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Cellular Technology in Emerging Markets

Rauno Granath
Nokia Siemens Networks

Amit Sehgal
Nokia Siemens Networks

Ajay R. Mishra
Nokia Siemens Networks

1.1 Introduction

From the remotest areas of the developing world to the most advanced areas of the developed world, connectivity has become a key issue. How to connect the 'unconnected' is an issue that is facing the governments of most of the developing countries, while mobile operators in advanced countries are looking towards connecting their consumers to enhanced services. While the developing world is trying various advanced technologies, it is not necessarily following the path taken by the developed world. They are trying out various permutations and combinations of technologies to reach their goal to connectivity and profits. In this context, it becomes important to understand the various technologies that would help technologists in the developing world realize their ultimate goal – getting the 'unconnected' connected in the shortest duration of time.

1.2 ICT in Emerging Markets

During year 2009 the global cellular industry was able to celebrate its 4th billionth subscription to its services. By any means this is a staggering figure. It is even more staggering to realize how short a time it has taken to achieve this. It is hard to come up with any other example

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where a new technology has proliferated and diffused throughout the world, to all continents, countries and markets and among all consumer groups, cultures and socio-economic strata. How did this happen? Was it planned and designed into the specifications and implementations of early cellular technologies? It is quite safe to say that the huge success of the most common and used cellular technologies has taken the industry itself by a little bit of surprise. However the global ecosystems around the cellular technologies have not been 'stunned' by the success, rather the growth momentum and positive response have been used as strong levers to develop the next steps in the evolution towards even richer and more penetrated services.

Looking back 20 years, the first cellular or mobile services were clearly created for and targeted to the business segment. The clear value addition was the mobility itself. People who carry out businesses which are not tied to a fixed office desk and location obtained a great productivity boost by being connected all the time. One can think of some other examples where 'freeing people from a fixed place' will bring obvious economic benefits – at the macro level as well as at the individual level. One of these could be by comparing people having watches instead of a 'grandfather's clock' inside a house. Having a 'time with you' greatly enhanced the way one can plan and synchronize interactions with other people.

'Mobility' was the first phase of cellular penetration and while the actual number of users in the first phase was relatively low, it was as important because it demonstrated business viability as well as showing some of the main requirements. As the users were mainly from the business segment their requirements became very apparent in 2nd generation technology specifications and functionalit of the systems. Some of the seeds for future global success can be traced here: international roaming, globally harmonized frequencies allowing use of the same device – or a simpler device, certified interoperability between network and user devices, etc. All of this started to push the industry towards a truly global scale, enabling the immense cost benefits later.

The next phase of rapid penetration took place when individual consumers started to see a similar value in being connected. For the first time the concept of 'affordability' really kicked in. When the overall cost of getting and being connected became low enough compared to the perceived value there was a true mass market adoption – in any given market, throughout the world. One can only conclude that the basic demand – everybody's basic human need to communicate – is very universal.

In many mature markets that phase was reached during the early-2000s. Perhaps it's a better topic for a book about social behaviour but it became increasingly difficult – even impossible to participate the society without being individually connected – all the time. At this phase an additional boost for the mass market came through 'fixed-to-mobile substitution' – people actually gave up, or never subscribed to fixed services any more. It also meant that most households practically had a mobile device for every family member and market penetrations reached close to or above the 100 % mark.

Around the mid-2000s a similar development was already clearly seen in many developing markets as well. Here, the concept of 'affordability' comes out in the clearest way. There are three basic pillars for this which can be illustrated as shown in Figure 1.1.

Liberalization of the whole telecommunications sector – and the resulted regulatory environment – is at least as important an element in overall affordability as any of the technology-derived innovations and business models. This was actually one key element in, for example Western European mobile success. In most countries the telecom infrastructure was regarded as a natural monopoly, among other utilities, due to the costs of building and operating the

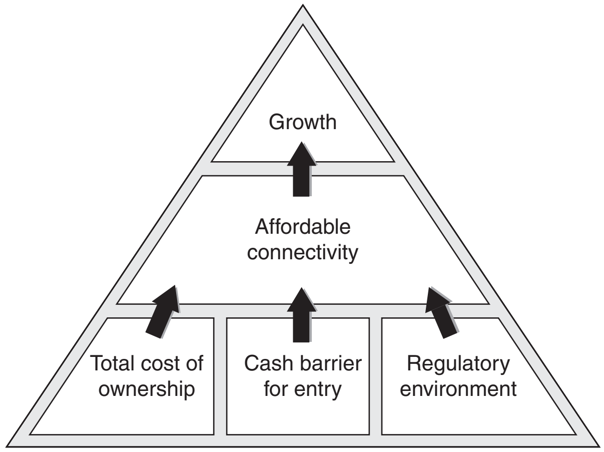

Figure 1.1 The three pillars of telecom development in emerging markets.

fixed telephony networks. In many cases it was a government-owned monopoly, and in some cases partly due to privately and partly government-owned set-ups. With the advent of the first cellular technologies and mobile telephony services the sector was ready for a drastic change. The cost dynamics and advantages of cellular technologies made it feasible to open the sector for competition, overseen by national regulatory bodies. Free competition in a transparent regulation environment is the best mechanism to really push all technological innovations and cost break-throughs to the end consumer.

Nothing highlights this better than an example from Nigeria. During the early part of the 2000s Nigeria licensed its first four mobile operators, three privately owned and one incumbent. In just 18 months the country's telephony penetration doubled (Trends in Telecommunications Reform, ITU, 2003). In other words, the mobile operators were able to provide, in 18 months, as many connections as the government-owned fixed telephony provider from the beginning of the country's independence!

Whereas regulatory environment is more of the industry topic in each country the other two elements of affordability are very much user- or consumer-centric. Cost, or rather the Total Cost of Ownership (TCO), is the obvious one. The TCO includes all the costs that it takes to get and stay connected: the cost of the handset, the cost of the subscription and the ongoing cost of the service itself. All of these typically also include government taxes. Technology innovations and a massive global scale have greatly reduced the TCO over the last few years.

Another important element is 'Cash', that is how do people finance the consumption of the service. One of the great business model innovations stemming from developing markets is the pre-paid model where services can be consumed in very small increments – matching the daily cash situation of particularly low-income segments.

Playing with the two aforementioned aspects – the universal human need to communicate and the concept of affordability being the main drivers for penetration – it is easy to model and understand the huge global success of mobile telephony services. Modelling with the well known 'income pyramid' one can readily see that each step downwards in 'affordability' brings in a larger potential customer segment (Figure 1.2).

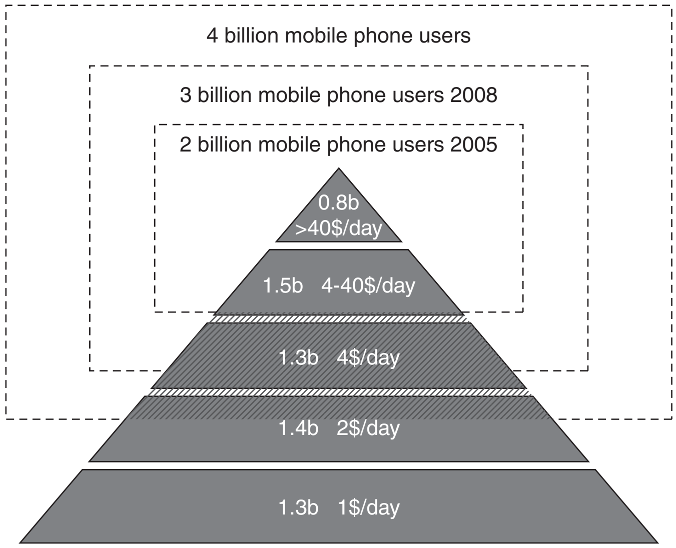

Figure 1.2 World population split according to income segment (USD/ capita/day).

The rapid development of connectivity through mobile technologies in developing countries throughout the 2000s was early on identified as one true opportunity to bridge the 'digital divide'. In fact, advancing the benefits of ICT technologies was adopted as one of the UN Millennium Development Goals.

Several international studies have come up with clear evidence between the mobile phone penetration and macroeconomic development. In a typical emerging market, an increase of 10 mobile phones per 100 people boosts the GDP growth by 0.6 percentage points (Vodafone policy paper, 2005). A 2006 study by McKinsey and Company (in cooperation with the GSMA) found that the indirect impact of mobile phone penetration is at least three times as great. In addition, the latest study by the World Bank (Quian, 2009) comes up with the figure of a 0.81 percentage GDP boost for low- and middle-income economies.

Lately, the focus of research has been in broadband, instead of pure voice services. The same World Bank study shows clearly that the 0.81 %-unit boost will increase to 1.12 with usage of the Internet and all the way up to 1.38 %-units in the case of broadband connectivity for the services and the Internet.

While the basic mobile connectivity continue to increase beyond the 4B mark it is now important to have a similar advance in broadband connections. Interestingly, very similar mechanisms and market behaviour seem to have now taken place in mature markets that led to the massive increase of mobile voice services 10 years ago. Mobile broadband services have become affordable – in terms of cost, cash and regulatory environment – so that there is a 'fixed-to-mobile' substitution going on in many markets. The industry has come up with the necessary technology (speed, latency and end-user devices) and business models (flat rate pricing) enabling rapid consumer acceptance. Several new services – like social networking – are once again extending the social dimension to the picture. People want to get into their services independent of the place and time.

While the technology can't provide all the answers to unlock the potential of broadband in developing markets, it surely has a key role as well. The industry knows what it takes to give broadband connectivity a similar success in all parts of the world – and for all people. Affordability and access, relevant services for people to enhance their business, social or personal interests will truly make the whole ICT as 'the biggest democratizer of opportunities ever seen'.

1.3 Cellular Technologies

Mobile operators use the radio spectrum to provide their services. Spectrum is a scarce resource and has been allocated as such. It has traditionally been shared by a number of industries, including broadcasting, mobile communications and the military. Before the advent of cellular technology, the capacity was enhanced through a division of frequencies and the resulting addition of available channels. However, this reduced the total bandwidth available to each user, affecting the quality of service. Introduced in the 1970s, cellular technology allowed for the division of geographical areas (into cells), rather than frequencies, leading to a more efficient use of the radio spectrum. Figure 1.3 details the evolution of cellular technologies and the dominant ones at the present time and for the coming years.

Based on usability, cost and quality and quantity of services etc, the evolution of cellular technology has been divided into generations.

1.3.1 First Generation System

Also referred to as 1G, this period was characterized by analogue telecommunication standards and supported basic voice services. The development started in the late 1970s with Japan taking a lead in deployment of the first cellular network in Tokyo, followed by the deployment

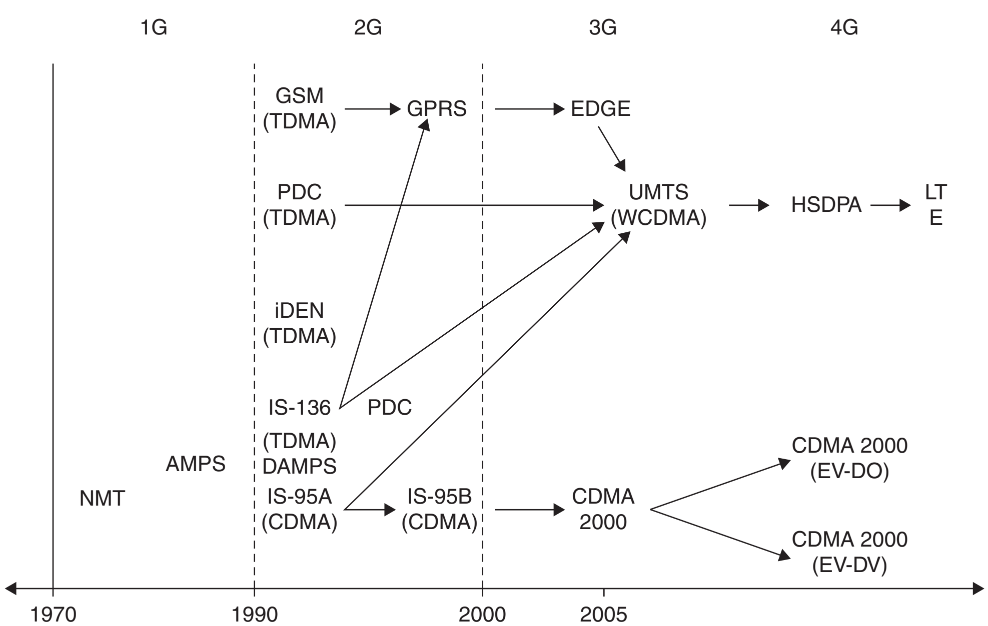

Figure 1.3 Evolution of cellular technology.

of NMTs (Nordic Mobile Telephones) in Europe, while the 'Americas' deployed AMPS (Advanced Mobile Phone Service) technology.

Each of these networks implemented their own standards – with features such as roaming between continents non-existent. This technology also had an inherent limitation in terms of channels, etc. The handsets in this technology were quite expensive (more than $1000).

1.3.2 Second Generation System

As we have seen above, the various systems were incompatible with each other. Due to this, work towards development of the next technology was implemented that would lead to a more harmonized environment. Such work was commissioned by the European Commission and resulted, in the early-1990s, in the next generation technology known as the 'Second Generation Mobile Systems', which were also digital systems as compared to the first generation's analogue technology. Key 2G systems in these generations included GSMs (Global Systems for Mobile Communications), TDMA IS-136, CDMA IS-95, PDC (Personal Digital Cellular) and PHSs (Personal Handy Phone Systems).

IS 54 and IS 136 (where IS stands for Interim Standard) are the second generation mobile systems that constitute D-AMPS. IS-136 added a number of features to the original IS-54 specification, including text messaging, circuit-switched data (CSD) and an improved compression protocol. CDMA has many variants in the cellular market. CDMAone (IS-95) is a second-generation system that offered advantages such as increase in coverage, capacity (almost 10 times that of AMPS), quality, an improved security system, etc.

GSM was first developed in the 1980s. It was decided to build a digital system based on a narrowband TDMA solution and having a modulation scheme known as GMSK. The technical fundamentals were ready by 1987 and the first specifications by 1990. By 1991, GSM was the first commercially operated digital cellular system with Radiolinja in Finland. With features such as pre-paid calling, international roaming, etc., GSM is by far the most popular and widely implemented cellular system with more than a billion people using the system (by 2005).

1.3.3 Third Generation System

This improvement in data speed continued and as faster and higher quality networks started supporting better services like video calling, video streaming, mobile gaming and fast Internet browsing, it resulted in the introduction of the 3rd generation mobile telecommunication standard (UMTS). These third generation cellular networks were developed to offer high speed data and multimedia connectivity to subscribers. Under the initiative IMT-2000, ITU has defined 3G systems as being capable of supporting high-speed data ranges of 144 kbps to greater than 2Mbps.

The Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) mobile phone technologies. It uses W-CDMA as the underlying standard. This was developed by NTT DoCoMo as the air interface for their 3G network FOMA. Later, ITU accepted W-CDMA as the air-interface technology for UMTS and made it a part of the IMT-2000 family of 3G standards.

CDMA2000 has variants such as 1X, 1XEV-DO, 1XEV-DV and 3X. The 1XEV specification was developed by the Third Generation Partnership Project 2 (3GPP2), a partnership consisting of five telecommunications standards bodies: CWTS in China, ARIB and TTC in Japan, TTA in Korea and TIA in North America.

1.3.4 Fourth Generation System

In the 18th TG-8/1 in 1999, a new working group WP8F was established for looking into the efforts to develop the systems beyond the IMT-2000. As IMT-2000 was not able to solve the problems related to higher data rates and capacity, next generation systems (also called as 4G) development was give that mandate. A 4G system will be a complete replacement for current networks and be able to provide a comprehensive and secure IP solution where voice, data, and streamed multimedia can be given to users on an 'Anytime, Anywhere' basis, and at much higher data rates than previous generations. Some features of 4G include the following:

- The intention of providing high-quality video services leading to data-transfer speeds of about 100 Mbps.
- The 4G technology offers transmission speeds of more than 20 Mbps.
- It will be possible to roam between different networks and different technologies.
- 4G basically resemble a conglomeration of existing technologies and is a convergence of more than one technology.

1.4 Overview of Some Key Technologies

Let us now have a look at the some of the key technologies.

1.4.1 GSM

GSMs (Global Systems for Mobile Communications) was the first commercially operated digital cellular system. Developed in the 1980s through a pan-European initiative, The European Telecommunications Standards Institute (ETSI) was responsible for GSM standardization.

Today it is the most popular cellular technology. By mid-2009, GSMs have a user base of over 3.9 billion in more than 219 countries and territories worldwide; with a market share of more than 89 % (the global wireless market is more than 4.3 billion). In addition, GSM has the widest spectral flexibility for any wireless technology – 450, 850, 900, 1800 and 1900 MHz bands; tri- and quad-band GSM phones are common. Thus it is rare that users will ever travel to an area without at least one GSM network to which they can connect.

GSM uses TDMA (Time Division Multiple Access) technology and is the legacy network leading to the third-generation (3G) technologies, the Universal Mobile Telecommunication System (UMTS) (also known as WCDMA) and High Speed Packet Access (HSPA). GSM differs from its predecessors in that both signalling and speech channels are digital and thus is considered a second generation (2G) mobile phone system.

GSM is a very secure network. All communications (voice and data) are encrypted to prevent eavesdropping. GSM subscribers are identified by their Subscriber Identity Module (SIM) card. This holds their identity number and authentication key and algorithm. Thus it's the card rather than the terminal that enables network access, feature access and billing.

1.4.2 EGPRS

Enhanced GPRS (EGPRS) is another 3G technology that allows improved data transmission rates. Here EDGE ('Enhanced Data Rates for GSM Evolution' – a new radio interface technology with enhanced modulation) is introduced on top of the GPRS and is used to transfer data in a packet-switched mode on several time slots, as an extension on top of the standard GSM. This leads to almost an increase in data rates of almost three-fold.

The major advantage of EDGE is that it does not require any hardware or software changes in the GSM core networks. No new spectrum is required and thus EDGE can effectively be launched under the existing GSM license. WCDMA (including HSPA) and EDGE systems are complimentary. There is a wide range of EDGE capable user devices in the market, including USB modems, modules for PCs, phones, routers, etc.

EDGE was first deployed by Cingular (now AT&T) in the United States in 2003. By mid-2009 there were more than 440 GSM/EDGE networks in 181 countries, from a total of 478 mobile network operator commitments in 184 countries.

1.4.3 UMTS

The Universal Mobile Telecommunications System (UMTS) is a voice and high-speed data technology that is 'part' third-generation (3G) wireless standards. Wideband CDMA (WCDMA) is the radio technology used in UMTS. Furthermore, UMTS borrows and builds upon concepts from GSM and most UMTS handsets also support GSM, allowing seamless dual-mode operation. Therefore, UMTS is also marketed as 3GSM. UMTS is based on Internet Protocol (IP) technology with user-achievable peak data rates of 350 kbps.

UMTS builds on GSM and its main benefits include high spectral efficiency for voice and data, simultaneous voice and data for users, high user densities supportable with low infrastructure costs, high-bandwidth data applications support and migration path to VoIP in future. Operators can also use their entire available spectrum for both voice and high-speed data services.

UMTS has been in commercial usage since 2001, in Japan. As of April 2009, it was available with 282 operators in more than 123 countries and enjoyed a subscriber base of 330 million.

As for GSM, UMTS can also work over a wide range of spectrum bands – 850, 900, 1700, 1800, 1900, 2100 and 2600 MHz bands (450 MHz and 700 MHz are expected to be added soon). Thus transparent global roaming is an important aspect of UMTS. Also, UMTS operators can use a common core network that supports multiple radio-access networks, including GSM, EDGE, WCDMA, HSPA, etc. This is called the UMTS multi-radio network (shown in Figure 1.4) and provides great flexibility to operators.

UMTS networks can be upgraded with High-Speed Downlink Packet Access (HSDPA), sometimes known as 3.5G. Currently, HSDPA enables downlink transfer speeds of up to 21 Mbs.

1.4.4 CDMA

Code Division Multiple Access (CDMA) was originally known as IS-95. It is the major competing technology to GSM. There are now different variations, but the original CDMA is now known as cdmaOne.

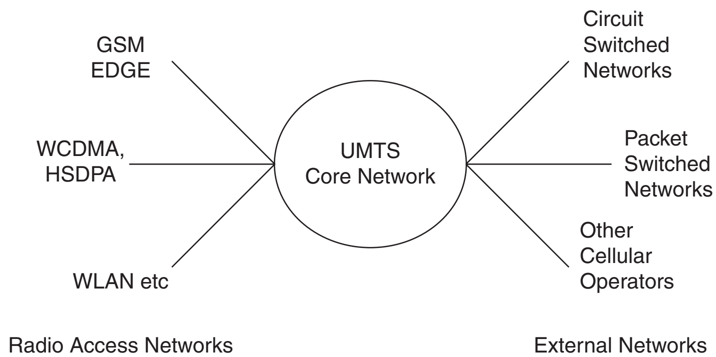

Figure 1.4 UTMS multiradio network.

Currently there is cdma2000 and its variants like 1X EV, 1XEV-DO and MC 3X. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800-MHz and 1.9-GHz bands. CDMA employs spread-spectrum technology along with a special coding scheme and is characterized by high capacity and a small cell radius.

CDMA was originally developed by Qualcomm and enhanced by Ericsson. However, QUALCOMM still owns a substantial portfolio of CDMA patents, including many patents that are necessary for the deployment of any proposed 3G CDMA system. It has now been granted royalty-bearing licenses to more than 75 manufacturers for CDMA and, as part of these licenses, has transferred technology and 'know-how' in assisting these companies to develop and deploy CDMA products.

CDMA was adopted by the Telecommunications Industry Association (TIA) in 1993. In September 1998, only three years after the first commercial deployment, there were 16 million subscribers on cdmaOne systems worldwide. By mid-2009, there were around 500 million subscribers on CDMA (including variants).

Another variant of CDMA is TDS-CDMA. Time Division Synchronous Code Division Multiple Access (TD-SCDMA) or UTRA/UMTS-TDD, also known as UMTS-TDD or IMT 2000 Time-Division, is an alternative to W-CDMA. Although the name gives an impression of simply a channel access method based on CDMA, its applicability is to the whole-air interface specification.

The technology is promoted by the China Wireless Telecommunication Standards group (CWTS) and was approved by the ITU in 1999. It is being developed by the Chinese Academy of Telecommunications Technology, Datang, and Siemens AG, and is China's country's standard of 3G mobile telecommunication. However, it is expected to remain as a niche market technology as it lacks a large ecosystem and would muster limited research and development. In addition, necessary competition and economies of scale to reduce investments and generate demand might be missing, besides the fact that its delayed arrival has given rival 3G technologies a good head start. TD-SCDMA came under spotlight as one of the technologies used in the 2008 Olympics at Beijing, China.

1.4.5 HSPA

High Speed Packet Access (HSPA) is a collection of two mobile telephony protocols, namely High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access

(HSUPA). It is basically an extension/improvement of the performance of existing WCDMA protocols. HSPA improves the end-user experience by increasing peak data rates up to 14 Mbps in the downlink and 5.8 Mbps in the uplink, according to network and user device capabilities.

Mobile broadband is a key part of the commercial offering of most mobile network operators today and the strong market uptake which has been seen in every market is boosting revenues and profits. The path to mobile broadband began with WCDMA and has grown globally with HSPA to boost capacity and user data speeds. Several operators have positioned HSPA as an alternative to fixed broadband, with the added value of mobility.

HSPA has been commercially deployed by over 270 operators in more than 110 countries, as of 2009. Data traffic and revenues are growing strongly with HSPA. According to GSA surveys of the mobile broadband market, WCDMA has a 72 % market share of commercial 3G networks. More than 90 % of the 275 commercial WCDMA network operators have launched HSPA.

1.4.6 LTE

LTE (Long Term Evolution) is marked as the 4th generation of mobile technology designed to provide uplink peak rates of at least 50 Mbps and downlink peak rates of at least 100 Mbps. The specifications support both Frequency Division Duplexing and Time Division Duplexing. Designed as a flat IP-based network architecture it can replace the GPRS Core Network and ensure support for, and mobility between, some legacy or non-3GPP systems such as GPRS and WiMax.

LTE has been designed to offer 'rich' broadband user experience and will further enhance mobile value-added services and applications supporting banking, gaming, health categories, etc. Even experience with more demanding applications such as interactive TV, mobile video blogging, advanced games, etc will also be significantly improved.

The main advantages with LTE are high throughput, low latency, 'plug-and-play', besides improved end-user experience and simple architecture resulting in low-operating expenditures. LTE will also support seamless integration with older network technologies, such as GSM, CDMA, UMTS and CDMA2000. LTE is the natural migration choice for GSM/HSPA operators. LTE is also the next generation mobile broadband system of choice of leading CDMA operators, who are expected to be in the forefront of service introduction.

With over 39 LTE commitments in 19 countries, at least 14 networks are expected to be commercially deployed by 2010. It is expected that there will be nearly 34 million users worldwide by 2010 that are expected to reach 400–450 million users by 2015. Some of the first operators intending to deploy LTE include Verizon Wireless, MetroPCS Wireless and US Cellular in the United States, NTT-DOCOMO and KDDI in Japan, TeliaSonera, Tele2 and Telenor in Europe, China Mobile in China, and KT and SK Telecom in Korea, in 2010.

1.4.7 OFDM

OFDM (Orthogonal Frequencies Division Multiplexing) is a broadband technique like CDMA. In this, instead of modulating a single carrier as is the case with FM or AM, a number of carriers are spread regularly over a frequency band. Orthogonal FDMs (OFDM) spread-spectrum techniques distribute the data over a large number of carriers that are spaced apart at precise frequencies. This spacing provides the 'orthogonality' in this technique which prevents the demodulators from seeing frequencies other than their own.

OFDM has been successfully used in DAB and DVB systems. For DAB, OFDM forms the basis for the Digital Audio Broadcasting (DAB) standard in the European market. For ADSL, OFDM forms the basis for the global ADSL (Asymmetric Digital Subscriber Line) standard. For Wireless Local Area Networks, development is ongoing for wireless point-to-point and point-to-multipoint configurations using OFDM technology. In a supplement to the IEEE 802.11 standard, the IEEE 802.11 Working Group published IEEE 802.11a (details of these standards are described later in Chapter 7 of this book) which outlines the use of OFDM in the 5.8 GHz band. This technology is starting to play an important role in development of fourth-generation networks.

1.4.8 All IP Networks

NGNs (Next-Generation Networks) are 'packet-based' networks, based upon Internet Protocol. Complementary to LTE, another project under development at 3GPP is SAE (System Architecture Evolution). While LTE aims at an evolved radio access network, SAE deals with core network, with a focus on packet domain. Thus the developments of the 3GPP system are compliant with Internet protocols. It is an evolution of the 3GPP system to meet the growing demands of the mobile telecommunications market and is designed to make use of multiple broadband technologies and other 'Quality of Service'-enabled transport technologies where service-related functions are independent from underlying transport-related technologies. This will ensure generalized mobility which will allow consistent and ubiquitous provision of services to users, besides the capability to deliver telephony, television, data and a host of other services at lower marginal cost then the current networks. In 2004, 3GPP proposed IP as the future for next-generation networks and began feasibility studies into All IP Networks (AIPNs).

1.4.9 Broadband Wireless Access

Broadband wireless technologies have opened up possibilities of high-speed, affordable Internet access anywhere and at any time. Although this technology has been available for quite some time, however, 'islands' of proprietary deployment has significantly increased the cost of service and hindered its global expansion. Around about 2003, broadband wireless began to emerge as the key to resolving connectivity bottlenecks. A typical BWA spectrum in shown in Figure 1.5.

Several governments started appreciating the importance of broadband connectivity for social, economic and educational development. They started initiatives to support sustainable broadband services in various regions. Meanwhile, standardization bodies such as IEEE and ITU also started work towards standardization of technologies and harmonization of regulatory frameworks worldwide.

Some key technologies that fall under BWA are described in the following sections.

1.4.9.1 WiMAX

WiMAX stands for 'Worldwide Interoperability for Microwave Access'. It was developed by the WiMAX Forum; formed in June 2001 to promote conformity and interoperability of

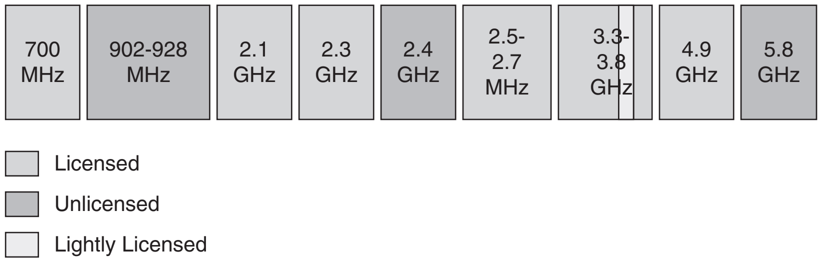

Figure 1.5 Broadband wireless spectrum.

the standard. WiMax was designed as an alternative to cable and DSL, to enable the 'last-mile delivery' of wireless broadband access and has been considered as a wireless 'backhaul technology' for 2G, 3G and 4G networks. However, it is also a possible replacement candidate for other telecommunication technologies such as GSM and CDMA, and can also be used as an overlay to increase capacity.

WiMAX's main competition comes from existing and widely deployed wireless systems such as UMTS and CDMA2000. Also, 3G/LTE technologies are being touted as 'WiMax killers'. By 2008, WiMax had a subscriber base of more than 2.5 million with 450 WiMAX networks deployed in over 130 countries.

1.4.9.2 Wi-Fi

Wi-Fi stands for 'Wireless Fidelity'. With Wi-Fi, it is possible to create high-speed wireless local area networks, provided that the computer to be connected is not too far from the access point. In practice, Wi-Fi can be used to provide high-speed connections (11 Mbps or greater) to laptop computers, desktop computers, personal digital assistants (PDAs) and any other devices located within a radius of several dozen metres indoors (in general, 20–50 m away) or within several hundred metres outdoors.

1.4.9.3 Wireless LAN

WLAN (Wireless Local Area Network) is commonly known as Wireless LAN. Generally it is understood as being the technology which links two or more computers or devices without using wires. WLAN uses spread-spectrum or OFDM modulation technology based on radio waves to enable communication between devices in a limited area. In WLAN, users get the ability to be connected to a network while still be able to move around within a broad coverage area.

1.4.10 IMS

The IP Multimedia Subsystem (IMS) is an IP-based architectural framework for delivering voice and multimedia services. The specifications have been defined by the 3rd Generation Partnership Project (3GPP). This is based on the IETF Internet protocols and is 'access-independent'. It supports IP to IP sessions over 802.11, 802.15, wireline, CDMA, GSM, EGPRS, UMTS and other packet data applications.

IMS intends to make Internet technologies, such as web browsing, instant messaging, e-mail, etc, in addition to services such as WAP and MMS, ubiquitous. IMS is expected to lead to new business models and opportunities.

IMS has given the operators and service providers with the power to control and charge for the services they have provided. Some of the key services involve multi-media messaging services (MMSs), ‘Push-to-talk’, etc. There are ‘Capex’ and ‘Opex’ savings when using the converged IP backbone and open IMS architectures. There are also some hidden advantages such as usage of standardized interfaces which would prevent operators from being ‘bounded’ by single supplier’s proprietary interfaces and the existing infrastructure can be used to create new services.

1.4.11 UMA

Unlicensed Mobile Access (UMA) is the commercial name of the 3GPP Generic Access Network (GAN) standard. This technology provides access to GSM and GPRS mobile services over unlicensed wireless networks such as Bluetooth and 802.11.

This technology enables its users to roam and handover between cellular networks and wireless LANs/WANs using dual-mode (GSM/Wi-Fi) mobile handsets, ensuring a consistent user experience for their mobile voice and data services. This is akin to convergence between mobile, fixed line and Internet telephony.

The fundamental idea behind UMA was to provide a high bandwidth and low-cost wireless access network integrated into operator cellular network. Features such as seamless continuity and roaming were a part of this. This led to development of the UMAC (Unlicensed Mobile Access Consortium0 that promoted the UMA technology. UMAC worked with the 3GPP and the first set of specifications appeared in 2004. 3GPP was defined by the UMA as a part of the ‘3GPP Release 6’ (3GPP TS 43.318) under the name of GAN (Generic Access Network)

1.4.12 DVB-H

Digital Video Broadcasting (DVB) is a suite of internationally accepted open standards for digital television. This standard is led by a consortium of over 270 broadcasters, manufacturers, network operators, software developers, regulatory bodies and others in over 35 countries. It is intended as an open technical standard for the global delivery of digital television and data services. Services on this standard are currently available on every continent with more than 220 million DVB receivers deployed.

The concept of providing television on handheld devices led to the development of DVB technology for handheld or DVB-H. The Digital Video Broadcast (DVB) Project started research work related to mobile reception of DVB-Terrestrial (DVB-T) signals as early as 1998, accompanying the introduction of commercial terrestrial digital TV services in Europe. The EU sponsored projects, such as ‘Motivate’ and the ‘Media Car platform’ came up with various conclusions, for example transmissions possible on DVB-T networks, but more robustness needed and the addition of spatial diversity increases the reception performance which helped in the development of mobile TVs. In the year 2002, work started in the DVB Project to define a set of commercial requirements for a system supporting handheld devices. The technical work then led to a system called Digital Video Broadcasting-Handheld (DVB-H), which was published as a European Telecommunications Standards Institute (ETSI) Standard EN 302 304 in November 2004.

1.5 Future Direction

Radio technology and standards are still very much in an active development phase. Researchers are continuously coming up with advancements for optimally using the spectrum and in ways which are cost-efficient as well. Complex signals processing mathematics are employed to reconstruct a data stream from an encoded radio wave. With processing powers becoming cheaper, more complex algorithms can be used to improve performance. While there are theoretical limits to such improvements, it is still a long way off.

Similarly, work is ongoing to provide better user experience, for example if the same handset can work with multiple standards then it can be used as an extension within small premises and used as an handset when the person leaves the building.

Thus it is certain that in the coming years, radio technology will become more digital and smarter. It is then up to regulators and technologists as to how this advancement will be encapsulated within the existing and future regulatory and deployment frameworks.