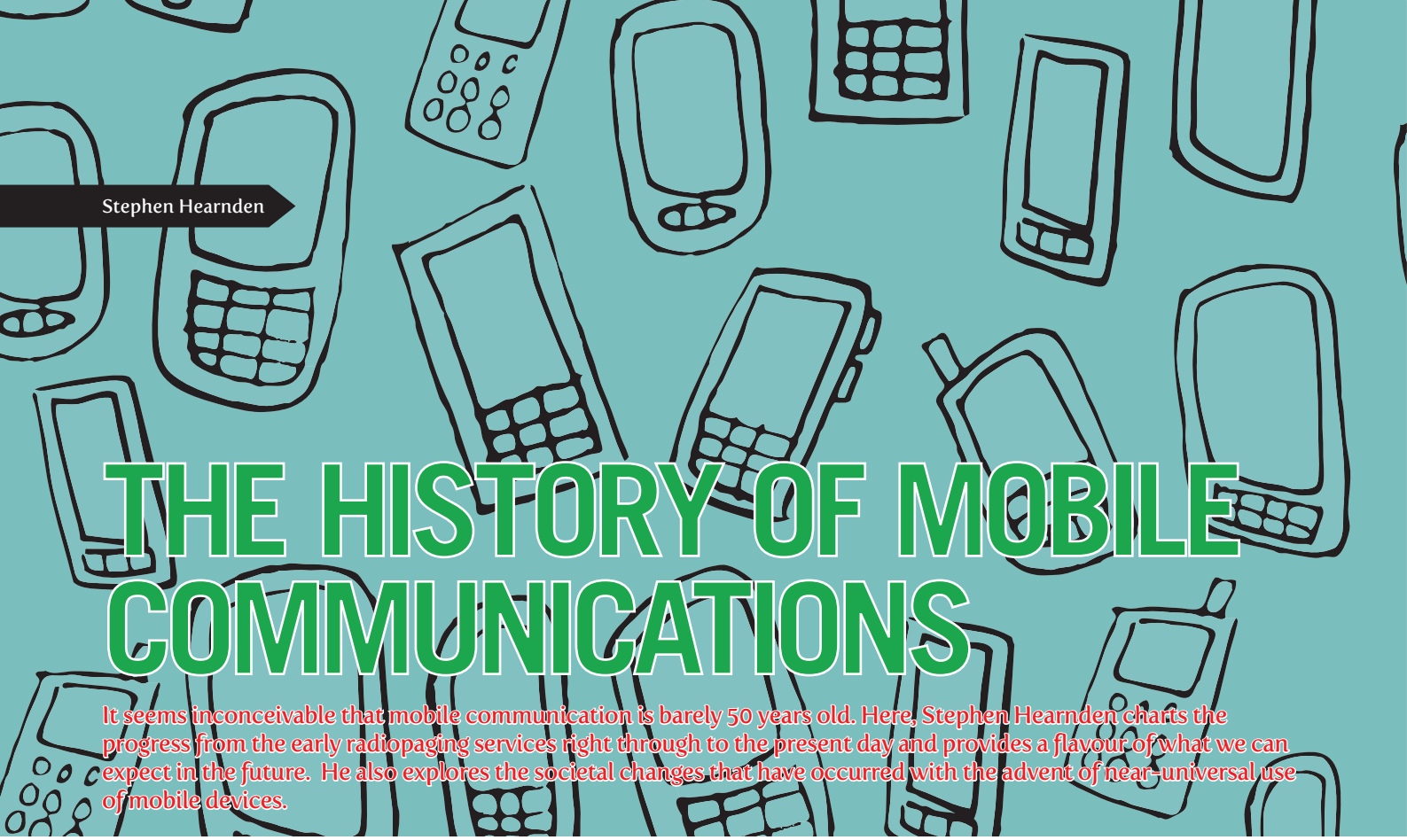

Stephen Hearnden

THE HISTORY OF MOBILE COMMUNICATIONS

It seems inconceivable that mobile communication is barely 50 years old. Here, Stephen Hearnden charts the progress from the early radiopaging services right through to the present day and provides a flavour of what we can expect in the future. He also explores the societal changes that have occurred with the advent of near-universal use of mobile devices.

THE EARLY DAYS

It is impossible to underestimate the importance of mobile communications and how they have changed our lives. From the ability to make and receive calls almost anywhere in the world seamlessly, to being able to access the Internet whilst on the move, of the many inventions of the last 50 years, mobile communication must be near the top in the effect it has had on people's lives.

The first mobile communication services that became available were developed in the early 1970s in the UK and a little earlier in the US. These were one-way paging services that sent a telephone number to a user in the field with a small pocket pager. Some of these services were limited to a site, for example a hospital or university campus, and some were regionally based.

This required the operator who was paging the individual to know what region the person was in. As it was a one-way service with no acknowledgement, the operator had no idea whether the message had been received. Soon there became a demand for a national service and the Post Office (PO) in the UK deployed a network of paging sites and offered a national service.

As the service developed, the need for more characters became essential and the Post Office developed a standard giving a capacity of 80 alphanumeric characters; but again it was only one-way. In the 1980s there were around 3.2 million users of pagers worldwide and by the 1990s this peaked at around 22 million. Then, with the advent of cellular, the services began to decline and, although there were newer paging services including two-way ones, they only continued as a niche service. Hutchinson's (now 3 in the UK) national paging service closed in 2000.

In parallel with the roll-out of paging services there were attempts to develop radiophone services. These, like the paging services, were limited in their capabilities and also suffered from a lack of frequency spectrum. Radiophone System 1, the very first public mobile telephone service in the UK, was made available in 1959. It was of limited capacity and provided coverage in the South Lancashire area.

It was not until 1965 that service was made available in London. The launch coincided with the opening of the Post Office Tower which was the location for the base station transmitters covering the central London area. The launch of System 2 saw the beginning of the ever-increasing rise in popularity of the mobile phone. It had only nine frequency channels though! It's hard to imagine only nine calls being made in London at the same time!

To operate, a mobile call was initiated by lifting the handset, manually selecting a free channel and pressing the call button (specific channels were used in specific areas, busy channels were indicated by an engaged light

To call a mobile from a fixed telephone it was necessary to call the radiophone operator by dialling 140 (in London) and requesting the 5-digit number of the mobile to which you wished to be connected. The operator would key in the number which would be transmitted using a 5-tone sequence to all mobiles on the calling channel.

Radiophone 3, the successor service, had 55 channels and, although it was a manual system, it was still an operator-connected half duplex system. It was replaced by Radiophone 4 in 1983 which was an automatic service. In both cases to ring the phone it was necessary to know in which region the called party was located. To increase capacity, the channel spacing was reduced from 25 to 12.5kHz which gave a total of 95 channels. It didn't take long with the erlang tables to see that the total capacity was limited to around 10 –15,000 users. There were many more but these were illegal! It

was said in those days that, because there was a long waiting list for service, the PO had developed waiting list management into an art form. It was clear another solution had to be found.

CELLULAR – THE EARLY YEARS

In May 1982 Kenneth Baker, the Minister of State for Information and Technology in the Department for Trade and Industry, received a joint approach from Securicor (a parcels delivery company) and BT Enterprises to form a joint company subsequently known as Telecom Securicor Cellular Radio Ltd (Cellnet) with a request to offer a UK nationwide cellular service. The venture was 51% owned by BT and 49% by Securicor and subsequently became 60/40%.

During this time telecommunications regulation changed and, with the new Telecommunications Act 1983, this opened up the market to competition for the first time. Another company, Racal Vodafone, bid for the second licence which was granted in 1983 and two years later the two operators launched within days of each other in January 1985. The licences were granted for 25 years.

In the two years leading up to the launch there was intense activity to decide on a standard and to free-up spectrum for the two operators. Much of the research work on the air interface standard was done at the BT research laboratories in Suffolk. The results were presented to a joint industry Government group run by the Department for Trade and Industry.

Several existing standards were investigated including the Nordic Mobile Telephone standard (NMT450/900) and the North American Advance Mobile Phone service (AMPs) standard. Eventually it was decided to adapt the AMPs standard for European use, i.e. a 25kHz not a 30kHz channel plan to fit in with European practice. This became known as TACS - Total Access Communications System. It was an analogue technology using Frequency Division Multiplex with a digital call set-up technology and a simple analogue tone call clearing technology. Each operator was granted 300 frequency channels with a national coverage obligation.

In 1983, the Commission of European Post and Telecommunications allocated the 900MHz band for a pan-European cellular radio system and allowed countries to offer interim services in these bands. Therefore the frequency bands selected were 890 to 905 and 935 to 950MHz. An additional 10 + 10MHz was reserved for what was to become the Global System for Mobile (GSM) communications directly above these bands. Cellnet opted for a 12-cell repeat pattern at launch moving to a 4-cell repeat pattern after about two years and used Motorola equipment. Racal Vodafone opted for a 7-cell repeat pattern using Ericsson equipment.

The operators weren't allowed to offer service to the end customer at that time so a network of service providers and dealers was established, most selling on both networks. The opening tariffs were £25 per month and 25 pence per minute. Allowing for inflation these figures are very high by today's standards.

As a personal aside, I joined Cellnet six weeks after the launch when we had one mobile switching centre in the network and eight base stations with 1500 customers (February 1985). The business plan I inherited showed a growth of 20,000 customers by 1995 (10 years) but we exceeded that in seven months. Racal Vodafone had similar growth. It was clear that both operators had dramatically underestimated the market possibly due to the pent-up demand that couldn't be satisfied by older radiotelephone systems.

Even with high tariffs and a subsequent increase in the per-minute charge inside the M25 (the London orbital motorway) to choke off congestion (unsuccessfully), the customer base continued to grow and, at a peak, the networks had around 1.5 million customers each. Network investment ran at £200m per year and, after three years, additional spectrum was found, termed Extended TACS, which gave each operator a total of 660 channels. The service by today's standards was not brilliant with dropped calls and overhearing being a major source of customer dissatisfaction. That was after the operators had managed to give a reasonable coverage footprint. It was clear that, without new technology, these networks would run out of steam; a new solution was required.

By the 1990s there were some 22 million people using pagers.

GSM AND 3G

The standard for GSM was started in 1983 and by 1987 the parameters for the air interface were decided, allowing European countries to start in earnest planning for new digital cellular radio networks. At that time only a few countries had competition, most only had the incumbent PTT operator. However, by the time of the 1992 launch of GSM in the UK, most countries launched with two operators. Germany had an aggressive new entrant operator that was anxious to steal a march on the Deutche Telecom, the incumbent operator, but was stymied by the lack of type-approved mobiles leading to GSM being renamed 'God Send Mobiles'!

Originally it was seen that up to 18 countries would adopt GSM in Europe, but in the event it has become a truly global standard with operators now in 219 countries. It is a credit to the designers of the standard that it has been capable of expansion, not only in terms of numbers of customers, but in terms of numbers of networks it can support with roaming. The key improvements of GSM over TACS was the security from overhearing and cloning it offered, as well as better aural quality, capacity for the operators, a text messaging capability and of course roaming. Also, the use of the Subscriber Identity Module (SIM) card allows the subscription to the service to be decoupled from the handset.

Text messaging, which was a by-product of the design, was and still is the most profitable service offered by the operators. The A5 security algorithm which provides the user with security was, at the time of its launch, the strongest cypher in

commercial use. Even after 20 years, it still provides a secure function and, although there have been papers published on how to attack it, in practice the service still remains pretty secure.

GSM is a Time Division Multiple Access (TDMA) system based on Integrated Services Digital Network (ISDN) at the network level. Each radio frequency carrier, which is 200kHz, supports eight voice channels. Terrestrial GSM now covers 90% of the world's population. Its data capability has evolved since its launch from simple data at 9.6kbit/s, through General Packet Radio Service at 40kbit/s, to Enhanced Data-rates for Global Evolution at up to 384kbit/s. All these upgrades required careful planning to ensure backwards compatibility with older equipment. New GSM networks are still being installed in some parts of the world and it is expected that they will continue to be used well into the 2020s.

In parallel with the roll-out by Cellnet (now O2) and Vodafone of GSM the UK Government decided in around 1990 it wanted more mobile network operator competition; Mercury 1 to 1 and Orange were awarded licenses. A third operator was initially licensed but the licence was handed back and the spectrum was eventually reassigned. The standard they chose to use was GSM1800, a similar standard to GSM (now renamed GSM900) which allowed fully interoperability between the networks with dual-band phones.

A 4-operator market in the UK prevailed until the arrival of Hutchinson 3G (now known as 3) following the 3G auction (of which more later).

Like all things it became time to move on to the next standard namely 3G or Universal Mobile Telecommunications System (UMTS) as it is sometimes known. Even before GSM was launched in 1992 R&D engineers were busy designing the GSM replacement standard, only this time it was being led by manufacturers and not operators. This has led to some critical comment that 3G is overly complicated and expensive and isn't end user friendly. 3G does, however, offer more capacity than GSM as well as higher data rates. It is a Code Division Multiple Access (CDMA) Frequency Division Duplex system and, although it has a Time Division Duplex capability as well, very few if any operators have adopted it in a big way

In 2000 came the 3G auction. By now governments and regulators were beginning to recognise the value of the spectrum and, rather than going for a straight beauty competition, the spectrum award was based on an auction. The spectrum for 3G in the UK are the bands 1885 to 2025MHz for the mobile-to-base (uplink) and 2110 to 2200MHz for the base-to-mobile (downlink). There were five lots of varying sizes and after 100 rounds the existing four operators plus 3 were awarded the lots at a total cost of £22.4Bn. The industry was stunned. Not only did the UK Government get more revenue than they could ever have imagined, but the effect of taking this money out of industry delayed the network roll-out by the operators for a number of years.

3G, if we are honest, has not been as successful as GSM and has taken about 10 years to become fully functional and, as with all these things, during that time people have been busily preparing for the next standard called 4G or Long Term Evolution (LTE). However 3G does offer the ability to deliver internet functionality to the handset. Another problem that has become apparent; other countries outside of Europe often use different frequency bands due to the composition of the ITU international frequency tables. As the commonality of frequency bands has become more difficult, the need for multi-band handsets to support GSM 850/900/1800 and 3G 900/1800/2100/2600 has become vital.

When 3G was first launched data rates struggled to reach 1Mbit/s. If this was shared between a number of customers the user experience was poor. As the standard evolved, with more advanced coding technologies for the air interface, 16QAM (Quadrature Amplitude Modulation) moving to 64QAM and the use of smart antennas, the rate improved to 14.4Mbit/s.

Operators are understandably cautious because of the costs involved. In the last three years, this increase in system capacity has transformed the mobile market. No longer was the customer faced with a small 2-tone screen or at most a 3 x 3cm colour screen. This decade has seen the birth of the smartphone with Blackberry, Apple, Samsung and Nokia battling it out in the marketplace for the share of a burgeoning market. Phones have developed with a number of different operating systems such as Symbian now fading away to be replaced by proprietary systems offered by Apple and Blackberry with Samsung and others plumping for Android and Nokia opting for Windows 8. In parallel with this smartphone explosion, we have seen apps developers coming up with brand new programmes that we didn't think we would need but we now can't do without. Bus map timetables, National Rail, Facebook, Twitter, BBC - you can all name your favourites. All for a bundled package of about £20-30 per month. A far cry from the £25 and 25p tariff of 1985! No wonder 43% of all new phones sold or rented in the UK currently are smartphones. The sheer scale and choice just shows how a truly competitive market can work.

4G AND BEYOND

What does the future hold for mobile communication - and in particular mobile broadband (as that is where the action now is and will continue to be in the future)? The next round of spectrum auctions is scheduled for 4th quarter 2012 after a two year delay. Without taking sides, this is the most complicated auction the UK regulator, Ofcom, has attempted, as it has been subject to numerous legal challenges which are partly the reason for the delay. The spectrum at 800 and 2.6GHz will be packaged and, assuming the auction goes ahead, we expect to see the 4G networks rolling out in 2015. These will offer more and higher capacity which will be required to do more of the heavy lifting as mobile becomes the broadband delivery vehicle of choice for the young.

SOCIETAL IMPACT

It is quite clear that mobile communication has changed the way people live and work. No longer are people tied to the house or the work place but are free to conduct their lives where ever they want. In fact many people would find it impossible to have their current life style without the mobile phone. This ranges from the single

parent juggling child care and their job to the sales executive who is constantly in touch with their customers all over the world. In Africa for example the mobile is becoming all-pervasive, more so than TV, and is used for communication between the young, for farmers to check on crop prices to optimise harvesting time, to use for micro payments where banks are scarce.

The young too are dependent on their phones and many say it is the device they could least do without.

There are, of course, many benefits- especially with the number of apps available on smartphones. Many of us have apps which add value to our lives and couldn't imagine how we ever did without mobile communications. Banking and shopping using a mobile device is increasing and is set to take over from the laptop over the next few years. By the end of this year there will be over 6bn mobile subscriptions worldwide. Ericsson forecasts that mobile subscriptions will reach 9bn in 2017 of which 5bn will be mobile broadband connections. Mobile is scheduled to overtake fixed use by 2014 and this has already happened in the less developed markets.

The other explosion in the mobile communications market that is increasingly being exploited by people is the use of WiFi to complement the use of mobile, either via the home or office broadband or increasingly through public WiFi hotspots. Even as I am writing this, [August 2012] M&S is making WiFi available in stores to allow customers to compare prices and look at what is available or on special offer.

AUTHOR'S CONCLUSIONS

Mobile communications has come a long way since those early paging systems and many of us would have found it impossible to believe just how the market has developed over the last 50 years. The future is impossible to predict but, unless someone invents extra-sensory perception, the mobile market will be more of the same but bigger and better and more innovative. The only constraint in the very long term is the finite availability of spectrum but, although the engineers can't break the laws of physics, there are more techniques being developed all the time that will eke out the spectrum in the future to provide even more capacity.

In this short article it is difficult to do justice to a subject that has radically changed our lives over the last half century and is set to change lives even more in the future. Hopefully the article has given you an insight into the world of mobile communications and what it means for mankind.

ABBREVIATIONS

AMPs	Advance Mobile Phone service	CDMA	Code Division Multiple Access
GSM	Global System for Mobile	ISDN	Integrated Services Digital Network
LTE	Long Term Evolution	PO	Post Office
QAM	Quadrature Amplitude Modulation	SIM	Subscriber Identity Module
TACS	Total Access Communications System	TDMA	Time Division Multiple Access
UMTS	Universal Mobile Telecommunications System		

ABOUT THE AUTHOR

STEPHEN HEARNDEN

Stephen Hearnden has a career spanning over 40 years in the ICT sector. He has recently taken over the role of Director of Technology in October 2012. Before that he joined Intellect in March 2005 as Director of Telecommunications after a successful career as a Telecommunications Consultant. During that period he was an interim CTO for a North American startup company and was Programme Manager for the UMTS Forum. Other roles in the mobile sphere included due diligence and expert witness work. Prior to that, his career in BT was as General Manager of the BT Wireless Futures Team responsible for R&D, collaboration, trials and engagements with start-up companies looking at new technology. Before that he was in a corporate technology role looking at advanced second generation technologies, all third generation mobile technologies and wired and wireless access. During that period he was a member of the BT Wireless and BT Cellnet bid team responsible for technology associated with bids in the UK and other markets around the world. In the early 1990s he was in an operational role in BT Cellnet holding the post of CTO for six years during the rollout of analogue cellular and the start of GSM. He has published a number of articles during his career and has spoken at many conferences around the world. Stephen provides technical support for many of the programmes in Intellect. He is also a Director of the Information and Communications Technology Knowledge Transfer Network and a member of the Board of editors for the Journal of The Institute of Telecommunications Professionals. Stephen received his degree in Electronics in 1971 from the University of Kent following which he joined BT. He is a member of the Institution of Engineering and Technology and a Chartered Engineer.