network for a particular application. For better device roaming to occur, there are also efforts needed to enable dynamic power control chipsets for these devices as WLAN for example requires more power than WWAN. Hence, companies like Intel is targeting to propose dynamic power control software standards such as in standard initiatives like IEEE 802.11 LoFi. The software standards is likely to be submitted to IEEE in 2003 and to be completed by 2005. Hardware chipsets are likely to be ready only then to enable dual mode 3G/WLAN handsets and PDAs with built-in 802.11 support and dynamic power control.

As users may move from a hotel to an airport, we would need service roaming, secure authentication, accounting (one bill) and administration. To enable seamless roaming from an application point of view, Mobile IP may need to be implemented to allow for session handover. Mobile IP solves the issue of changing IP addresses, thus allowing users to roam without losing the session. Companies are already working towards providing solutions, e.g. Birdstep, GreenPacket, ipUnplugged, Lucent Technologies, Netseal and Transat.

Deployment Scenarios. There are three possible deployment methods available for WWAN/WLAN roaming:

a) No Coupling

- The 3G and WLAN networks are completely independent access networks.
- Users have separate contracts with each network.
- Mobility could be supported through IETF inter-domain mobility mechanism external to the WLAN and 3G networks such as SIP (Session Initiated Protocol) or Mobile IP. This means that information has to be passed to high levels of the network during handover, impeding fast intersystem handovers.

b) Loose Coupling

- The main difference compared to the No Coupling solution is that the 3G and WLAN networks use the same AAA (Authentication, Authorisation and Accounting) subscriber database for functions such as security, billingIntegrated Inter-Operator AAA Model and customer management.

Please refer to Figure 5.

c) Tight Coupling

- The WLAN network is connected to the 3G core network in the same manner as other 3G radio access technologies (UTRAN, GERAN), using the IuhI2 interface (very similar to the Iu interface).
- The mechanisms for mobility, QoS and security of the 3G core network can be reused.
- SGSN and GGSN need to be updated to be able to handle the much higher bit rates supported in the WLAN network.

Conclusion on deployment scenarios. The final architecture and solution has not yet been decided. The preferred choice of coupling method would most likely depend on the background of the network operator.

- The Tight Coupling approach would probably be the preferred solution for legacy GSM/3G operators.

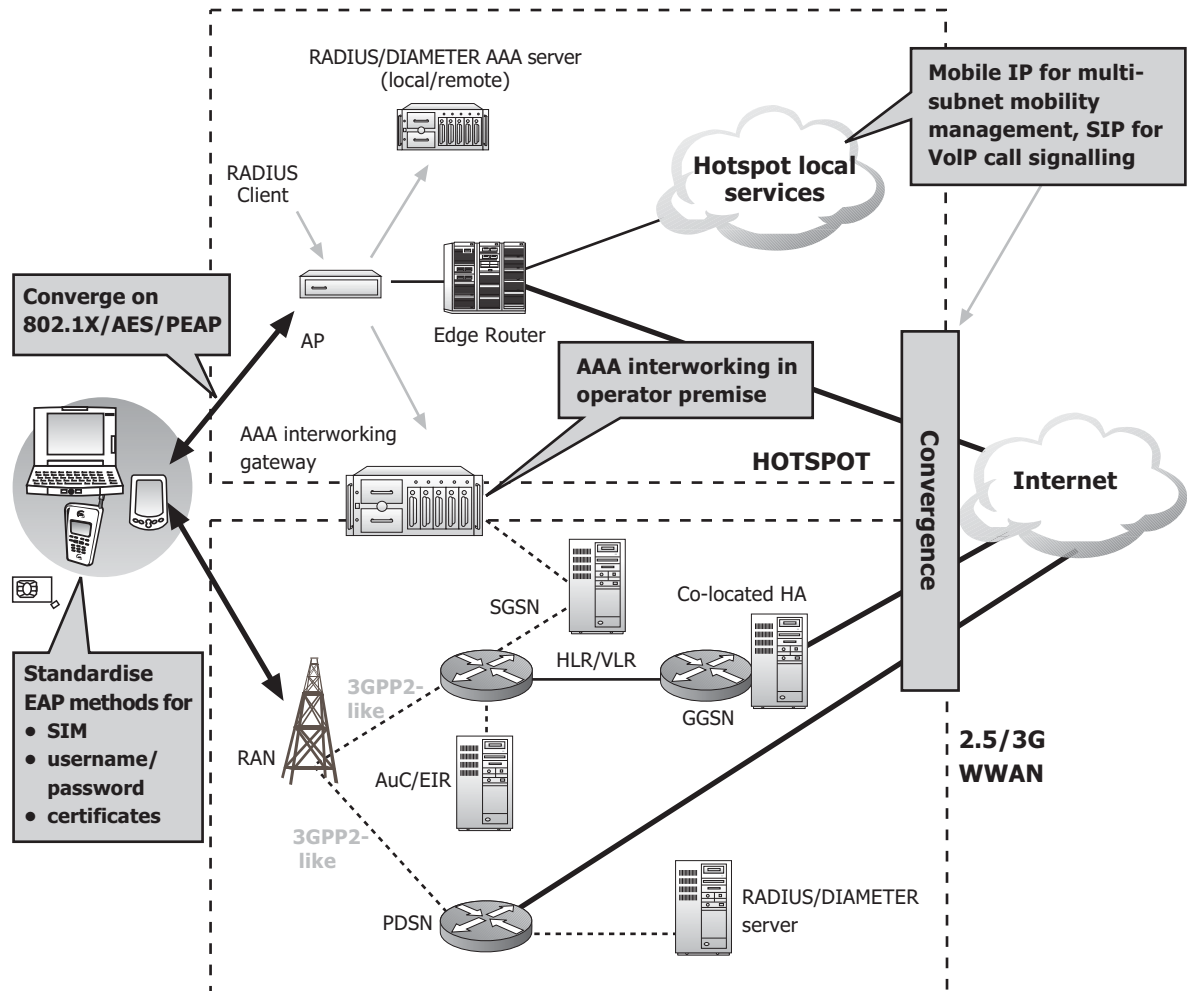


Figure 5. 802.11 Hotspots-AAA Convergence
(Source: Intel)

- The Loose or No Coupling approaches would probably be preferred by WLAN oriented operators.
- Future 3G releases clearly points towards an "all-IP" 3G network. This implies that the Tight Coupling method may become less relevant in the future.

Authentication. Authentication can be carried out either via non-SIM or SIM based mechanisms.

Non-SIM based authentication. For non-SIM based authentication, 802.1x security standard has an extensible authentication framework for port-based access control and it can be used with a number of authentication methods, including:

- MD5 - Based on RFC1321, a one-way authentication using username/password.
- EAP-TLS (Transport Layer Security) - RFC 2716, implemented in Windows XP, requires mutual certificate-based authentication.
- EAP-TTLS (Tunneled Transport Layer Security) - An IETF draft, implemented by Funk Odyssey, which extends TLS to securely tunnel further information - notably, client sub-authentication based on legacy passwords.
- LEAP (Lightweight EAP) – Cisco's own variation on EAP, implemented by AiroNet products, that provides mutual authentication based on password challenge-response.
- PEAP (Protected EAP Protocol) - A new Internet draft designed to overcome some of the vulnerabilities that exist in other EAP methods, providing secure mutual authentication and legacy sub-authentication.

SIM based authentication. A dual SIM approach is to have separate SIM cards for WWAN and WLAN access. A single SIM approach is to use the de facto mobile SIM card readily available in handsets and to communicate for authentication with the laptop via Bluetooth. SIM-based authentication can also be done with one-time password (OTP) delivered via SMS. Otherwise, we can also use an authentication model based on a static password and ID mechanism.

Three SIM based authentication methods have been proposed to IETF and 3GPP. These proposals may enable the mobile operator to provide a unified authentication and billing purposes in future which is considered today a critical success factor.

- Nokia's EAP-SIM. Uses a modified GSM method to perform mutual authentication and ciphering to protect against weakness in WLAN security. This draft currently has not included PEAP.
- Intel-Transat EAP-SIM-GMM. Uses standard GPRS procedures using GMM messages or encapsulation and simulation GPRS kind of behaviour on WLAN. This method works for UMTS as well. This draft proposes to include PEAP as an additional authentication method and has support from others like Cisco, Gemplus and Microsoft. Via the standardisation process in IETF, these players are making efforts to convince Nokia (and operators) to further include PEAP.
- Nokia and Ericsson's EAP-AKA. Uses the standard UMTS methods using USIM cards which include mutual authentication, ciphering and data integrity features. Compared to the previous two drafts, this draft on EAP-AKA is limited in scope to USIM enabled infrastructure.

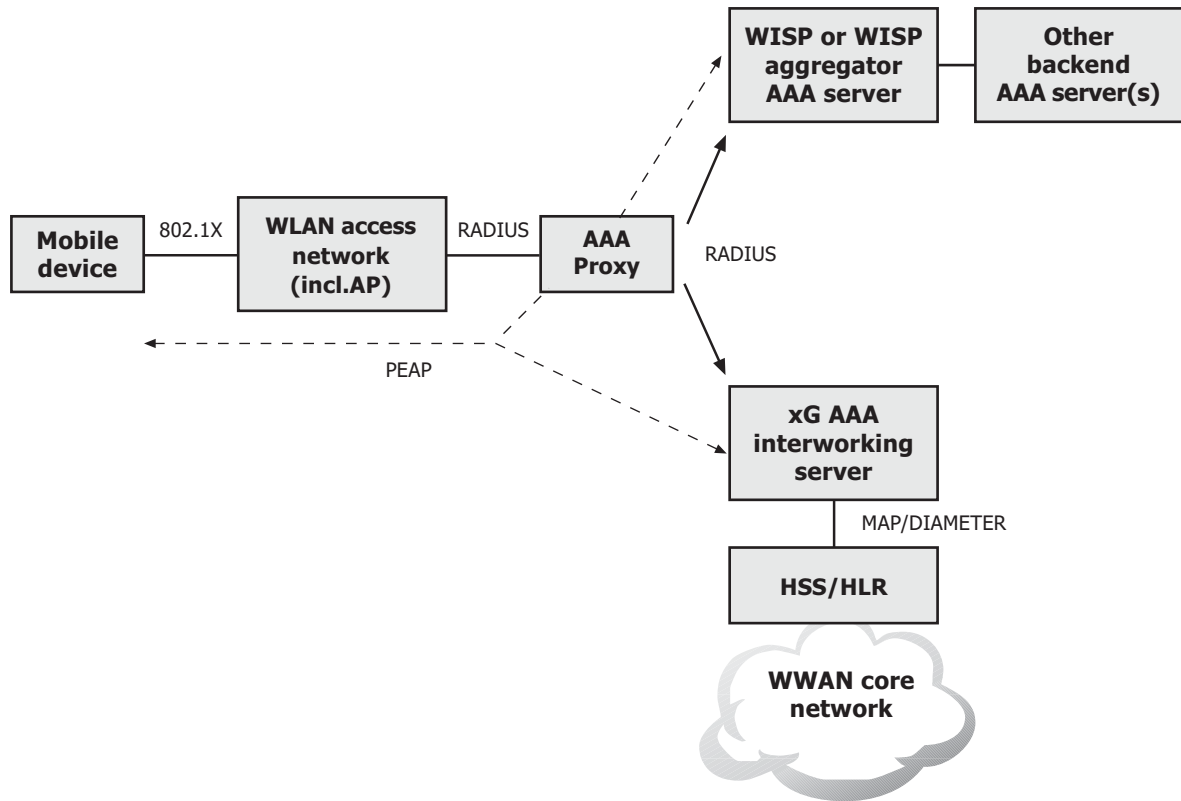


Figure 6. Integrated Inter-Operator Roaming AAA Model
(Source: Intel)

Requirements for WLAN & WWAN Roaming. Some requirements before WLAN/WWAN roaming is possible are listed below:

- Mobility (handover WLAN <-> WWAN) should be supported. WLAN interworking with GPRS and UMTS must adhere to standards by international bodies as elaborated earlier.
- The user should be notified of any possible degradation of the provided quality of service due to change of access network.
- Partnership or roaming agreements between a WWAN network operator and a WLAN network operator should give the user the same benefits as if the interworking was handled within one network operator.
- Subscriber billing and accounting between roaming partners must be handled. The industry is also working towards the harmonisation of IETF and 3GPP AAA standards.

- Subscriber identification should be such that it can be used both in a pure WWAN / WLAN environment and in a WWAN - WLAN interworking scenario.
- The subscriber database could either be a shared database for both WWAN/WLAN networks or separate databases maintained by both the WLAN and WWAN network operators. The latter method requires the two operators to have a customer data sharing agreement and data exchange via a gateway.

3 Mobile Enabling Technologies, Applications & Services

Taxonomy. To provide a better clarity of this chapter 3, we have organised the diverse mobile enabling technologies, applications and services under the following classification:

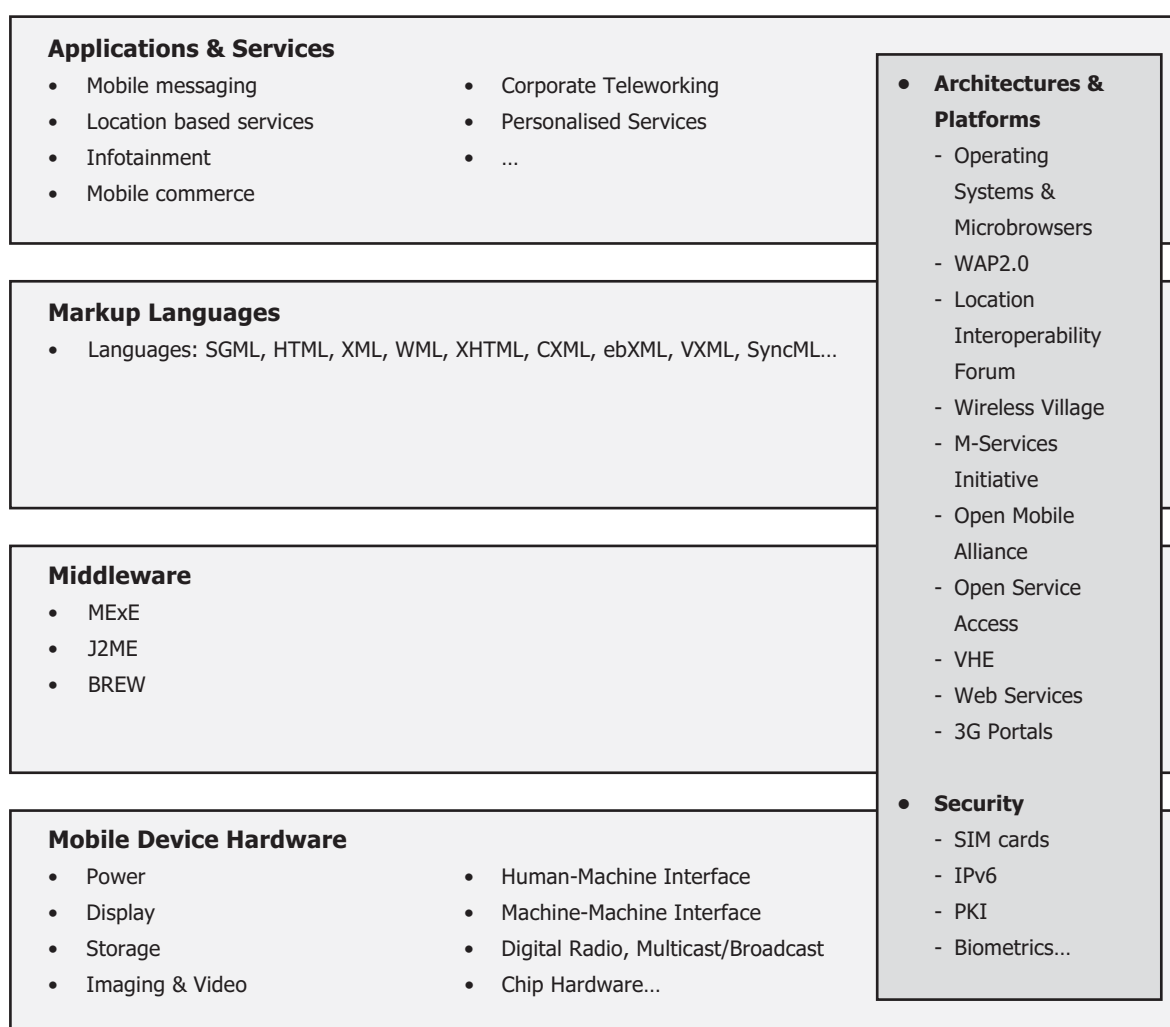


Figure 7. Mobile Enabling Technologies, Applications and Services

Introduction. Enabling technologies in mobile devices form an intricate web of complementary and competing offerings from different MNCs, technology savvy start-ups and consortiums of strategic partners. There is also a wave of competition between open standards and proprietary solutions.

Against the backdrop of the economic downturn, costly 3G license & capital expenditure, there is increased attention from the financial community on the telecom industry. Wary of stock prices, the telecom industry has basically undergone a back to reality check with more prudence and focus on return on investment. Several trends are noted:

- Advanced markets in countries such as Singapore are increasingly dependent on replacement of handsets and new data services (e.g. multimedia services) for growth;
- Faced with same crisis as the optical networking industry in terms of excessive stocks as a result of cutting of capex, worldwide inventory levels have returned to normal in 2002 for the mobile wireless industry;
- There is a trend towards more production outsourcing to curtail costs and allow flexible supply strategies, or to facilitate more focus on internal R&D while there are still a limited number of major handset vendors who prefer to keep control on internal production;
- To prevent mishaps such as recalls of handsets as well as OS upgrading exercises for mass consumers, industry alliances are formed to standardise testing and qualification processes for components, promote common platforms, modular software and produce reference design architectures. Chipset designs, protocol stacks, development tools etc are increasingly licensed to third party manufacturers in their benefit;
- Market consolidation of players (exit of some, mergers and acquisitions, combined development of 3G chips);
- Increased handset customisation to specific market segments;
- Increasing entry barrier to new players due to overwhelming control over market share by a few top brands;
- According to UMTS Forum reports, worldwide revenues for 3G services are expected to reach US\$322 billion annually by 2010, with an average of US\$30 spent monthly on 3G data services.

3.1 Wireless Payment and Charging

Besides technologies, there are other critical issues such as charging, billing and payment. Many of these issues are largely decided via a commercial process. Hence, it is not appropriate for us to discuss in detail here. Nevertheless, we would highlight some key events below.

Theoretically, many types of transactions may be done via handsets. Billing can be done via many options such as based on volume, airtime, transaction, content or URL access. Payment can be micropayments or macropayments. Trials are already started to test embedded contactless chips in mobile handsets for micropayments. By 2005, we could possibly see more handsets embedded with a contactless interface for proximity, transport, fixed POS (point-of-sale) payments. Micropayments can also be via Bluetooth or Infrared interfaces but these have not seen any major success. Stored value micropayments are especially useful for unattended POS. Other payment methods include i-mode's "combien?" (French for "how much?") service using bar codes downloaded to handsets for scanning at convenience stores which act as payment points for mobile bills.

3GPP has defined contents-based charging APIs to facilitate an open standard environment for billing. There are other electronic payment standards in progress taken by parallel industries such as EMV (Europay MasterCard Visa) for credit/debit applications and CEPS (Common Electronic Purse Specification) for micropayments. In particular, EMV migration will be completed in Europe by 1 January 2005 and in Asia by 1 January 2006. Hence this emergence of a unique standard will probably encourage chip-based implementations for financial applications that should preferably be compliant to EMV. CEPS has not seen any major commercial milestones.

A key step in security for payments is the announcement from MasterCard and Visa that Mastercard will adopt 3D Secure for payment authentication. In addition to this, the "Verified by Visa" service and 3D Secure is already in production as of 2002 for WAP and will be available commercially using SMS in 2003. The availability of such services will provide a framework for credit, debit and pre-paid payment for mobile commerce with the assurances of payment to the providers of such products and services. Such efforts will facilitate authentication for remote mobile macropayments.

There are also several e-money regulatory initiatives, RFID/contactless smart card related standardisation work and national infrastructure rollouts, Electronic Bill Payment and Presentation (EBPP) initiatives happening outside the telecommunication world. These initiatives especially in the financial, banking, credit/debit card, transit and government ID sectors present a potential synergistic call for collaboration or exchange of knowledge/initiatives between both the telco and non-telco communities. However, the synergy goes beyond a simple collaboration into a more complex intricacy, as there is also competition between the telco community and the financial community in e-payment, and internally within these circles themselves.

PayCircle Consortium (www.paycircle.org). This non-profit organisation was formed in January 2002 to define standard APIs for mobile payments, regardless of the payment systems

used by application or service providers. Currently the large number of incompatible payment systems has hindered the growth and uptake of m-commerce. PayCircle defines open and uniform interfaces based on existing standards. It has released a PayCircle Payment Web Service specification downloadable from its website. PayCircle currently represents more than 30 companies, including CSG Systems, Hewlett-Packard, Oracle, Siemens and Sun Microsystems as Board Members.

Mobile Payment Forum (www.mobilepaymentforum.org). Established in Nov 2001, the Mobile Payment Forum is a cross-industry organisation to create a framework for standardised, secure and authenticated mobile payments, based on payment card accounts. The Forum intends to efficiently act as the bridge between the mobile and financial industries to accelerate the maturity of the mobile marketplace.

Being based on payment card accounts, this Forum is strongly driven by credit card companies such as American Express, JCB, MasterCard, Visa, but also include board members from telcos such as Hutchison3G, NTTDoCoMo, Telecom Italia Mobile, T-Mobile International and Vodafone. Associate members include non-telco companies including smart card companies, banks, IT companies. One of Singapore's telcos Starhub is also an associate member. The Global Mobile Commerce Interoperability Group, GMCIG initiated by MasterCard in Jun 2000 has converged to Mobile Payment Forum.

Mobile Electronic Transactions (www.mobiletransaction.org). This is an initiative started in Apr 2000 by Ericsson, Motorola and Nokia to establish an interoperable framework for secure mobile transactions and ensure consistent user experience independent of mobile devices, services and networks. The initiative builds on some existing core technologies based on open industry driven standards. There are currently about 50 associate members.

Mobey Forum (www.mobeyforum.org). Formed in May 2000 aims to encourage the use of mobile technology and trust intermediation in financial services – such as payment, remote banking and brokerage. Among the founder members are banks and financial institutions such as ABN-AMRO Bank, Banco Santander Central Hispano, Barclays, BNP Paribas, Deutsche Bank, HSBC Holdings, MeritaNordbanken Group, Skandinaviska Enskilda Banken, UBS, as well as Ericsson, Motorola, Nokia and recently Proton World. Between MeT and Mobey, MeT covers wider aspects of all types of mobile transactions whereas Mobey focuses on banking and financial services.

The above are but some examples to demonstrate the diversity in the number of forums formed around different business circles in the world for secure mobile payments based on different technologies and approaches. At present, the Mobile Payment Forum and PayCircle Consortium seems to be more prominent than other forums. Some of these forums are heavily

focused on chip and PKI, some on authentication only, yet others on open API standards. Ultimately, some collaboration would be needed to drive a common end to end standard and be aligned to more established global organisations such as ITU/3GPP/3GPP2.

3.2 Mobile Device Features

Mobile Handsets by Technology Type. We note that CDMA2000 based technologies have seen an earlier market adoption than WCDMA and the latter will only grow in later years to catch up with CDMA with the driver from earlier GSM adopters especially from Europe. Yet according to figures by ARC Group, for particular countries like China, the number of CDMA2000 based handsets predicted (28.6m) will continue to outshine WCDMA handsets (15.2m) even in 2007.

However, GSM based technologies are spread over networks of GSM, GPRS, EDGE and WCDMA. In this entirety, GSM based technologies are still majority dominant as of today and will continue to be so in 2007 and probably beyond. According to ARC Group's market figures, CDMA based handsets are forecasted to occupy only about 15% of the total handset global market in 2007. GSM based handsets occupy 80.5%, and the rest of 4.5% accounted for by 2G PDC and TDMA handsets.

ARC Group also forecasted a total of 880 million handsets worldwide by 2007. The breakdown of these handsets in 2007 is as follows:

- the majority or 45% of handsets on GPRS;
- 18.5% of handsets are of 2G type;
- 34% of handsets belong to 3G models. Of these 299.5 million 3G handsets, CDMA2000 1xRTT accounts for about 18%, CDMA2000 1xEV/3xRTT for about 26%, WCDMA for 56% (from both GSM and PDC);
- And the minority or 2.5% of handsets are EDGE based. We note that with the increasing interest in EDGE networks, this figure is likely to be higher if revised.

Judging also from ARC figures, the Asia Pacific region overtook Europe in terms of handset sales and became the world's largest handset market in 2001, and will continue to experience a dramatic growth curve much faster than their European and American counterparts now through 2007.

Device Segmentation. Mobile devices are seeing many end-user oriented production and customisation. Device segmentation was not obvious in the initial years of mobile wireless when all you ask for was a simple phone. But it has now become the norm and this is partly

due to intense competition in the device market, the growing need to differentiate products, compete against established brands, and capture targeted buyers.

Some models are low-end voice devices, others are high-end business models, yet several others innovated with disposable models that are friendly to the environment. Many are emotion appealing and lifestyle oriented such as with SMS keyboard, hardware personalisation with hippie changeable covers, software personalisation with screensavers, health related rate measurement features, MP3 player, and Bluetooth connected earpiece. Meanwhile, some people prefer shock resistant or waterproof for sports use, dust proof for industrial use with integrated scanners. Other models are specially designed for women, or very expensively made of precious metals and jewellery for the luxurious elite. The fashion world too has seen designer labels offering chic accessories (hardware personalisation) while handset manufacturers are contracting top designers from companies like Apple and Nike to add that aesthetic magic.

Even toy and gaming consoles are integrated with wireless capabilities, so do tracking devices. Handsets are also becoming gaming consoles. Java gaming is already available on MMS enabled models. The trend towards java enabled phones and SIM cards will also allow post issuance of applications which is critical to enabling dynamic configuration and user's personal customisation of services on his device. The new generation of MMS enabled phones strongly reflects a convergence towards PDA-like interface with four way navigation button or joystick and the like, and by 2007, a colour screen display and camera input could just be commoditised as basic features.

Device Multi-Modality. Mobile applications hinge importantly on the form factor of devices. The form factor must be flexible in:

- The optimal way to present the response. Based on the device capability, social circumstance, personal preference, and etc, the response could be presented either visually or through voice, or even both. For example, private information should be presented visually instead of being read to you while in public.
- The optimal way to take the input. Again, based on the device capability, social circumstance, personal preference and etc, the best input method, whether it is visually, or through voice, can be chosen by users at their wish. For example, it is much safer to input your bank account and password visually instead of talking to it when you are trying to execute a bank transaction in public.

In all, the support for multimodality should significantly improve the usability of the mobile devices. Multimodality refers the ability of the mobile users who are able to pick/switch the user interaction channel when interacting with the same application.

Convergence with Computing and Other Functionalities. Not only do mobile handsets become more PDA-like, wireless PDAs or WDAs (Wireless Digital Assistants) with mobile network connectivity are also fast becoming the norm. The line blurs between a smartphone (PDA-like handset), PDA, WDA, PC tablet, handheld PCs, notebooks and consumer electronics like handheld gaming consoles, portable handheld TVs, FM radio & MP3 players. These devices indicate the trend to convergence in communication, broadcasting, entertainment and computing functionalities. Hence, while handsets may be segmented into focused functionalities targeted at specific user groups, they also converge into powerful devices to target high end user groups who desire multi-functionalities.

3.2.1 Power Technologies

As future networks are data intensive, source power technologies would need to be smarter with new materials, new energy management software to allow longer talk/standby time. RF components in handsets occupy more than 50% of the total power consumption in a handset, hence low power electronics technology is useful. With the development of software radio, there would be less RF circuitry. Unfortunately, power technologies are lacking by 5 to 10 years behind the evolution of semiconductor chips, leading to an unhealthy discrepancy for mobile multimedia services.

Battery materials have evolved from NiCd (Nickel Cadmium) to NiMH (Nickel Metal Hydride), then to Li-ion (Lithium-ion) and finally to Li-poly (Lithium Polymer). The trend is towards low cost, small volume, light weight, high energy density, low self discharge rate, no memory effect during recharging, as well as mouldable to different form factors. Unfortunately, some of these requirements are contradictory and typically, the cost increases by a few orders of magnitude with better technical performances.

Fuel Cell Technology. One major and possibly future dominating technology trend is the use of fuel cells such as zinc-air cells, aluminium-air cells, direct methanol fuel cells, proton exchange membrane type fuel cell, all of which by the way, are environmentally friendly and provide high energy densities with yet limited size. These are replaceable cartridges that one can replace when depleted. Hybrid power sources are also possible implementation options as seen in automobile applications.

Invented since decades ago, fuel cells began with satellite and space applications, now in automobile applications, as well as for mobile devices. Some reports show that micro fuel cells can provide roughly ten times more power capacity than Li-ion batteries and thus suitable for future 3G and beyond computing hungry mobile devices. Fuel cells contain raw materials that are cheap such as methanol, zinc and aluminium. However there are also expensive rare

metals used to make the cells such as platinum and ruthenium. Hence, cost control needs to be resolved before mass commercialisation.

While some vendors claim to be able to produce commercial fuel cell batteries within the next couple of years, mass commercialisation is not expected to be within the 2007 timeframe. However, for laptops, Casio intends to commercialise its proton exchange membrane type fuel cell as early as in 2004.

Other interesting power sources have also emerged but in general not considered to be mainstream products. Traveller friendly chargers such as Motorola's FreeCharge, use manual cranking via a handle to generate electrical power from mechanical power thanks to a dynamo at work. A 60-second cranking effort would generate about 3 minutes of talktime. Solar power is a popular alternative too based on the use of photovoltaic cells and commercial products are already available for handsets for battery recharging.

3.2.2 Display Technologies

Some advanced camera-enabled handset models today offer rotating LCD screens. Although most handsets now use LCD technology either on glass or on flexible circuits, some of the latest display technologies include organic polymers that offer low cost and are used today in light emitting diodes (LEDs). Organic LEDs (OLEDs) are thinner, have wider viewing angles (up to 170 degrees), use less power than the LCDs and does not need to be backlit unlike LCDs. Other display alternatives are investigated for military products such as 'zero power' display with cholesterics and electronic ink technology that is power efficient.

Players in OLED technologies include Cambridge Display Technology, Dupont, Kodak, Motorola, Philips, Sanyo, Toshiba and Universal Display Corporation. Commercial OLED products are expected soon.

Just like the evolution of TVs and PCs, the colour screen will find its way into mobile handsets as a basic feature in the future. The initial demand for Sony Ericsson's T68, the first model to offer colour display, outstripped supply at times. Like MMS, colour displays add to the emotional experience of users. Most if not all of 3G handsets will have a colour display. The only exception could be low-end voice centric models.

Current display capability still lags behind that of the handset camera resolution (which is typically of 24-bit colour depth and 640x480 pixels). Most current displays in the market still range from 256, to 4096 (12-bit), to 65536 (16-bit) colours. This is nothing comparable to the typical PC screen display (24- to 32-bit, or 16 million to 4 billion colours) that consumers are

used to. Current development efforts towards better TFT-LCD displays with 260 000 colours, and with more efficient power consumption are already in progress and are expected in CDMA 1xEV-DO models, and are available for Japan's 3G FOMA handsets.

3.2.3 Storage

It is estimated⁴ that the global annual production of print, film, optical, and magnetic content would require roughly 1.5 billion gigabytes of storage, roughly the equivalent of 250 megabytes for each man, woman and child on earth. Storage technology and applications are certainly an important part of our lives.

With the introduction of multimedia features into handsets such as MP3 music files, handset storage has also exploited either additional digital media tokens, or higher density SIM cards in megabyte range, other than on-board handset RAM memory storage. Digital media tokens mostly based on flash memory can allow transfer of files conveniently from one device to another. It can also manage files from different formats such as MP3 and WMA (MP3 being Moving Pictures Experts Group audio layer 3, and WMA being Windows Media Association). However, digital media tokens suffer from standardisation issues whereby competing vendor products exist such as CompactFlash cards, SmartMedia cards, MultiMedia cards, Secure Digital (SD) Media cards, and Memory Stick.

CompactFlash was first introduced by SanDisk Corp. in 1994 and Toshiba followed suit with SmartMedia cards. Some others use the MultiMedia cards and Sony also offers its proprietary Memory Sticks. However, many of these cards lack built-in encryption for digital music & data security hence, the latest Secure Digital (SD) Memory cards in August 1999. As of June 2002, there are about 450 different companies supporting the SD Media standard, which was jointly developed by Matsushita, SanDisk, and Toshiba. The SD card technology offers robust storage of 256 MB and 512 MB currently while GB capacities are fast coming into the market. Along with the use of these media cards, the Secure Digital Music Initiative (SDMI), a digital content protection standard for PC and mobile devices included, is also supported by companies in industry sectors comprising of consumer electronics, music content providers, IT as well as in wireless telecommunication.

SIM cards will evolve to USIM (UMTS SIM cards) cards for 3G handsets, and their storage capacity together with performance will continue to increase with more sophisticated demand from applications such as Java applets, multi-application operating systems (mainly JavaCard), digital certificates and PKI, multimedia files, financial applications etc.

4 Source: School of Information Management and Systems at the University of California at Berkeley.

Eventually, although USIM cards can potentially provide the capacity and portability of digital media cards or tokens, it is unlikely to pose itself as a competing technology. Digital media cards or tokens offer anonymity while the USIM card will remain a critical component of subscriber identification in the handset. Additionally, leveraging on its status of controlled and certified secure environment, the USIM will be a key enabling element to provide service configuration, management of preferences, as well as personal storage. As such, the USIM card technology will stay in the handset, whereas certain models of handsets targeting at specific user groups will incorporate media card slots for that group of applications (e.g. MP3 users and handsets will need such digital media tokens).

Memory Chip Technology. MEMS (Micro-Electro-Mechanical System) technology also offers mass storage of 1 to 10 Gbytes/cm² with access times of 1-3ms, streaming bandwidths of over 50Mbytes/second, and power consumption of less than a watt. This technology is still under research development. Although cheaper than DRAM, it is slower (but faster than a harddisk drive). Yet, its low power, non volatile storage leveraging on parallel atomic force imaging would outperform densities of conventional magnetic and optical storage, lending itself to 3G/4G wireless multimedia applications, transforming handheld devices into powerful terminals.

Nevertheless, other approaches seem more promising and pragmatic. The default choice today is of course flash memories. 3G USIM flash card memories may offer today up to 64Mbytes of storage, such as those demonstrated by Gemplus, while current typical 2G and 2.5G handset SIM cards only use 8 to 64Kbytes. Other very promising memory technologies include ferroelectric RAM (FRAM) and polymer based FRAM (PFRAM), as well as magnetic RAM (MRAM).

3.2.4 Imaging & Video

Mobile imaging applications involve the use of digital cameras attached or integrated in handsets or PDAs. Mobile push services, especially for retail outlets and restaurants for example, could make more interactive and appealing offers with animated images to nearby mobile users. From simple MMS, digital postcards, to 3D animated screensavers with alarm wake-up feature, animated icons or logos, picture emails, and finally sending very short self-captured video clips, these are early precursors to more power-packed future video streaming and conferencing on mobile devices. Early 3G models such as Samsung SPH-E120 (CDMA 1xEV-DO) are integrated with video cameras. 4G handsets are likely to offer better video applications.

Video applications may need more efficient codecs and compression techniques, faster & smaller chips, better displays, higher network bandwidths, longer battery life are needed. Real time video streaming uses transmission protocols such as UDP, RTP, RTSP and RSVP. MPEG-4 formats seem to be the de facto standard for video applications although there are also some

offering proprietary formats like Israel's Emblaze technology in Samsung's SGH-V100 and that there are other streaming technologies from strong competitors like Microsoft and Real Networks. In fact, 3GPP has chosen MPEG-4 as the open multimedia standard for 3G. MPEG-4 is highly scalable and can adapt ingeniously to different platforms like mobile handsets or PCs. It also incorporates digital rights management. Leading players in video solutions for mobile handsets include Emblaze Systems, Microsoft, Oplayo, PacketVideo and RealNetworks.

In general, MPEG-4 has many profiles and versions. Each profile specifies what coding features that the decoder can support. So far, there is no known successful attempt to stream real-time video using MPEG-4 core profile in which video-object segmentation is required. Most of the video-conferencing applications use MPEG-4 simple profile or MPEG-4 advanced simple profile. Although there are many profiles, each profile is created by adding new features to the baseline profile (MPEG-4 simple profile). The MPEG-4 part 10 standard is very much a new algorithm that has an entirely new bitstream format. The baseline profile is totally different from MPEG-4 simple profile. MPEG-4 part-10 is developed together with ITU and is known to ITU as H.264. Currently, the community is working towards the standardisation of version 1, which is scheduled to be finalised early next year. It promises a bitrate savings of 50% at the same visual quality compared with other video standards, albeit much more computational complexity. Compression savings can lead to savings in usage cost when we are billed based on data volume.

ARC Group predicts that by 2007, 200 million out of the 880 million total handsets in the world will be sold with integrated digital cameras (excludes counting of handsets that use external camera accessory such as some models from SonyEricsson). Some opined that this forecasted figure could be higher. CMOS cameras are cheaper but less performing. Although better in quality, coupled charged devices (CCD) are more power hungry and more expensive. In some 3G terminals, we see that CCD swivel mount type of camera interface is incorporated.

Imaging applications are not only from one mobile device to another, or redirecting via SMS notification to a web retrieval site for picture messages. The opposite way round, from server based or Internet based applications to mobile devices, is equally sought by innovative companies to provide imaging services to mobile subscribers, including RealNetworks. This will bridge the Internet world of rich contents to mobile subscribers. Today, we see online services for photo printing from popular imaging companies like Kodak or Fujifilm. Tomorrow, we could see the same services being offered to mobile subscribers with the advent of camera handsets and PDAs.

In Singapore, remote IP monitoring solutions via PDAs, GSM and GPRS handsets are offered by RyeSon Security International's Wireless RyeView for example. Although the quality is only up to 5 frames per second if on a GPRS network assuming already maximum data speed of

about 170kbps, the application has gained several corporate customers to visually monitor their network of office sites. This is a precursor to IP multimedia solutions via 3G handhelds.

3.2.5 Human-Machine Interfaces

Besides the above mentioned camera enabled visual interface, other user interfaces include external miniaturised keyboard, touch screen, stylus, intelligent text input, voice commands, scrolling buttons, 4-way navigation control, joystick, handsfree headset, media cards and one touch shortcut buttons for Internet access.

Handwriting recognition software comes from several players such as Advanced Recognition Technologies' SimpliWrite for PDAs and smARTwrite for handsets, Communications Intelligence's Wordcomplete and Jot, Microsoft's Transcriber, Motorola's QuickPrint and WisdomPen, Palm's Graffiti and Paragon Software's Pen Reader. The innovation in these handwriting technologies is the increasing ability to recognise pictorial characters such as in Mandarin. New products such as tablet PCs are also improving the handwriting recognition capabilities.

Amongst the most popular intelligent text input technologies is T9 by Tegic Communications and eZiText by Zi Corporation. Others include Fastap by Digit Wireless and iTAP by Motorola. These text input technologies support user personalisation via user defined dictionaries and support varied languages with some focusing on specific regional languages such as Mandarin.

There is also a range of different scrolling and navigation devices. Gaming focused handsets are likely to incorporate 4-way navigation controls or joysticks. Joysticks can be integrated into the phone or be sold as innovative clip-on's such as SnakeBITE joystick for Nokia 33 series of handsets. Examples of scrolling devices include Nokia's NaviRoller, Sony's JogDial, Spectronic's Sidetouch. Another leader in touch screen technology is Synaptics. It has two products for the mobile market which are Clearpad (touchpad) and Spiral (inductive pen sensor).

There are also very intriguing and almost StarTrek-like technologies being investigated by players such as Samsung (Scurry) and a Swiss company called Senseboard Technologies. It involves typing on a virtual air keyboard, requiring sensor technologies such as gyroscopes or muscle sensing rubber pads. There are also other cheaper and practical technologies based on image sensing such as Virtual Devices' Virtual Keyboard meant for PDAs and mobile handsets. This is a compact flashlight projecting a keyboard image on any surface and allows users to type on the image while tracking the location of their fingers.

3.2.6 Machine-Machine Interfaces

Machine to machine connectivity for mobile handsets, PDAs, handheld PCs, or other networked devices and peripherals can be done via a number of wireless means such as Bluetooth, infrared, HomeRF, WLAN etc. From body area networking (between wearables and handheld devices), to personal area networking or piconets, such local connectivity can be extended to wider area networking via for example the inclusion of a LAN access point. More importantly, the concept of ad hoc networking can be accomplished with such local area networking technologies. This will allow ad hoc set up of networks to facilitate multi-party gaming, multi-party conferencing and sharing of files, and enable group work collaborations. An ad hoc network is primarily a wireless network that is formed spontaneously by mobile devices without the aid of a fixed infrastructure or central administration.

Local connectivity will also provide basic needs of connecting to a digital video recorder, digital camera, headsets and printers etc for the individual. There are also opportunities for peer to peer transactions and networking between individuals, or with content and service providers, at many varied places too such as retail outlets, shopping malls, airports, libraries, and other public places. Other important application areas for local connectivity may reside in access control, remote control (with automobiles, smart home appliances, etc), as well as proximity payment. These areas will come with their own needs in terms of application management and security.

Machine to machine interactivity and intelligence may also be possible in the far future with autonomic computing. This is an emerging R&D technology area pursued or exploited mainly by big MNCs such as IBM, Microsoft, Motorola and Sun Microsystems. The autonomous intelligence of machines to handle computing complexities on behalf of humans imitates our own biological autonomic nervous system. The MNCs are also pursuing open standards for these autonomic systems. Autonomic systems could track own resources, share them with other systems, repair themselves, maximise and optimise how resources are used, prevent and fix server failures, system crashes, virus and hacker attacks. Initial autonomic features are found in IBM database and server products, Sun Microsystems' grid computing technologies.

Bluetooth (www.bluetooth.com). Bluetooth is described fully in the Connected Home Roadmap report, hence we would not delineate much here. Basically, Bluetooth allows inter-wireless full duplex communications within a short range of about 10m and operates in the ISM band at 2.4GHz, designed for replacing cables, especially proprietary cabling. With optional amplifiers, the range can be extended up to 100m. Voice is transmitted over Bluetooth via a switched connection while data is transmitted via packet networking.

Designed to operate in a noisy radio frequency environment, Bluetooth uses a fast acknowledgement and frequency-hopping scheme at 1600 times per second to make the link

robust. Data transmission rates are expected to be between 720kbps and 1Mbps, depending on transmission overheads. Such data rates are sufficient for most applications today although not as fast as WLAN or HomeRF. However with convergence, the Bluetooth specifications have also included a LAN access profile for dial up networking. Although slower and operating within shorter distances, Bluetooth has other benefits to offer compared to WLAN. Bluetooth is cheaper, does not consume more power than WLAN, does not require setting up of hotspots, has a smaller form factor ideal for mobile devices and can operate with other mobile devices anywhere anytime. Nevertheless, we note that both technologies are designed for different emphasis and markets.

Bluetooth, currently at version 1.1, is a global standard driven by the Bluetooth Special Interest Group and is supported today by more than 2800 organisations including 3Com, Ericsson, IBM, Intel, Lucent, Microsoft, Motorola, Nokia and Toshiba. Test, qualification and interoperability issues are areas that the Special Interest Group is actively promoting, besides developing standardised interpretations of the Bluetooth specifications via user models and protocol profiles. Bluetooth will be found on many 3G handsets too and is expected to be a basic feature on the majority of handsets by 2007.

Ericsson has also developed the concept of Bluetooth enabled e-wallet. It is a conventional wallet look-alike weighing 100g that hosts four ISO 7816 smart card readers as well as your coins and currency notes. The wallet communicates with the mobile phone via Bluetooth. The e-wallet is an alternative solution to dual-chip or dual-slot phones. Wireless POS (point of sale) terminals can be installed at retail outlets, supermarkets or even vending machines.

USB Interface. In some 3G mobile handset models, there is also an USB interface. USB2.0 offers transfer speeds at 480Mbps. This opens up connectivity options for various USB based devices such as new generation USB smart cards (potentially for storage, authentication, payment etc), USB hard disk storage via various media storage tokens, and also for synchronisation purposes with the PC. Currently, contact based smart cards compliant to ISO 7816 are also undergoing amendment to further include USB2.0 interface for faster and more efficient data transfer than its current 9.6kbps. This will enable contact based smart cards to outperform contactless card operation, which is at typically implemented speeds of 106kbps to 211kbps today.

In conclusion, machine-machine interfaces would greatly improve in the future with two key trends namely ad hoc networking and autonomic computing, along with flexibility, inter-roaming and bandwidth improvements in physical local connectivity technologies.

3.2.7 Digital Radio & Multicast/Broadcast

Analogue FM radio is now found on some handset models. The evolution could be from analogue FM free-to-air broadcast towards that of Digital Audio Broadcasting (DAB) offering up to 1.4Mbps data bandwidth or even towards TV reception on a handset with related standards such as European DVB (Digital Video Broadcasting). DVB could also broadcast data not just video, thus providing point-to-multi-point multi-media service. However, such convergence between mobile networks and TV broadcasting evolution is still not commonly seen, some in conception stage, others in limited handset models such as Samsung's SCH-M220 CDMA2000 handset with VHF and UHF reception capability. To internally integrate TV quality contents into mobile networks and handsets would require a constant data rate of 4Mbps, which will not be met by 3G networks but could be met by 4G networks which are conceptualised to claim a data rate ranging from 20Mbps to 100Mbps.

Many of audio and visual transmissions require compression technologies. As such, work on multimedia codecs, declarative contents (content that describes its QoS requirements), etc are in progress. Qualcomm's QTV% multimedia suite for TV broadcasting on CDMA2000 includes MPEG-4 video decoder and MPEG-4 low complexity encoder. Battery life, power consumption are definitely a show stopper to such 4G and TV convergence trends, and hopefully be better resolved with technologies such as micro fuel cells in mobile devices. Just as fuel cells are not coming anytime soon, 4G networks neither. We may have to wait until 2010 or even later for this convergence to occur.

Nevertheless, efforts are underway and 3GPP Release 6 (scheduled for June 2003) includes features such as multimedia broadcast/multicast (MBM). MBM services can allow for example point-to-multipoint multimedia broadcast transmission from broadcast service providers, and point-to-multipoint multimedia transmission to subscribers of multicast service providers. Web casting applications (for entertainment or e-learning) for both consumers and corporate users are hence a future possibility with mobile wireless.

3.2.8 Chip Hardware Trends

Market Trends. In device hardware chipsets, the trend is for major handset vendors to license their chipset designs to interested third parties as well as to outsource the production of chipsets mainly to plants in Asia Pacific (e.g. Flextronics, BenQ). There is also a trend of industry grouping and consolidation to jointly develop multi-mode 3G chipsets. While WCDMA chipsets are developed by many, CDMA chipsets are dominated primarily by Qualcomm.

Central Processing Unit, CPU Chips. CPU chips will need to offer increasing processing power in MIPS (millions of instructions per second). A single demanding UMTS application can require up to 300 MIPS. Major players in CPU chips for mobile devices are for example AMD, Intel, Motorola and Transmeta. Most are currently using 0.13 micron manufacturing technology. R&D in clock speeds using new materials such as InP (Indium Phosphide) on Silicon is pushing the limits to 70GHz. Improvements in chip technology will also cut power consumption by handsets. However commercially, we see in 2002 mobile processors emerging in the 200-400MHz range, progressing to 400-600MHz in 2004, 600-800MHz in 2006 and possibly +1GHz by 2007. Some opined that this speed progression may be faster.

Digital Signal Processing, DSP Chips & Application Specific Integrated Circuits, ASICs. DSP and ASIC chips are familiar in handsets for many functions including codecs and hands-free telephony. System-on-chip open platform designs are emerging trends with major vendor products like Texas Instrument's "Open Multimedia Applications Platform (OMAP)" and Intel's "Personal Internet Client Architecture (PCA)".

With the advent of 3G that brings about many different specific areas of applications, there is a trend to introduce Application Specific Standard Products (ASSPs), which can be seen as a bridge between general processing DSP and System-on-Chip Application Specific ICs (SOC ASICs). These ASSPs integrate specific wireless functions (e.g. GPS, MPEG, Bluetooth, graphics accelerator) into the base chip, while providing peripheral connections to other specific applications such as multimode GSM/GPRS/3G chip support and display function. Hence, some functions that are 'must-have' or 'less evolutionary' wireless features are automatically included, while other more dynamic features are made as modular add-ons for easier upgrades.

Miniaturisation Trends in Chips. This is neither new nor specific to the mobile industry. Chip miniaturisation towards higher density of transistor count has been ongoing since its invention. The compactness of handheld devices is a crucial virtue for mobility, convenience and consumer appeal. Sub-micron technologies down to 0.09 micron are used to make miniaturised wireless chips. On the extreme end of miniaturisation for wearables, HP and Swatch have joined efforts to develop wireless communication devices that are wristwatch look-alikes. NTT also has similar development plans for PHS wristwatches. Others like sportswear integrated with MP3 and phone features are also envisaged. Whether such wearables will be popular with users depends on their value propositions with respect to cost and specific application environments.

One of the challenges to miniaturise portable terminals is the need to integrate Gallium Arsenide (GaAs) amplifiers with silicon-based bipolar and CMOS components, as well as with numerous non-transistor-based frequency selective passive components. Silicon technologies have improved tremendously, doubling performance every 18 months, integrating active components

might become possible between low noise amplifiers (LNAs), solid state power amplifiers (SSPAs), phase-locked loops, RF and IF mixers and baseband demodulation circuits.

Future 3G communication systems may also require many small bandwidth channels for large number of users that are separated using frequency selective passive components. This in turn requires high quality factor (Q) filters for selectivity and low insertion loss and extremely stable low phase-noise oscillators. While certain ceramic and SAW technologies can help to meet such requirements, they may be space consuming, leading to a considerable number of discrete components in the terminal design. To lower the number of RF discrete components, low cost silicon-based technologies such as micro-electromechanical systems (MEMS) are potential candidates. Besides its low cost, another advantage of MEMS is their compatibility with Monolithic Microwave Integrated Circuits (MMICs) and opto-electronics, suitable for smart antennas too. This could lead to future multi-chip modules (MCM) for multi-band wireless transceivers and wearable 3G/4G gadgets such as wrist communicators, as well as enabling wideband software radio.

Packaging. In electronic packaging, relatively small I/O count packaging such as DIP (Dual In-line Package) were used initially in the 1970's. This is followed in the 1980's by surface mounting technologies. To achieve high density peripheral interconnects, packages such as QFP (Quad Flat Package), and then area-array interconnects such as BGA (Ball Grid Array) and CSP (chip scale packaging), and finally advanced area-array interconnects such as flip chip BGA have come into existence over the last ten to fifteen years. Today, active research is ongoing to achieve finer pitch flip chip technologies that will allow integration of even more I/O interconnects onto a single chip with better performances and shorter interconnects.

Besides working on two dimensional performance enhancements, new 3D packaging technologies are also offering wireless chipsets better miniaturisation and integration. Examples include stacked CSP (S-CSP) heavily used in wireless and mobile devices. S-CSP technologies used today in for example i-mode phones are still enabled by wire bonding. Future developments will include both wire bonding and flip chip interconnection. Fine-pitch BGA (fBGA) has also been used with stacked flash multi-chip packages (MCP) for memory chips for mobile devices. These trends indicate that even at chip level, we see the concept of convergence in action, whereby BGA, CSP and stacking technologies converge to bring about more flexible and smaller form factors for innovative designs in mobile devices.

3.3 Middleware

We would discuss here middleware technologies such as 3GPP's MExE, Sun Microsystem's J2ME and Qualcomm's BREW. In general for middleware development, one of the reasons that

the Internet is so successful is the vast number of developers who can develop Internet applications against standard-based application servers. To replicate the same success, some opined that we could do the same for the development of mobile solutions. What we require furthermore is that the application server is a mobile-enabled Internet application server, and not a mobile-only application server. Although mobile solutions have their unique requirements, many functionalities offered by the Internet application server are also relevant for mobile solutions. Authentication, authorisation, MVC model, load balance, failover, cache are just a few samples of functionalities offered by the Internet application server that are also applicable to mobile applications.

3.3.1 Mobile Station Application Execution Environment

Mobile Station Application Execution Environment, MExE. The 3GPP has a working group called MExE whose purpose is to standardise the application environment for 2.5G and 3G. A consistent application environment is beneficial to handset vendors, application developers, operators, service providers and of course to end users. MExE currently encompasses established protocols such as WAP and Java. Qualcomm is proposing BREW and Microsoft is proposing Common Language Runtime (CLR) from .NET Compact Framework to be included as MExE classmarks.

A MExE classmark is a specification that defines services that a mobile terminal can support. A MExE compliant application will hence only run on a MExE supported terminal. For example, MExE includes the current following classmarks:

- Classmark 1. This is related to WAP enabled terminals, specified in early 3GPP Release 99. For example, this provides browser capabilities.
- Classmark 2. This is related to Java terminals based on PersonalJava and JavaPhone specifications. It has more processing flexibility and resources than the earlier classmark. Additional APIs are also included to define network protocols such as Gopher, FTP, HTTP/1.1 and HTTPS.
- Classmark 3. This is related to the latest Java J2ME specifications including CLDC and MIDP (see following chapter on J2ME). This is desirable to support Java based applications.

A terminal can support one or more classmarks. A likely combination is for a terminal to include both classmarks 1 and 3. This is because classmark 2 related to PersonalJava and JavaPhone were more popularly implemented with older terminals than with 3G terminals. 3G terminals are likely to adopt the latest Java J2ME specifications.

For future developments, it seems that MExE application development environment is losing momentum and that the work is likely to move to Open Mobile Alliance (OMA), the future dominant force in mobile wireless.

3.3.2 Java 2 Micro Edition

Java 2 Micro Edition, J2ME (<http://java.sun.com/j2me>). Java has seen very strong support from handset vendors and is likely to be ubiquitous by 2007. With over 2.5 million global Java developers, many operators will launch Java services. Currently, Java games are already offered with the new MMS enabled mobile handsets. J2ME is the version of Java 2 adapted for devices with limited resources such as PDAs, handsets, set top boxes and handheld game consoles. While J2ME specifications are for devices, JavaCard specifications are meant for SIM cards. JavaCard operating system allows for post issuance and loading of Java applets (e-purse, PKI, loyalty, credit/debit, other subscription services etc) into the SIM card. It thus positions the SIM or USIM as an open multi-application platform that can offer a highly secured execution environment.

J2ME specification is based on a concept involving configurations and profiles (see figure below).

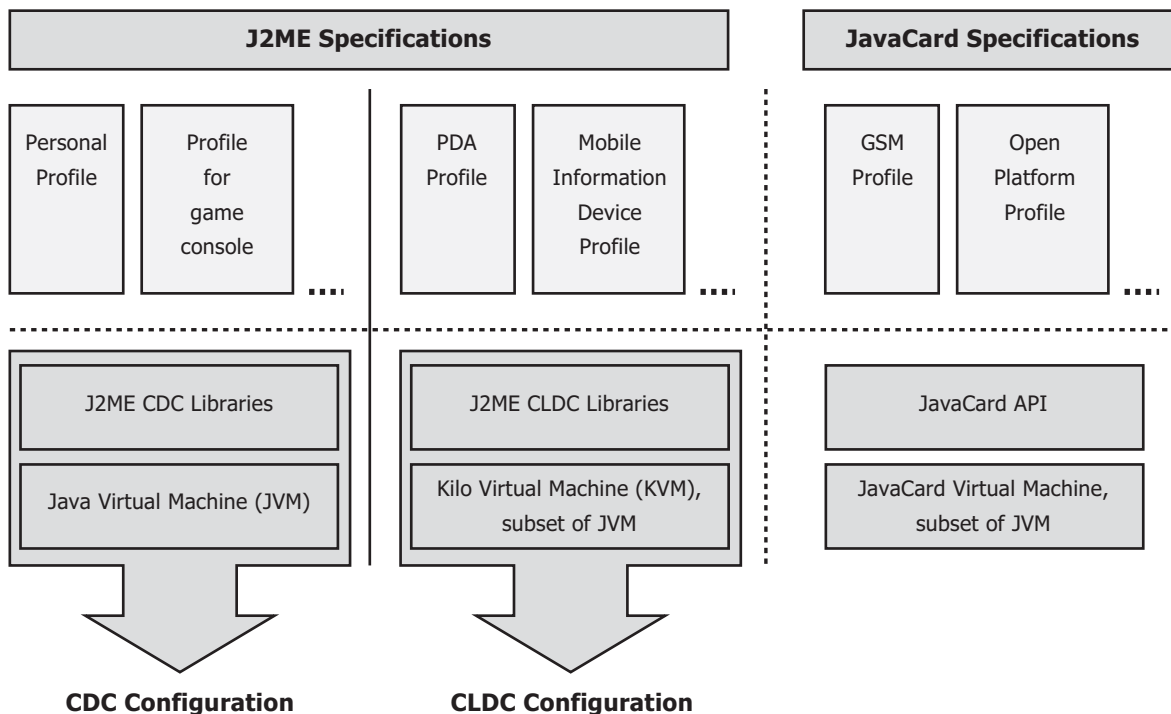


Figure 8. J2ME and JavaCard Architectures for Mobile Devices & SIM Cards

A configuration is comprised of a virtual machine, core libraries, classes and APIs. Currently, there are two J2ME configurations: the Connected Limited Device Configuration (CLDC) and the Connected Device Configuration (CDC).

CLDC is designed for devices with constrained CPU and memory resources. Typically, these devices run on either a 16- or 32-bit CPU and have 512 Kbytes or less memory available for the Java platform and applications. A mobile handset or PDA for example could belong to a CLDC configuration.

On the other hand, a CDC is designed for next generation devices with more robust resources. Typically, these devices run on a 32-bit CPU and have 2 Mbytes or more memory available for the Java platform and applications. An example would be set-top boxes for satellite TV receivers.

The above two configurations sit below the profiles. A profile details the specific collection of Java APIs (classes/methods) that supplement the configurations to provide capabilities for a specific vertical market or device type. According to the needs of a specific industry, profiles are defined through the Java Community Process (JCP), and may be initiated by industries without Sun's direct involvement.

MIDP 1.0 (Mobile Information Device Profile) is the wireless profile that is currently used in all Java enabled mobile handsets outside Korea and Japan. Next Generation MIDP or MIDP 2.0 has just been finalised by the JCP process and handsets compliant to MIDP 2.0 are expected to hit the market earliest end Q2 2003. MIDP 2.0 also specifies a standard OTA (Over The Air) mechanism for downloading java applications via OTA provisioning to mobile devices.

Due to inadequacies of CLDC and MIDP 1.0, handset manufacturers extend the APIs with their own proprietary API libraries to provide more features. Hence, a Java application written for a specific handset has little chance of running on another vendor's Java enabled handset, which defeats the whole concept of portability. This is perhaps the biggest challenge facing Java in the mobile wireless market. However, the long-term situation is likely to improve with better versions such as MIDP 2.0 and other open API packages that are being developed through the JCP process. These include JSR-135 Mobile Media API, JSR-120 Wireless Messaging and JSR-180 J2ME SIP API.

PDAP 1.0 (Personal Digital Assistant Profile) which is currently out for public review in the JCP process is the profile for PDA devices. It builds on MIDP 1.0 and adds common PDA features like PIM (Personal Information Management) APIs, serial port connectivity APIs and file system APIs. The profile is expected to be finalised by end 2002 with applications expected soon after.

Security of Java. MIDP1.0 restricts each Java application to operate within a sandbox which prevents access to sensitive APIs or functionalities of the device, thereby enhancing security. This however restricts the range of applications and what developers can offer to users. However, in MIDP 2.0 (which also supports Secure Socket Layer), applications can be cryptographically signed so that their authenticity and origin can be validated. In this case, the authentication keys could be stored in SIM. This new security framework specifies that some "trusted" or "privileged" applications, based on their signature or user's explicit permission, can gain access to protected APIs outside the sandbox. Also in future, we could manage in the SIM card the entire authorisation table that tells what applications can do and what they cannot do.

Currently in the JCP process is JSR 177, the Security and Trust Services API for J2ME. When approved, it will provide standard Java APIs to SIM cards for automatic authentication, authorisation on wireless networks, automatic single sign-on and digital rights management for SIM-enabled wireless devices. This paves the way for new opportunities in applications such as mobile commerce, loyalty programmes, etc.

Competition to Java. Competing technologies such as Qualcomm's BREW, Microsoft's .NET Compact Framework are seen to be of limited threat to Java as they have yet to gain the kind of widespread acceptance that Java enjoys. Java's closest competitor the BREW platform has an integrated Java VM (Virtual Machine) that enables Java applications to run on BREW-enabled handset as well.

Initially IN-FUSIO's ExEn game engine was also thought be a competing game engine technology to Java as MIDP 1.0 offers limited game functionalities. However, even IN-FUSIO has embraced Java. Only recently Panasonic launched its first ExEn-enabled colour handset, GD 87, across Europe and not surprising, the handset supports ExEn version 2.0 which, according to the company, is fully J2ME MIDP 2.0 compliant.

In another example of Java's growing acceptance, the popular Research In Motion's Blackberry device has been entirely written in Java code for its operating system to allow more optimal performance. ARC Group predicts that practically all handsets will be Java enabled by 2007, and by 2004, Asia Pacific will see the biggest market in Java handsets.

3.3.3 Binary Runtime Environment for Wireless

Binary Runtime Environment for Wireless, BREW. BREW is a wireless application development platform and runtime environment developed by Qualcomm for its CDMA handsets.

Running in a native environment on the device, BREW has the possibility of faster and more complex applications than Java applications, which are interpreted on the fly, because Qualcomm's CDMA chipsets are optimised for BREW. BREW also provides a set of enhanced APIs to access the embedded chipset functions (Wireless Internet Launchpad™) such as Bluetooth, MP3, MPEG-4, GPS and voice recognition. In addition, BREW supports a Java Virtual Machine on which Java applications can run.

BREW goes beyond the function as an application development platform; it encompasses a distribution mechanism as well. In fact BREW Distribution System (BDS) allows third-party developers to negotiate terms and pricing directly with carriers and then receive payment in an efficient and consolidated manner. In addition, BREW applications must pass Qualcomm's testing and certification suite (TRUE BREW) before they are hosted on Qualcomm's server. Once the application is designated TRUE BREW, it is given a digital signature that identifies it to BREW-enabled handsets and made available to carriers.

According to Qualcomm, there are over 650 000 subscribers using 7 different BREW handsets as of May 2002, and the cumulative number of BREW application download count is 4.75 million. KDDI, Japan's second largest wireless carrier with 10 million cdmaOne subscribers has begun to deliver applications on its BREW platform-based handsets since April 2002. And last fall, Korea Telecom Freetel (KTF), a Korean CDMA carrier, was the first operator to launch data application services based on BREW using handsets from LG Electronics and Samsung. Besides the two Asian operators, Verizon Wireless (US) has also adopted the BREW platform. In June 2002, Sony Online Entertainment announced plans to develop games for wireless devices using BREW. Qualcomm also announced that China Unicom would offer the technology to a portion of its 30 million subscribers by Q4 2002.

Although BREW does provide the operators with a complete solution to secure premium revenues, it also introduces a great number of dependencies on Qualcomm. With BREW, Qualcomm will have control from the development to certification and finally to the distribution of the applications. It is hard to imagine the rest of the industry ceding that kind of control to a single company. Moreover, BREW is too Qualcomm-specific and CDMA chip-biased. Consider that Gartner estimates that roughly 75% of the world uses GSM phones, and that ARC Group also estimated that in 2007, about 80.5% of handsets are GSM based (15% CDMA2000 and rest of 4.5% are 2G TDMA or PDC handsets), CDMA and BREW would seem to be at a disadvantage. Qualcomm claims that although BREW started with CDMA, it intends to extend this platform to other wireless technologies such as GSM. Hence, much remains to be seen.

3.4 Architectures & Platforms

We will examine here architectures and open platforms driven by industry alliances, operating systems, microbrowsers, WAP2.0, as well as location architecture & technologies. Many of these open platforms and standardisation efforts by industry alliances serve to provide a consistent user interface and interoperability between applications.

3.4.1 Operating Systems & Microbrowsers

Traditional handset manufacturers like Nokia, Ericsson and Motorola used to develop hardware, operating systems and applications in-house. Possibly due to a shortening product life cycle, operating systems have been outsourced. There is currently no unified standard for mobile operating systems and a fierce competition is waged between several main contenders: Microsoft's Windows CE/SmartPhone 2002/Pocket PC 2002 Phone Edition, Symbian OS (formerly known as EPOC), Palm OS and Linux/eCOS. We would analyse these below.

Industry players such as Audiovox, Casio, Compaq, Everex, HP, Fujitsu-Siemens, Philips, Sharp, Symbol and Toshiba use Microsoft's Windows CE. Since plans to use Windows CE fell apart possibly due to high per unit licensing fee, Symbian was formed in 1998 by Ericsson, Motorola, Matsushita, Nokia and Psion. Its operating system, EPOC from Psion, is targeted at wireless mobile phones and handheld computers. On the whole, proprietary OSes are still reigning the marketplace in today's handsets but the trend is towards majority open platforms by 2007. Due to its leading position in the handset market, Symbian OS is currently the market leader and is expected to continue to be so in 2007.

Sun Microsystems, Philips and NTT DoCoMo have joined Symbian and licensed EPOC. The Open Mobile Alliance is also reviewing the specifications and going to adopt Symbian OS. Symbian OS version 6.0 supports Bluetooth, WAP, HTML and Java, as well as speech and handwriting recognition. Symbian OS version 7.0 for 3G handsets supports in addition to version 6.0 features such as IPv6, SyncML, EMS, MMS, email, fax, C++ and web-browsing.

On the other hand, Microsoft has acquired STNC in May 99 who supplies Symbian with its microbrowser HitchHiker. Microsoft has also acquired Swedish Sendit AB in July 99 for its Internet Cellular Smart Access server and mobile communication protocol, which is licensed for use in EPOC. New product like the Pocket PC 2002 Phone Edition for wireless PDAs and high end handsets has seen first commercialisation into the xda device by mm02 (In Singapore, this is first offered by local telco Starhub with GPRS subscription). VoiceStream Wireless in the USA is an operator that supports Pocket PC 2002 Phone Edition on its GSM/GPRS network. SmartPhone 2002, previously codenamed Stinger, is based on Windows CE 3.0, and is found in

for example Sendo and HTC (Taiwanese) products. With the aggressive .NET strategy, Microsoft is certainly going to be a tough competitor to Symbian OS but is unlikely seen to outshine the latter in the short term.

3COM is relatively a smaller player with its Palm OS in the handset market but still a current leader in the PDA market although its market share is expected to drop to 30-40% by 2007 according to ARC Group. Also, according to eTForecasts' report on "Worldwide PDA Markets", Palm OS is losing in the global PDA market share to Pocket PC. In 2002, the worldwide market unit sales of Palm OS amount to 7.08 million units (about 42% of global PDA market) while Pocket PC accounts for 5.63 million units (about 34% of global market share). By 2006, Pocket PC will account for 17.15 million units (about 42% of global market share) whereas Palm OS will take up 11.48 million units (or about 28% of global PDA market share).

In a bid to fight off competition, Palm OS has been licensed to CDMA phone vendors such as Kyocera and Samsung. Its OS division has now been spun off as PalmSource subsidiary. The new version 5.0 will include both Bluetooth and IEEE 802.11b WLAN support. Recently, Palm has announced its joint development with IBM to develop software programs for Palm PDAs, such as secure email and IBM's Sametime instant messaging application, in the next version of IBM's WebSphere Everywhere Access business platform. This is a challenge to Microsoft as the first version of the WebSphere Everywhere platform runs on Microsoft's Pocket PC devices. The joint deal between Palm and IBM is said to be more extensive than the one with Microsoft, but not exclusive in the sense that IBM can renegotiate with Microsoft and Palm can still collaborate with AOL Time Warner's instant messaging platform. On the other hand, Psion and 3COM are developing interoperability between their operating systems. Nokia has implemented PalmOS over EPOC platform. Symbian is actively developing interoperability with Windows CE. Microsoft has also licensed Windows CE for video games machines and digital set top boxes.

Linux and Embedded Configurable Operating System, eCOS. Linux is still relatively a newcomer in the handset market but backed by strong computing players such as Compaq, HP, IBM, Intel and Sharp. The huge Chinese market is also another reason not to ignore Linux. Some Chinese companies are already tying up deals with overseas partners to develop Linux based Internet appliances. Some other companies like Transmeta is releasing Mobile Linux. The obvious advantage is that Linux source code does not require royalty fees unlike other operating systems. While there are currently no handset model incorporating Linux, as most platforms are still PDA based for Linux, there are some companies such as RidgeRun who has developed Linux based software for GSM/GPRS and 3G handsets. An important development is the joint venture of 3G Lab and Red Hat which resulted in the successful development of an open source based operating system called embedded Configurable Operating System (eCOS) for mobile devices like 2.5G and 3G. The code for alpha version of eCOS ver2.0 was available since May 2002, and a beta version is being prepared.

It is not clear now how far Linux can compete in the market for mobile devices. However, as per today in terms of applications developed for these operating system platforms, a survey by ARC Group revealed that Java applications top the list, followed by applications for Windows CE, then Symbian OS, lastly for Palm and then Linux.

Microbrowsers. Browser technologies that we are familiar with in the online world are for example Internet Explorer and Netscape. Mobile microbrowsers complement the operating system and can be burned into a handset, embedded into the SIM card, or added to the handset via post device issuance downloads. Major microbrowser trends include:

- Downloadable browsers which are multi-modal and multi-channel allowing access not only to text and multimedia portals, but also voice portals, and over a range of different networked devices using different network technologies.
- XHTML enabled browsers that are fast becoming the norm for new handsets models while most microbrowsers now support languages in the range of WML, HDML, HTML and cHTML.
- J2ME enabled microbrowsers which are also increasingly popular with handset vendors due to the popularity of java technology and java enabled games.
- Developmental efforts towards standardisation in human machine interface specifications for mobile devices. This is already completed for desktop devices in a series of ISO standards (ISO 14915, 9241, ISO-IEG 11581, 13714 and 11580) and would require according to the UMTS Forum, an equivalent to be established for mobile devices.

OpenWave (previously known as Phone.com) dominates the market with its Openwave Mobile Browser (www.openwave.com) for mobile handsets and Palm devices. Among the licensees of Openwave Mobile Browser are Ericsson, Kyocera, Motorola, Nokia, Qualcomm, Sagem, Siemens, Samsung and Toshiba. Basically, this browser is widely supported by 45 device manufacturers on 165 handset models with over 200000 software developers. It comes in two versions: WAP edition (WAP 1.2.1) and Universal edition (WAP 2.0). The browser is compatible with both GPRS and 3G standards, and supports over the air provisioning.

There is also a host of other microbrowsers including many proprietary ones. Microsoft has launched Microsoft Mobile Explorer (MME 3.0) and vendors like Benefon, Hyundai, SonyEricsson and Samsung have supported this microbrowser too. MME is independent of operating systems and can be implemented over Symbian OS. It is probably the only worthy competitor to Openwave Mobile Browser due to Microsoft's presence, and MME focuses on corporate applications. Access' Compact NetFront is a microbrowser for i-mode phones. Another example is Espial's Escape microbrowser, supported by Motorola (for DigitalDNA products) and Intel

(for web tablets). Palm OS v3.1 and above uses Jataayu WAP browser. A list of other microbrowsers includes EZWAP, Opera, Palmscape, Proxiweb and Eudora etc.

SIM based browsers, while offering less possibilities than handset based ones, are seen today as complementary as they allow to offer browsing services to the widest subscriber base. Giesecke & Devrient, a major smart card solution provider, has developed a SIM card based browser STARSIM for wireless Internet access. Across Wireless (formerly AU System) with Ericsson & Setec has also offered similar SIM card loaded browser. Gemplus also offers SIM card based browser that could work with various backend servers. However, these implementations are "proprietary" in their respective context. There is a global standard initiative called the SIMalliance formed by five major leading smart cards suppliers (Gemplus, Giesecke & Devrient, Oberthur Card Systems, ORGA Kartensysteme and Schlumberger) to maximise the GSM operator's benefits from interoperable SIM card technologies. The first set of specifications, called the SIM @lliance Toolbox, or S@T, was announced in Mar 2000 and provides a standard SIM based browser protocol that is now widely adopted in particular in Europe.

3.4.2 WAP 2.0

WAP 2.0 is the next generation of WAP specifications that brings the wireless world closer to the Internet. The motivation is to extend Internet technologies to wireless networks, bearers and devices. It also capitalises on a wide range of new technologies and advanced capabilities such as higher-speed bearers (e.g. HSCSD, GPRS).

WAP 2.0 provides support for protocols such as IP, TCP and HTTP. By adding these Internet protocols and standards and providing interoperable optimisations suitable to the wireless telecommunications environment, the WAP specifications provide an environment that permits wireless devices to utilise existing Internet technologies. This support has been motivated by the emergence of high-speed wireless networks that provide IP support directly to the wireless devices. In particular, it added the Wireless Profiled HTTP (WP-HTTP), Transport Layer Security (TLS) and Wireless Profiled TCP (WP-TCP) specifications while retaining support for the WAP protocol stack.

WP-HTTP is a profile of HTTP for the wireless environment and is fully interoperable with HTTP/1.1. The basic model of interaction between the WAP device and WAP proxy/WAP server is the HTTP request/response transaction. In addition, it supports message body compression of responses and the establishment of secure tunnels.

A wireless profile of TLS will permit interoperability for secure transactions. This profile for TLS includes cipher suites, certificate formats, signing algorithms and the use of session

resume. The profile also defines the method for TLS tunnelling to support end-to-end security at the transport layer.

WP-TCP provides connection-oriented services and is fully interoperable with standard TCP implementations in the Internet. It incorporated a number of mechanisms to improve performance in long thin networks as recommended by IETF (RFC2757). WP-TCP offers 2 methods of implementation across wired and wireless networks. One way is to use a split TCP approach where a WAP Proxy interfaces between both networks (see figure below). In this way, it provides a simple way to shield problems associated with wireless links from the wireline Internet and vice versa while allowing TLS tunnelling at the transport layer.

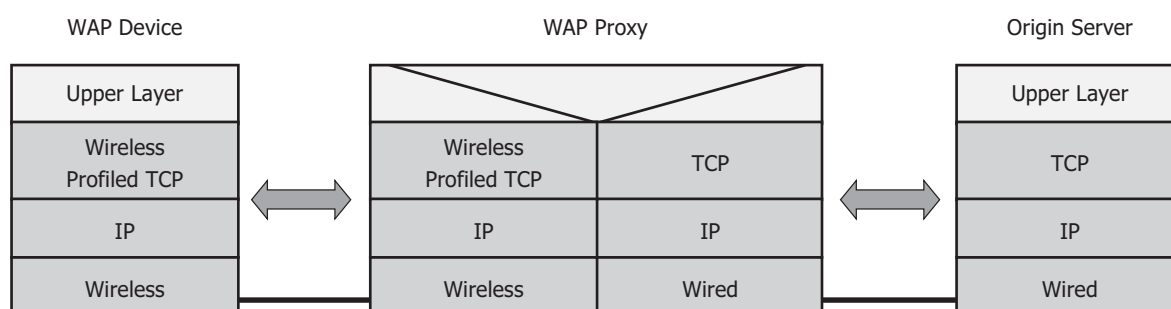


Figure 9. Wireless Profiled TCP With WAP Proxy
(Source: WAP 2.0 Specification)

Another method is direct access between the client and the server (see figure below). In this mode, a wireless IP Router is used to interface at the bearer layer. WP-TCP implementations must support both modes of operation.

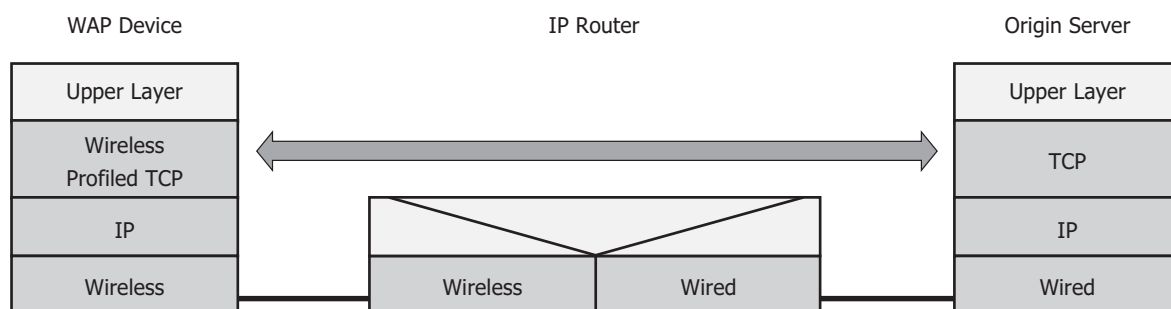


Figure 10. Direct Access
(Source: WAP 2.0 Specification)

WAP 2.0 specifies XHTML Mobile Profile (XHTML-MP) for new content and WML 2 to support legacy WAP 1.x content. These markup languages provide the appropriate presentation services for wireless devices, while capitalising on their unique advantages. By supporting XHTML, WAP 2.0 diminishes the border between the wired and wireless Internet. The same content can be understood and presented by both traditional browsers and WAP micro-browsers, removing the content migration effort. XHTML-MP does profiling of end-user devices' display capabilities; therefore content can be presented properly and consistently in different devices.

Since XHTML is very similar to HTML, there will not be much difficulty in learning the markup language, as compared with WML. And since XHTML will be used on the fixed Web, developers only need to remember which tags are not used on WAP 2.0 phones. Also, WAP 2.0 makes use of Wireless Cascading Style Sheets (WCSS) to control the presentation of XHTML pages allowing richer text formatting.

Wireless Application Environment (WAE). WAE, since WAP version 1, has been built fundamentally on World Wide Web technologies. New developments in base Internet technology allow WAE 2.0 to converge with, or adopt, more standard Internet technologies than was possible in WAP version 1. Among these technologies is support for eXtensible Hypertext Markup Language (XHTML) and Cascading Style Sheet (CSS). In addition, backward compatibility with legacy WAP 1.x content is maintained using WML version 2 (WML2). Version 2 also brings improvement in internationalisation support via pictogram and new functionalities such as External Functionality Interface (EFI), and support for Synchronisation Markup Language (SyncML). WAE 2.0 supports content format such as WML1 (legacy WML specified under WAP 1.x), XHTML Basic, XHTML Mobile Profile, WML2, and WCSS etc.

3.4.3 Location Interoperability Forum

The purpose of Location Interoperability Forum (LIF) is to define, develop and promote, in co-operation with global standards and technical specification making bodies, a simple, ubiquitous and interoperable location services solution that works across wireless networks of different technologies in order for Location-Based Services (LBS) to be widely deployed and accepted by consumers worldwide. LIF will be consolidated into Open Mobile Alliance, which we will describe later.

LIF has published the latest Mobile Location Protocol (MLP) Release 3.0.0 to enable different parties like wireless operators, geographic information services and application service providers to exchange location information. MLP is an XML based application-level protocol that allows exchange of location information like latitude and longitude co-ordinates between Internet applications and infrastructure and a wireless network, irrespective of underlying air

interface and positioning technology. MLP provides basic location services defined by ETSI and 3GPP to obtain the latitude and longitude of the mobile users in a mobile network.

It is more useful for third party LBS applications to obtain the street name or zip code rather than a latitude and longitude co-ordinates of mobile users from the mobile network. Hence, LIF is working on the next version of MLP specification to allow Internet applications to supplement raw location data with value-added information such as maps, routes, points-of-interest, geo-coding and reverse geo-coding.

Privacy is a major concern when it comes to LBS. Proper privacy handling is an important issue to be considered, in order to promote widespread deployment of LBS. It covers many aspects, such as ownership of location information, disclosure of location information, usage of location information and lawful intercept. Abuses to location information of mobile users may lead to endangerment to lives. Fortunately, some devices provide options to disable location detection, or passwords and user IDs, while network based location technology requires the switching off of handsets. Most LBS solution, provide features for user to choose whether or not he or she wishes to be identified by the service provider. Seeking subscriber authorisation is key to providing effective localised services.

The GSM Association (GSMA) has highlighted that privacy issues cannot be fully resolved in the HLR (Home Location Register) because it does not support sufficient number of user privacy profiles needed for different applications, which naturally limits the user's possibility to use a wide range of LBS. There are also some implications that the privacy issue in a roaming scenario is complicated.

Wireless Location Industry Association (WLIA) in the US has established some guidelines for member companies setting acceptable standards for protection of the individual privacy of users of wireless devices that may be located using signal location technology. The standards will govern use and compilation of personally identifiable data, including location information linked to individuals, and will prescribe responsible practices in the emerging wireless signal location industry.

3.4.4 Wireless Village

The world of desktop Instant Messaging is characterised by multiple, competing, proprietary technologies and a lack of interoperability. Wireless Village, founded in Apr 2001 by Motorola, Ericsson and Nokia, is an open standard initiative to promote the standardisation of mobile Instant Messaging and Presence Services (IMPS). The aim of the initiative is to develop and promote a universal protocol for mobile IMPS and ensure interoperability in a multi-vendors

environment. IMPS besides covering the basic functionality of instant messaging (chat), it also entails other functionalities such as presence, group and shared content management. The Wireless Village initiative is to specify the protocols to cover all these functionalities.

The roles of Wireless Village Initiative are as follows:

- To create an open, common protocol for providing interoperable mobile instant messaging and presence services among workstations, network application servers, and mobile information appliances, such as mobile phones, handheld computers, PDAs and other mobile devices.
- To accelerate the market's vision of ubiquitous instant messaging and presence services from any mobile device to any other networked device. The initiative will work with end users, device manufacturers, IMPS providers, infrastructure developers, application developers and service providers to define a common mobile IMPS protocol, the Wireless Village protocol.
- The Wireless Village initiative is designed so that existing IMPS solutions can be updated to interoperate with those based on the Wireless Village initiative.

The Wireless Village initiative liaises with a variety of other standardization bodies, either to cooperate in making the specification, or to work with the organizations to ensure the adoption of the Wireless Village technology. In July 2002, the Wireless Village version 1.1 specification was updated from the initial version released in February 2002. This latest version reflects the intensive work and reviews from a large number of the more than 170 Wireless Village supporters.

The Instant Messaging allows end-users to send and receive messages containing content such as pictures, music, images and graphics. The specifications are used for exchanging messages and presence information between mobile devices, mobile services and Internet-based instant messaging services. The protocol is optimised for the requirements of mobile devices and wireless networks.

The Internet Engineering Task Force (IETF) has efforts underway for some time to standardise IMPS for the Internet environment. They will define and address the specific needs of IM for the wireline network environment. SIP/SIMPLE specification is a product of IETF for IMPS in the fixed-line world. The PAM (Presence and Availability Management) Forum is a consortium that is dedicated to defining a set of application programming interfaces to facilitate development of interoperable applications for presence and availability management. They are not defining the format or OTA protocols necessary to communicate with instant messaging or presence services.

Both PAM and SIP/SIMPLE were claimed by some segments in the mobile industry to be the competing standards of Wireless Village though Wireless Village claimed that it was more complementary rather than competing standards. In any case, similarly like LIF, Wireless Village is also going to be consolidated into OMA and it is more likely that OMA specifications will prevail.

3.4.5 M-Services Initiative

Also known as Mobile Services Initiative, this industry alliance was established in June 2001 by the GSM Association, primarily to standardise GPRS based data services and applications. The scope of work includes the following technologies:

- SIM Application Toolkit
- WAP 2.0
- GUI (Graphical User Interface)
- Multimedia downloads and messaging such as EMS and MMS
- SyncML (for data synchronisation, see later chapter on SyncML)
- The latest phase II work announced in February 2002 would include support for MExE and Java.

3.4.6 Open Mobile Alliance

Having too many different industry alliances is not healthy for interoperability, it is high time for some industry consolidation. The Open Mobile Alliance (OMA) Ltd. (www.openmobilealliance.org) was established in June 2002 by the consolidation of the WAP Forum and the Open Mobile Architecture Initiative, with participation from about 200 companies representing the world's leading mobile operators, device & network suppliers, information technology companies and content providers. It aims to promote interoperable services across countries, operators and mobile terminals that will meet the needs of the user. With this consolidation, the WAP Forum name will no longer be related to the WAP 2.0/XHTML specification but will be subsumed and the specifications made available under the OMA. The OMA will become a key worldwide mobile application standards body.

OMA will be a Very Prominent and Central Alliance. Other alliances such as the Location Interoperability Forum (LIF), SyncML, MMS Interoperability Group (MMS-IOP) and Wireless Village, each focusing on mobile service enabler specifications, have announced their signing of Memorandums of Understanding of their intent to consolidate with the OMA.

Amongst the technologies that OMA is deciding on are Multimedia Messaging Services (MMS), Java and WAP 2.0/XHTML browsing, as well as other technologies such as Digital Rights Management (DRM), authentication, location & presence identification, and device management.

3.4.7 Open Service Access & APIs

An Open Interface. Application Programming Interface (API) is a critical building block towards multi-vendor interoperability for 3G portals and services including messaging, location based services, multimedia calls, content based charging, policy management, service registration and discovery etc. The key partners developing standard APIs for applications and framework are 3GPP, ETSI, JAVA for Integrated Networks (JAIN) and Parlay Group.

The Open Service Access (OSA/Parlay) framework adopted by the 3GPP defines open APIs. The OSA/Parlay was formerly known as Open Services Architecture created by the Parlay group. It defines an architecture that enables third party applications to access the network functionality through an open standard interface - the OSA/Parlay APIs. The API provides an interface that exposes the network capabilities or Service Capabilities Features (SCF) to 3rd party applications outside the operator's network domain. 3GPP has adopted OSA/Parlay in its UMTS Release 5 (released in Q2 2002) architecture as an enabling technology that will allow the creation of services and applications.

Currently, this set of APIs is being defined and standardised by the Joint OSA/Parlay API group, comprising of the Parlay Group, 3GPP and ETSI. Requirements coming from the 3 bodies are taken into account and all meetings are joint meetings. However each body generate its own document format. The Joint OSA/Parlay Group also works very closely with a working group from JAIN (Java API for Integrated Network) community. JAIN Java APIs binding is expected with the Joint Parlay APIs.

The New Parlay Value Chain. The mobile industry in general has come to term with the fact that the key to increasing ARPU is not identifying a killer-application but rather, delivering of value-added (VA) services to subscribers. OSA/Parlay architecture with its open interface opens up the creativity and potential of the telecommunications services market in a similar way that the development of web browsers did for the Internet. Consequently the OSA/Parlay API allows 3rd party developers/service providers to emerge and participate in the new value chain, thereby fuelling the availability of innovative applications/services that are critical to sustaining the entire ecosystem. In this sense, all players (Network operator, Service Provider, Application Developer and End Users) along the value-chain stand to gain from this technology and standard.

Some of the key benefits are:

- **Interoperability:** This is key to providing consistent services.
- **Common Platform:** A common development paradigm that encourages the growth and diversity of services. The unified APIs will enable the reuse of skills/software across multiple products.
- **Greater Functionality:** Services and applications can access network information and resources. (E.g. presence, location, user data).
- **Ease of Service Integration:** The OSA/Parlay platform enables inter-working between existing networks and future service capabilities.
- **Network Agnostic:** Provides a high abstraction layer across different Network (PSTN, 2.5G, UMTS, IP-based). It is also a recommended enabling platform for the UMTS Rel 5 network architecture.
- **Portability:** Internal/external applications or services can be readily ported on different network with OSA gateway. Applications and services can still be accessed even as the network evolves towards the UMTS standard.
- **Cost/Time Saving:** Reduction in cost/time for development and deployment means a time-to-market introduction of next generation applications on existing network.
- **Maintains Control:** The Framework interface provides authentication and authorisation for application use of network resources.
- **Customisation:** OSA/Parlay will enable operators and service providers to better address niche market requirements by offering custom built applications. (E.g. Enterprise related applications).
- **Convergence:** Enables the convergence of IT and Telecommunications.
- **Larger Developer Communities:** The common APIs lowers the entry barrier for the IT and Internet developer community, thereby greatly expanding the pool of application developers. Currently, there are about 3 million Java developers as compared to 10 000 IN (Intelligent Network) developers.

With new exciting application to offer subscribers, network operators can benefit from greater network traffic and hence an increase in revenue. Moreover, from the user perspective, an open market will result in more service and applications at competitive prices. Given Singapore's small domestic market, OSA/Parlay could potentially provide a common platform for creating services that are not only interoperable within the local networks but also exportable to the global mobile market.

The parlay initiative began in 1998 with only 5 founding members and today there are more than 50 members such as BT, Ericsson, France Telecom, IBM, Lucent, Microsoft, Nokia, NTT Group, Siemens and Sun Microsystems. Even though the specifications are still incomplete (e.g. in the area of MMS integration), OSA/Parlay has been gaining significant momentum in the past half a year, especially in the European telecom industry. Aepona announced earlier this year, in Feb, the world's first commercial deployment of OSA/Parlay gateway in the Telecom Italia network. 4 to 8 other European operators are expected to adopt OSA within the next 12 months. Several independent trial projects are also in process; the latest being the OPIUM project initiated by IST which involved the participation of 3 European operators.

The development of the OSA/Parlay technology is likely to intensify over the next 12 months with the next Parlay member meeting in Oct in Dublin and the 2nd OSA/Parlay workshop (sponsored by EURESCOM) in Nov in Heidelberg. Parlay 4.0 specification is expected to be released by end of the year. Furthermore, EURESCOM P1110 & VESPER, the 2 European trial projects, will have been completed, by Dec this year. Consequently the trial results, feedback and recommendations will be critical in shaping the future development and widespread adoption of OSA/Parlay standard on a worldwide scale.

Approach via Open APIs versus Proprietary APIs. However, it is unlikely in the initial stages, that operators will be willing to expose all their network capabilities to 3rd party applications via the open interface. And this might prove to be the biggest obstacle that can thwart the open access approach. Currently some operators are looking at opening up access to their location and positioning databases. In fact, Vodafone is the first UK operator to enable 3rd party location-based services via the Open Mobile Internet Platform (OMIP) from Siemens. The OMIP is a Siemens proprietary technology and is seen as a potential competing technology to OSA/Parlay. The OMIP borrows a similar architectural concept from the OSA/Parlay work but the interface offers simpler API based on SOAP over HTTP and LIF standard for location-based services. The current focus of OMIP is on location-based services, thus it seems that OMIP offers an interim solution for operators who are banking on LBS applications even though in terms of functionalities, OSA/Parlay interface is more comprehensive.

3.4.8 Virtual Home Environment

Virtual Home Environment, VHE. The VHE stems from the 3G concept that users should get consistent portability of personal services and achieve the same productivity anywhere in the world from which they access these services and roam. The VHE concept is hence independent of global network operators, satellite or terrestrial access modes, and locality (local or overseas, at home, on the move or at work). The concept also allows the monitoring and activation of services at home from remote locations (electrical power switching on/off, aircon on/off, security system on/off, intrusion alerts sent to mobile device with home monitoring cameras, movie/TV programme recording etc). This would enable seamless integration of home network services with mobile devices.

Mobile Wireless Internet Forum, MWIF (www.mwif.org). We have described earlier under the mobile network chapter about standards organisations such as 3GPP and 3GPP2. Here we will introduce another organisation called MWIF. The MWIF was established in January 2000 as a non-profit, international industry consortium. Its objective is to drive acceptance and adoption of a single, open, mobile wireless Internet architecture that is independent of the access technology.

In a May 2002 press release, MWIF together with OHG, 3GPP and 3GPP2 announced that they will take a phased approach to harmonise the IP Multimedia Core Networks between 3GPP and 3GPP2, this will for example allow global roaming of IP multimedia services and contribute further to the VHE vision. Specifically, the work refers to the OSA/PARLAY (see above chapter on OSA) based framework for service APIs and the IP Multimedia Subsystem (known as IMS in 3GPP and MMD in 3GPP2). This includes the creation of a single IMS reference model and consistent terminology to describe common IMS functional entities.

IMS is standardised in Release 5 of UMTS networks by 3GPP. IMS uses SIP (see network chapter) as protocol for Internet and wireless, IPv6 (with IPSec security), supports roaming functions inherently and all kinds of access networks (GPRS, UMTS, WLAN). Amongst the advantages of IMS to a MNO (Mobile Network Operator) are efficient network control, quality of service, security and billing. It opens a new portal to non-real time and real time IP services, peer to peer mobile IP services (multi-player role-playing games), as well as converged services (voice and gaming, or voice and application sharing).

3GPP had proposed four different methods to provide VHE services:

- CAMEL Service Environment (CSE). Provided via Application Servers, interaction with IMS can be direct, via IP Multimedia-Service Switching Function (IM-SSF), or via the OSA-Service Capability Server (OSA-SCS);

- MExE. This allows applications to be developed to suit the specific terminal capabilities independent of terminal platform. Applications residing on MExE-enabled terminals can then interact with a MExE server to provide VHE services;
- UMTS SIM Application Toolkit (USAT). Applications loaded into USIM cards can interact with applications located on a SAT server;
- OSA. A server-centric approach described in earlier section that provides services via open APIs. This is the most favoured approach as it is applicable to both 3G and non-3G terminals (unlike MExE or USAT approaches that are limited in scope of applicability).

There are also pockets of R&D projects and activities around VHE. For example, there is a joint R&D effort between 8 major European telcos to define an IP based network solution to support VHE in project EURESCOM P920 entitled "UMTS Network Aspects". Research in 4G on software reconfigurable radio technologies is also taking into account VHE requirements for mode switching transparency to users when they roam, so that the users do not have to care about what new air interface they are connected to or from which network they are drawing mobile services.

Other examples include a pan-European middleware development project (www.vhe-middleware.org) supported by companies like Fujitsu, Nokia, Philips and Siemens, to define middleware software technologies that are to be used in the application server and in end-user terminals for establishing a VHE. The middleware developed will be applicable to wireline and wireless access, independent of access devices (PDAs, handsets, PCs) and user category (consumer or business). This project is part of the ITEA (Information Technology for European Advancement) initiatives, a pan European R&D programme. The project aims to help position Europe as a leading technology innovator in VHE. Amongst the demonstrators used are a multi-standard mobile terminal (with GSM, GPRS, UMTS, DECT, Bluetooth, WLAN/HomeRF components and Smart Card), a set-top box with Bluetooth and/or WLAN/HomeRF and/or DECT wireless interconnection module and PSTN/ISDN interface, as well as a smart card subsystem.

3.4.9 Wireless Web Services

IDA has facilitated a roadmap report on Next Generation Internet Applications in its Feb 2002 Release, which has elaborated on the trends of web services. Web services are self-contained, self-describing, loosely coupled software components that can be described, published, discovered, and invoked over a network. They can dynamically locate and interact with other Web services component on the network to provide a service without intervention. Web services comply with certain industry standard specification and are platform cum language neutral. Web services enable computers to compile and share information in a way to help users more conveniently manage their time and their tasks.

Market Overview. Many major vendors such as HP, IBM, Microsoft, Oracle and Sun have announced their Web services architecture. Only Microsoft bases its architecture on Windows based platform, with the rest basing their architecture on Java. Other players include Qualcomm's BREW platform.

The wireless web services will mainly be a competition field between Microsoft's .NET Compact Framework and Sun Microsystems's J2ME web services. The J2ME web services specification comes under the Java Community Process JSR172. At present, Microsoft is earlier to market in the sense that the .NET Compact Framework (for mobile devices Pocket PC and SmartPhone 2002) is already in beta version and is expected to ship in the second half of 2002. Microsoft's wireless .NET strategy also includes Mobile Information Servers and Exchange, as well as IP telephony via SIP in Windows XP.

The J2ME web services specification expert group has just been formed and not expected to be released until summer 2003. This means that compliant products will only be available even later. Yet, Sun does have a lead in terms of Java technology adoption for mobile devices. Besides heavily supported by handset vendors with the release of Java enabled handsets, Symbian OS also supports Java and JavaCard 2.1.1 is also gaining ground in SIM cards. In particular, Nokia has partnered with IBM and Sun Microsystems on a Java-based J2ME web services strategy.

Beside the major IT vendors, several smaller companies are also building Web services development frameworks. These players include BEA System's Web Logic, The Mind Electric, which makes Glue, a Java-, XML- and SOAP-based platform for constructing Web services; Eltegra, which produces Exadel, an XML component server and platform; WebCollage and its Syndicator product; and Bowstreet, a startup that produces the Business Web Factory and has announced co-development agreements with both Sun and HP. Even SAP, the Enterprise Resource Planning vendor, has come up with its own concept of Web services.

Architecture. Interoperability is the key element that must be present for different Web services component to interact with each other. Web services uses three dominant XML standards, WSDL, UDDI and SOAP to accomplish its basic service publication, location and binding functions.

- SOAP is an XML-based messaging protocol that provides a standardised enveloping mechanism for communicating document-centric messages and remote procedure calls using XML. SOAP messages support the publish, locate and bind operations in the Web services architecture.
- The document that describes the Web services is the WSDL document. These documents may reference other WSDL documents and by referencing the URLs of other Web services, it is able to request for their services. WSDL defines the interface and mechanics of service

interaction and is the de-facto standard for XML-based service description, forming the minimum service description required to support interoperable Web services.

- The UDDI business registry features an indexed list of the URLs of the WSDL documents and a description of the Web services. As such, UDDI performs the registry function of Web services by providing the service of locating Web services. The below figure depicts how these technologies are related in the Web services architecture.

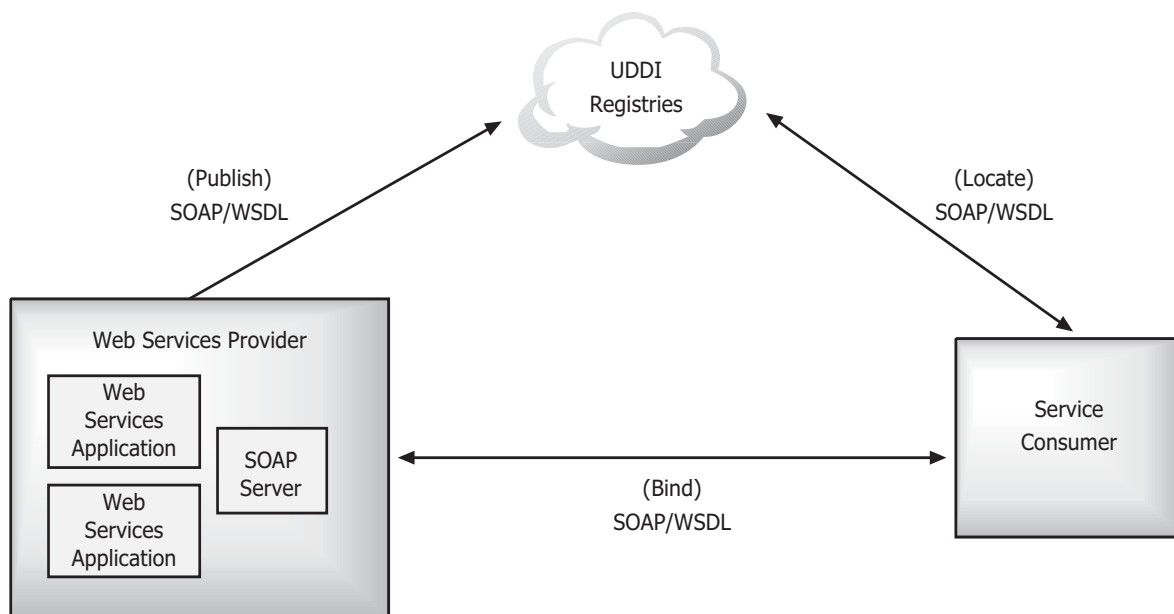


Figure 11. Architecture of Web Services

3.4.10 3G Portals As Delivery Platforms

The UMTS Forum has produced a reference handbook entitled "3G portal study" (report no. 16 available on www.umts-forum.org). According to UMTS, many 3G services will be made available from so-called 3G portals via the mobile transmission network to end user devices. The UMTS reports indicated that revenue from 3G portal services could amount to over US\$200 billion by 2010 and that a number of industry players are already actively engaged in developing 3G portal services market. Needless to say, content is king and 3G portals will be an important platform means to deliver 3G contents and services to the end users.

The 3G portal business is relevant to mobile operators, content & application developers, handset/PDA/laptop manufacturers and portal operators (e.g. generic or horizontal portals

like MSN and Yahoo, niche or vertical portals to specific consumer or corporate users). The guiding principle for 3G portal services is to make the necessary yet complex range of technologies behind these services as transparent as possible to the user and to develop simple to use interfaces & devices.

UMTS Forum's definition of 3G portal types include:

- Mobile intranet/extranet portals (mainly for corporate employees or business-client use);
- Customised Infotainment portals;
- Multimedia Messaging Services portals;
- Mobile Internet portals;
- Location based services portals.

Amongst the most important technology recommendations of UMTS are:

- Markup languages such as XHTML and HTML are preferred;
- Open content format and compression standards are preferred, namely JPEG 2000 for images, MP3 and MP3 PRO (half the storage space compared to MP3) for audio and music, as well as MPEG-4 for video.

There are many different proprietary and open media formatting standards for audio, graphics and video contents. For audio, there are MP3, MP3 Pro, RealAudio, Windows Media Audio, iMelody, MPEG Advanced Audio Coding (AAC). For graphics, there are JPEG, JPEG 2000, GIF, Macromedia Flash, Wireless BitMap (WBMP), W3C's Scalable Vector Graphics (SVG) and Binary Format for Scenes (BIFS). For video, there are ITU's H.263, MPEG-4/H.264, QuickTime, ActiveMovie, RealVideo and Windows Media Video (WMV). According to UMTS Forum, these will converge into integrated multimedia standards under MPEG-7, MPEG-21, RTFD1.0 (Recommended Technical Framework Document) and Windows Media Player.

For future development, the UMTS Forum also noted that technical R&D is required to enable richer capabilities that cannot be delivered today on current state of portal technologies. The Forum has also identified further critical areas for a concerted industry collaboration to enable smooth delivery of services over 3G portals such as:

- End-to-end security
- Privacy
- Billing & payment
- QoS
- Interoperability
- Content format & compression

3.5 Markup Languages

Introduction. Markup languages began in 1986 when SGML (Standard Generalised Markup Language) was developed for electronic documents. SGML is used for describing markup languages. HTML (Hypertext Markup Language) for the Internet, an ISO 8879 compliant SGML application developed in 1990, then popularised markup languages as the entire world became connected online.

As more vertical applications come onboard, HTML began to show insufficiency in catering to the needs of specific industries. Thus, XML was created and accepted as a W3C (World Wide Web Consortium) standard in 1998 to expand the capabilities of markup languages to meet our increasingly demanding needs. The Extensible HyperText Markup Language (XHTML) is a family of current and future document types and modules that reproduce, subset, and extend HTML, reformulated in XML. XHTML Family document types are all XML-based, and ultimately are designed to work in conjunction with XML-based user agents. XHTML is the successor of HTML, and a series of specifications has been developed for XHTML. More information can be found at www.w3c.org.

Mobile Markup Languages. Until recently, the mobile industry was divided into two dominant camps in markup languages: WML (Wireless Markup Language, XML based and created in early WAP days) and cHTML (compact HTML used in Japanese i-mode handsets).

WML was created to adapt to the constrained environment in mobile devices, however, the need to convert existing contents mostly HTML based to WML format was one of the factors that led to its demise, besides the slow take up of new WAP services. Based on HTML, i-mode saw better success for data services than WML. The popularity of HTML hence led to WAP2.0 specifications to introduce XHTML Basic (Extensible HTML) in addition to WML for backward compatibility. NTT DoCoMo has also adopted XHTML Basic. The specifications for XHTML Basic were completed in December 2000.

XHTML Basic is a compacted version of XHTML 1.0, and belongs to the series of XHTML specifications. It is designed for Web clients that do not support the full set of XHTML features, for example web clients such as mobile phones, PDAs, pagers, and set-top boxes. The document type is rich enough for content authoring. XHTML Basic is designed as a common base that may be extended. The goal of XHTML Basic is to serve as a common language supported by various kinds of user agents.

E-commerce Markup Languages. Meanwhile, the e-commerce industry has also strongly supported CXML (Commercial XML) and ebXML (e-business XML). CXML created in 1999 is supported by 40 e-commerce companies mainly for the exchange of catalogue contents over the

Internet. ebXML is greater global initiative by United Nations and OASIS approved in 2001 for B2B transactions and SCM (Supply Chain Management).

VXML (Voice eXtensible Mark-up Language). To enable multi-modal access and navigation, VXML standard for voice & speech based applications is driven by VoiceXML Forum with core participants like AT&T, Lucent and Motorola. Currently, voice commands are the typical type of implementation on mobile handsets for a friendlier user interface. There are also voice portals pioneered by companies like BeVocal, HeyAnita and Tellme.

Voice and speech technologies face the challenges of speech recognition/authentication, echo cancellation and natural language processing. Advanced speech and language technologies and services are among the fastest growing segments of the technology industry. Amongst the players are Advanced Recognition Technologies' smARTspeak CS (used by for example Motorola and Samsung), Domain Dynamics' Tespar and ScanSoft's RealSpeak (acquired from Lernout and Hauspie). For speech, there is also SALT (Speech Application Language Tags). SALT aims to extend the capability of existing markup languages to further include interactive speech.

SyncML (Synchronisation Markup Language). In Personal Information Management (PIM) applications, synchronisation tools are critical for the user. The SyncML protocol enables interoperability between different vendor products for data synchronisation. It is an open standard industry initiative formed in February 2000, supported by over 675 companies and sponsored by names like Ericsson, IBM, Lotus, Motorola, Nokia, Palm, Psion, Starfish Software, Matsushita. The 3GPP has also adopted SyncML as the de facto standard for mobile data synchronisation.

Suitable for constrained devices like mobile handsets and PDAs, SyncML is XML based and can support various transport protocols such as HTTP, WSP (WAP) and OBEX (used in Bluetooth sync profile). The Bluetooth sync profile is likely to be updated with SyncML for interoperability. SyncML is based on a client-server architecture and can support diverse synchronisation modes such as unidirectional, bi-directional, slow sync (rigorous comparison of each data field), etc.

SyncML v1.1 was released in April 2002. SyncML can be found on handsets such as Nokia 9210, 9290 and 7650, as well as Ericsson T39m, T65, T68 and R520m.

The Future on Markup Languages. From the above, we see there is strong support in HTML and XML based technologies. It looks like XHTML based languages will become the dominant mobile data markup language for the future, as it is adopted by both current dominant players namely Open Mobile Alliance and NTT DoCoMo.

Already, some of the existing contents are converted into the new XHTML format. With XHTML, there is a hope to reconcile competing markup language standards for 3G services. This is beneficial not only for the mobile industry but also for end users. For the moment, we may see dual mode handsets offering backward compatibility for WML while incorporating the newer standard XHTML Basic. This conclusion is likely to be true for GSM based users, but for CDMA users, alternative solutions by Qualcomm such as BREW mentioned earlier may possibly dominate.

XHTML 2.0 is the most recent effort by W3C in markup languages but is not as ready as XHTML Basic. It is intended for rich, portable web-based applications and has its roots from HTML 4, XHTML 1.0, and XHTML 1.1. However, it is not intended to be backward compatible with its earlier versions but application developers familiar with earlier versions will be comfortable working with XHTML 2.0 according to W3C. The first working draft on XHTML 2.0 was released in Aug 2002. The final specifications recommendation date is not determined yet, but according to current status, it is likely to be ready in Q3 2004.

XHTML 2.0 that includes in particular XForms, proposed by the W3C, could be the markup language that developers will use to develop the next generation multi-channel and multi-modal mobile applications. Today, many mobile applications are mono-channel. For example, a J2ME application can be accessed by devices with a J2ME runtime environment. A WML application can reach to the handsets with a WAP browser. Such mono-channel applications significantly limit the potential user space. Applications developed in XHTML2.0 with XForms and are executed in the mobile-enabled application servers could allow users to interact with the same application from different channels: via WAP browser, via fixed-line voice phone, via PocketPC and so on, or even switching channel from one to another.

In addition, some opined that a mobile-enabled Integrated Development Environment (IDE) for mobile applications should further grow the mobile application developer community and accelerate the development cycle. A mobile-only IDE may not be what developers want but rather a mobile-enabled standard IDE. It may be easier for the developers to learn the mobile-specific development paradigm from a known IDE that they use to develop web applications.

Programming Languages – Java and C++. Other than markup languages, software programming languages like Java and C++ seems set to dominate the mobile industry. Borland supports for example both Java and C++, and these can be used to develop applications for 2.5G and 3G over OSes like Symbian OS. Many SIM cards are already pro-Java. Started as a programming language by Sun Microsystems, Java has rapidly expanded to enable breakthrough usage for the corporate enterprise infrastructure and applications, wireless and mobile devices. J-Phone, a Japanese operator, is for example a very successful advocate of Java. It inaugurated J-Sky services in June 2001, a range of Java services, and subsequently its data calls exceeded voice calls over its network.

3.6 Security For Mobile Devices & Applications

In this Release November 2002, there is also a separate track on Security Technologies for E-Commerce. Many of the cryptographic technologies, standards, industry alliances, PKI, smart cards, biometrics etc are discussed in that roadmap. Here, we aim to highlight more aspects of security related to mobile wireless.

Smart Cards. Smart chip cards would be a key enabling technology for secure mobile commerce. The mobile phone is an ideal smart card reader that is pervasively deployed. SIM Application Toolkit (SAT) protocol can be used for secure over-the-air provisioning (OTAP) as SMS or as cell broadcast message to update SIM cards. SAT phase 2+ offers two way communications between the SIM card and the mobile terminal. The WAP Forum, now known as Open Mobile Alliance, has developed specifications for WAP SIM cards (or WIM) which implement the Wireless Transport Layer Security (WTLS) for secure transactions since versions 1.2 and above. Omnitel, Gemplus, Nokia and Sonera were amongst the pioneers who demonstrated push services and secure online payment through WIM with WAP version 1.2.

The other wireless technologies such as iDEN, TDMA, AMPS, CDMA which inherently do not include smart cards as part of the wireless network are beginning to recognise the benefits enjoyed by smart cards-based systems. Nextel has deployed SIM cards in its IDEN network. The CDMA industry has standardised what is known as the UIM card to be used over 3G CDMA as well as 2G CDMA. China Unicom is leading the way by plugging a UIM in every CDMA handset they distribute. With 3G USIM specifications, the SIM card is no longer a privilege of the GSM community.

UMTS Subscriber Identity Module Cards, USIM. USIM cards, a mandatory SIM card standard for 3G terminals standardised by 3GPP, can offer stronger authentication and security features with PKI, a multi-application environment, a connectivity to data channels, full featured phonebook and other new functions. The relevant USIM standard specifications by 3GPP include (source: UMTS Forum):

- TS 31.101/ETSI TS 102 221 – described the physical cum logical characteristics of the USIM card and the interface between the card and the terminal (handset);
- TS 31.102 – describes the characteristics of the USIM application;
- TS 31.111 – USIM Application Toolkit (USAT);
- TS 33.102 – describes security architecture;
- TS 23.048 (formerly GSM 03.48) – for secure messaging applications;
- TS 51.011 (formerly GSM 11.11) – for digital cellular telecommunications system Phase 2+ and interface between SIM and terminal.

In the near future, USIM cards could host flash memories up to 64Mbytes (e.g. Gemplus) for limited multimedia data storage, storing subscription profiles and access rights to applications, storing cookies when surfing as well as other applications. Via connectivity interfaces in the handset such as Bluetooth and infrared, data transactions with the SIM or USIM card is possible for example for micropayments.

Several USIM cards also incorporate JavaCard 2.1.1 virtual machine, suitable for multi-application issuance and loading. Existing open standard multi-application operating systems besides the dominant JavaCard from Sun Microsystems, include MULTOS from the MAOSCO consortium and Windows for Smart Cards from Microsoft. Windows for Smart Cards operating system seems to have quietened since Microsoft has reverted to a third party licensing model. MULTOS is no longer seen today as a candidate OS for smart cards in cellular systems.

Other than the normal contact chip card that works in a handset, USIM contactless smart card is also another possibility. In fact, there had been many trials with different options of implementing a smart card chip: single chip in handset solution, double chip in handset solution (one for SIM, another for credit/debit purposes), ISO compliant contactless chip, e-wallets connected via Bluetooth, and full size smart card slots in handsets. Another patent pending method by Briza Technologies is a standalone credit card reader that can be connected to a handset via its local connectivity interface and that generates a proprietarily encoded SMS.

Contactless cards are fast becoming the de facto smart card standard due to its convenience, speed of use, durability, increasingly capability in asymmetric cryptography and boosted by mass adoption via micropayment applications such as transit and others like door access. Amongst the ISO 14443 standards for contactless proximity cards, there are 2 types of normative standards: type A and type B. Type A originated from patented Mifare technology from Philips and the popular commercial version is based on an enhanced proprietary version called type A Mifare – in which the contactless interface is based on hardwired memory logic. Type B is newer than type A standard and is oriented towards processor friendly applications. Type B is gaining popularity as there is no license fee involved. However, command set specifications for type B to ensure interoperability between applications are still lacking in ISO 14443 specification. There are many other proprietary types not accepted currently into ISO 14443 which are type C to G such as Sony's type C which is implemented in transit systems in Hong Kong and Singapore. More recently, there Philips and Sony have joined forces to develop 'Near Field Communication' products which are A and C compliant.

Public Key Infrastructure (PKI). Encryption algorithms belong to two classes: symmetric and asymmetric. Commonly used symmetric methods include single DES, which is being replaced by the more popular de facto standard of 3DES (triple DES), and the US has released a new symmetric encryption called Advanced Encryption System or AES. There is a strong

base of 3DES users, but AES is also seeing increasing adoption especially from symmetric crypto-communications in the wired space. While successful attacks on 3DES are not known, it is felt that it is only a matter of time that this happens and customers who are concerned about security have already implemented AES in their environment.

Asymmetric encryption is supported by 3G standards such as in USIM card specifications. PKI uses asymmetric encryption, which is stronger than symmetric encryption but slower. Although slower, PKI-based wireless security can provide a total solution for confidentiality, integrity, authentication and non-repudiation. WTLS and PKI could help spur the development of secure mobile e-commerce. Initial WAP products will benefit from the security provided by server-side certificates, extending to WAP servers, gateways and backend systems. With the release of WTLS 1.2, client-side WTLS products and services would emerge. Study Group 7 of the ITU Telecommunication Standardisation Sector (ITU-T) has approved a new edition of Recommendation X.509 to supersede the 1997 edition, in close collaboration with ISO/IEC and ISOC/IETF. This will help to enable the use of digital certificates for e-commerce.

PKI leaders such as Baltimore, Entrust, Verisign and Sonera are some of the protagonists. Verisign and Entrust also provides WAP server certificates. The Radicchio alliance (www.radicchio.org) formed by EDS, Ericsson, Gemplus and Sonera SmartTrust was launched in September 99 to promote wireless secure commerce and has 33 members to date. Amongst its new agenda is to look at how to integrate biometrics.

Elliptic Curve Cryptography (ECC) is an asymmetric encryption alternative for implementing public-key cryptography. The advantage ECC has over other traditional asymmetric cryptographic methods such as RSA is that much smaller keys can be used to achieve the same encryption strength, hence reducing computational overhead. ECC-based devices require less storage, less power, less memory and less bandwidth. Leading companies such as Baltimore, Certicom, Entrust and RSA are already providing ECC products. In Singapore, Netrust's WAP server certificates based on Entrust implementation also support ECC. We expect to see increased proliferation of ECC products for mobile applications.

IPSec/IPv6. When GPRS becomes more widely used, it is conceivable that IPSec will be used as the underlying protocol to secure the transmission of sensitive data for mobile devices. IPv6, which supports IPSec, will also gain popularity for secure end-to-end wireless communications, especially with the increasing maturity of MobileIP standard by IETF. The SIM card, being tamper-resistant, is always used to uniquely identify the mobile user independent of terminal and could be used to store the IPv6 address of the user. Nevertheless, end-to-end security today is supplied by almost if not all proprietary solutions and open standards are not likely to happen anytime soon.

Biometrics could encompass voice, fingerprint, iris and retinal scanning, hand and face geometry, as well as signature keystrokes. Biometric technology can be integrated with PKI to provide a secure authentication mechanism for both wired and wireless applications, especially financial transactions.

SAGEM has integrated a fingerprint embedded sensor on their dual mode mobile phones. Acoustic smart cards such as AudioSmartCard and VocaliD are targeted at mobile commerce without the need for smart card readers. In the US, a company called Keyware Technologies is offering layered biometrics authentication solution. While fingerprint sensors are initially popular with handsets, with the advent of integrated camera in 3G handsets, one would wonder if the more accurate iris scanning technology dominated by Iridian would become a natural choice. However, the use of iris scanning (less intrusive than retina scanning) would also require not just any digital camera but specific camera qualities that cannot be met with current wave of handset cameras. Although currently available for PC e-commerce applications and also as a webcam, iris scanning products for mobile handsets will have to wait for cheaper and yet better camera interfaces for commercial viability.

3.7 Applications and Services

In this chapter, we elaborate on applications and services in the mobile world. At the core of these applications is the basic functionality to address effective human communications, as well as enhancing the e-lifestyle and work productivity. Also many of these applications are ported and adapted from the PC online world such as email, instant messaging, streaming applications and MP3. Yet there are also more mobile specific applications such as location-based services, navigation services, MMS postcards and E911 emergency services.

Also, mobile technology is evolving so fast that new mobile devices are brought to the market almost every now and then. However consumers may have to struggle to configure and update these devices. Application providers may have difficulty to provision and update applications on these devices. Remote device and application management services offered by the service providers should greatly increase the likelihood of the new device acceptance.

3.7.1 Mobile Messaging

Short Message Service, SMS. Mobile messaging applications can include voicemail, SMS, EMS, MMS, video messaging, fax, cell broadcasting, email, instant chat/messaging and unified messaging. SMS has fuelled a very successful beginning in mobile data usage uptake. In Singapore, millions of SMS are sent each month, and the world sends more than 20 billion SMS

monthly. With predictive text software technology in handsets, SMS was more made even more convenient and has made its way to interactive TV game shows, news programmes, or for simple business & financial applications as value added services. Currently, in Singapore for example, a mobile phone number is also used as an email address belonging to a subscriber, and email messages can be truncated into SMS formats for the user.

Mobile & Fixed Line Messaging. The SMSC of the mobile network can deliver SMS messages to a PSTN network using the ETSI standard SMS Fixed Line (Release in Jan 02). Hence, the SMS messages can now be sent from fixed to fixed/mobile phones and vice versa. But new phones will be required to support Fixed Line SMS. The Fixed Line SMS has just been introduced recently in a few countries such as Philippines, Germany and Sweden. In fact in Singapore, SingTel has just launched this service in June 2002.

Enhanced Messaging Service, EMS. EMS extends the text limit of 160 characters of SMS to further include extended text capability by concatenation, ringtones, logos, picture cards and limited animation icons. EMS specifications are standardised via 3GPP, of which release 5 was published in Dec 2001. EMS is supported by the M-Service initiative, and has seen implementations in both GSM and CDMA handsets. Although many handset vendors also support EMS feature, one important leading handset vendor, Nokia, is missing from action in EMS. Nokia's original and proprietary Smart Messaging launched in 1997, with capabilities akin to EMS, was rejected out of M-Service initiative in favour for EMS due to its proprietary nature. Today, EMS faces strong competition from MMS.

Multimedia Messaging Service, MMS. MMS is an open standard set by 3GPP. MMS has the ability to send and receive messages comprising a combination of text, sounds, images, audio and video. MMS has roots in both SMS and Internet standard e-mail. It takes the best of both systems and provides a mobile-optimised solution for multimedia messaging. The MMS message can be sent to both a mobile phone and regular email address. MMS uses the WAP and GPRS as bearers for the transmission of MMS messages. The arrival of 3G will eventually bring MMS to its full potential, but is thought that GPRS will give enough bandwidth for most uses until that time, with the exception of video streaming services.

The content for MMS will come from two sources – third party application providers or like SMS, from mobile users themselves. The majority of push content requests will be done via the web, with the convenience of the PC interface and due to the small penetration of MMS enabled handsets in the market. As highlighted, users themselves can generate content. The mobile user with a built-in camera in the MMS enabled phone can snap pictures and forward to their friends.

The underlying technology in MMS is a thin client architecture making full use of plug-ins. MMS compared to EMS will require new messaging centres in terms of infrastructure upgrading.

The future for messaging applications would be in rich multimedia and hence the combination of text, imaging, music, polyphonic tones, animated icons and screensavers, and the like will capture a portion of the market especially for early adopters. Yet, the pricing for MMS services will greatly affect its take-up rate, as well as the penetration rate of MMS-enabled handsets and camera-enabled handsets. It is unlikely that we would see the same phenomenal success as with SMS. It is further so when many subscribers still own a non MMS-enabled handset or are bound by existing hardware subsidy contracts, or when MMS local and global interoperability has yet to be resolved between handset vendors and operators. While these are issues that will fade with market evolution, in 2007, the basic cost efficient or even free value proposition of simple text messaging like SMS would still be more popular.

Looking at the success of Sha-mail (MMS-like) service in Japan by J-phone, MMS may also be the saviour for GPRS which has been under utilised in most mobile networks due to lack of compelling mobile services. Ultimately, streaming and video conferencing would be natural extensions to multimedia messaging but would require minimally an average bandwidth support of 384kbps for sufficient quality.

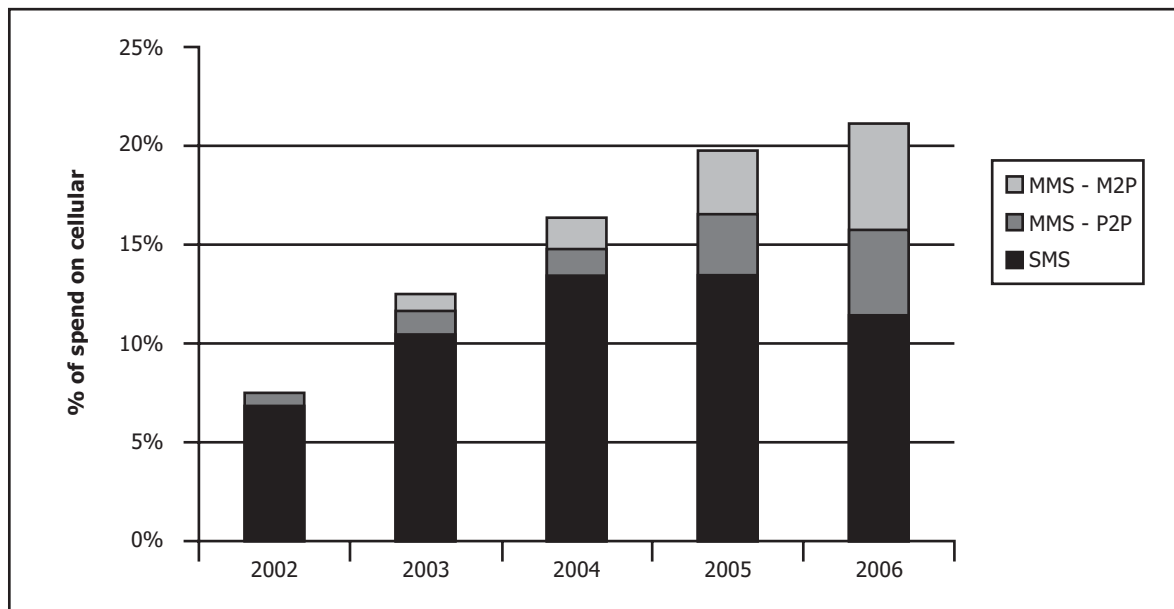


Figure 12. Percentage of User Spending on MMS versus SMS
(Source: Ovum)

Market Projections. Below are global statistics on MMS:

	2002	2003	2004	2005	2006	2007
Telecompetition Inc. (Feb 2001) from UMTS report no.13 (Global revenues in MMS both consumer and business applications)	US\$200m	US\$2b	US\$4.5b	US\$7.3b	US\$14.5b	US\$22.1b

Table 2. Market Projections on MMS

Ovum predicted the above percentage share comparison between SMS and MMS and forecasted that it will be at least 5 years from 2002 before MMS overtakes SMS in revenues.

3.7.2 Location Based Services

Location based services (LBS) can be for both pull (upon user request) and push services (without user request, with permission and/or without permission of user). LBS can be used for personalising information updates, service offerings etc to a group of specific users in a location or to users in a specific location.

Examples of LBS are:

- Navigation & mapping;
- proximity search & mobile version of yellow pages;
- traffic monitoring & alerts;
- instant presence alerts or buddy finder;
- automated taxi booking;
- location or zone sensitive/aware gaming;
- fleet or inventory tracking;
- localised updates & service offerings (e.g. event updates for tourists, or for enquiring on the historical data of a place/building of interest);
- pull or push services in mobile commerce, example from nearby retail stores and restaurants via proximity alerts, sales alerts and mobile discount coupons;
- security services such as in E911 emergencies, for the physically challenged and the elderly, or to allow parents to track the location & safety of their children;
- intelligent customer services from call centres or technical support staff.

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Market Projections. Below are global statistics on LBS:

	2002	2003	2004	2005	2006	2007
Telecompetition Inc. (Feb 2001) from UMTS report no.13	US\$0	US\$0.7b	US\$1.8b	US\$2.7b	US\$3.9b	US\$5.8b
Allied Business Intelligence					US\$40b in revenue	
ARC Group				US\$33b in size		
Cahners In-Stat				US\$13b in revenue		
Ovum			US\$4.7b in size		US\$19.5b in size	
Strategis Group				US\$16b in revenue		

Table 3. Market Projections on Location Based Services

3.7.3 Infotainment

Infotainment can consist of various services involving information retrieval and entertainment such as event updates, news, web surfing, weather, stock quotes, betting results, directory assistance, gaming, inter-language translator, music, videos etc. Many of these services on infotainment are managed from portals either from telco operators or other third party providers.

Wireless Gaming. Amongst the many infotainment services, wireless gaming could be an interesting application for many users especially for the youth sector. Gaming could evolve from individual gaming to networked gaming either via local connectivity like Bluetooth or via expanded networks. In fact, multi-party gaming could be a driver for mobile gaming uptake.

Datamonitor expects the Asia Pacific region including Japan to attain US\$10b in revenues by 2006 for the wireless gaming market amounting to 220m gamers by then, growing from just US\$827m in 2001. By 2006, China is expected to lead the number of gamers with 41% share, while Japan and South Korea will follow with 37.4% and 10% respectively. Wireless gaming are unlikely to generate revenues in their emergence as there is a need for 2 to 3 years of time to generate a critical mass in wireless gaming user communities and content providers. The interaction between users and contents can be a vicious or virtuous cycle, and to encourage familiarity with wireless gaming in its initial deployment stages, operators may offer free or cheap contents.

Market Projections. UMTS also provides statistics on global revenues in customised infotainment via portals as below:

	2002	2003	2004	2005	2006	2007
Telecompetition Inc. (Feb 2001) from UMTS report no.13	US\$0.7b	US\$5.8b	US\$11.2b	US\$17b	US\$31.9b	US\$48.1b

Table 4. Market Projections on Infotainment

3.7.4 Personalised Services

Unique Identity. The mobile handset is an excellent personal carrier because it knows your identity, your location, time of transaction or access, your billing address and they are pervasive. SIM cards can provide personalisation possibilities and the current approach favoured by many is that of web-centric and thin client architecture due to limited resources on handsets. When coupled with biometrics security such as fingerprint, iris or facial recognition, the biometric identity becomes an additional unique feature for the individual that can be exploited for personalised services.

Providing simple but strong digital ID services is an enabler to the adoption of a wider range of personalised services. Identification framework already exists, which is the network authentication infrastructure itself, 3GPP is however preparing a proposal to bring it to the application and services level. To be mentioned too is the "t2r" (Trusted Transaction Roaming) project driven by the Radicchio initiative and backed by Orange, Vodafone, Liberty Alliance and others. This project aims at building an interoperable framework for Identity, Security and Privacy Management in mobile networks, leveraging on the existing security and roaming infrastructure.

Personalisation Technologies. Yet, the ability to map the handset to a specific individual identity is just the tip of the iceberg for the personalisation technology industry. For instance, a typical personalisation engine would offer more functionalities such as a profile manager, a content manager and a presentation manager. These features are compatible to the concept of autonomic computing, context-awareness and basically machine intelligence. The profile manager records your personal data and preferences but also tracks your usage habits. A content manager performs filtering of information and services to match your profile preferences. A presentation manager delivers filtered content to your handset in the format your handset requires and in the style you would like to see. Broadvision, Vignette, Art Technology Group, Autonomy and IBM are some examples of players in personalisation technologies.



There can be two waves of trends in personalisation: open standardisation and proprietary solutions. In open standards, an example would be the industry's effort to define common languages such as XSL (Extensible Stylesheets Language) to enable the transcoding of contents aggregated from content providers in a standardised presentation format to be delivered to handsets. The user can define individual stylesheet preference on his or her handset. In proprietary systems, an example would be in ring tone downloading solutions for most vendors. Nokia for example uses two formats: Ringing Tones Text Transfer Language (RTTTL) and Smart Messaging protocol based on binary format.

Possibilities of Personalisation. A successful personalisation suite or platform can potentially be like a good user interface that can be licensed globally. In fact, it is a trend started by major handset vendors to license both hardware and software personalisation accessories to others. A simple idea of colour changing indicator for different caller groups can be patented. In Singapore, we have also produced creative products such as human electrical massage accessory usable with PDAs that are now licensed to brands like Handspring. This suits our increasing preference in healthy lifestyles.

- **Commerce.** Personalisation provides configurable one-to-one mobile commerce and effective lifetime customer relationship management (CRM).
- **Portals.** WAP or 3G portals are user customisable and subscribers can build their own homepages. These portals can be used for individual, corporate or commercial purposes.
- **Hardware Personalisation.** An example is the Concierge button found on Nokia's luxurious Vertu model. A single press on the button will connect the user to an exclusive team of operators providing services and assistance to world travellers. Other examples include gaming covers with incorporated game control keys and full coloured screens (e.g. proprietary Smart Skin™ capable phones from Wildseed), customised covers with own photographs, or one touch button to access Internet on i-mode phones.
- **Software Personalisation.** This could be as simple as customised alerts for stock quotes or Samsung's SGH-A400 models designed for women whereby there is pre-configured access to websites for women. Another example is building a common platform or OS with different 'applets' for different categories of preferences and services, such as with Java multi-application OS for SIM cards to allow post issuance loading of applications and subscription services.
- **Instant Messaging.** According to Baskerville, mobile instant messaging is worth US\$1.4 billion in revenues in 2002, growing to US\$9.2 billion by 2006. In a typical instant messaging software application, we can create buddy lists and this is a form of personalisation. From

buddy lists, we can further personalise with group messaging or group chat. Often coupled inside instant messaging packages is individual profile definition, although this can obviously also be defined independently of an instant messaging software into a handset such as into the SIM card. Mood agents used in online instant messaging solutions are today in simple graphical icons to indicate current state of emotion or current state of availability (e.g. out of office, away from desk, online etc). Mood agents can evolve to more profound technologies like software agents for habit and usage monitoring that can lead to better automation of services. Personal profiles, mood indicators, habit learning software, location/presence indicators are possible tools for customising information, pull and push services delivered to a handset.

- **Ringtones, Group Icons and Logos.** Personalised downloads are currently amongst the most popular applications by users. Ring tones and operator logos have proven to be popular personalisation features. While ring tones have evolved to polyphonic quality, other innovation include inserting voice labels of caller names into ringing tones so that we know who is calling immediately without looking at the caller ID display especially when our eyes are occupied with other work tasks. Popular music has also been translated into ringing tones to suit certain groups of users.
- **Digitised Music.** Creating personalised music lists into a handset instils a greater sense of individual personality. MP3 player enabled handsets are already in the market and the future is about rather over the air download of MP3 music into handsets. Direct audio streaming is possible with RealNetworks' RealOne software for Nokia 9210I handsets, but ultimately there is still a question of quality of streaming, file size, network bandwidth, copyright issues and billing models. MP3 based on MPEG-1 standard is not the only format for audio codecs although highly popular, other more recent developments in Advanced Audio Coding or AAC (in MPEG-2 standard) are also making inroads for mobile digital music. Some mobile operators have also begun offering online website storage for personal music libraries.
- **Mobile Webcasting.** With video streaming capabilities in future handsets and the development of Multimedia Broadcast/Multicast feature in 3GPP Release 6, mobile webcasting is a form of personalised service to an individual or to a group. Interesting mobile services such as streaming of soccer matches, pop concerts, movie and TV preview clips, news flash, security monitoring (home/office intrusion alerts), business seminars, educational geographic trips, e-learning packages are examples of how our users and businesses can benefit from next generation handsets in the longer term.

3.7.5 Mobile Commerce

Mobile commerce can comprise of mobile shopping, banking, gambling, stock trading, ticket purchasing, cinema booking, item auctioning, retail purchasing and micropayment applications.

Mobile commerce could be rekindled with imaging and video capabilities of handsets. Be it selling books, groceries, CDs or what amazon.com could offer and ebay could auction, the handset could act as an effective micropayment tool, as well as credit card tool with future developments. With pictures, graphics and video, we would make a better salesman in mobile commerce than just plain text.

Perhaps, even peer to peer commerce on handsets could be a reality in future. Peer to peer handset commerce could also generate traffic and usage from subscribers, increasing ARPU. Currently, payment tools like Mondex smart cards can allow peer to peer micropayment. In countries like Singapore, there are also regulatory controls on multi-application stored value cards such as the requirement of a bank to act as a payment clearinghouse. And increasingly, we will see national monetary authorities setting new codes in mobile payments to cater to new areas of growth.

Together with the benefits imaging and video applications bring to mobile subscribers and businesses, we would unfortunately also see worrisome trends in the infiltration of adult entertainment and online gambling to mobile handsets, which may have social and moral consequences. While current text based interface does not seem alluring for online gambling on handsets, future offers of java technology, graphics and audiovisual capabilities may result in the migration of current online PC versions to mobile devices.

Already, ARC Group predicts that adult entertainment to mobile networked devices will become the third most popular mobile picture application after MMS and character download (e.g. animated logos). The infamous adult entertainment in the Internet world has always been topping payment fraud trends to credit card companies like MasterCard and Visa (whether it is real fraud or refusal to admit having accessed a service). While non-repudiation is difficult to achieve in the online PC world because PKI enabled chip smart cards are rarely used, the intimate billing relationship between the operator and the mobile subscriber, and also, the intimate relationship between the operator and third party service providers, would help to curb payment fraud. Otherwise, the handset is always equipped with a chip SIM card for scalability to include non-repudiation with PKI. These trends can either encourage or discourage adult services on mobile devices.

Mobile Internet Browsing. Today, online commerce is done via fixed line Internet services typically on PCs. Mobile Internet is unlikely to offer the same experience as with fixed line

Internet access although mobile networks and devices are developing for the better. Nevertheless, a relatively smaller market compared to other mobile applications could develop around mobile Internet surfing be it for web-based email access or quick access to favourite websites. In fact, according to some statistics by IDC and companies like NEC, email with some web browsing (for melody/picture downloading, news, weather forecast etc) appears to be the main application for mobile Internet usage, for example in countries like Japan with i-mode, J-sky and EZweb services.

Market Projections. Below are global statistics on mobile Internet access

	2002	2003	2004	2005	2006	2007
Telecompetition Inc. (Feb 2001) from UMTS report no.13	US\$0.2b	US\$0.8b	US\$1.5b	US\$2.2b	US\$3.9b	US\$6b

Table 5. Market projections on Mobile Internet

3.7.6 Corporate Teleworking

Mobile for Business Uses. The trend in wireless devices towards richer data features is not only consumer oriented. The increased integration with computing, location technologies, mobile web services, local networking features, WLAN/WWAN roaming are facilitating mobile devices for business use.

Mobile intranet/extranet portals provide the link to out-of-office employees for internal corporate use, or for corporate use in dealing with client services and management. With IPv6 being integrated into wireless platforms, we can have secure wireless VPNs. Microsoft for example has launched Mobile Enterprise IPv6 Servers for corporate solutions to extend office intranets to mobile employees via secure IP VPN services. Unified messaging can also help to consolidate the various voice mails, emails and fax mails. Common services accessed could be product catalogues, corporate directories, service manuals, email, order & delivery status, inventory updating, pricing details and other vertical applications specific to each business.

In addition to the consumer-oriented applications, more high value-added and complex enterprise applications will be introduced. Many if not all of enterprise application suppliers are mobilising the enterprise applications for the mobile workforce, as these mobile-enabled applications become the competitive advantage for their business offerings. Sophisticated mobile enterprise applications could allow telcos to start to recoup infrastructure investments.

Mobile Enabling Technologies, Applications & Services

Mobile Wireless

Market Projections. Below are global statistics on mobile intranets/extranets:

	2002	2003	2004	2005	2006	2007
Telecompetition Inc. (Feb 2001) from UMTS report no.13	US\$0.9b	US\$3.1b	US\$5.9b	US\$8.5b	US\$15.3b	US\$23.6b

Table 6. Market Projections on Mobile Intranet/Extranets

4 Singapore Landscape

Overview. The local telecommunication market was fully liberalised on 1 April 2000 and the cap on foreign ownership of telcos operating in Singapore was also lifted. One of the prominent effects of the liberalisation was the cutting of IDD rates by an average of 60%, and with IDD Call Back and VoIP, by as much as 80%. The Code of Practice for Competition on the Provision of Telecom Services released by the IDA came into force with effect from 29 September 2000.

Singapore's integrated telecommunications infrastructure for both wireline and wireless as well as pro-business policies have provided a conducive environment for R&D activities for wireless technologies. Together with its multi-ethnic and innovation-friendly population, Singapore is poised to serve as the ideal test bed for the development and launch of new wireless applications, products and services.

Singapore's designed submarine cable capacity exceeds 21 Tbps, and it offers direct Internet connectivity to over 30 countries (with direct Internet connectivity of more than 90Mbps each to key regional markets such as Australia, China, Hong Kong, India, Japan, South Korea and Taiwan).

Given its global connectivity and accessibility to the Asian market, more than 6,000 multi-nationals and local wireless players have established their wireless R&D and test-bed activities in Singapore. Despite the global economic downturn and the exit of several players, the telecom industry continues to see an increase in the number of Facilities-Based Operators (FBOs) and Services-Based Operators (SBOs). There are now about 35 FBOs and 620 SBOs licensees. The projected capital investment from FBOs and SBOs for 2002-2004 is estimated at more than S\$3 billion. Today, there are also 8 WLAN service providers covering over 40 hotspots.

Singapore has one of the world's highest mobile phone penetration rates at 75.1% as of August 2002. Since July 2000, mobile phone penetration has exceeded fixed line telephony penetration. In view of burgeoning wireless developments, the Wired With Wireless programme was launched in October 2000 with S\$200 million to catalyse wireless industry development and position Singapore as Asia's launch pad for wireless products and services.

By 2006 in Singapore, Datamonitor expects US\$101m in revenue from mobile wireless gaming, from US\$3 million in 2001. In addition, 34% of this revenue will originate from pay-per-play model (fee charged for each game), while 28% comes from subscription-based model (e.g. monthly flat fee) and 28% from sponsorship model (sponsored by companies for free usage by selected groups of people).

The number of Singapore wireless gamers will increase from 500 000 in 2001 to 3.6 million in 2006, taking into account that people can also have multiple game subscriptions. StarHub estimated that wireless gaming could contribute to about 10% of its revenue. SingTel claimed that more than a third of their 1.4 million subscribers have tried mobile phone gaming from their game portal.

As of August 2002, the local mobile market is of the below status:

Licence	Paired (MHz)	Unpaired (MHz)
A	1920-1935.1 and 2110.3-2125.1	1914.9-1920
B	1935.1-1950.1 and 2125.1-2140.1	1909.9-1914.9
C	1950.1-1964.9 and 2140.1-2154.9	1904.9-1909.9
D	1964.9-1979.7 and 2154.9-2169.7	1899.9-1904.9

Table 7. Local Mobile Subscribers and Penetration Rate

Out of these mobile subscribers, 810800 are pre-paid SIM card subscribers. Mobile services revenues from both voice and data services are expected to rise from US\$725 million in 1999 to US\$1 billion by 2004 according to Gartner Group.

4.1 Singapore's 3G Spectrum Licensing

On 11 April 2001, IDA issued three provisional 3G licences to M1, SingTel Mobile and Starhub Mobile at S\$100m each. The 3G rollout deadline for these local operators is 31 December 2004. After an industry consultation, IDA for the time being will not consider 3G infrastructure sharing.

In the area of spectrum allocation, IDA has also released in May 2002 a publication on "Spectrum Management Handbook" to promote greater regulatory transparency and industry understanding of the nation's radio frequency spectrum management. Another publication on "National Numbering Plan" was released at the same time. Much earlier in November 2001, a Radio Spectrum Master Plan was also released.

In August 2001, three 2G Spectrum Rights have also been provisionally awarded to M1, Singtel Mobile and StarHub Mobile. Each bidder was awarded two 2G spectrum lots at the reserve price of S\$120,000 per lot. Each spectrum lot is a generic 2 x 5MHz GSM 1800 spectrum block.

During the 3G auction process, 2 x 60MHz of paired plus 20MHz of unpaired 3G spectrum was made available. This was divided into four blocks - with one block consisting of 2 x 15MHz of paired spectrum and 5MHz of unpaired spectrum, and three blocks consisting of 2 x 14.8MHz

of paired spectrum and 5MHz of unpaired spectrum. IDA would not issue any new 3G licence before 1 January 2006 from the additional estimated 160MHz spectrum identified by International Telecommunication Union (ITU) for 3G services⁵.

Total Mobile subscribers	3102200
- GSM 900 subscribers	2307900
- GSM 1800 subscribers	794300
- CDMA subscribers	0
Mobile Phone Penetration	75.1%

Table 8. Frequency Band Available for 3G Auction

4.2 Local Telecommunication Cluster

4.2.1 Telecommunication Operators

There are three major mobile service providers operating in Singapore namely SingTel Mobile, MobileOne and Starhub Mobile. Their networks are upgraded to GPRS.

SingTel Mobile (www.home.singtel.com). The SingTel Group was incorporated in March 1992 and became a public company in October 1993. SingTel is the dominant provider of telecommunications services in Singapore with more than 1.5 million mobile subscribers in Singapore as at June 2002, representing half of the market share. In Australia, SingTel is the second largest provider of mobile communications services with 4.23 million subscribers as at June 2002. SingTel is also the second largest provider of long distance services in Australia. As at June 2002, SingTel has close to 25 million mobile subscribers in Asia Pacific, covering Singapore, Australia, India, Indonesia, Philippines and Thailand.

SingTel Mobile, the mobile operator arm of SingTel, has launched MMS applications. Like most MMS applications, messages can be viewed on the Internet via a SMS message notification for those who do not own a MMS enabled handset. And like all other local operators, Singtel Mobile also provides Java based coloured gaming downloads for these new MMS- and Java-enabled handsets.

MobileOne - M1 (www.m1.com.sg). M1 was formed in August 1994 and is owned by a consortium comprising the Keppel Group, Singapore Press Holdings and Great Eastern

⁵ The 160MHz spectrum was identified at the International Telecommunication Union (ITU) WRC-2000 (World Radio Communication 2000 Conference) as additional spectrum for IMT-2000 (International Mobile Telecommunication) services (i.e. 3G services).

Telecommunications (a joint-venture between Cable & Wireless plc and Pacific Century CyberWorks). In May 1995, it won the licence to operate Singapore's second cellular telephone service as well as a radio paging service. Both services were launched on 1 April 1997.

M1 currently serves over 1 million customers, representing a 34% share of the total mobile market. Besides providing local and international voice services, M1 expects MMS to contribute to its data revenue by 1% to 2% by Q2 2003. M1 is the first operator in Singapore to launch MMS locally on 3 August 2002, in partnership with Nokia. It could take about 9 to 12 months after the launch to reach critical mass of 20% to 25% of user handsets that are MMS-enabled. The initial charging rate for MMS services in the first month of launch was free. Subsequently, depending on the message volume sent, the charging rate is between 50 cents to S\$1.20, with only calling party pays. At the time of launch, MMS roaming was still not available.

Starhub Mobile (www.starhub.com.sg). StarHub, launched in April 2000, is another mobile operator. It is a joint venture controlled by Singapore Technologies Telemedia, but including as shareholders NTT Communications, British Telecom, Singapore Press Holdings and Media Corporation of Singapore. Its mobile market share in fiscal year 2001 was 16% with about 460000 subscribers and an ARPU of S\$60. Starhub aims to increase its subscriber base to 600000 for FY2002 and increase its non-voice revenue from 7% in FY2001 to 9% in FY2002.

StarHub provides a full range of information, communications and entertainment services over fixed, mobile and Internet platforms. It operates its own nation-wide broadband network that delivers multi-channel PayTV services, data services, voice services, and Internet access services. StarHub also operates its own GSM and GPRS network. It is the only operator in Singapore offering free incoming calls to mobile subscribers.

4.2.2 Industry Association

Singapore Information Technology Federation (SITF) – Wireless Chapter (www.sitf.org.sg/wic). Supported by IDA, the Wireless Chapter was set up under the auspices of the SITF. It provides a means for different organisations in the wireless value chain to network with each other. By bringing together the different players in the local industry, the Wireless Chapter seeks to promote the advancement of Singapore's mobile wireless communications business and the adoption of wireless-enabled solutions both locally and globally.

Similar to work in the USA by Wireless Location Industry Association (WLIA) on privacy protection which can facilitate LBS, the Data Privacy Working Group under the SITF is currently drafting a localised version of the privacy policy. This is with participation from the local LBS

and related industry including telecom operators, mobile carriers, network infrastructure providers, mobile handset manufacturers, healthcare, medical and emergency response, legal and privacy law enforcement, systems integrators, content providers, aggregators, advertising and marketing, customer relationship management firms and wireless application researchers.

4.2.3 Research Community

This section describes some of the local research organisations under the national Agency of Science, Technology And Research (A*Star) and their related wireless activities.

Data Storage Institute, DSI (www.dsi.nus.edu.sg). DSI was established in April 1996 through the expansion of the Magnetism Technology Centre founded in June 1992 by the A*STAR and NUS. It is amongst the world's top six research centres⁶ in data storage technologies and offers an exciting spectrum of world class next generation data storage technologies. Many mobile multimedia applications and connected mobile computing devices will require storage functionality, be it in the form of magnetic, optical, volatile/non-volatile technologies.

Institute for Communications Research, ICR (www.icr.a-star.edu.sg)⁷. The ICR was strategically formed to excel globally in telecommunications R&D, namely wireless and optical communications. To help create a world-class communications industry in Singapore, ICR is focused on creating intellectual property of value to Singapore's economy; expand Singapore's R&D talent pool; attract foreign investments; build Singapore's indigenous companies into global, technologically-competitive players; and create start-up companies founded on its disruptive technologies. As a national research institute for Singapore's telecommunications industry, ICR focuses on world-class R&D in its various programmes to create cutting-edge technologies that keep the industry in the lead.

The programmes are:

- **Internet Technologies**

Objectives:

- To research and develop new Internet protocols, algorithms and mechanisms for next-generation Internet
- To build core competencies in Internet protocols and algorithms through core and industry projects

⁶ The 160MHz spectrum was identified at the International Telecommunication Union (ITU) WRC-2000 (World Radio Communication 2000 Conference) as additional spectrum for IMT-2000 (International Mobile Telecommunication) services (i.e. 3G services).

⁷ ICR and LIT have merged in November 2002 to become I2R (Institute for Infocomm Research).



- To participate in and contribute to international standardisation efforts
- To focus on Internet Protocol version 6 (IPv6)

Areas of Expertise:

- TCP/IPv6 protocol stack software development
- Mobile ad hoc networks
- IPv6 based network testbed system integration
- IPv6 QoS, mobility and IP security

- **Mobile Device-to-Device Communications**

Objectives:

- To research and develop mobile devices and protocols for short-range wireless communications
- To develop location estimation techniques and systems for indoor applications
- To develop enabling technologies for Intelligent Transportation Systems

Areas of Expertise:

- Short-range wireless communications
- Ad hoc network base positioning
- Ultra-Wideband Radio
- Radio-over-Fibre
- Radio Frequency Identification (RFID)

- **Future Mobile Communication Systems**

Objectives:

- To design and develop hardware and software modules for 3G cellular communication systems
- To study and propose advanced technologies for 3G and 4G systems

Areas of Expertise:

- 3G WCDMA software and platform development
- Smart Antenna systems for base stations and mobile terminals
- Embedded and wideband antennas
- Software configurable radios
- Lineariser for mobile terminals

- **Pico & Broadband Access Networks**

Objectives:

- To research, design and develop prototype components for pico networks in the home, office and public environments
- To research and develop advanced communication technologies suitable for next generation local and broadband access communications

Areas of Expertise:

- High-speed wireless LAN chipset development
- High speed OFDM algorithm design for high data rate WLANs
- Public access wireless LAN
- Bluetooth Protocol stack development
- Digital Subscriber Line system design

Institute of Microelectronics, IME (www.ime.org.sg). The IME was formed in 1991. IME develops new critical technologies that cut across a wide spectrum: circuit design and modelling, semiconductor process technologies, advanced packaging, failure analysis and reliability, and micro-electro-mechanical systems (MEMS).

Radio Frequency Integrated Circuit (RFIC) has been identified as an area of strategic focus by IME. In circuit design, IME is among the first few organisations in the world to have successfully developed RFICs in CMOS technology for wireless communication applications such as Bluetooth, CDMA and WCDMA. Some of their current design challenges include CMOS RF 5GHz WLAN 802.11a and CMOS/BiCMOS 10GHz optical communications IC blocks in Si and SiGe technologies. In the area of mixed signal design, IME has developed A/D and D/A converters for audio as well as broadband applications.

In addition, IME and EDB have jointly established the Infocomm Signal Processing Programme to train engineers in the fundamentals of DSP for audio, video, speech, wired and wireless communications. This is in response to growing demand for skilled manpower to support infocomm activities.

Institute of Materials Research & Engineering, IMRE (www.imre.org.sg). Established in 1996, IMRE undertakes research in selected fields of materials science and engineering. IMRE houses 4 divisions namely Opto- and Electronic Systems Cluster, Molecular and Bio-materials Cluster, Micro- and Nano- Systems Cluster, Materials Science and Characterisation Cluster. IMRE develops novel organic light-emitting display (OLED) materials and processes, polymeric materials for enhanced device reliability and manufacturability as well as new application areas for OLED technology.

Laboratories for Information Technology, LIT (www.lit.a-star.edu.sg). LIT undertakes research in information science and technology, in particular, on enabling technologies and processes that would drive new and enhanced services in a knowledge-based economy.

LIT focuses its research efforts in the areas of Ubiquitous Computing, Distributed Systems, Media Engineering, Signal Processing, Knowledge & Discovery and New Initiatives. A list of projects undertaken by LIT includes:

• Advanced Cryptographic Algorithms project • Advanced Encryption project • Advanced PKI and applications • Agent based secure p2p • Crypto Algorithms and Protocols • Bio-Computing (BiC) Group • Bio-Discovery (BiD) Group • Computational Conceptual Semantics • Content Based Audio Analysis and Retrieval project • Data mining and Analysis of medical data • Digital Image and Video Album project • E-Service Infrastructure Group • E-Service Planning and Deployment • Generalised Multiple Protocol Label Switching (GMPLS) project • Graphical Models project • Homogeneous Agent-Based Research Platform (HARP) project • Intelligent Cyber Agents (ICA) Group • Intelligent Multilingual Information Extractor project • Interactive Cyber Avatar project • Knowledge Discovery, Management, and Application (Knowledge DMA) project • MPEG7 metadata testbed project • MPEG7 tool development project	• Mobility Management project • Media-Convergence-Content Testbed project • Media Mining Group • Media Security Project • Natural Language Understanding (NLU) Group • Non-Repudiation Services for Messaging System project • ONDMS • Optical Networking Services Group • Perceptual Human Media Group • Personal Media project • Pervasive devices project • Pervasive Systems Group • Quality of Service/Policy Based Network project • Robot-human interaction project • Robust Face Recognition project • SARS (Secure and Reliable Streaming) • Secure Multimedia project • Secure Peer-to-Peer Framework project • Secure Video Conferencing System project • SENSE project • Service Creation Group • Service Gateway project • Universal Media Access Group • VINIO
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Table 9. List of Software/Middleware Research in LIT

4.2.4 Government Partner Agencies

Agency for Science, Technology and Research, A*STAR (www.a-star.edu.sg).

A*STAR overlooks the 13 research institutes and centres in Singapore of which some are described earlier.

In August 2002, five local government agencies⁸ launched a new initiative called "Technology for Enterprise Capability Upgrading, or TEC-UP", bringing the research community closer to the industry. TEC-UP is a government co-funded programme suitable for companies with at least a 30% Singaporean ownership whereby A*STAR Research Scientists and Engineers (RSEs) are encouraged to help local companies for a period of up to two years by being loaned or seconded to assist the companies upgrade their technical capabilities.

⁸ The agencies are A*STAR, EDB, IDA, International Enterprise Singapore (IE Singapore), as well as Standards, Productivity and Innovation Board (SPRING) Singapore.

During the full-time secondment of two years, these RSEs will carry out R&D and run innovative projects for the host company and have full access to their parent Research Institute's facilities to carry out their mission. Host companies have the option to permanently retain the RSEs when the secondment period ends.

Singapore Economic Development Board, EDB (www.sedb.com). The EDB is the lead agency that plans and executes strategies to sustain Singapore as a compelling global hub for business and investment. There are also various funding schemes available from EDB such as Innovation Development Scheme (IDS), Local Industry Upgrading Programme (LIUP) and Startup Enterprise Development Scheme (SEEDS). For the Infocomms & Media (ICM) industry, some of the highlights anchored by EDB are:

- Microsoft's S\$5 million XML Web Services Centre in 2001. Apart from showcasing XML solutions and providing software developers with the resources to design, prototype and test commercial XML web services, the centre will also be training 1,000 software developers.
- Ericsson Cyberlab announced that it would double its R&D budget to S\$20 million as well as create a GPRS and 3G development and testing environment for mobile applications. Ericsson first embarked on setting up a GPRS environment in March 2001.
- On the network equipment front, Siemens announced its plans to establish an R&D centre focusing on next-generation Internet Protocol-based mobile core networks. This is a first by Siemens in the region.

Singapore Land Authority, SLA (www.sla.gov.sg). The SLA launched in May 2002 a Call for Business Collaboration (CFC(B)) supported by IDA on LBS Map Content Providers to supply digital map-based data for LBS. This has so far resulted in awards to three consortia which are Starvision Information Technology, Wheresoft Geocommerce and V3 Teletech.

Siemens has also set up the Siemens Location Enabling Centre (SLEC) in Singapore, supported by SLA and IDA, to train professionals from the region in LBS. Siemens offers a comprehensive standardised LBS test bed facility for Singapore wireless application developers. It includes development support towards a powerful LIF-compliant API, which will be used globally by leading operators to deploy location services.

Standards, Productivity and Innovation Board, SPRING (www.spring.gov.sg). SPRING Singapore has three areas of focus: productivity and innovation; standards and quality; small and medium-sized enterprises (SMEs, see also www.smefirststop.org.sg) and domestic sector.

The Telecommunications Laboratory was first set up in 1999 and provides one-stop telecommunications and electromagnetic compatibility testing cum product qualification facilities. For instance, it incorporates a Bluetooth technology laboratory and is the first in the region to do so. Many MNCs and SMEs have benefited from these facilities for local product development and exports. Mobile users can also look forward to the Product Listing Scheme-Specific Absorption Rates (PLS-SAR) label service from SPRING, which will also conduct continual check on an annual basis of SAR values of certified mobile phones. In accordance to international standards, SAR values below 2.0 watts per kilogram over 10g of tissue are allowed in Singapore.

Supported by SPRING and IDA, the Information Technology Standards Committee (ITSC) is an industry-driven IT standardisation group in Singapore. Coming under the auspices of the Singapore Standards Council, ITSC is the national representative to ISO/IEC Joint Technical Committee 1, and other international standardisation forums such as UN/CEFACT and EAN International. ITSC promotes and develops standards in several areas including automatic data capture, cards and personal identification, construction industry IT standards, eFinancial services, information exchange, e-learning standards, multimedia representation, security and privacy standards.

A Memorandum of Understanding (MOU) on the Electronic Bill Presentment and Payment (EBPP) initiative was concluded between SPRING, IDA and the EBPP Working Group. Under the MOU, the stakeholders will work together to develop a national framework, code of business practice and technical messaging standards for EBPP in Singapore. EBPP enables companies to save time and costs in processing bills and free up resources which can be redirected to improve customer service. With EBPP, billing costs can be cut by 50 to 90%, according to a report by Giga Information Group in January 2001. Besides direct control over both the timing and the amount of payment, consumers could also query directly the bills presented. This saves time and effort for both the billing organisations and consumers.

4.3 IDA-Industry Initiatives

4.3.1 Wired With Wireless Programme

Infocomm Development Authority of Singapore, IDA (www.ida.gov.sg). IDA is a dynamic organisation with an integrated perspective to developing, promoting and regulating info-communications in Singapore.

The Wired With Wireless programme serves to jumpstart the development of wireless industry in Singapore and position Singapore as a living lab and business catalyst for wireless

developments in Asia. It is a multi-pronged programme that will enable Singapore to have the best integrated wireline and wireless infrastructure for the seamless delivery of rich multimedia content, with focus on areas such as wireless multimedia and messaging, mobile commerce, location-based services, machine-to-machine communications and wireless enterprise. Below depicts the programme's strategy:

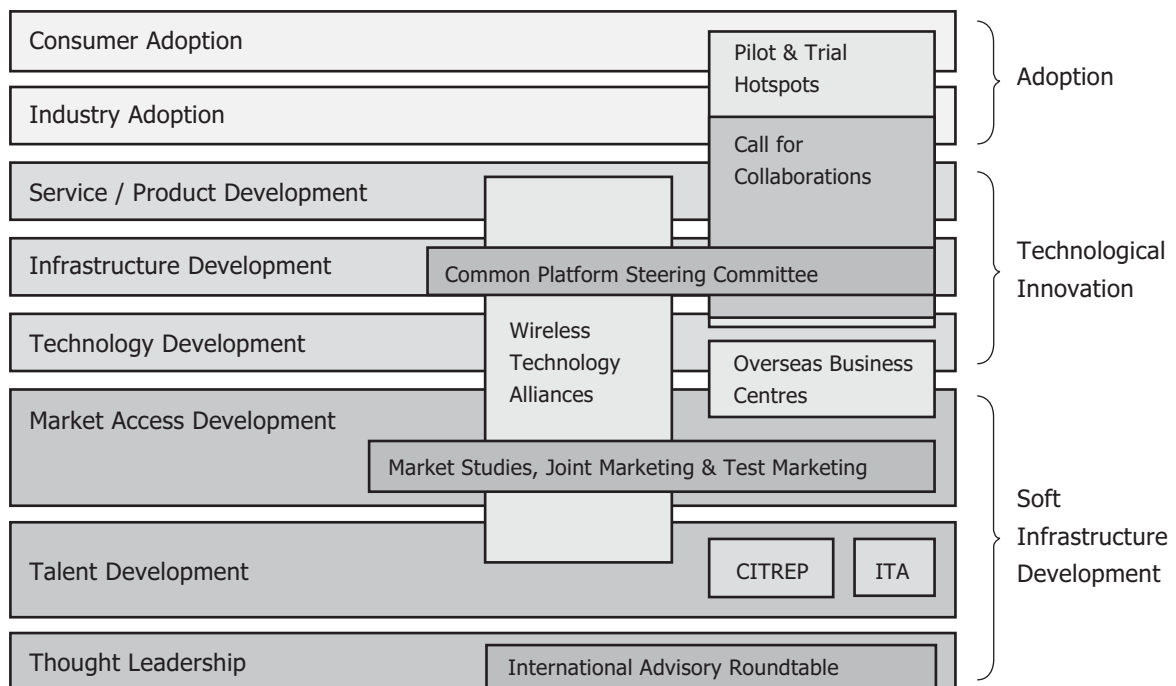


Figure 13. IDA's Initiatives in Wireless Development

Pilot & Trial Hotspots (PATH). PATH, introduced in May 2001, is an industry development initiative under Wired With Wireless programme that accelerates the development of innovative infocomm infrastructure, applications and products. It facilitates this by supporting the trial and piloting of emerging infocomm technologies and best-of-breed services. The entire budget for all trials in promising emerging technologies under PATH is now S\$78 million, up from a total of S\$48 million announced in November 2001.

The programmes are aided by appointed PATH Assessment Centres such as Application Service Provider Centre (ASPC), Ericsson Cyberlab, Java Smart Services Lab, M1 and NYP-Cisco IP Convergence Lab, to date. Each of the PATH Assessment centres will contribute consulting personnel as well as incubation, piloting and test-bedding facilities to qualifying projects. They will autonomously source, screen, evaluate and recommend to IDA potential PATH projects

based on IDA's guidelines. These guidelines cover the PATH initiative's objectives, focus areas and strategic thrusts.

Starting off the wireless development by encouraging proof-of-concept and value of wireless applications and technologies, the next step for PATH will be to facilitate the integration of applications, platforms and devices to provide a seamless connectivity for everyone on the go, anywhere, any time, and on any device.

Overseas Business Centres (OBC). Also initiated in May 2001, complementing PATH is the Overseas Business Centres (OBC) initiative. It seeks to address the technology development and market access needs of the Singapore wireless industry by providing a platform for collaboration between Singapore-based companies and foreign technology players.

Under OBC, Singapore-based companies and their foreign technology partners can benefit through joint development in, two ways:

- a) Singaporean companies can establish a market presence through increased direct access links with the corporate headquarters of wireless global players. It allows them to rapidly export their products and services to, and beyond the region by access to marketing channels, technology and roll out resources;
- b) Foreign OBC partners stand to gain from the proliferation and adoption of their technology beyond its country of development.

Under the OBC initiative, Hewlett-Packard and IDA signed a Memorandum of Intent in May 2001 on a joint Partnership Program, aimed at promoting the development of wireless applications between Singapore and Japan.

Wireless International Advisory Roundtable. Two wireless International Advisory Roundtable have been convened to provide thought leadership on the future of wireless communications and to guide the strategic directions for the development of wireless industry in Singapore. Conceived under IDA's Wired With Wireless, both roundtables were attended by corporate chiefs of global wireless companies and leading visionaries of the communications revolution.

Common Platform Steering Committee. Following a recommendation from the International Advisory Roundtable, the Common Platform Steering Committee was formed in October 2001. The committee includes members from IDA, all three local mobile operators, a local wireless research centre, as well as industry members and associations; it provides a platform for the resolution of issues that require consensus, such as interoperability and common codes of practice. Two working groups – the Wireless Java Common Platform Working

Group and the Location-Based Services Working Group – were also formed to determine how to fully exploit and accelerate the growth of wireless Java and location based services in Singapore.

Wireless Technology Alliance (WTA) and Market Development (MADE). On 20 June 2001, two initiatives were announced, namely the WTA and MADE. These new initiatives complement earlier initiatives on PATH and also Overseas Business Centres which focused on creating a dynamic test bed for innovation. These two new initiatives will provide the wireless industry players with the additional impetus to develop, test and launch their products in Singapore.

Creativity and Innovation are the tenets of WTA. The WTA aims to encourage industry alliances that will stimulate the development of innovative wireless products and services. The WTA will serve as a platform for the sharing of technology, co-development and co-deployment of new wireless products and services in Singapore. Targeted at wireless application developers, wireless technology leaders, Institutes of Higher Learning and Research Institutes, it will facilitate the consolidation of “best of breed” technologies, and enable application developers faster access to the latest cutting-edge technology. An initial sum of S\$13.5million has been allocated for this initiative over the next 3 years. The first partnership under the WTA was established in June 2001 with the signing of the Memorandum of Intent for the establishment of the JWCC between Sun Microsystems, the ICR and IDA (see Java Tarik Programme later in this report).

The Market Development (MADE) initiative aims to facilitate market development through enabling test marketing, joint market research and promotion activities. MADE aims to assist companies in the above activities so that they will be able to acquire the necessary market knowledge and shorten their learning cycles. This will allow them to move faster into potential markets. IDA will also work with companies to showcase successful products and services through joint marketing activities.

Call For Collaboration (CFC). The Wired With Wireless programme acknowledges the need for concerted efforts across the entire value chain to implement open, innovative and scalable wireless projects.

- **Mobile Payment CFC.** Call in your coffee order or make tour reservations on your mobile phone and instead of fumbling with your wallet to pay, use your mobile phone to do it. In the not too distant future, this will be the scenario as Singapore announced the start of rollout for true end-to-end mobile payment solutions implemented through the mobile payment CFC launched in May 2001. An investment totalling S\$20 million is committed to funding these trials with between S\$7million to S\$12million contributed by IDA and the remainder, coming from the industry. Four consortia have been selected to trial mobile payment solutions:

- a) Consortium comprising NCS, NETS, SingTel Mobile, Starhub Mobile, MobileOne, VISA, Eng Wah, Diethelm, National Library Board, NUS and DBS;
- b) Consortium comprising Nokia, NETS and DBS;
- c) Consortium comprising ST Electronics, Citibank, BCS Information Systems, wizVision, mVent, Green Dot Capital, Starhub Mobile, CET Technologies, mPayment, MasterCard International, Cathay, Premas International, CalendarOne, National Service Resort & Country Club;
- d) Consortium comprising Systems@Work, HP MEB, Gemplus, Suntec City and VISA.

The mobile payment solutions will further strengthen Singapore's position as an ideal test bed and launch pad for wireless applications, products and services. The solutions will come in three basic forms: direct debit payment solutions, stored value solutions and credit card solutions. The implementation of an open, secure, and scalable mobile-payment solution requires a concerted effort of several parties. These include multiple mobile operators, multiple banks, hardware and software vendors. Consortia members will be running the trials with various retail vendors including well-known brands such as Tricon, Cathay Cinema and Eng Wah Cinemas as well as merchants at Suntec City. The mobile payment solutions are also made possible via the collaboration of the island's three key mobile operators.

- **Mobile Workforce & Wireless Java CFCs.** In May 2002, A total of 26 successful consortia have been awarded to conduct trials of proposed solutions for a mobile workforce, or in wireless Java. The successful consortia were selected from participants in the two most recent Calls for Collaborations that are part of the IDA's Wired With Wireless initiative. They were for the development of Mobile Workforce solutions and applications using J2ME-based wireless Java Technology.

Twenty awards were made to successful consortia for trials of solutions enabling a Mobile Workforce. These solutions take advantage of the mobility offered by wireless technologies for personal information management, sales force automation, field force automation, supply chain management, resource planning and remote monitoring. Through the adoption of such solutions, enterprises can gain competitive advantages in the form of faster decision making, productivity gains, cost savings, responsiveness to customer demand and visibility over the processes and operations. The total value of Mobile Workforce projects is S\$16 million, of which the IDA will support up to S\$6.5 million.

Six awards were made for trials in Wireless Java. The Wireless Java CFC seeks to encourage the development of innovative and commercially viable Java applications and services. Total value of Wireless Java is S\$1.8 million, of which the IDA will contribute up to S\$700000.

- **Pervasive Wireless Access CFC.** Under IDA's Call for Collaboration (CFC) for Pervasive Wireless Access, invitations are open to global wireless technology players who can do these in Singapore:

- Test bed and demonstrate the pervasive wireless access of content and applications through the use of GPRS, 802.11 WLAN and Bluetooth;
- Showcase the possible integration of wireless access technologies to support the way professionals at work and at play.

The convenience and productivity gain resulting from pervasive wireless access is significant. For example, we are potentially able to access, retrieve and exchange information whenever and wherever we are - at our workplace, public buildings, outdoor environment, community areas, and homes - without wires.

- **Wireless Tourism CFC.** The CFC for Wireless Applications in Tourism was announced on 22 February 2002 to encourage the piloting of innovative Wireless applications for Singapore's tourism sector in collaboration with the Singapore Tourism Board (STB). The areas for collaboration are classified under informational, transactional, experiential and targeted areas. Selected projects will qualify for funding by STB from existing grant funds such as the Tourism Development Assistance Scheme (TDAS).

4.3.2 Mobile Computing Centre for Palm OS.

In April 2001, Temasek Polytechnic, Palm and IDA signed a memorandum of intent (MOI) for the establishment in Singapore of Mobile Computing Centre, a Palm authorised training centre located at Temasek Engineering School. It is the first of its kind in Asia Pacific. The Mobile Computing Centre will provide Palm OS platform training for developers located in Singapore and Asia Pacific, equipping them with skills to address an increasing worldwide demand for handheld computing solutions.

4.3.3 eGarage for Mobile and Wireless Computing

Ngee Ann Polytechnic (NP)'s School of Information and Communications Technology (ICT) and Hewlett-Packard Singapore signed a US\$1.6 million Memorandum of Understanding (MOU) to set up an eGarage (formally XML Garage) Programme and Showroom at NP. This is to promote innovation and technopreneurship in XML-based e-services and mobile computing-related technologies. This is complemented by a new Diploma IT (Mobile Computing) available since July 2002 at NP.

4.3.4 Java Tarik Programme

The Java Tarik programme driven by IDA and Sun Microsystems has seen the growth, via the establishment of competency centres, of Java enabled applications and services since it was first conceived in 1997. So far, IDA, Sun Microsystems, together with the various Research Institutes and Centres as well as Institutes of Higher Learning and other partners, have invested a total of S\$25 million in the competency centres.

The Java Tarik programme's main objective is to grow the expertise of local enterprises to become world-class developers and exporters of IT products and services for Singapore. This is done through building of new competencies within the developer community, developing key partnerships between companies and gaining access to new markets in the region. Several significant outcomes include industry technology transfer, venture capital investment, manpower development and innovative proof-of-concept pilots. To date, over 100 companies have participated in the various Java Tarik initiatives with more than 50 new applications developed.

The programme has established the following competency centres:

- Java Tarik I - Java Competency Centre;
- Java Tarik II - ASP Centre;
- Java Tarik III - Java Wireless Competency Centre (JWCC);
- Java Tarik IV - Java Smart Services Lab (JSSL).

The most recent being JWCC and JSSL launched in August 2002, whereby IDA and Sun Microsystems celebrated Java Tarik Day. Hosted by the Institute for Communications Research (ICR), JWCC aims to help position Singapore as a premier hub for wireless services and applications in the Asia Pacific region. JWCC will provide local developers with facilities to jumpstart their development efforts through consultancy services, a validated Wireless Framework components and training programmes, as well as assistance from strategic technology partners and telecom service providers.

JWCC is now offering the following services to developers:

- Wireless Java Developer Forum - a web-based support platform for developers;
- Over-The-Air (OTA) Provisioning service - a service that enables developer partners to upload and the public to download Java wireless applications.

JWCC also initiated Singapore's first J2ME Student Entrepreneur Developer Programme (October 2002 – January 2003), with support from IDA and Sun Microsystems, targeting at

students of the Institutes of Higher Learning. Successful J2ME wireless applications can be hosted free of charge at JWCC for public trial and for any telcos to screen through the applications for commercial arrangements between the students and/or the respective school.

JSSL aims to position Singapore as a regional hub for development of web services by driving the adoption and provision of web services in the local industry through research, pilots and trials, incubation and manpower development. JSSL has also been appointed as the fifth PATH Assessment Centre to help shortlist and recommend to IDA potential Java-based web services projects for pilots and trials. In turn, JSSL will also contribute consulting personnel, as well as incubation, piloting and test-bedding facilities to qualifying projects.

JSSL's objectives include:

- The development of necessary skills and capabilities particularly within the manufacturing sector;
- The development of an adaptable industry-wide open-standards reference architecture that allows companies to increase productivity and efficiency during web services deployment. Without such a reference, companies would not be able to concentrate on their core competencies in the development of such services;
- The development of innovative pilots through partnerships with MNCs and local developers so as to provide referential results to the rest of the industry.

4.3.5 .NET MySingapore

In April 2002, the IDA has signed a memorandum of intent (MOI) with Microsoft to jointly launch a nation-wide web services initiative called .NET MySingapore. The initiative will include the world's first pilots of community-based web services.

After the pilots, other further initiatives include the following:

- Creation of additional community web services that enable Singapore citizens to easily access and utilise community services and organisations. On 15 October 2002, a community net www.bigtrumpet.com was officially launched, initiated by NTUC Income;
- Working with an academic partner to develop new training curriculum and the world's first programme for certifying web services professionals, and establishing a Microsoft .NET Professional Certification;
- Establishment of a Microsoft-IDA overseas development programme designed give Singaporean developers better access to new web services technologies developed by

Microsoft in the United States. This will involve the creation of a position at Microsoft's research facilities in Redmond, Washington, co-funded by Microsoft and IDA;

- Establishment of an emerging technologies lab with EDB and IDA to jointly explore new technologies in co-operation with both academia and industry. This is another vehicle used to bring the .NET environment closer to Singapore. The lab would work with researchers to investigate new programming approaches and then test them in Microsoft's real-world software development environment.

5 Conclusion

We have summarised the key trends today in 2002 and tomorrow in 2007 in the executive summary, as well as in the roadmap chart produced alongside this report. In this section, we look at the general vision and direction ahead for mobile wireless development.

A word on Security: anticipating the growing need. When the mobile environment garners richer multimedia capabilities, increasing online and peer to peer connectivity, over the air provisioning and dynamic application loading, ad hoc networking capabilities, we would expect security protection to be increasingly important. Anti-virus protection, authentication, integrity, confidentiality, non-repudiation of transactions, and protection against hackers are needed. At present, little focus is placed on security implementations in 3G, but rather focusing on the take-up rates of mobile data applications and the future of emerging services like LBS and MMS etc. However, moving forward, we see the need to increasingly focus on security implementations, which has become part of a desired vision for 4G by some. Furthermore, there is an emerging new trend towards autonomic computing by machines which includes too a component consisting of self-protection and repair against security attacks.

In our vision described in the Foreword of this entire report, we note the long-term trend of moving towards *an integrated broadband infrastructure*, and *the mobility of applications and services*. The development of mobile wireless networks, mobile enabling infrastructures and services is already hinting at the future convergence of heterogeneous spheres of our daily schedule and routines. Be it at work, at home, on the move locally or overseas, the increasing capabilities of mobile wireless networks and devices will extend our reach to familiar online PC consumer and business applications to wherever we are, whenever we want and with an increasingly consistent user interface. This is part of ubiquitous connectivity.

Emerging 3G mobile networks could offer average data rates of up to 384kbps, while in the longer term, 4G networks could reach peak rates of 100Mbps targeting average data rates of 20Mbps at least. In fact, certain 3G standards such as HSDPA (high speed downlink packet access) for WCDMA in 3GPP Release 5 today is exploring downlink rates of up to 10Mbps, with up to 20Mbps downlink for Release 6 (but commercial deployments are expected around 2005). This development coupled with the decreasing computational power differences between handheld devices and desktops would ease the mobility of applications from the wireline to the wireless domain.

Communication in the near future will evolve from simple voice calls to rich multi-party multimedia communications, instant messaging and presence services, location based services, as well as one-to-many multimedia broadcast and mobile webcasting. This will enhance

individual communication features but also open up enterprise opportunities such as in the areas of mobile e-learning, mobile seminars, corporate teleworking and marketing.

Pivoting on more sophisticated demand that needs to be present, pervasive or anywhere computing will advance communication to higher realms. Computing applications will migrate from simplistic mobile games, rudimentary calculator functions to mobile web services, multi-party role play gaming, Java-enabled applications, packet-based multimedia applications, mobile VPN solutions, bundled voice/data and data/data applications. In addition, the development of IP Multimedia Subsystem specifications will work towards the vision of interoperable roaming of these services across both CDMA and GSM networks across the world, enabled also by other open interfaces and standards. Eventually, we would move from the mainly individual centric space to a more group centric collaborative space whereby technologies such as ad hoc networking and security technologies for trusted collaborations would become important enablers. Security will also need to interoperate over heterogeneous environments from LAN to public, from wireline to wireless to provide the user with uninterrupted connection to the various forms of services.

The way ahead for mobile wireless also sees the need for the integration and convergence with content and services from various clusters such the arts and media, entertainment, finance, IT & communication, broadcasting, healthcare, education and the government sector.

From where we stand today and this future that we see, much work remains to be done in mobile wireless development to reap new opportunities and benefits for our infocomm community. There is also ample space for further collaborations to make things happen for mobile users.

2G	Second Generation
2G+	Enhanced Second Generation
3G	Third Generation
4G	Fourth Generation
AES	Advanced Encryption System
AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
ARPU	Average Revenue Per User
ATM	Asynchronous Transfer Mode
AUC	Authentication Centre
BREW	Binary Runtime Environment for Wireless
CAMEL	Customised Application of Mobile Enhanced Logic
CDC	Connected Device Configuration
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CEPS	Common Electronic Purse Specification
CFC	Call For Collaboration
cHTML	compact HTML
CLDC	Connected Limited Device Configuration
CoA	Care-of-Address
CS1-4	Coding Scheme 1 to 4
CXML	Commercial XML
DHCP	Dynamic Host Configuration Protocol
DO/DV	As in CDMA 1xEV-DO/DV – Data Only/Data & Voice
DVB	Digital Video Broadcasting
ebXML	e-business XML
ECC	Elliptic Curve Cryptography
eCOS	embedded Configurable Operating System
EDGE	Enhanced Data Rates for Global Evolution
EMS	Enhanced Messaging Service
EMV	Europay MasterCard Visa (specifications)
ETSI	European Telecommunications Standards Institute
EV	As in CDMA 1xEV - Evolution
FA	Foreign Agent
FBO	Facilities Based Operator
FCC	Federal Communications Commission
FDD	Frequency Division Duplexing
FDMA	Frequency Division Multiple Access
FSK	Frequency Shift Keying
GAIT	GSM ANSI Interoperability Team

GGSN	Gateway GPRS Support Node
GPRS	General Packet Radio Service
GPS	Global Positioning System
GRX	GPRS Roaming Exchange
GSM	Global System for Mobile communications
GSMA	GSM Association
HLR	Home Location Register
HSCSD	High Speed Circuit Switched Data
HTML	Hypertext Markup Language
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMPS	Instant Messaging and Presence Services
IMT-2000	International Mobile Telecommunications-2000
IP	Internet Protocol
IPv6	Internet Protocol version 6
ISDN	Integrated Services Digital Network
ITR	Infocomm Technology Roadmap
ITU	International Telecommunication Union
J2ME	Java 2 Micro Edition
JAIN	Java for Integrated Networks
JTAC	Japanese Total Access Communications
LAN	Local Area Network
LBS	Location Based Service(s)
LED	Light Emitting Diode
LIF	Location Interoperability Forum
MAC	Media Access Control
MEMS	Micro-Electro-Mechanical System
MIDP	Mobile Information Device Profile
MLP	Mobile Location Protocol
MMAC	Multimedia Mobile Access Communication
MMS	Multimedia Messaging Service
MN	Mobile Node
MNO	Mobile Network Operator
MPEG	Moving Picture Experts Group
MVNO	Mobile Virtual Network Operator
NMT	Nordic Mobile Telephone
OFDM	Orthogonal Frequency Division Multiplexing
OHG	Operator Harmonisation Group
OMA	Open Mobile Alliance
OSA	Open Service Access

PAM	Presence and Availability Management
PATH	Pilot & Trial Hotspots
PDA	Personal Digital Assistant
PDC	Personal Digital Cellular
PHY	Physical Layer
PIM	Personal Information Management
PKI	Public Key Infrastructure
PMR	Private Mobile Radio
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service
RF	Radio Frequency
SBO	Service Based Operator
SIM	Subscriber Identity Module
SIP	Session Initiation Protocol
SMS	Short Message Service
SOHO	Small Office Home Office
SyncML	Synchronisation Markup Language
TACS	Total Access Communications System
TAP	Transfer Account Procedure
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division – Synchronous Code Division Multiple Access
TIPHON	Telecommunications and Internet Protocol Harmonisation over Networks
TLS	Transport Layer Security
UHF	Ultra High Frequency
UMTS	Universal Mobile Telephone System
USB	Universal Serial Bus
USIM	UMTS SIM Card
UTRA	UMTS Terrestrial Radio Access
VHE	Virtual Home Environment
VOD	Video-on-demand
VoIP	Voice over Internet Protocol
VPN	Virtual Private Network
VXML	Voice eXtensible Markup Language
W3C	World Wide Web Consortium
WAP	Wireless Application Protocol
WARC	World Administrative Radio Conference
WCDMA	Wideband CDMA
WDA	Wireless Digital Assistant (Wireless PDA)
WG	Work Group

WLAN	Wireless LAN (Local Area Network)
WML	Wireless Markup Language
WP8F	Working Party 8F
WWW	World Wide Web
xHTML	extensible HTML
XML	Extensible Markup Language
XSL	Extensible Stylesheet Language

IDA Technology Roadmap November 2002

Mobile Wireless

With active contribution from the industry and research community, IDA has launched the *Infocomm Technology Roadmap Release November 2002*. You have either attended the Roadmap Symposium or downloaded a copy of the Technology Roadmap document from our website. Your feedback is valuable to us to better our future services for you. We appreciate if you could spare a few minutes to fill up the following survey.

Please return the completed questionnaire to IDA:

via Fax: **+(65) 6211 2211 (Attention to Ms Saliza Mohd)**

or via Mail to the address on the previous page.

Company Name : _____

Your Name : _____

Designation/
Area of Expertise : _____

Email Address : _____

Contact Number : _____

Q1. With regards to the Roadmap Report Release November 2002 on "Mobile Wireless", please rate the following on a scale of 1 to 6.

Factors	Excellent				Poor	
Usefulness of the roadmap	6	5	4	3	2	1
Completeness of coverage and contents	6	5	4	3	2	1
Ease of understanding	6	5	4	3	2	1
Usefulness of the Roadmap Chart 2002-2007	6	5	4	3	2	1
Relevance to you or to your business strategy/planning	6	5	4	3	2	1

Comments (if any):

Q2. Please indicate the accuracy (in terms of trend & development) of each chapter in the Technology Roadmap Report. Please rate them on a scale of 1 to 6.

Chapter	Accurate			Inaccurate		
Mobile Networks	6	5	4	3	2	1
Mobile Enabling Technologies, Applications & Services	6	5	4	3	2	1
Singapore Landscape	6	5	4	3	2	1
Roadmap Chart 2002-2007	6	5	4	3	2	1

Comments (if any):

Q3. Do you have any suggestions for improvement on the Technology Roadmap?

Q4. If you are an industry or related player in Mobile Wireless, what are the strategic business areas and recommendations for future development that you deem appropriate for and unique to Singapore's competitiveness?

Q5. Would you like to be informed of our future Infocomm Technology Roadmap Seminars/ Reports? Yes / No

.... Thank You

MOBILE WIRELESS ROADMAP 2002 TO 2007

		2002	2003	2004	2005	2006	2007
Network Trends		2.5G CDMA2000 1xRTT deployed (40-60kbps typical) - CDMA2000 1xEV-DV proposed for 3G standard, supersedes CDMA2000 3xRTT (unlikely to see daylight in near term) - CDMA UIM cards in pilot allow roaming to GSM/WCDMA - Seen initial 3G WCDMA deployed (100-200kbps typical) - HSDPA standardised for WCDMA (offers up to 8-10Mbps), to compete with CDMA20001xEV-DV - Work on 4G in progress - Singapore: GSM/GPRS (20-40kbps) networks in force; GPRS/WLAN hotspot dual mode access available; 3G provisional licenses awarded to 3 local telcos on 11 April 2001	- CDMA2000 1xEV-DO commercialised (300-600kbps typical) - CDMA carriers begin commercial use of UIM cards - EDGE Classic and Compact networks emerge (<384kbps) - Network independent roaming (GPRS, GSM, 802.11b) more stable, service platforms converge for consumers & enterprise portals. WLAN sees more aggressive deployments mostly by wireless carriers, some by wireline & independent WISP - Few WCDMA carriers may deploy CDMA2000 1xEV-DO - Singapore: see WLAN roaming agreements amongst local operators, also MMS/MMS and SMS/MMS interoperability	3G CDMA2000 1xEV-DV deployed (<2 to 4.8Mbps, 120-300kbps ave), few WCDMA carriers may deploy CDMA 1xEV-DV - TDSCMA picks up in China - WLAN/WWAN operators share common standardised authentication & billing - GPRS roaming: GRX based & GRX peering solutions dominant - Singapore: 3G deployment by 31 Dec 2004, no 3G infrastructure sharing	- Global market predominantly on 2.5G and some 3G in selected countries - May see initial deployment of HSDPA for WCDMA - Seamlessly combined WLAN/GSM/GPRS/UMTS networks, traffic steering between radio networks	- More 3G networks deployed - All CDMA networks (including IS95) use a UIM card - Singapore: no new 3G license to be awarded before 1 Jan 2006	3G networks become commonplace - Multiple candidate technologies for 4G: IP based, Software Defined Radio, UWB, space-time coding, OFDM, smart antennae, etc - Early intent by some to deploy 4G networks though most 4G deployments expected around 2010 (speed of up to 100Mbps) - Towards end to end IP
Trends in Enabling Technologies. Applications & Services		- Mobile processors 200-400MHz emerge - WWAN/WLAN laptop access cards available - R&D in micro fuel cell batteries with ten times longer duration 802.11 based (at board level) laptops emerge; proprietary experimentation & solutions in GPRS/WLAN roaming - Commercial Organic LEDs for coloured displays emerge - Storage cards at 512Mbytes & USIM cards at 64Mbytes (lab) - User interface: gaming covers commercialised, innovative imaging and sensing technologies for keyboard entry - BGA, CSP, stacked technologies converge in chip packaging - Symbian OS and Palm OS challenged by Linux eCOS, Microsoft's WinCE/Smartphone 2002/PocketPC 2002 - UIM based credit cards piloted over 3G in Japan and Korea - Singapore: saw MMS services; remote IP monitoring services; series of CFCs launched: mobile payment, mobile workforce, wireless Java, wireless tourism; Spectrum Management Handbook released by IDA	- Emergence of multi-mode GSM/GPRS/UMTS handsets, TDSCDMA handset ready in China - Multimedia: mobile software based 3D graphics & MPEG-4, Part 10(H.264) video emerges 802.11 based (at board level) laptops are prevalent; GPRS/WLAN roaming standardised solutions available - IMS compliant services deployed with GPRS - Emergence of charging platforms to link users to merchants; Event based billing by smart mobile proxies provides flexibility based on volume, airtime, transaction, content, URL access - First Pilots using Verified by Visa via SMS will complete and move into production - First deployments of embedded contactless function in handsets - Open Mobile Internet Platform products based on OSA/Parlay - Massively scalable intelligent notification services offered to overcome information overload - LBS that users are likely to pay: resource management, LBS gaming, emergency/security services, personalised services - Singapore: Enterprise mobile data wireless applications take off; Data Privacy Working Group proposes privacy policies, enabling LBS; Deployment of J2ME MIDP applications by local telcos	- Mobile processors >400-600MHz emerge - Multimedia: mobile hardware accelerated 3D graphics emerge - Large percentage of laptops with 802.11 - Standardised solutions for EDGE/WLAN roaming available - Mobile VPN based on IPv6 gains pace - Mobile gaming begins to generate significant data revenues - Commercialised laptop fuel cell power - Storage cards at Gbytes & USIM cards at hundreds of kbytes (commercially) - Mobile webcast/broadcast emerge - SIM card provides rights management & cryptographic services for J2ME based applications - First mobile payment schemes based on EMV are running commercially - USB2.0 in some 3G handset models	3G/WLAN dual mode phones & PDAs with built-in 802.11 support with dynamic power control emerge - Virtual Community Networks using P2P, multi-hop & energy aware routing - Wireless web services gain pace - More handsets embedded with contactless interface for proximity, transport, fixed POS payments. - Mobile payment deployed on a large scale for micropayments	- Mobile processors >600-800MHz emerge - Prototype micro fuel cell power for mobile devices - Multi-mode terminals gaining pace including 3G + Digital Broadcasting (DAB/DVB) terminals - Massive deployment of trans-national identity services with emergence of global certification authorities	- Mobile processors >1GHz emerge - Active RF components/MEMS solutions emerge for software radio - Storage cards in Gbytes range - Video conferencing possible with limited QoS

MOBILE WIRELESS ROADMAP 2002 TO 2007 (cont'd)

		2002	2003	2004	2005	2006	2007
Trends in Enabling Technologies, Applications & Services		STANDARDS • 3GPP, GSM and IEEE create workgroups on WLAN/WWAN interoperability standards • 3GPP's MExE loses momentum; work likely to move to Open Mobile Alliance (OMA) • XHTML/WML2.0 included in WAP2.0 • Open APIs available in 3GPP Release 5 by OSA/Parlay, JAIN Java API binding expected • IP Multimedia Subsystem (IMS) to be standardised in phases by OHG, 3GPP, 3GPP2 & MWIF will result in global roaming of IP services over both GSM and CDMA networks • SyncML dominant language for synchronisation • J2ME Mobile Information Device Profile (MIDP) 2.0 finalised • J2ME Personal Digital Assistant Profile (PDAP) 1.0 finalised • Verified by Visa & 3D Secure commercially available for WAP • IrFM standard released by IrDA; guidelines for IrFM released by Visa International	STANDARDS • 3GPP Release 6 in June 2003 incorporates multimedia broadcast/multicast features; 3GPP adopts MPEG-4, Part 10 • OMA becomes dominant standards body for mobile application standards above the IP network layer; completes first major standards release • OMA & JCP provide specs enabling interoperable downloadable Java applications • Release of J2ME web services specifications in summer 2003 • LBS interface from GMLC to ASP domain according to LIF standards and roaming supported but user privacy still issue • Mobile Payment Forum & 3D Secure drive secure payment • Verified by Visa and 3D Secure commercially available production for SMS and IVR	STANDARDS • IEEE WLAN standards for QoS completed • Liberty Alliance leverages a distributed architecture that includes complementary client based solutions • OMA standardises LBS fusion technology that fuses multiple LBS technologies together for optimal operations both indoors & outdoors. • 3G portals built on XHTML, JPEG2000, MP3, MP3 Pro, MPEG-4 open standards • JavaCard OS on USIM cards preferred standard	STANDARDS • WLAN: Dynamic power control for 802.11 is standardised	STANDARDS • Majority of handsets Java enabled. J2ME dominant standard for application development versus BREW	STANDARDS • Symbian OS is one of the several dominant OS's on handsets while Pocket PC overtakes Palm OS for PDAs • IP multimedia services can roam across both GSM and CDMA WWAN and WLAN networks • 3G portals converge on integrated multimedia standards: MPEG-7, MPEG-21, RTFD1.0 and Windows Media Player
	Market Figures	• MMS global revenue at US\$200m [Telecompetition] • Customised infotainment global revenue at US\$0.7b [Telecompetition] • Mobile internet global revenue at US\$0.2b [Telecompetition] • Mobile intranet/extranet global revenue at US\$0.9b [Telecompetition] • Singapore: Telecoms market fully liberalised since 1 April 2000; mobile penetration rate at 75.1% (Aug02); 35 FBOs & 620 SBOs; 8 WLAN service providers, over 40 WLAN hotspots	• MMS global revenue at US\$2b [Telecompetition] • LBS global revenue at US\$700m [Telecompetition] • Customised infotainment global revenue at US\$5.8b [Telecompetition] • Mobile internet global revenue at US\$0.8b [Telecompetition] • Mobile intranet/extranet global revenue at US\$3.1b [Telecompetition]	• MMS global revenue at US\$4.5b [Telecompetition] • LBS global revenue at US\$1.8b [Telecompetition] • Customised infotainment global revenue at US\$11.2b [Telecompetition] • Mobile internet global revenue at US\$1.5b [Telecompetition] • Mobile intranet/extranet global revenue at US\$5.9b [Telecompetition] • Singapore: Mobile voice and data services revenue at US\$1b [Gartner]	• SMS still occupies majority market share over MMS [Ovum] • MMS global revenue at US\$7.3b [Telecompetition] • LBS global revenue at US\$2.7b [Telecompetition] • LBS global revenue at US\$13b [Cahners In-Stat] • LBS global revenue at US\$16b [Strategis Group] • Customised infotainment global revenue at US\$17b [Telecompetition] • Mobile internet global revenue at US\$2.2b [Telecompetition] • Mobile intranet/extranet global revenue at US\$8.5b [Telecompetition]	• MMS global revenue at US\$14.5b [Telecompetition] • Instant Messaging and Presence Services reach global revenue of US\$9.2b [Baskerville] • Wireless gaming in Asia Pacific region including Japan reaches US\$10b in revenues [Datamonitor] • LBS global revenue at US\$3.9b [Telecompetition] • Customised infotainment global revenue at US\$31.9b [Telecompetition] • Mobile internet global revenue at US\$3.9b [Telecompetition] • Mobile intranet/extranet global revenue at US\$15.3b [Telecompetition] • Singapore: Wireless gaming revenue at US\$101m with 3.6m gamers [Datamonitor]	• MMS begins to overtake SMS in revenues [Ovum] • GSM based handsets (includes WCDMA) = 80.5%; CDMA handsets = 15%; other handsets (PDC/TDMA) = 4.5% [ARC] (PS: GSM figure could be lower, CDMA higher, others lower) • 200m out of 880m handsets are with integrated cameras (23%) [ARC] (PS: this figure could be higher) • MMS global revenue at US\$22.1b [Telecompetition] • LBS global revenue at US\$5.8b [Telecompetition] • Customised infotainment global revenue at US\$41.8b [Telecompetition] • Mobile internet global revenue at US\$6b [Telecompetition] • Mobile intranet/extranet global revenue at US\$23.6b [Telecompetition]

Cautionary note: The various market figures forecasted above for 2002-2007 quoted from analyst firms would seem to be on the high end. Please exercise prudence in their interpretation for other usage.