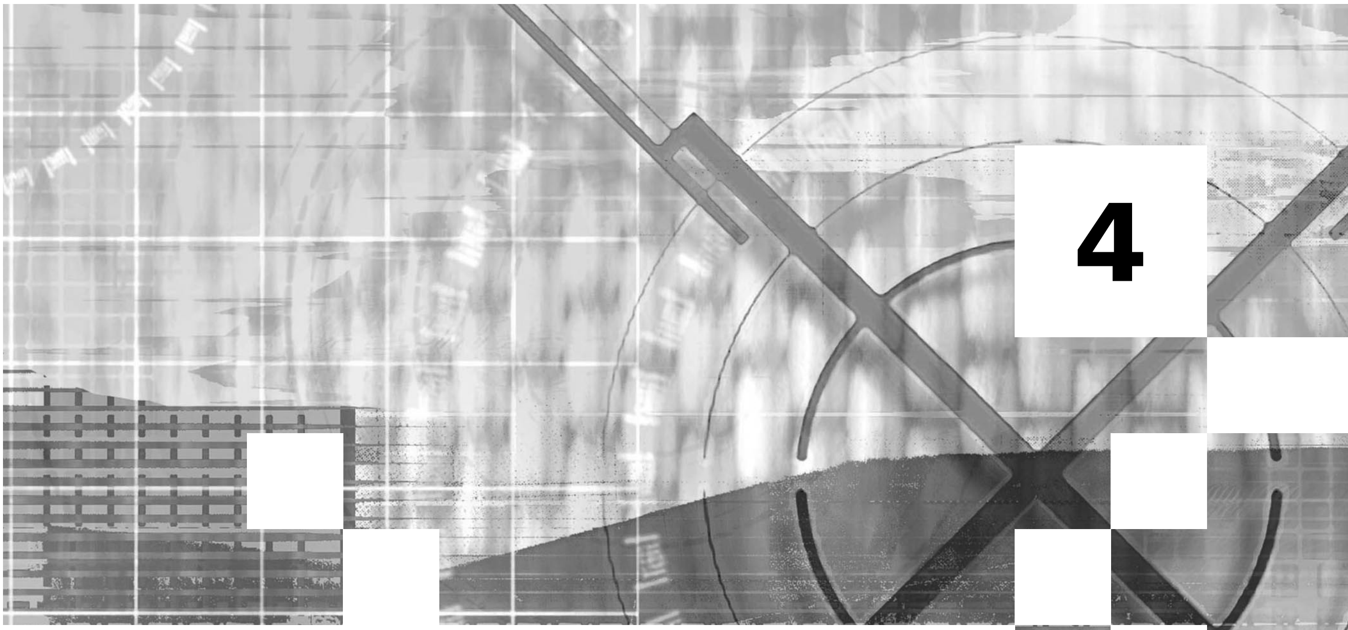


4 Mobile systems

Project manager's responsibilities

- To understand the potential, limitations and rapid change of mobile technologies
- To recognize the place of mobile technology in convergent technologies
- To understand the capabilities of the mobile services currently available and how best to fit these to particular user requirements

Why mobile telephones?

The growth in use of mobile telephones has been a success story of the past few years. We are close to considering mobile telephones (or just 'mobiles') as appliances like refrigerators, televisions and video recorders. You know when something has reached this stage when people ask 'What mobile do you have?' rather than 'Do you have a mobile?' A 2001 survey of consumers' attitudes to new technology in the home (carried out by Gallup on behalf of Pace) indicated that hand-held mobile devices for messaging were top of most people's gadget lists and in 2001 50% of all calls in Scandinavia were being made using mobiles.

Telephony and radio grew up at the same time: the start of the twentieth century. Initially you needed something like a ship, or at least a motor vehicle, to carry the sheer weight of equipment needed for what was then called wireless, and until the 1920s the radio spectrum carried telegraphy, like Morse code, rather than speech. With the 1920s came speech and the birth of radio as a means of communication and entertainment.

Part of the issue over size had to do with the use of valves (or vacuum tubes) and although valiant efforts were made at producing portable radiotelephony units (known to the military as R/T) it wasn't until transistors and then integrated circuits came into existence in the 1950s to 1970s that telephones could really get mobile. Power was also an issue and mobile telephones need small effective batteries coupled with low power consumption, and low heat generation as well. Longer wavelengths needed bigger antennae, so early mobile systems needed whip antennae of several feet in length because at the time it wasn't practical to work at the ultra-short wavelengths (high frequencies) we do today. And then there was the cost.

So the developments in electronics made it possible to produce a telephone small enough to be practical on the move. Initially it might have been the size of a small suitcase but that was no problem: we put them in motor cars and called them car telephones.

A smaller phone wasn't the only issue. Early car telephone systems worked with a single transmitter working to each telephone. This was very wasteful of radio spectrum and certainly didn't encourage volume usage and production. It wasn't until the idea of using small cells of transmitter/receiver coverage and letting the phones move between the cells that the infrastructure was able to handle high volumes of use. Instead of a single transmitter on the top of a hill – the broadcasting model – mobile phones used lots of small, low-powered transmitters on nearby buildings and on small masts.

The infrastructure problem was solved by using a cellular structure – hence cellular telephones or cell-phones. The idea of using many small cells each covered by its own low-powered transmitter (called base stations) was suggested in 1947 by AT&T in the USA, but it took until 1968 before the regulatory body in the USA (the FCC) allocated sufficient frequencies for trials. By the late 1970s cellular telephony was a reality and the first such network started in 1979 in Tokyo. The first US system started in Chicago in 1983 followed by the UK in 1985. The networks and telephones were analogue. The next step was to make the system digital and this helped make the telephones themselves smaller and cheaper: eventually. There were early fears that the extra cost of digital handsets would stop the take-up of mobiles. In fact mobile telephony has a history of exceeding predictions with a mid-1980s report suggesting that the UK usage would be 20,000 in 1990 when in fact it reached a million. Such underestimations seriously affect the radio spectrum allocated by governments, so they are not a trivial matter.

Digital brought a world standard (but not used in Japan or in some of North and South America) called GSM. Competing operators started to bring the prices down, users could buy a cheap phone and pay for calls as they went using pre-pay cards. This resulted in mass use of mobiles in most of the world with places like Finland and Japan showing the way. Mobile phones were no longer the preserve of business. (Unfortunately the Pay-as-you-go phone pricing was based on the assumption that users would actually make calls. A significant number of them did not, only using the phone in 'emergencies'.)

The situation in the USA was not as strong. This was partly because of a charging structure that made people pay to receive mobile calls rather than to originate them and also because of a more fragmented and patchy coverage. But the USA is a big and sprawling country. Ironically, mobile phones proved very practical in emerging nations. Putting in base stations for a mobile network is often more cost-effective than laying cables. And guarding a few base stations is easier than trying to stop theft of copper cables from a wired network in remote locations.

Eventually the mobile telephone became a disposable item. A facility called 'chat and chuck' became possible where the phone itself was so cheap that it could be discarded when the airtime ran out. No keypad was needed because voice recognition could be used, putting the computing power in the network rather than in the handset and also making it cheaper. The phone could even become small enough to be contained in the phonecard. In these cases, unlike Pay-as-you-go, users could make calls but not receive them because the phones did not need to have a telephone number at all.

Incidentally, you will sometimes hear the developments in telecommunications – fixed as well as mobile – referred to as POTS and PANS: POTS are the Plain Old Telephone System and PANS are Positively Amazing New Stuff (or similar).

There's more to mobiles than telephony

Mobiles started out as telephones. In some parts of the world that is their main use. But the growth areas in mobile communications are not necessarily for speech. The Small Message System (SMS) designed for use with pagers is available on most mobiles. On some networks of the world messaging is free and many times sending a quick message is better than making a voice call. The result is that SMS has taken off in a big way. The 'billion messages a month' mark was passed in Europe in April 1999. You may be limited to only 160 characters (70 if you are using multi-byte languages such as Japanese) and your recipient must have an SMS-capable device but it has led to schoolchildren in Scandinavia repeatedly messaging each other across the playground and bullying by SMS has become a twenty-first century problem in some schools. You don't pass notes in school any more, you message. But don't forget to turn off the warning 'BLEEP!'.

Much of the SMS traffic consists of service messages such as a notification of a voice mail message. It is possible to gateway between e-mail and SMS with the user's telephone number becoming part of their address and another common use of SMS is notification of arriving e-mails and faxes. Downloading of new ring tones for mobiles is also done using SMS. Vehicle tracking systems taking status input from the vehicle and combining it with global positioning information can then send the resulting data over SMS. SMS is asynchronous (meaning that it is not a 'real-time' activity) and does not need a continuous connection to the network other than for the times of sending and receiving. It can fit in around synchronous network traffic such as speech and it is a 'push' technology. Unfortunately, being a push technology means that you can be sent unsolicited messages. So SMS is vulnerable to spam.

After SMS came icon-messaging and it was possible to connect up your laptop and surf the Internet using your mobile telephone, but at a snail-pace 9600 bits per second. (Slow for people who never had to use a modem at 300 bits per second or telex!)

At the time of writing the mobile industry is looking towards so-called third generation systems (called 3G) which are just starting to be rolled out. If the original analogue cell-phones were 1G then digital cell-phones were 2G and the next big step was a broadband (by wireless standards) infrastructure which was to be called the Universal Mobile Telecommunications System – UMTS.

Part of the plan for UMTS is to allow seamless movement of telephone calls between different types of cell. You might have a pico-cell in your home or office (a very low-powered mobile phone cell working like a cordless telephone and possibly connecting to your land-line telephone line) with more familiar cells working at an urban, rural and district level. In theory you could even reach the coverage of last resort using satellites.

The mobile telephone user will, in theory, have access to more bandwidth which makes it possible for several services to be used simultaneously, or for a few broadband services such as video-telephony or media-rich Web surfing to be possible. This could be in situations we now recognize as typical for mobile telephone use or it could extend this, for example by making

special arrangements to provide Internet access to airline passengers. At the opposite end of the scale, a UMTS phone handset might be able to move seamlessly between being a cordless phone in your home to working as a cell-phone away from home.

In between 2G and 3G is 2.5G. This takes existing mobile telephone systems and stretches their capabilities to provide more bandwidth. Using GSM for a data call makes what is called a circuit switched data connection since for the duration of the call the user has use of a circuit. High Speed Circuit Switched Data (HSCSD), General Packet Radio Service (GPRS) and Enhanced Data Rate for GSM Evolution (EDGE) are three 2.5G steps on the road to 3G.

HSCSD allocates more of the radio spectrum between the user’s telephone and the base station to give higher data rates. It otherwise works like a normal mobile call but for data it can give a theoretical maximum speed of 28.8 kilobits/sec. For mobile operators it is mainly a software upgrade (and users need new phones) so is easy to implement and is already out there on some networks. All calls are discrete dial-up calls and you pay for the duration of the call as usual.

GPRS goes a stage further than HSCSD and provides an always-on connection for data which can handle 172.2 kilobits/sec although since data is sent in packets the connection is not necessarily continuously in use.

A third evolution, called EDGE, builds on GPRS and changes the way the mobile cell is used to make it more efficient. In theory EDGE will give 384 kilobits/sec, but this will only be possible under certain conditions such as close proximity to the base station. Always-on connections also have to vie with each other for use of the ‘space’ available in the mobile cell so it is possible for many users to slow each other down. Any switched calls, such as for voice, will deny space to the always-on connections. In practice, space may need to be reserved for each form of communication. This is similar to the concept of a contention ratio in ADSL where a number of users, typically ten or twenty, share the bandwidth.

These 2.5G technologies may well coexist. It is particularly likely that circuit switched data calls and always-on data calls will coexist because certain applications are suited to one or the other. A video-telephone call would best be served by circuit-switched while web browsing or e-mail is best served by always-on. It is also worth noting that 'always-on' data is not the preserve of 2.5G systems. The Japanese (and some American) 2G mobile telephone systems are using a method of transmission that also allows for this kind of connection.

The i-mode system, provided in Japan by NTT DoCoMo, gives mobile telephone users access to web-like services on their mobiles. Apart from a service fee, users pay for their data calls by the amount of data transferred, not by time. This is different to the Wireless Application Protocol (WAP) technology used in GSM.

Unfortunately mobile systems will rarely achieve a throughput of data as fast as the maximum claimed. For example, UMTS/3G in theory offers over two megabits of data transfer, but typical mobile rates were predicted to be as low as 500 kilobits. This is partly because of transfer overheads but also because working truly mobile – while moving – introduces errors in the raw transfer which slow down the user's data rate. Being stationary close to a base station would give much better performance. Also in the real world there will be interference and congestion. In the early stages, technological difficulties in producing the handsets could reduce the practical rates as well.

We should also mention that wireless LAN cards and Bluetooth technologies are also mobile communication methods. Wireless LAN systems like IEEE 802.11 (Wi-Fi) which is marketed as, among others, Lucent's Orinoco or Apple's AirPort enable users to achieve basic Ethernet speeds (11 megabits being the current state of this particular art) without needing wires. This is revolutionizing the networking of schools and open-plan offices. Wireless LAN itself is not giving rise to many applications; rather it is enabling a freer use of things we normally can do over our fixed networks. Bluetooth, on the other hand, is aimed fair and square at linking devices together at high speeds across very short distances, such as from hand to mouth or mouth to belt, or phone to laptop. In this it has similarities with the application of infrared communications such as IrDA but it is not restricted to line-of-sight. The aim here is to let us carry on doing much of what we currently do with these small devices, but without having to keep plugging them into each other. Again it possibly means more for freedom of movement than the generation of new applications.

Web on mobiles

Mobile access to the Internet, for web browsing and e-mail, is available using some mobile telephone handsets. Some of these combine a cell-phone with a Personal Digital Assistant (PDA) and have a small but reasonable screen size of the order of 160 by 100 pixels, sometimes in colour. Arguably, the future of mobile Internet lies more with PDAs than with phones but, despite the small size of display available on a phone, mobile Internet exists.

The primary limitation is the display on the telephone handset. This is usually only a small number of lines of as few as eight or ten characters. This does not give much room for manoeuvre in web design. Both i-mode (the system marketed by NTT DoCoMo in Japan) and WAP provide Web access on handsets but they operate in different ways. i-mode handsets include browsers that recognize a subset of HTML whereas WAP browsers use WML, which is a derivative of XML. The difference means that an i-mode phone can display any website, although ones not designed for the system may, as DoCoMo put it, 'not display properly': an understatement perhaps. An i-mode user will automatically be given an e-mail address on the handset, initially based on the phone number but changeable. A telephone number can be an i-mode URL so that clicking on the link dials the call.

A WAP site is inherently different to an ordinary website and this is because of the limitations of a handset display. The website becomes a WAP deck and the individual screens (pages) that are displayed are called cards. Moving from one card to another involves moving between small sections of the deck to display a different card. A deck is (at least in early WAP implementations) limited to 1400 bytes in size. Since the WML is based on XML it follows much stricter syntactical rules than HTML, which is rather loose. The result of this is that websites cannot be displayed on a WAP browser even if they fitted the small screen on a handset, and need to be specially coded with WML and its scripting extensions in WMLScript. However, these WML decks can be held on ordinary websites with ordinary-looking URLs (but with .wml at the end). If you open a WML deck in a standard HTML browser it will either show the WML as plain text or ask you to save it to disk if the WML MIME type is not one your browser recognizes. There are also several WAP emulators available on the Web and these allow you to browse WAP sites using a web browser.

Whether a WAP phone can access the Internet at large, in search of WML, depends on the service provider. A walled garden might be provided (a self-contained subset of the Internet ready 'wapped') or a gateway to the Internet itself. Since WAP is designed to put as little load on the phone as possible – the WAP micro browser is a very 'thin' client in this client–server relationship – the gateway has to do a significant amount of processing.

From the mobile operator's perspective, WAP provides a mechanism for sending data to the user much like SMS. Indeed, WAP sits on top of what is called a bearer, and SMS can be one of these bearers although the 160-character limit is restrictive. But whereas SMS can push messages to the user, WAP as it presently stands cannot. Since SMS is free-of-charge to receive (and WAP using dial-up air time is definitely not so) system messages using SMS will not inconvenience the user.

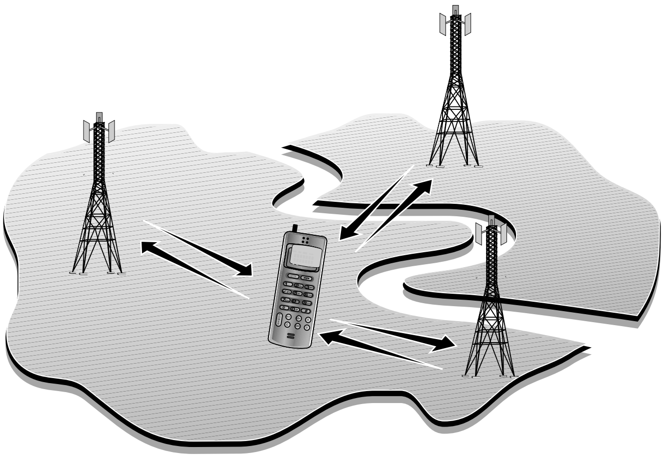
At the time of writing, WAP is a new development and has suffered from being sold as a means of surfing the Web on your mobile telephone – a task for which it is not ideal. It can be argued that with broadband data available through 3G mobile systems WAP is a very short-lived possibility. But it can be used very effectively to retrieve short items of information such as train timetables, news headlines or where the public toilets are.

Location-based services

A mobile telephone, by definition, has no fixed abode. However, once you know where it is at 'this' moment you can feed it with information pertinent to its location. This can range from very localized information along the lines of 'when will the next tram arrive?' to more general 'what movies are showing in town and starting within the next half hour?'

A mobile telephone network always knows which cell a cell-phone occupies since this is the way the system works (ignoring ambiguities when the phone is at the edge of more than one cell). But a cell can range in size from a few hundred metres in a city to several kilometres in the open countryside. The FCC in the USA has recognized this as a problem when alerting emergency services to respond to cell-phone calls. Whereas a fixed line such as a road-side phone booth has a known position, a cell-phone does not. The FCC's approach has been to ask for positioning systems to be built into the cell-phone system so that 67% of the time an emergency call can be positioned within 125 metres. This needs to be accurate enough to pinpoint whether an accident is on one carriageway of a highway or the other and was cited as one reason why the US-run GPS satellite system increased its civilian resolution recently. Even if the telephone does not have GPS built-in, it is possible that the motor car soon will.

But GPS is not the only way. If the cell-phone has sufficient processing ability then it can triangulate its position from the base stations in range. This can be done by GSM phones with what is called the SIM Application



Tool Kit. Since the phone will usually be receiving more than one base station at any time and since accurate timing information is available from these base stations, or since signal attenuation can be measured or since sometimes the angle at which the phone signal is detected at the base stations can be determined (by detecting which of a circle of directional aerials is receiving the signal), the system can pinpoint the phone's location. Some of these systems require modifications to the handset or to the base station or to the network infrastructure.

Even though the mechanisms described above may not, at this point, be ones that are available to programmers of WAP sites, it is still possible to provide location-based services. The interim solution is a simple one: you ask the phone's user to tell you where they are. This probably involves asking for a post or ZIP code since the databases containing the information will usually rely on these codes to geographically pinpoint the data. Alternatively you can ask the user to choose from a list of place names. This, at least, enables you to try the services out without having to wait.

Location-based services are considered a key opportunity for mobile service operators and so should have similar potential for application and content developers. The link will best work where there is data which is resolved by location and which people want to access while on the move. The handset (or PDA) needs to be able to display sufficient information for it to work. A small WAP phone handset display is not likely to show sufficient detail for a good map, but a PDA will. You will no longer ask a passing stranger how to get to your hotel, you will call up a map on your PDA which will show where you are and what route to take.

There is an irony in this situation. The telephone was originally a device to enable us to communicate at a distance. Location-based services on our mobiles will bring us more information about what we are close to.

A broadband future

Simon Buckingham, Managing Director of Mobile Lifestreams Limited, listed a number of key applications for mobile data in a paper published on the GSM World website. He listed:

- access to Internet chat rooms;
- textual and visual information such as news and sports results;
- live transfer of digital stills from camera to website;
- videoconferencing, surveillance and other video applications;
- web browsing;
- collaborative working;
- high-quality audio for broadcast or law-enforcement purposes;
- job allocation and briefing for repair workers and general dispatch work such as for taxis;

- corporate e-mail and intranet;
- Internet e-mail;
- asset tracking and vehicle positioning;
- home automation.

There are two different aspects to mobile broadband: better connection at a distance and doing away with wires. Simon's list covers the former. If we have access to faster connections in a device as small as a telephone, or at least something we can put in our pocket, then we can make information come to us, wherever we are. This can be location-based but it can just as easily be web surfing, listening to Internet radio or videoconferencing. In fact, it could be anything that you could do at your desktop.

The dilemma with mobile broadband comes more from the mobility than from the data, since whatever services can make use of the increased amount of data the equipment still needs to be carried around. Of course we might go back to the notion of the car phone and the luggable rather than portable telephone. But this assumes that key elements of desktop systems cannot be made more compact and lighter. We can replace the keyboard with speech recognition or have a keyboard that we can fold up like a handkerchief and put in our pocket. We could have a folding display, or wear eye-phone glasses to see whatever we needed to see.

More realistically in the short term we could use a broadband mobile phone to access two linked services simultaneously. This might involve booking a hotel by talking to the travel agent and simultaneously looking at room plans and maps via the Web. Collaborative working between colleagues already happens using desktop videoconferencing systems but it could easily extend to a business-to-consumer transaction. Making it work with a mobile telephone can greatly enhance things like tourism and travel as well as telemedicine. If you have an always-on connection in place then telemedicine can extend to include continuous remote monitoring of a patient. People can be sent home for observation remotely in circumstances where today they would have to stay in hospital.

This promise of mobile technology has to be tempered with concerns about safety and health when radio transmitters are used so close to the body and the head in particular. Mobile telephones are regarded as a safety hazard in aeroplanes and in hospitals, many local authorities will not let cell-phone masts be put near schools and there are an increasing number of objections being raised by local residents when new masts are planned almost anywhere. These concerns cannot be ignored, especially since 3G mobile networks, working at higher frequencies, will need more masts. Only time will tell if the health and safety issues come to dominate the use of the technology – it is sobering to remember the optimism about the 'power of the atom'.

The second part of broadband mobile is less to do with telephones and more to do with computer networks. We've already mentioned standards like IEEE 802.11 (Wi-Fi) and Bluetooth, which are enabling people to do away with wires in their offices, schools and homes. There are even publiclyaccessible wireless networks in places like airports. Currently these systems are limited to 11 kilobits per second but in time the speed of the links will get faster although the very fast speeds may well only be available over very short distances. The limitations of many current systems are compounded by them using radio frequencies that are shared with many other devices including microwave ovens. This is an obstacle that can be overcome in time and there is a vision of 'holistic communications', where every device would be able to talk to every other device and, sitting in the centre of this, would be a very mobile portable computer.

Olivetti's famous active badge experiment, which equipped identity badges in an office with infrared sensors, allowed the office 'system' to know where people were. Telephone calls would be routed to the telephone next to them and when they walked up to a computer workstation it would immediately come to life with their own personalized desktop. (If they wanted privacy they just put the badge face down to obscure the infrared sensor.) Extend this concept to a museum or art gallery and make it work with a visitor's own mobile phone or PDA. Without necessarily invading visitors' privacy it would be possible for a museum to provide individually tailored information and in a broadband world this could include video to show objects in action.

It may be that mobile systems will always lag behind their wired counterparts when it comes to speed of access but in many ways the opportunities that mobile systems offer are greater than for any other part of the emerging convergent technologies. It is even possible that, before long, all our personal communication will be wireless.

THEORY INTO PRACTICE 4

Set a challenge for you and your colleagues to come up with three clearly-defined location-based services that would be useful for a person to access by a PDA.

Perhaps you could pitch your ideas to a mobile service operator as a funded research project.

Summary

- The introduction of a cell-based infrastructure established mobile communications for the masses.
- Digital technology allowed smaller, lighter, standardized and ultimately cheaper mobile phones.
- SMS text messaging has proved a highly successful extra facility.
- 3G systems look towards the use of broadband via UMTS and seamless movement between different types of cells.
- Broadband will allow more services including richer media services.
- Different types of connection – switched-circuit or always-on – serve different purposes.
- Wireless LAN and Bluetooth technologies are revolutionizing networking by linking devices at high speeds across short distances.
- Mobile access to the Web via WAP and i-mode have strong limitations partially overcome by the larger display of a PDA.
- Location-based services can reach people with information tailored to their roving position and are proving of interest to mobile operators.
- Wireless services offer great potential and, eventually, all our personal communication may be done this way.

Recommended reading

www.phonewarehouse.com/History.htm
Phone Warehouse in Houston, Texas have an interesting set of mildly technical articles about the history of the telephone: wireless and wired. The history of the telephone itself includes the incredible but true stories of the man who was a few hours too late to patent the telephone, the measles epidemic that led to the invention of telephone numbers and the undertaker who invented automatic dialling to frustrate the attempts of rivals to steal his business.

http://www.gsmworld.com is the website of the GSM Association and includes background information on the technology.

Simon Buckingham, Managing Director of Mobile Lifestreams Limited has written a number of briefing documents on mobile telephone technology which can be found at http://www.mobilepositioning.com

Another comprehensive site is Mobilecomms Technology at http://www.mobilecomms-technology.com/

The Pace Report 2001 ('Consumer attitudes towards digital television in the UK and US') is published by Pace Micro Technology plc, Victoria Road, Saltaire, Shipley, West Yorkshire, BD18 3LF, United Kingdom. www.pace.co.uk. A summary report is available at http://www.pace.co.uk/documents/PR/pacereport01.pdf.

Akass C. (2001). *Smart Machine in a Smart World* (Holistic comms), London: *PCW*, June 2001 issue

Dornam A. (2000). *The Essential Guide to Wireless Communications Applications: From Cellular Systems to WAP and M-Commerce*, Upper Saddle River, NJ: Prentice Hall