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FOREWORD

This paper was presented to the Working Party on Telecommunications and Information Services Policy (TISP) in December 2003. It was declassified by the Committee for Information, Computer and Communications Policy at its meeting in April 2004.

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DEVELOPMENT OF THIRD-GENERATION MOBILE SERVICES IN THE OECD

MAIN POINTS

The commercialisation of Third Generation (3G) mobile services in the OECD has been delayed for a number of reasons. These include the delay in delivery of 3G terminal equipment, other technological problems and the financial crises affecting the telecommunications industry. However, during 2003 commercialisation of 3G services began to accelerate in a number of OECD countries. The fact that some mobile operators in OECD countries, such as in Japan and Korea, acquired more than 13 million and 18 million 3G subscribers respectively within a relatively short period is evidence of this trend. As 3G deployment continues at a rapid pace in many OECD countries, it is expected that 3G will become a major force of mobile communications within a couple of years. The 3G platform provides converged voice, data, Internet and multimedia services supported by a high data rate. The benefits of 3G services are based on the following features:

- High data rates of at least 128 Kbps in motion and 2 Mbps or more with low mobility.
- Packet-switched-based services enabling broadband audio-visual services.
- Improved spectrum efficiency with greater capacity.
- Expected global roaming across different 3G operational environments.

Governments played a role in the migration to 3G technologies. This role included government involvement to various degrees in the standardisation process, in spectrum allocation through World Radiocommunication Conferences under the auspices of the ITU, and in a number of countries the launch of 3G services was determined through spectrum licensing processes which set target dates for the launch of services. Several governments, such as the United States, Canada, Japan and Korea, have permitted spectrum flexibility and allow existing operators to deploy whatever technology they want in their existing bands. This flexibility has led to some of the first introductions of 3G in the marketplace. However, the investment in and implementation of 3G networks and services has been led by the industry.

Some important recent developments in telecommunications may have implications for data and multimedia communications and therefore for 3G services:

- Growing popularity and importance of broadband Internet access.
- Convergence of telecommunications and broadcasting services resulting in multimedia applications via mobile.
- Development of Internet Protocol (IP) technologies as a strategic element in the design and use of telecommunications networks.
- Development of other wireless technologies such as wireless LANs and Bluetooth.

In support of market-led progress, policy makers in OECD countries have acted to facilitate the development of 3G services in recent years. For example most countries, with a few exceptions such as Iceland, have allocated appropriate spectrum to 3G operators by giving licenses. Some regulators have also allowed infrastructure sharing among 3G operators for a number of reasons, including reducing network investment costs, reducing the environmental impact of antennae sites, and to facilitate new

entrants by providing access to existing antennae sites. Regulators are also trying to ensure that any infrastructure sharing does not have adverse competition implications. There are also some countries that are attempting to authorise trading of 3G licensed spectrum. The new regulatory framework in the European Union which came into force in July 2003 has opened the way for all EU member states to allow spectrum trading if they choose to do so.

Despite these developments, the 3G market at present is far from mature in many OECD countries and hence it is difficult to predict its continued rapid growth. There are a number of negative aspects, noted below, which may impact on initial 3G market developments, although some of them might be normal characteristics of an emerging market.

- High licence costs as well as acquisition costs have impacted on the 3G business model of some operators.
- The market demand for 3G applications is difficult to predict at present.
- Initially, handset shortages and software problems in some 3G technologies slowed the deployment of 3G networks.
- Voice call handovers between 3G and older networks are still not smooth in some 3G technologies.
- There is uncertainty in pricing, particularly for access to broadband audio-visual services (multi-media content).
- The possible commercialisation of mobile systems beyond 3G is viewed by some market players as arriving earlier than expected, with consequent impacts on 3G technologies.

The impact of 3G development can also be highlighted by comparing with other wireless technologies, in particular with second-generation (2G) mobile and wireless LANs:

- Pricing of 2G and 3G are interrelated and competitive, particularly for voice calls, and this may place pressure to reduce overall mobile tariffs.
- The variety of 3G applications is increasing, and many of these applications cannot be provided by 2G, this will result in a clear market distinction between 2G and 3G, and will strengthen the position of 3G.
- While 3G operators need a spectrum licence to provide services, wireless LAN providers use unlicensed radio spectrum**,** although a telecommunications license may still be required.
- Recent technological developments seem to be creating complementarities between 3G and wireless LANs.

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I. INTRODUCTION

This paper analyses the development of third-generation mobile services (3G) in OECD countries. A brief description of the definition of 3G and its migration path is followed by an analysis of the benefits and shortcomings of 3G services. The paper further examines regulatory issues raised by 3G development and recent market developments including pricing issues. Finally, the paper undertakes a comparative analysis of 3G with wireless LANs and other alternative wireless technologies.

Mobile telephony has made dramatic progress among OECD countries in recent years. There were only 15 million mobile subscribers in the OECD area at the end of 1991; years later there are more than 600 million.[1] According to the ITU (International Telecommunication Union), the number of mobile subscribers surpassed that of fixed telephone worldwide in March 2000. Although there were only 1.4 million mobile subscribers in comparison with 410 million fixed telephone subscribers in 1986, there were about 1.14 billion mobile subscribers in comparison with 1.10 billion fixed line subscribers in 2002.[2] An estimate also shows that between 20% and 40% of voice traffic originates on mobile networks and wireless revenue will soon overtake the total fixed switched-access market in Europe.[3]

It is particularly salient that the mobile industry started to deliver services that provide broadband applications in recent years. The growth in broadband Internet penetration has added momentum to the use of advanced mobile systems. OECD data show that there were 75 million broadband subscribers as of June 2003. In some OECD countries, a large number of Internet users have adopted broadband Internet access. In Korea, for example, broadband subscribers represent 94% of total Internet subscribers. In line with this growth, mobile (or wireless) broadband Internet access has become a key economic component for OECD countries to drive the next wave of broadband. In addition, convergence of telecommunications and broadcasting services to create multimedia applications, which have affinity with advanced mobile systems, has seemingly accelerated the technological developments in the mobile industry.

3G mobile technology can provide not only voice and data but also video, music, and other broadband audio-visual services.[4] An estimate shows that the value of such "professional" mobile services will grow from USD 3 billion in 2002 to USD 30 billion in 2006.[5] Although second-generation (2G) systems also have large numbers of subscribers, the data rates transmitted by 2G systems are very limited. The 3G mobile systems have been developed to support a higher data rate than traditional mobile systems and to allow for video calling, broadband services and location-based services to a high degree of accuracy. An estimate predicts that the 3G market will reach USD 40 billion by 2005.[6] It appears that 3G is on the threshold of changing the landscape of wireless communications. Accordingly, operators are determined to create more user dependence on 3G mobiles by personalised applications as well as tariff packages to spur more business and private use of 3G.

At present those OECD countries that have commercialised 3G services are still in the minority, although about a third of them have already started commercial services. Even in those countries that have commercialised 3G services, the development is limited in terms of coverage and the number of subscribers. This initial slow progress was due to a number of problems such as the lack of handsets, technical glitches, and undeveloped business models. Nevertheless, in many countries where operators were permitted to migrate their 2G systems to 3G, deployments of 3G systems have attracted a large number of subscribers. Some sources report that there are more than 94 million 3G subscribers worldwide, and the number might be underestimated as many operators have not yet publicly reported their subscriber data.[7] Worldwide there are currently more than 480 models of 3G terminal devices with 3G systems in 40 countries.

II. OVERVIEW OF 3G

The second generation of mobile phones (2G) appeared in the early to mid-1990s as a variety of digital technologies. Most 2G standards are based on circuit-switched technology, and they have provided the mobile telecommunications industry with an exponential growth in terms of the numbers of subscribers as well as new types of services.

Some 2G services used a CDMA (Code Division Multiple Access) technology known as cdmaOne, standardised in the United States as IS-95.[8] CDMA is a digital wireless technology that allows multiple users to share radio frequencies simultaneously without interfering with each other. With this technology, a voice or data call is assigned a unique code that distinguishes it from others and all of the signals hop and spread over a shared frequency band. As stated later, most of the new 3G services also include technologies based on CDMA technologies. CDMA systems have been implemented in about 63 countries and served an estimated 202 million subscribers according to the CDMA Development Group (CDG).[9]

At the same time, the TDMA (Time Division Multiple Access) standard, originally known as IS-54 (EIA/TIA/IS-54, superseded by EIA/TIA/IS-54-B and C), was developed in a number of countries such as the United States, although several other technologies were also developed simultaneously. This technology provides each call with a time slot in order to allow several calls to be contained in one channel. Since TDMA can allot six time slots to each channel, it has a capacity to deliver up to six times as much information in the same bandwidth as a single analogue, first-generation AMPS channel. The TDMA system served 113 million users at the end of 2003, according to the GSM Association.

The Global System for Mobile (GSM), operating in the 900 and 1 800 MHz bands, was adopted throughout Europe and in other parts of the world including the United States. It is a combination of Frequency Division Multiple Access (FDMA) and TDMA and has become the most widely deployed 2G technology. With this technology, the signals of eight calls are multiplexed in time over a single channel. Japan developed a different standard called Personal Digital Cellular (PDC), operating in the 800 and 1 500 MHz, based on TDMA technology. In the United States, the government did not select a single standard for 2G and allowed operators to choose from a variety of standard**s**. According to the GSM association, GSM systems have been implemented in 208 countries/areas and serve more than 1 billion subscribers as of February 2004.[10]

Between the different 2G standards there has been little or no roaming capability, although in recent years the availability of tri-standard terminals has grown.[11] For example, it is difficult to make a direct call from a GSM to a CDMA terminal because it has to go through a PSTN network.

Mobile technology upgrades have made 2G services appear to users like 3G services, even though their features do not reach the level of 3G technology. This upgraded technology is sometimes termed '2.5G' by some industry analysts, but there is no agreed-upon definition of what constitutes 2.5G technologies. A main advantage for this category of technologies would be 'always-on' capability for Internet access, which has provided a great deal of infrastructure efficiency as well as improvements in service delivery. Many operators are deploying services with these technologies instead of waiting for 3G since they are capable of delivering many of the 3G services with higher speeds than 2G. However, increasing numbers of operators are preparing their transition towards 3G technology.

This technological category is quite varied. One of the most popular technologies used would be General Packet Radio Service (GPRS), although some may characterise it as 2G technology because it had been used in 2G networks prior to the time that the term 2.5G came into widespread use. The following box summarises the details of each technology.

Box 1: Examples of intermediate technologies between 2G and 3G

HSCSD (High-speed Circuit Switched Data)

This is the first enhancement to GSM service. It enabled GSM users to deliver data three times faster. The circuit-switched technology improved the data rates up to 57.6 Kbps by introducing 14.4 Kbps data coding and by aggregating four radio channels timeslots of 14.4 Kbps, allowing users to access the Internet, and send and receive e-mail.[12]

GPRS (General Packet Radio Service)

This is an upgraded TDMA and GSM technology, which has introduced packet switching to the core network. While it was expected that GPRS would provide data rates of up to 171.2 Kbps, the current practical data rate is limited to 40-60 Kbps.

Source: OECD

2.1 What is 3G?

The third generation (3G) mobile is a generic term for a set of mobile telephony technologies using a set of high-tech infrastructure networks, handsets, base stations, switches and other equipment to allow high-speed Internet access, broadband audio-visual services, and voice and data communications. It commonly refers to a group of mobile technologies that have been approved in the ITU. They are mobile systems having data rates ranging from 128 Kbps to around 2 Mbps.[13] It seems better not to set a maximum speed for 3G because the extent of future technological change is not clear. Hence it would be better to categorises 3G as having a maximum speed of around 2 Mbps rather than fixing it 'up to 2 Mbps'. As stated later, some 3G services provide maximum speeds of more than 2 Mbps, such as 3-4 Mbps, but they may still be 3G as the next generation, sometimes referred to as '4G' by some industry analysts, will realise much faster speeds. However, it is important to note that the boundaries between 'Gs' or generations are not defined at present. Some countries, such as the United States, do not define any technology generations for reasons of technological neutrality so as not to regulate the different mobile technologies separately. Thus, while it is convenient to use different classifications such as the term '2G' to refer to a group of technologies below 3G, this paper is not attempting to delineate the boundaries between 2G, 3G and 4G (or even '2.5G') that is attempted by some industry analysts.

In 1986, the International Telecommunication Union (ITU) initiated work on developing a global future public land mobile telecommunications system (FPLMTS), which was renamed IMT-2000 (International Mobile Telecommunications-2000) in 1994. Currently, five standards have been specified as IMT-2000, based on various combinations of CDMA, TDMA, SDMA, single-carrier, FDD, and TDD, which became commonly known as 3G mobile. The following table briefly summarises the five standards.

Table 1: IMT-2000 standards established by the ITU

Full name	Common names
CDMA Direct Spread	UTRA FDD
	W-CDMA
	UMTS
CDMA Multi-Carrier	CDMA2000[14] 1X and 3X
	CDMA2000 1xEV-DO
	CDMA2000 1xEV-DV
CDMA TDD	UTRA TDD 3.84 mcps high chip rate
	UTRA TDD 1.28 mcps low chip rate (TD-SCDMA)
	UMTS[15]
TDMA Single -Carrier	UWC-136
	EDGE
FDMA/TDMA	DECT

Source: ITU[16]

The most significant technical change in some 3G technologies compared with 'intermediate technologies between 2G and 3G' might be the radio transmission technology, requiring new base station

systems with the appropriate antennas.[17] With this development, 3G can support data rates at 128 Kbps or higher when the caller is mobile, *e.g.* in a vehicle, 384 Kbps for pedestrian traffic, and 2 Mbps or higher for indoor traffic. In addition to the network changes new terminals had to be developed to support the capabilities of 3G systems. Furthermore, a high degree of standardisation worldwide has made it easier to ensure interoperability and roaming between service providers.

Table 2: Mobile telephony systems

	2G	Intermediates between 2G and 3G	3G
Speed	10 - 66 Kbps	66 -128 Kbps	128 Kbps - around 2 Mbps
Features	Voice, voice mail, receiving simple e-mail messages	Voice/Fax, voice mail, sending and receiving large e-mail messages, Internet browsing, navigation	Voice/Fax, global roaming, sending and receiving large e-mail messages, high-speed Internet navigation, videoconferencing, TV streaming
Handsets	Voice only terminals	Dual mode TDMA and CDMA, Voice and data terminals	Multiple modes, voice, data and video terminals
Compatibility	Not all compatible with 3G (Some specific technologies compatible with 3G, *e.g.* EDGE)	Not all compatible with 3G (Some specific technologies compatible with 3G, *e.g.* EDGE)	Compatible with 2G, 2.5G and Bluetooth under certain conditions

Source: OECD

2.2 IMT-2000 family

As mentioned above, the ITU approved a set of five 3G standards in May 2000 from proposals by several regional standards developing organisations. One of the most important steps of the ITU relative to 3G developments was its ability to bring the evolution process of existing 2G mobile standards, such as CDMA, TDMA and GSM under one umbrella.[18] In spite of these five standards, there are only two main competing standards: W-CDMA and CDMA2000.[19] The migration paths from CDMA to CDMA2000 and from GSM/GPRS to W-CDMA are the most common. For example, it has been predicted that approximately 80% of all mobile subscribers will follow the GSM to W-CDMA evolution track.[20] However, there has been some convergence of GSM and TDMA technologies in the 2G and 2.5G phases with the development of the GPRS/EDGE standard. Therefore some TDMA operators have the possibility to adopt the W-CDMA standard in addition to the CDMA2000 standard.[21]

On this basis, the key features of IMT-2000 could be summarised as follows:[22]

- High degree of commonality of design worldwide.
- Compatibility of services within IMT-2000 and with the fixed networks.
- High quality.
- Small terminal for worldwide use.
- Capability for multimedia applications and a wide range of services and terminals.

The following table and box will summarise the features of main 3G standards as well as explain the variants of CDMA2000 technology.[23] Additional subsequent tables will briefly describe the features of other 3G standards.

Table 3: Main 3G standards

	Features	Adoption rate	Variations
W-CDMA	- Makes use of a 5 MHz carrier channel and can transmit and receive information with faster speeds than systems operating in a smaller frequency band. - This standard requires new spectrum to offer services.	- An estimate predicts that worldwide subscribers to W-CDMA-based services will reach 90 million by the end of 2007.[24]	- In Europe this standard is known as UMTS (Universal Mobile Telephony System). - Enhancements such as HSDPA allow data rates of around 10 Mbps in the downlink.
CDMA2000	- Makes use of a 1.25 MHz carrier channel and can transmit and receive information with faster speeds than systems operating in a smaller frequency band.	- The CDMA Development Group (CDG) reported that the number of CDMA2000 global subscribers surpassed 90 million as of February 2004.[25]	- The variants include CDMA2000 1X, 1xEV-DV, 1xEV-DO, and CDMA2000 3X. - 1xEV-DV allows high-speed packet transmissions of up to 3.091 Mbps in the forward and 1.8456 Mbps in the reverse link.

Source: Telekom Internet.

Box 2. Variation of CDMA2000 technologies

(a) CDMA2000 1X
The specification for this ITU-approved standard was developed by the Third Generation Partnership Project 2 (3GPP2) consisting of five telecommunications standard bodies: CWTS in China, ARIB and TTC in Japan, TTA in Korea and TIA in North America. This standard provides the capability to double the voice capacity of cdmaOne networks and delivers peak data speeds of 307 Kbps in mobile environments. Some may regard this standard as 'intermediate between 2G and 3G' rather than 3G in terms of its limited data rates. Since the first commercial launch by SK Telecom in October 2000, the subscriber base has grown by 700 000 per day.[26]

(b) CDMA2000 1xEV-DO
The specification for this ITU-approved standard was also developed by the 3GPP2. It is a technology that puts voice and data on separate channels to achieve a data rate of 2.4 Mbps. With this peak data speed, this standard supports applications such as MP3 transfers and video conferencing.[27] This standard was first commercially launched by SK Telecom and KT Freetel in Korea in 2002.

(c) CDMA2000 1xEV-DV
The specification for this ITU-approved standard provides integrated voice and simultaneous high-speed packet data multimedia services at speeds of up to 3.09 Mbps. CDMA2000 1xEV-DO and CDMA2000 1xEV-DV are both backward compatible with CDMA2000 1X and cdmaOne.

(d) CDMA2000 3X
The specification for this ITU-approved standard is part of what the ITU has termed IMT-2000 CDMA MC and uses 5 MHz spectrum to provide speeds of 2-4 Mbps.

Source: CDMA Development Group, Telekom Internet.

Table 4: 3G standards other than W-CDMA and CDMA2000

	Comments
CDMA TDD	This standard is composed of TD-CDMA and TD-SCDMA. TD-CDMA is based on TD/CDMA proposed by ETSI and W-CDMA/TDD proposed by ARIB of Japan. TD-SCDMA is based on a proposal by CWIS.[28] This standard can allocate uplink and downlink time slots flexibly to accommodate asymmetric demand.[29] In February 2004, the Global UMTS TDD Alliance was founded by members of the UMTS TDD community, including both operators and vendors from around the world.[30]
TDMA single carrier	This specification was developed by TIA with an input from the Universal Wireless Communication Consortium to facilitate the migration from TDMA and GSM. Since it uses less bandwidth than W-CDMA, it can be an alternative for TDMA and GSM when additional bandwidth is not available. EDGE (Evolved Data Rates for Global Evolution) is an example of this specification, which is a protocol developed by ETSI that enables data transfer rates of up to 384 Kbps. It uses the 900/1800 MHz band and is a part of the valid GSM licenses obtained by operators. EDGE has been specified to enhance the throughput per timeslot for both HSCSD and GPRS.[31]
FDMA/TDMA	This standard is a TDMA TDD system defined by ETSI, and is also known as digital enhanced cordless telecommunications (DECT). As of September 2003, no OECD countries plan to adopt this standard for 3G services.

Source: OECD.

Systems beyond IMT-2000

Systems beyond IMT-2000, which would be denominated '4G' by some industry groups, will become IP based technology, although no commercial services have been provided yet.[32] The distinctions between 3G and the systems beyond IMT-2000 are not necessarily clear at this stage. However, some operators are attempting to conduct trials for the new services. In Japan, for example, a leading operator of '4G' development NTT DoCoMo announced plans for a field trial of a system beyond IMT-2000 in Yokosuka, where DoCoMo's Research and Development centre is located. According to DoCoMo, its new system demonstrated data rates of 100 Mbps for the downlink and 20 Mbps for the uplink.[33] Network capacity is said to be at least 10 times that of 3G systems.[34] The networks also need to be able to handle volatile traffic patterns such as multiple transmissions of multimedia messages from camera phones.[35] In Korea, some companies, such as Flarion, ArrayComm, IP Wireless, Navini and Nortel Networks, are testing their systems beyond IMT-2000 with potential operators in that country.[36] Some estimates have predicted that systems beyond IMT-2000 will account for 14% of total mobile data revenue with 50 million subscribers by the end of 2007. It also anticipates that infrastructure relative to the new systems will reach USD 5.3 billion in 2007.[37]

In June 2003, the ITU approved recommendations to encourage the 'further development to IMT-2000 and systems beyond IMT-2000' with a target to put these to practical use in 2010. Preliminary discussions seem to indicate system requirements of 50 times the data transmission speed of 3G, parallel to that of fibre-optics and with no deterioration of voice and image even if users move at a fast speed. However, no clear requirements exist yet. The ITU World Radiocommunication Conference (WRC) in 2007 will consider identifying additional spectrum for IMT-2000 systems and systems beyond IMT-2000.[38]

III. CURRENT FEATURES OF 3G

This chapter deals with current features of the 3G system in order to understand the regulatory implications and market developments among OECD countries.

3.1 Benefits of 3G

Increased bandwidth

As stated earlier, 3G technology has enabled increased bandwidth of up to 2 Mbps in fixed applications, 384 Kbps at pedestrian speed, and 128 Kbps when moving.

User-friendliness

For certain applications mobile terminals may be simpler to use, and under such circumstances will generally help in promoting the use of broadband Internet. As an example some people do not use the Internet simply because it is hard for them to manipulate PCs. In Japan 23.4% of non-users of the Internet say that difficulty to manipulate PCs discouraged them from using the Internet.[39] The fact that a large percentage of users have or will have access to the Internet through mobile terminals in Korea should have a positive impact on Internet developments.[40] In Europe, it is expected that 76% of consumers will have an Internet-enabled mobile phone and the majority of them will use it regularly in 2008.[41] In some countries, it seems that market growth is increasing more rapidly in mobile phones, including 3G, than in PCs. In Finland, for example, retail sales of mobile phones amounted to EUR 103 million (USD 120 million) in the first half of 2003, which is a 16% increase from 2002, whereas PC sales remained at the level of 2002 at EUR 67 million (USD 78 million).[42]

Roaming

Some may argue that one of the distinct benefits of 3G in comparison with 2G would be that 3G can seamlessly be used across international borders. Although there are several ways to provide international roaming capability in 2G services even where different countries do not use the common technologies, roaming is generally much easier in 3G because 2G operators typically offer multi-band or multi-mode phones to enable roaming, which are often more expensive than other terminals. From this perspective, it would be important that regulators ensure the availability of global roaming. However, it does not necessarily imply that a single international standard is required.

Inter-working between IMT-2000 systems and with legacy fixed and mobile systems, which provide coverage and global circulation of terminals, is an essential issue since, for the user, global access to his/her services and applications is important. Regarding this aspect, it is important to note that specific multicode terminals will be available as commercial networks become a reality. SIM (Subscriber Identification Module) cards are another solution that can help overcome some of the interoperability issues between networks, but require the use of multiple handsets to operate on different networks. In support of achieving these interoperability and roaming goals, the third generation partnership projects 3GPP and 3GPP2 have agreed to work to ensure:

- Interoperability between the 3GPP IMS mobiles and 3GPP2 IMS mobiles (a 3GPP IMS mobile can set up a session with a 3GPP2 IMS mobile and vice-versa).

- Application level inter-system IMS roaming (given that the mobile supports the visited network's access network and IP transport technology, a 3GPP IMS mobile should be able to roam into a 3GPP2 network and vice-versa).

Another interoperability issue that should be considered would be the impact of the introduction of data services with IMT-2000. Given that IMT-2000 technologies are relatively new, interoperability of software and applications on IMT-2000 terminals and across borders will become increasingly significant. An organisation, the Open Mobile Alliance, was formed with the goal to deliver open standards for the mobile industry, helping to create interoperable devices that work across countries, operators and mobile terminals and are driven by users' needs.

However, there is an issue pertaining to roaming, which is an economic rather than a technical one. Each operator charges roaming fees to the operator of a subscriber who is in their geographic area, where appropriate commercial roaming agreements are in place. These fees reflect the commercial aspects of roaming including financial risk and are sometimes high as a result of a lack of competition in roaming charges largely because of the industry structure in which services are tied to networks. The end-customer roaming tariffs are related to the underlying wholesale tariffs, which are currently under investigation by the European Commission.

It should also be noted, however, that roaming requires more than merely multi-band/multi-mode handsets which can operate in different environments. Essential prerequisites for roaming include, for instance:

- Interoperable network-network interfaces between the 'home' network and the 'visiting' network to which the user is roaming.

- Handsets with appropriate radio and network protocol stacks so that the handset can communicate with the 'visiting' network.

- An understanding of the contents of the subscriber/user identity modules (SIM/UIM) in the different network environments so that the user can be correctly identified.

- Commercial roaming and its associated service level agreements between different operators to permit the usage of respective networks by their subscribers.

A variety of applications

Given that the demand for voice, e-mail and SMS (Short Message Service) applications can be met by 2G, they will no longer be "killer" applications of 3G. In order to drive market adoption of 3G, differentiated services and applications that will benefit from the functionality of 3G have to emerge. In this context, diversity in applications would be one of the strongest advantages of 3G mobile. For business users, 3G has a potential to transform the way business is conducted. For consumers, 3G can be an important part of daily life in many cultures if users have embraced the technology and embedded it into their lifestyle. In addition to traditional mobile applications, some new types of 3G applications are highlighted. The extent to which customers will be interested in utilising such applications delivered on small LCD display screens is at present unclear.

Box 3: Main 3G applications

Video calling
One of the key differentiators between 2G and 3G would be the capability to make a video calling. Some analysts predict that video calling would become the most popular killer application provided over 3G. Some operators, such as Hutchison 3G Australia, provide 3G video calling services to countries without a 3G network.

Camera phone
3G mobile can be combined with other electronic equipment such as digital cameras, although camera phone ability is also available over GPRS. For example, NTT DoCoMo announced in May 2003 that it sold more than 10 million camera phones since it launched the first model, SH251i, in June 2002. In Japan, camera phones are particularly popular among users between the ages of 20 and 30 who account for approximately 60% of total sales.[43] According to a report, more than 55 million consumers worldwide will own camera-phone handsets, more than double the 25 million in 2002.[44] In terms of shipments of devices, camera phone shipments accounted for about 18.2 million units in 2002 and 7.8 million in the first quarter of 2003.[45] Some predict that camera phones will grow 64% in 2004 to nearly 100 million units.[46]

Mobile e-commerce
Some 3G services will facilitate mobile e-commerce. For example, Tarang Software Technologies announced in August 2003 that it would launch 'DoCommerce', a wireless account aggregation service for Japan's NTT DoCoMo. The service would enable both DoCoMo's 2G and 3G handset users to shop using their mobile terminal and pay on line with their credit card. Initially, 10 virtual shops were on the DoCommerce dedicated site.[47]

Location-based services
3G enables location-based services which show subscribers where they are, how to find a certain place and so forth. Mobile operators estimate that revenues from high accuracy location-based services will grow to almost USD 12 billion by 2005 on the condition that low cost mass market enabling technologies would be in place to drive the market.[48]

Games and sports events
Video games could be one of the popular 3G applications. In some countries, 3G is becoming a popular platform for watching sport games as well. In the United Kingdom, for example, the market for mobile games is expected to be worth over GBP 50 million (USD 79 million) in 2003 and GBP 211 million (USD 331 million) by 2006.[49] In Italy, Vodafone Italia acquired the exclusive worldwide rights to show pictures of the games of some popular football teams in May 2003.[50] Similarly, Hutchison 3G Italy signed a nine-year agreement with the following football teams: A.S. Roma, Lazio, Juve, Milan, Inter, Reggina, Piacenza, Bari, Genoa, Salernitana, Reggiana for the broadcast of the goals and the most important images of home games on 3G phones.[51]

Broadband Internet access
3G enables users to access the Internet with a speed similar to broadband networks. This could be one of the most popular 3G applications giving 3G an advantage over 2G and 2.5G which do not have this capability. The typical broadband ability to use different functions simultaneously, such as voice call and data services, would also be a significant 3G feature.

Broadband audio-visual services
Broadband content can be delivered via 3G. This service will enable the transfer of a variety of media, such as audio, video, and pictures, to various users. Indeed, a research report indicates that the biggest reason that mobile phone subscribers will upgrade to 3G services is to download short videos,[52] and some operators are stressing this application. In the United Kingdom, for example, Hutchison 3G UK launched a sports video service, particularly for football fans, in March 2003.[53] In Korea, KTF started to transmit TV pictures direct to 3G mobile phones in February 2003. It is reportedly gearing up to deliver the programmes of nine different TV channels to its 3G subscribers on the basis of the alliances signed with three broadcasting companies (KBS, MBC and SBS) in October 2002.[54] In September 2003, the International Multimedia Telecommunications Consortium (IMTC) announced the first interoperability tests over a live 3G network of real time delivery of broadband audio-visual services through packet switched streaming.[55] Technological developments will further the use of broadband audio-visual services via 3G mobile. For instance, NEC developed an experimental mobile phone in July 2003 which will enable users to watch TV, but the October 2003 model uses up the battery within an hour when watching TV. Therefore, amelioration of quality including battery consumption is important for future diffusion. NEC is aiming to commercialise this phone in 2005.[56]

Source: OECD.

3.2 Status of development of 3G

High network deployment costs

The costs for network deployment for 3G are generally high because of denser cells than 2G.[57] Moreover, the network deployment experience for some 3G operators, particularly operators deploying the W-CDMA system, has been challenging due to the lack of available infrastructure and handsets. In the United Kingdom, for example, Vodafone has reportedly invested around GBP 3.5 billion (USD 5.7 billion), excluding license fees to launch 3G services.[58] Some operators have been challenged by the perceived difficulty in commercialising services and earning a profit, taking into account the cost of deploying networks in addition to the license fee. This seems to have resulted in delay in the deployment of 3G networks. Some operators argue that it will take three years before 3G service will be profitable and five years before they will have recovered network deployment costs.[59] Hence 3G operators have been trying to reduce operational expenditures when they deploy 3G networks.[60] Interestingly, solutions that directly address this problem have been developed in recent years.[61] In addition, operators who were able to migrate from their existing 2G networks in their current spectrum bands were able to deploy their 3G networks with relatively low capital investment by reusing their existing spectrum and core and radio networks.

At the same time, it appears that operators are currently facing a public policy paradox. While they are committed to deploy 3G networks in line with license conditions set by national governments, their implementation of these commitments is continuously frustrated and delayed by local, regional, and in some cases national regulations, usually linked to planning requirements.[62]

Coverage still expanding

Coverage provided by 3G networks is still limited, but in recent years some operators have expanded the coverage of 3G services. In Europe, for instance, Hutchison 3G (H3G) has 70% population coverage in the United Kingdom and Sweden, 55% in Italy, 35% in Austria and Denmark. In Japan, the service area of FOMA provided by NTT DoCoMo is expected to reach 99% of the population by the end of March 2004.[63] However, in the majority of OECD countries that have commercialised 3G services, only densely populated areas have been covered by 3G networks. The United States has two networks with national 3G coverage, Verizon Wireless and Sprint PCS.

Technical limitations

Some technical limitations are also impacting on 3G development. The ability to switch calls smoothly between 3G and 2G (handover) was a source of concern for some operators. Moreover, not all 3G networks will have interoperability with all 2G technologies. For example, NTT DoCoMo's 3G network does not support PDC in that PDC handsets cannot be connected with base stations of W-CDMA whereas cdmaOne can be connected with base stations of CDMA2000 1X. In addition, consumers may find it easier to choose inferior functioning in terms of 2G-3G interoperability because mobile phones that only support 3G are usually simpler and smaller than those that support both 2.5G and 3G concurrently.

Some argue that early 3G networks will not support both circuit-switched and packet-switched communications simultaneously.[64] However, recent technological development has allowed some networks to support simultaneous functionality, such as voice call during download as well as real-time video streaming, and commercial services have been available since 2003. At the same time, others suggest that IP is not ready to support real-time 3G multimedia even though operators envisage 3G as running entirely over a pure IP based network.[65] They argue that the requisite address space cannot be carried with the limited 32 bits address space of current IP version 4 (IPv4), considering there are more

than one billion mobile devices. Although 3GPP/3GPP2 defined IP version 6 (IPv6) to be used for allocating a permanent IP address to each mobile service, it is far from being deployed at present. In this context, there might be a risk that IP will not be able to support real-time broadband applications over 3G until the deployment of IPv6 is completed.

Market-based standards

In several countries, including the United States, Japan, Korea, and Australia, 3G operators are afforded greater flexibility in that a uniform standard has not been imposed by the regulator. A market-based approach to standard setting may have both advantages and disadvantages as compared with the imposition of a uniform standard as summarised in the following table.[66]

Table 5: Advantages and disadvantages of government-mandated and market-based standards

Approaches to setting wireless standards	Advantages	Disadvantages
Government mandated standards and harmonisation	May lower unit cost (of chipsets and terminal and network equipment) and afford greater variety of handsets by achieving greater coverage and larger economies of scale in the production of terminals/ handsets and network infrastructure equipment	May harm consumers in the long run by locking them into a technology that is inferior to one used elsewhere May stifle technological innovation and competition between wireless standards by tipping the whole world towards the mandated standard, but this effect may be mitigated by interconnection
Market-based standards	May stimulate more technological competition and innovation and greater price competition among competing incompatible standards	May result in fragmented networks and technical solutions may need to be used to ensure interoperability between networks, but these effects are mitigated to the extent interconnection and coverage are a substitute for compatibility

Source: *Standards in Wireless Telephone Networks*, Telecommunications Policy 27 (2003).

Limited speed

Even though 3G has enabled a number of mobile applications, for some users it is still slow in comparison with other broadband technologies such as wireless LANs or fibre-optic networks. Some even argue that the advantage of 3G will centre not on its high data rate but on its packet switched architecture.[67] However analysis has shown that a large proportion of 2.5G/3G users are prepared to pay more for higher speeds.[68] It is expected that future upgrades to 'systems beyond IMT-2000' services will provide substantially higher bandwidth comparable to existing wire-line broadband access.

Handset problems

Difficulties in commercialising 3G handsets have slowed the launch of some 3G networks. The fact that the mobile phones themselves include several different systems (for example, GSM and UMTS which need to work concurrently) has increased the difficulty of developing 3G handsets. However, delivery and technical problems are being overcome. The next hurdle to 3G network deployment will be user acceptance.[69]

In terms of roaming, handsets that allow access to both 3G and 2G networks are essential to 3G deployment. A number of advanced 3G handsets have been developed that have a full-colour widescreen display to be used for person-to-person video calling or viewing video content. An MP3 player and gaming capability are also combined into the handset.[70]

IV. REGULATORY AND POLICY ISSUES FOR 3G

4.1 Implementation of 3G policies

It is critical for policy makers to allocate and ensure appropriate spectrum for the operation of 3G services. Most OECD countries have allocated spectrum for 3G by giving licenses to operators.[71] Particularly in Europe, the effect of the decision made by the European Commission was influential for implementation. The UMTS Decision (128/1999/EC) required the European Economic Area (EEA) states to take all measures necessary to allow for the co-ordinated and progressive introduction of 3G services by January 2002 and in particular, to establish an authorisation system for UMTS no later than January 2000. While this decision did not require each member state to issue 3G licenses, it mandated member states to have the requisite legal, administrative and regulatory framework in place to allow operators to launch 3G services. Most OECD countries not members of the EEA also put in place a regulatory framework for the development of 3G services. Among the EEA members Iceland has not yet put in place the necessary policy framework and in March 2003 the European Free Trade Area (EFTA) Surveillance Authority accused Iceland of breaching an EEA decision on 3G policy implementation.

Policy makers have been pressured by a number of leading operators urging them to lighten 3G regulations. In Europe a number of operators requested the European Commission to take a more accommodating approach by softening obligations for 3G licenses.[72] In addition, in October 2003[73] the UMTS Forum appealed to governments and regulators to take a pragmatic look at their licensing arrangements. In response some countries have adjusted conditions on 3G licenses. In France, the initial two 3G license holders requested the government to reconsider their licence payment structure.[74] Subsequently, the government changed the terms of 3G license from a one-off charge of EUR 4.95 billion (USD 5.70 billion) to a one-off payment of EUR 620 million (USD 721 million) in addition to 1% of turnover for the duration of the license, which was also extended from 15 to 20 years.[75] Norway has softened the obligation for the 3G operators (Telenor and Netcom) by giving a 15 month postponement.

Canada, Mexico, and the United States and in the Asian OECD countries, the 3G licensing process has differed significantly from that in Europe. In the United States, the government did not assign spectrum for a specific mobile technology but allows operators to deploy services using available spectrum for which they are licensed. This technology-neutral policy has enabled the US operators to provide advanced wireless services, including 3G, in spectrum originally licensed for 1G (824-849/869-894 MHz) and 2G (1850-1910/1930-1960 MHz) systems. In October 2003, the FCC decided to make additional spectrum available in the 1710-1755 MHz and 2110-2155 MHz bands that can be used for 3G services.[76] The use of the upper band for 3G services is dependent in part on finding relocation spectrum for existing Federal government licenses in this band, including Department of Defence licensees.[77] In addition, existing bands that are licensed for cellular and PCS mobile services may also be used to support 3G services. These include 824-849 MHz, 869-894 MHz, 1850-1910 MHz, and 1930-1990 MHz, plus several other smaller bands in the 800 MHz range.

Some have argued that in some countries current spectrum allocated for 3G services may be in short supply in the near future. In light of this, some organisations have advocated a widening of the frequency range to be used for 3G in order to ensure future services. In January 2002, for example, the UMTS Forum proposed to the Electronic Communications Committee (ECC) to identify the 2 500-2 690 MHz frequency band to be used for European 3G (UMTS) services in the near future on the premise that extra spectrum will be needed by 2005.[78]

4.2 Minimum coverage requirements

Most OECD countries have set minimum coverage requirements in awarding 3G licenses. These requirements have placed pressure on license holders to deploy the network within a limited time frame. Nevertheless, operators have delayed deployment of 3G networks because of economic conditions in the telecommunication sector, technical challenges and difficulty in obtaining building permission in a number of countries. Some countries have in fact pushed back the minimum coverage requirements. In Poland, for example, the regulator pushed back the minimum coverage requirement in September 2003 from 25% of the population by the end of 2003 to 20% of the population by the end of 2007.[79]

Coverage requirements across the OECD vary (Table 6) and in some countries, such as Finland, there are no coverage requirements.

Table 6: Minimum coverage requirements for 3G licensing

	Minimum coverage requirements
Australia	No requirement
Austria	25% of population by December 2003 and 50% by the end of 2005
Belgium	30% of population within three years, increasing to 85% of population after six years
Canada	No requirement
Czech Republic	Licensees must launch a commercial public service with a UMTS system in Prague by 1 January 2006. The service shall be available in at least 90% of that area.
Denmark	30% of population by the end of 2004 and 80% of population by the end of 2008.
Finland	No requirement
France	80% of population within eight years following the issue of the licence.
Germany	25% of population by December 2003 and then 50% of population by December 2005
Greece	At least 25% of population by December 2003, coverage of the Olympic Games facilities, venues and main connecting routes in the Attica region by February 2004 and coverage of at least 50% of population by December 2006
Hungary	No requirement
Iceland	No 3G licensing
Ireland	A license: 53% of population (equivalent to the five major cities) by the end of 2005 and with the fulfilment of the minimum 80% population requirement by the end of 2007. B License: 33% of population by the end of June 2006 and 53% by the end of June 2008.
Italy	Regional capitals within 30 months and provincial cities within 60 months
Japan	50% of population within five years
Korea	No requirement (Operators are supposed to deploy networks each year according to their business plan submitted to the government when they applied for a license.)
Luxembourg	Not known
Mexico	No requirement
Netherlands	60% of population by the end of 2007
New Zealand	Not known
Norway	For Telnor 80% of population by 2008, for NetCom 76% of population by 2005, for Hi3G 30% of population by 2009.
Poland	For voice services, 25% of population by the end of 2003, 60% by the end of 2005, and 80% by the end of 2009, slightly less for 144Kbps data services.
Portugal	20% of population at the end of the first year of the validity period of the license, 40% at the end of the third year, and 60% at the end of the fifth year.
Slovak Republic	Not known
Spain	UMTS operators are free to decide the date of the commercial launching. Initial coverage should be, at least, cities with a population greater than 250 000
Sweden	Licensees have made commitments to cover at least 8 860 000 people (*i.e.* 99.98% of the population in December 2000) by the end of 2003.
Switzerland	50% of population by the end of 2004
Turkey	No 3G licensing
United Kingdom	80% of population by the end of 2007
United States	The government is not assigning spectrum specifically for 3G but is allowing mobile operators to implement 3G services using allocated spectrum.

Source: *Cellular-news*, UMTS-Forum, OECD.

In some countries, operators asked the regulator to postpone the deadline for commercial service launch, mainly due to the lack of handsets and equipment or to technical problems. In Portugal, for example, Optimus requested the regulator to move the dates of service launch from December 2002 to January 2004 after the original date was postponed from January 2001 to December 2002.[80] In Poland, operators demanded, and obtained from the regulator, a one-year delay in the deadline for launching 3G, until to January 2006. In the Czech Republic, the deadline for minimum coverage requirement as well as service launch was postponed from January 2005 to January 2006 at the request of 3G license holders. In France, the regulator ART announced that the obligation to launch 3G services was delayed to the end of 2004 for Orange and SFR.

4.3 National roaming

In many OECD countries, there is no regulation requiring national 3G roaming. In the majority of OECD countries that have regulations on roaming, operators are allowed to negotiate roaming agreements on a voluntary basis. However, some countries have set conditions under the old regulatory regime. In Greece, for example, national roaming is allowed as long as it does not result in only one radio access networks covering a significant part of the population. In Denmark, providers of public mobile communications network should meet all reasonable requests to formulate or modify national roaming agreements with another provider. Hence, operators can roam on each other's network and thereby provide 3G services which are not subject to the minimum obligations of the 3G licenses. In Spain, 3G roaming is not allowed under any circumstances. In France 3G license holders that are also 2G incumbents have to grant 2G roaming to new 3G entrants. The same requirement applies in Portugal but the requirement for 3G license holders that are also 2G incumbents to grant 2G-3G roaming to new entrants is limited for a period of five years from the date that the license was awarded. In Spain, 2G-3G roaming agreements are required only for three years.[81] In Norway, 2G-3G and 3G-3G roaming are allowed according to general rules. In Italy, Sweden and Ireland, national 2G-3G roaming provision is made in favour of the new entrant.

4.4 Infrastructure sharing

Infrastructure sharing among 3G operators has become an issue for policy makers. It could include access to the network or be limited to collocation such as through sharing of antennae sites.[82] Since incumbents have the advantage of existing 2G networks and some of those components could be used in 3G infrastructures, policy makers need to consider whether to allow other incumbents to oblige access to parts of the 3G infrastructure of incumbents.[83] On the one hand, infrastructure sharing could lead to quicker and better 3G coverage of areas that are seen as providing less economic return to operators. In individual cases, a decision may need to be taken whether 3G operators with significant market power should provide other operators and resellers with access to existing networks. Sharing of antennae sites has been viewed as a way to reduce environmental concerns. On the other hand, an important consideration in infrastructure sharing, particularly for core networks, is the potential competition concerns which may occur. Consideration should also be given to whether infrastructure sharing would impact on the roll-out speed in the short term.[84] Policy makers are required to strike an appropriate balance between 3G infrastructure competition and consumer benefits from having faster and wider deployment of 3G services.

Some recent decisions have been in favour of 3G infrastructure sharing, but only of antennae sites. For example, the European Commission gave permission for a 3G site-sharing agreement with specified safeguards between T-Mobile and mmO2 in the United Kingdom in April 2003, and in July 2003 it approved a plan by mmO2 and T-Mobile to share 3G infrastructures in Germany.[85] In the case of the United Kingdom it was stressed that there were no competition concerns on the proposed infrastructure sharing because it is restricted to smaller cities and rural areas. Furthermore, this arrangement may also avoid competition concerns since it is restricted to sharing basic network infrastructure such as masts, power supply, racking and cooling. In Germany, the regulator stated that each 3G license holder would be required to build its own network, each of which needed to ensure its 'competitive independence' during the lifetime of the license. This means that operators would not be allowed to

share backbone facilities such as switching centres even though they could share network elements such as masts and antennas.[86] In France, the regulator ART indicated in December 2001 that sharing of mobile infrastructure (site, base station, and controllers) was possible provided that the frequencies are managed independently by each operator. In Spain, the government agreed to permit 3G infrastructure sharing between operators in January 2004.[87] In Finland, operators are allowed to share 3G networks from April 2004. Licence holders will be able to deploy part of their networks together, although each licence holder must still have their own network covering 35% of the population.[88]

Some countries placed conditions on infrastructure sharing. In Ireland, for example, infrastructure sharing, with the exception of site sharing, will only be permissible when each operator has established a 3G radio access network infrastructure capable of serving at least 20% of the population using infrastructure which is wholly under the control or ownership of that operator. In the Netherlands, NMa (Netherlands Competition Authority), OPTA (Independent Post and Telecommunications Authority), and the V&W (Ministry of Transport, Public Networks and Water management) issued a joint memorandum that provided comprehensive clarification on collaboration in the deployment of 3G networks in September 2001.[89] They agreed to allow 3G operators to collaborate in the construction of 3G network components on the condition that competition between operators continued to exist and that operators compete against one another in providing 3G services. While they shared the opinion that collaboration in 3G network deployment could contribute to a more rapid 3G rollout, they clarified that collaboration must be limited to the joint construction and use of the 3G network infrastructures such as masts, aerials and network operation. On this basis, they did not permit the joint use of frequencies and core networks. In Sweden, network infrastructure sharing is allowed under the present 3G licensing regime as long as each operator has 30% of the population covered with its own infrastructure, the 70% remaining being sharable. The radio infrastructure includes antennas, transmission equipment and other intelligent parts of the network, while leaving aside masts, power supply, sites and so forth.

Some countries do not intervene in infrastructure sharing issues. The policy of the United States is an example. Although the US regulator has not issued regulations specifically addressed to 3G infrastructure sharing, in recent years, the regulator has been called upon to scrutinise on a case-by-case basis several infrastructure sharing joint ventures between various mobile operators. Based on this experience, the US approach generally has been not to intervene in infrastructure sharing issues, but the regulator has the authority to do so if issues of competitive harm are raised. The same general approach would be applicable to 3G infrastructure sharing should the issue arise. There is also a proposal by the FCC which examines whether infrastructure sharing is promoted or not as a means of bringing competition to rural areas.

4.5 Resale of spectrum

Spectrum resale is another issue being raised in the context of 3G development. Some OECD countries have permitted this, but most did not. In Norway, for example, spectrum resale is not allowed without special permission from the ministry. In recent years, however, pressure from some operators to add to flexibility by allowing spectrum resale has increased. In particular, spectrum trading has been introduced in a number of EU member countries after the new regulatory framework came into force in July 2003.

There are some cases in which operators attempted to trade spectrum. In July 2003, for example, the Spanish operator Telefonica Moviles intended to sell the spectrum it had acquired in Germany, Italy, Switzerland, and Austria in order to recoup some of its investment. Selling the license required legislative changes in all four countries. However, changes introduced in national legislations of Austria, Italy, and Switzerland will allow Telefonica to sell its licenses or frequencies.[90] Under the current legislation in Switzerland, for example, it would be possible to transfer the license to another operator as far as it is independent of other 3G license holders in that country. The new company to which the license could be transferred has to fulfil all the obligations, such as coverage requirements, as they are stated in the license. In Austria, provision has been made for spectrum trading,

and accordingly the entirety of Telefonica was sold to Mobilkom, which is currently obliged to sell off half of the 3G spectrum it acquired in the process (5 MHz).

Regulators will more or less face this issue in the future as an increasing number of operators may wish to enter or exit from the 3G market. For instance, 3G operator Hutchison 3G, which has no 3G license in Germany, may be interested in buying the spectrum from mmO2 if spectrum trading were allowed in that country.[91] In such cases, policy makers will have to take into consideration that there is a distinction between the resale of spectrum and the sale of a license and that there are a number of technical and economic factors to be taken into account in formulating spectrum policies in order to ensure that new entrants are not unfairly prejudiced.

4.6 Mobile Virtual Network Operators (MVNO)

Mobile Virtual Network Operators (MVNOs) are mobile telephone operators who provide services without having their own spectrum, and in most cases network infrastructure. Instead, MVNOs have business arrangements with network-based mobile operators to purchase minutes of use (MOU) for sale to their own customers.[92] In most OECD countries, access obligations to MVNOs are not explicitly stipulated as a 3G license condition. Under the new EU legislation of March 2002, in particular the Framework Directive (2002/21/EC)[93] and Access Directive (2002/19/EC)[94], and the related Commission recommendation on relevant product and services markets (2003/311/EC), MVNO obligations require operators holding Significant Market Power (SMP) in the mobile wholesale access and call origination markets to provide these services on regulated terms. The following table summarises the regulations on MVNOs for 3G services.

Table 7: Regulatory policies on 3G MVNOs

	Regulations on MVNOs for 3G services
Australia	MVNOs are permitted.
Austria	While MVNOs are permitted, no MVNOs are currently operating. Tele2 Austria plans to start as an MVNO.
Belgium	While 3G services are currently under planning, operators must have a network to offer the services as is the case with existing 2G services.
Canada	No 3G licensing.
Czech Republic	No official arrangements for MVNOs are in place.
Denmark	Access for service providers including MVNOs is part of a Danish regulatory framework. Providers of mobile networks are obliged to meet all reasonable requests for establishing interconnection agreements on national roaming. Tele2, which operates on Sonofon's network, is an example of MVNOs.
Finland	No MVNOs are currently operating. There are no plans to introduce legislation on MVNOs, but the government will follow EU regulations on this issue.
France	The government has given free rein to operators with regard to MVNOs.
Germany	No regulation.
Greece	The government has yet to determine policy on MVNOs.
Hungary	No official arrangements for MVNOs are in place.
Iceland	No 3G licensing.
Ireland	MVNOs are permitted, and are one of the evaluation components of the comparative bid criteria.
Italy	MVNOs are not allowed for a period of eight years from the commercial launch of UMTS services.[95]
Japan	MVNOs are permitted.
Korea	No official arrangements for MVNOs are in place, but the government has started to study whether MVNOs are necessary or not.
Luxembourg	No official arrangements for MVNOs are in place.
Mexico	No 3G licensing.
Netherlands	Although no official arrangements for MVNOs are in place, the government has determined that access should be granted on a reasonable cost basis with regard to interconnection.

Table 7: Regulatory policies on 3G MVNOs (cont'd)

	Regulations on MVNOs for 3G services
New Zealand	Not known.
Norway	MVNOs are permitted. Tele2 is the only MVNO for both 2G and 3G.
Poland	No official arrangements for MVNOs are in place.
Portugal	The government is currently examining the conditions required to allow MVNOs to operate.
Slovak Republic	No official arrangements for MVNOs are in place.
Spain	MVNOs have been permitted since March 2002. As of January 2004, licenses have been granted to BT IGNITE ESPANA, S.A. and TELE2 TELECOMMUNICATIONS SERVICES, S.L.
Sweden	MVNO access is stipulated for 3G operators to the extent that there is available capacity in the corresponding networks.
Switzerland	MVNOs are permitted. However, there were no MVNOs active on the Swiss market as of January 2004.
Turkey	No official arrangements for MVNOs are in place.
United Kingdom	The government has given free rein to operators with regard to MVNOs. Mobile network operators have no obligations to carry traffic for MVNOs.
United States	The government has refrained from regulating operators with regard to MVNOs. Mobile network operators have no obligations to carry traffic for MVNOs, nor are they restricted or limited in their ability to do so. US policy on MVNOs is not tailored specifically to 3G MVNOs, but rather applies generally to mobile network operators regardless of the type of services they offer or the technology they deploy.

Source: CIT-PriMetrica, European Commission, OECD.

4.7 Mobile number portability

Mobile number portability provides users with the ability to transfer their existing number to a new service provider. A number of OECD countries have recently implemented number portability for 2G and in certain cases have indicated that portability will also apply to 3G as well as between 2G and 3G. In the United States, for instance, the requirement for number portability went into effect in November 2003 and applies to all mobile wireless services. The EU set a deadline of July 2003 for the implementation of mobile number portability, but some EU countries have not yet implemented this policy. In Austria, for example, Hutchison 3G (3 Austria) complained to the regulator about the lack of progress in negotiations between Hutchison and other 3G operators in order to accelerate the implementation of mobile number portability.[96] Even in those countries that introduced mobile number portability such as the United Kingdom, where mobile number portability was introduced in January 1999, progress has been slow and its usage low due to the considerable cost as well as the delay required to transfer numbers between operators. Some countries, such as Germany and the Netherlands, charge users a fee to transfer mobile numbers. In Japan, the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT) estimated in September 2003 that it would cost more than JPY 140 billion (USD 1.28 billion) to implement number portability for both 2G and 3G.

Another relevant factor to be taken into account is that mobile number portability is highly dependent on the customer-friendliness of the solution. Mobile number portability has been a clear success in countries where it is easy for the customer to make use of this service, particularly in terms of porting time. In Australia, for example, the customer has to wait for only three hours to get his mobile number ported, which has allowed more than 40% of all customers to make use of the mobile number portability service. On the other hand, Germany faces a porting rate of far below 1% since the customer has to wait for more than six weeks until his number is ported. These examples indicate that mobile number portability will not show significant effects on the mobile market unless regulators are ready to put pressure on incumbent operators to introduce an effective and customer-friendly technical solution.

V. MARKET DEVELOPMENT OF 3G

5.1 Main trends in the 3G market

There are important differences among OECD countries in the commercialisation of 3G services. In some countries several different levels of technologies are merging into commercial services marketed as "3G". Similarly, technological standards adopted by some operators would be classified in the category of 3G by industry insiders even though some analysts may exclude them due to limited data rate. Thus, several operators have claimed that they have launched 3G services despite the fact that the average access speed is equivalent or similar to a level of 2G (or 2.5G). In Ireland, for example, Vodafone Ireland launched in May 2003 3G services which provide data speeds of up to 144 Kbps.[97] Although the service is within the range of 3G, the speeds might not allow users to enjoy high-speed mobile Internet access. In Mexico, Grupo Iusacell, S.A. de C.V. of Mexico announced the launch of a 3G service in April 2003. The service is provided by CDMA2000 1X voice and data networks, which offer access rates to 144 Kbps.[98] In Japan, KDDI (au) has provided 3G services using CDMA2000 1X standards since April 2002 with a data rate which was up to 144 Kbps, but it launched more advanced 3G services using CDMA2000 1xEV-DO standards in November 2003 offering peak data rates of 2.4 Mbps.[99]

User acceptance is a key factor in the commercialisation of 3G services. In some OECD countries users seem to have adapted quickly to 3G services. In Korea, for example, within eight months of its launch in November 2002, SK Telecom acquired more than one million subscribers to its 3G service called June, which provides multimedia services such as VOD and MOD.[100] In Japan, NTT DoCoMo believes that consumers want 3G technologies that allow video communications on the move having seen their subscriber numbers more than double, to 488 000 users, in the five months from January 2003 to May 2003.[101] By October 2003 the number of its 3G service subscribers exceeded one million.[102] The following table shows the increase in the number of DoCoMo's 3G (FOMA) subscribers since the launch of the service.[103]

Table 8: Number of NTT DoCoMo's 3G subscribers

Date	Number of FOMA subscribers
October 2001	The service was launched.
April 2002	100 000
March 2003	300 000
April 2003	400 000
June 2003	500 000
July 2003	600 000
August 2003	700 000
September 2003	1 000 000

Source: NTT DoCoMo.

In most other OECD countries, however, operators have had difficulties in promoting 3G services due to the limited market demand. In Western Europe, for example, some statistics show that 49% of mobile telephone users in the United Kingdom, France, Germany, Spain, Italy and Belgium are not interested in 3G services.[104] In Hungary, in October 2003, three mobile operators campaigned against the issuing of 3G licenses in the future stating that major investment in the technology was not ensured due to insufficient consumer demand.[105]

Arguably, one of the main difficulties has been the lack of killer applications. Even though operators provide a variety of services they seem not to have been attractive to users. For example, a survey in Germany in October 2003 indicated that 58% of the population did not know what UMTS was.[106] Another survey suggested that average consumers are not much interested in the multimedia applications of 3G such as streaming music and video conferencing. Consumers are more concerned about costs and do not want to pay higher prices for access to Internet services via 3G even though they might demand higher quality of services.[107] This immature market demand has impacted 3G network deployment schedules, and resulted in considerable delays in the introduction of 3G services.

Problems with handsets have also delayed diffusion. Some operators were obliged to postpone the launch of 3G (W-CDMA) services mainly due to the lack of handsets. In Finland, for example, the first commercial 3G service was not launched until September 2002 due to lack of handsets, even though it was the first country that provided 3G licenses, in March 1999. In the United Kingdom, mmO2's 3G network, which was originally supposed to be deployed in 2002, was still not operating in 2003 due to a lack of handsets.[108] In Japan, NTT DoCoMo had to recall 1 500 FOMA N2002 handsets because of a software problem[109] in November 2001.[110] Furthermore, incoming calls of NTT DoCoMo's FOMA T2101V handsets were missed when the phone was in energy-saving mode during January 2003.[111] In Italy, Hutchison 3G Italy had run out of handsets six months after the launch of 3G services on account of the popularity of the service.[112] T-Mobile stated in September 2003 that the introduction of 3G services in Germany would be dependent on the availability of adequate handsets. It is important to note, however, that the reasons for a shortage of 3G handsets have changed from the initial technical problems to the inability of manufactures to keep up with increasing user demand. However, the situation as regards handset availability continues to improve.

Technical problems have also caused delays in the deployment of W-CDMA networks. The United Kingdom-based Vodafone Group was reluctant to set a launch date for 3G services as of October 2003, insisting that it would wait until the service worked properly before launching, although it has launched a 3G service in Japan and data-only 3G services in Europe including the UK.[113] In Poland, 3G license holders asked the regulator to delay the launch date for 3G services in July 2003.[114]

The financial conditions in the telecommunications industry linked with a perceived uncertainty in the 3G market have also led some operators to pull out of the 3G market in spite of the fact that they have 3G licenses. In Germany, for example, Quam (joint venture by Telefonica and Sonera) decided to withdraw from the 3G market in 2002, although it has not returned the license yet. The company requested the German government to pay back the EUR 1 billion (USD 1.1 billion) VAT that it paid for its 3G license.[115] Other license holders also requested that their VAT payments be refunded, and the decision on this issue is still pending. Only Mobilcom returned its 3G license to the regulator RegTP in December 2003.[116] In Spain, Vivendi Universal indicated its intention to withdraw from the Xfera consortium, a 3G license holding company, by selling all of its shares in July 2003. Although Xfera possesses a 3G license in Spain, Vivendi Universal decided to withdraw because of high rollout costs as well as low user take-up rates experienced by other 3G operators.[117] Telefonica also announced in July 2003 that it would wish to sell its German, Austrian and Swiss 3G licenses to cut its losses in 3G services by focusing instead on the home market and on South America.[118] In Sweden, Orange Sverige AB has been forced to withdraw from the 3G market as part of its efforts to reduce its debt.[119] Svenska UMTS-nat AB, jointly owned by TeliaSonera and Tele2, agreed with Orange Sverige AB to purchase the license in January 2004.[120]

It may be significant that a number of 3G license holders who have pulled out of the 3G market in individual countries are new entrants in the relevant geographic market rather than incumbent 2G operators. The decision of new entrants to withdraw from the market could also be attributable to entry barriers, such as the first-mover and scale economy advantages of incumbent operators with an existing customer base, as well as over-optimistic business cases at the time of license attribution.

Instead of abandoning 3G businesses, some operators are beginning to offer data-only 3G services as their initial steps in recent years. In the United Kingdom, for example, Vodafone UK launched its Vodafone Mobile Connect 3G/GPRS data card targeted at corporate users in February 2004.[121] In Germany, T-Mobile will introduce a data card that supports GPRS, 3G and wireless LANs. In France, Orange announced its plan in February 2004 to start selling its 3G data cards during the second half of 2004.[122]

Table 9: Status of provision of commercial 3G services in OECD countries (as of April 2004)

	Status of providing 3G services
Australia	Hutchison 3G (3 Australia) started services in April 2003. Telstra started CDMA2000 1X services in December 2002. Vodafone Australia plans to launch services by 2005.
Austria	Mobilkom Austria followed One in September 2002 for technical launch of networks, and in April 2003 it started commercial services. Hutchison 3G (3 Austria) started services in May 2003. One plans to start services in the fourth quarter of 2004.
Belgium	Mobistar, KPN Orange, and Proximus plan to launch services during 2003. Among these, Proximus started technical launch of networks in July 2003.
Canada	Bell Mobility, Telus Mobility, Aliant Mobility and MTS Mobility have started CDMA2000 1X services in 2002.
Czech Republic	Eurotel and RadioMobil (renamed T – Mobile Czech Republic a.s. since May 2003) are obliged to launch services by 1 January 2006.
Denmark	Hutchison 3G (3 Denmark) started services in October 2003.
Finland	TeliaSonera Finland started services in certain regions in January 2003 and pre-commercial operation in December 2003. Radiolinja plans commercial launch during 2003 with testing services in January 2002.
France	Orange and SFR were supposed to launch services during 2002, but they are delayed. The regulator ART announced that the obligation to launch 3G services was delayed to the end of 2004 for Orange and SFR. Orange and SFR have started trial services and plan to launch commercial services during 2004. In April 2004, Orange launched pre-commercial 3G services in Toulouse using W-CDMA network.
Germany	T-Mobile started testing services in February 2002, although its commercial launch of services is being delayed. Vodafone Germany started trial services in 100 major cities in December 2003. O2 plans to start services in 2004.
Greece	Teleset is trial services. Vodafone-Panafon plans to launch services by the end of 2003. STET Hellas telecommunications launched services in selected markets in January 2004.
Hungary	No commercial service has been launched.
Iceland	No commercial service has been launched.
Ireland	Vodafone plans to start commercial services without mentioning an exact commencement date. O2 started limited services in selected markets in December 2003.
Italy	Hutchison 3G Italy launched commercial services in March 2003. Vodafone Italy plans to launch services in mid-2004.
Japan	NTT DoCoMo started services in October 2001 with testing services in May 2001. Vodafone Japan (former J-Phone) started services in December 2002 after testing services in June 2002. KDDI started services using CDMA2000 1X in April 2002 and launched services using CDMA2000 1xEV-DO in November 2003.
Korea	SK Telecom started services in February 2000. LG telecom started services in May 2001. KTF started services in June 2003. While both SK Telecom and KTF have used CDMA2000 technology, they also started W-CDMA services in December 2003.
Luxembourg	Tele2 started services in May 2003. P&T Luxembourg started services in June 2003.
Mexico	Grupo Iusacell started services using CDMA2000 1X in January 2003.
Netherlands	KPN Mobile plans to launch services during 2004. Vodafone Netherlands started testing services in September 2003.
New Zealand	New Zealand Telecom started CDMA2000 1X services in July 2002. Vodafone new Zealand plans to deploy 3G networks.
Norway	Telenor and NetCom are providing testing services. Hutchison plans to start services, although the schedule has not been confirmed.
Poland	Sferia started CDMA2000 1X services in November 2002. The launch date of other operators has been postponed to 2005.

Table 9: Status of provision of commercial 3G services in OECD countries (as of April 2004) (cont'd)

	Status of providing 3G services
Portugal	Vodafone Portugal started limited services in selected markets in January 2004. Oni Way implemented testing services in May 2001, but it has repealed its 3G license.
Slovak Republic	No commercial service has been launched.
Spain	All 3G operators set an UMTS system for technical trials before June 2002. From October 2003, Telefonica Moviles and Vodafone have UMTS pre-commercial systems. These companies plan to launch commercial services by the second/third quarter 2004. Vodafone plans to launch commercial services in the fourth quarter of 2004. Retevision Moviles has not made public the date of its commercial launching.
Sweden	Hutchison 3G (3 Sweden) started services in May 2003.
Switzerland	Swisscom announced to start 3G services for business customers in the first half of 2004. 3G services of other operators are expected to start during 2004.
Turkey	No commercial service has been launched.
United Kingdom	Hutchison 3G (3 UK) started services in March 2003. T-Mobile started data-only 3G services in February 2004. Orange, Vodafone and O2 plan to launch services not earlier than March 2004, but the company started trial services in February 2004.
US	Several operators announced the provision of nationwide 3G services including Verizon Wireless, which started CDMA2000 1X services in January 2002 and CDMA2000 IxEV-DO services in certain regions in September 2003. AT&T Wireless plans to launch services by the end of 2004.

Source: OECD.

Industry's effort to stimulate 3G markets varies. Some operators have delivered interesting video content over 3G networks. In Europe, for example, Hutchison 3G made a deal with MTV Networks Europe in September 2003 in order to allow subscribers to view music videos and original MTV programming over H3G video mobiles. MTV provides Hutchison 3G with four packages of localised content including Daily News, MTV What's Hot (live performances), Best of MTV (three weekly shows) and MTV Live Lounge (three weekly shows).[123] Operators' efforts can be seen in 3G equipment as well. In Japan, for instance, NTT DoCoMo announced in September 2003 that it would develop much smaller base stations for its 3G network than the current ones. The new micro base stations will allow the company to expand 3G service with greater flexibility and a more economical operational environment.[124]

Handset developments are also being used to enhance the growth of 3G. In Japan, for example, in July 2003 NEC developed a mobile handset that can receive signals from over-the-air television broadcasting. It plans to commercialise it in 2005.[125] However, the price of this handset will be higher by JPY 6 000-7 000 (USD 53.8-62.8) than existing ones. In September 2003, NTT DoCoMo announced that it would start marketing the FOMA F2042, the first data-card type terminal capable of high-speed packet data transmission for both uplinks and downlinks at a maximum speed of 384 Kbps.[126] One of the features of the F2402 is its ability to allow video calling from a PC to a FOMA videophone as well as to enable multi-accessing by letting users simultaneously transmit both voice and data.

In some countries, operators are encouraging other industries to use 3G systems. In Japan, for example, NTT DoCoMo, together with Japan Airlines (JAL), started testing from June to November 2003 3G applications for JAL ground staff use at Narita Airport. The test involved the use of 20 personal digital assistants (PDAs) and five personal computers equipped with FOMA data cards for simultaneous voice and data communications. Flight information and other data were sent via 384 Kbps packet transmissions over the network.[127] In Italy, Class Editori S.p.A, in co-operation with Ustream.it, created a financial-news TV channel called Cfn/CnbcMobile in April 2003, whose broadcasts can be viewed on 2.5G/3G mobiles.[128]

Some operators are attempting to combine 3G with satellite communications but this development is at an early stage. Tertio Telecoms announced in September 2003 that it was selected to provide its systems

to Inmarsat to launch a Broadband Global Area Network (BGAN) in early 2005. The aim is to provide mobile broadband services anywhere in the world using a new constellation of satellites.[129]

Roaming

From a market perspective, it is important for users to have roaming between the different generations of mobile phones. Roaming between 2G/2.5G and 3G networks will soon become the norm in some OECD countries. Recent technological developments are likely to facilitate the transition and roaming from 2G/2.5G to 3G. In the United States, for example, Qualcomm had successful W-CDMA field trials in Asia, Europe and North America in August 2003, which proved that users can have continuous services between 3G and 2G networks for voice and packet data services. Verizon Wireless also announced availability of a CDMA2000/GSM phone in early 2004, which allows Verizon's CDMA2000 users to roam on Vodafone's GSM in Europe and elsewhere.[130] In Germany, Infineon Technologies announced a complete 3G handset solution to promote the transition from 2G to 3G in February 2003.[131]

Roaming across national boundaries is also important to allow 3G users to communicate anywhere in the world. The fact that CDMA2000 operators have agreements allowing users to roam across networks in various regions of the world would substantiate this importance. There are some operators that have started international 3G roaming services. In Japan, for example, NTT DoCoMo started the World Wing international roaming service, in which FOMA subscribers can make and receive calls outside Japan by inserting a smart card that comes with their 3G handsets. NTT DoCoMo will not charge a monthly fee for this roaming service.[132]

Technological developments to ensure interoperability within 3G systems are also being developed. For example, IPWireless successfully completed the world's first interoperability testing between TD-CDMA (CDMA-TDD) and W-CDMA networks in July 2003. This test demonstrated that both TD-CDMA and W-CDMA standards for 3G can coexist in the same cell site as one network solution.[133]

Partnerships

There are an increasing number of alliances and partnerships to promote 3G services. This consolidation process is usually through mergers or joint ventures and has largely resulted from the significant costs for 3G licenses as well as network deployment. In the United States, for example, a group now known as 3GAmericas was created in January 2002 by a group of North and South American wireless service providers and equipment vendors to help the industry promote 3G networks. Member companies include AT&T Wireless, Cingular Wireless, Compaq, Ericsson, Lucent, Motorola, and Nokia.[134] In Austria, Kapsch tied up with CarrierCom to deliver value-added UMTS (as well as GSM) services to selected European markets in July 2003.[135] In Spain, 3G operator Xfera has made public that it is dealing with other 3G license holders in order to reach an agreement to share infrastructures and networks, as well as GSM roaming.[136] In Sweden, a license holder Europolitan (majority owned by Vodafone) and Hutchison 3G (3 Sweden) decided to jointly deploy the network to save costs.[137] In the United Kingdom, 3 UK partnered with lastminute.com to launch a service that allows 3 customers to search for deals on lastminute.com lifestyle products and travel information from their 3 video mobiles.[138] In Japan, NTT DoCoMo plans to launch an international videophone service in the United Kingdom in co-operation with 3 UK from October 2003. With this service, DoCoMo's 3G videophone users in Japan and Hutchison's 3G videophone users in the United Kingdom will be able to see each other while talking over the phone.[139] In Korea, SK telecom signed a memorandum of understanding with Alcatel in September 2003 in order to jointly develop and provide a wide range of integrated 3G applications such as mobile commerce, location-based services and gaming.[140]

5.2 Market developments in OECD countries

Australia

In October 2002, m.Net Corporation was providing limited 3G services by linking two South Australian cities to its 3G network. Motorola, Cisco Systems Australia, and Alcatel Australia are also involved in the m.Net Corporation consortium.[141]

In April 2003, Hutchison 3G Australia (3 Australia) launched its 3G network in Sydney and Melbourne.[142] In July 2003 it expanded its 3G networks by adding four new metropolitan regions across three more Australian states.[143] In January 2004, Hutchison 3G Australia introduced 'Videotalk to PC' a service that will allow customers to use their 3G handsets to make video calls with Web-camera-enabled PC users all over the world even in the countries without 3G services.[144]

Telstra announced that it launched 3G services for business customers using CDMA2000 1X standard in December 2002.[145] The company has significantly expanded its CDMA2000 1X network in the country, which covered approximately 1.5 million square kilometres or more than twice the area covered by Telstra's GSM network at the end of 2003. The network currently covers 98.3% of the population.

Other operators have yet to launch 3G services in Australia. Vodafone Australia will launch its 3G network using the W-CDMA standard by March 2005 as part of a global deployment by entering into partnerships with other operators. However, it announced in November 2003 that it would not partner any other operators in the deployment of its 3G network and take a slower approach to meet the collective needs of customers.[146] Optus will not launch 3G services until 2005.[147]

Austria

Although Mobilkom Austria officially announced in September 2002 the technical launch of 3G networks in all of Austria's state capitals with the exception of Salzburg, lack of handsets for about six months meant that service was delayed until April 2003. As of September 2003, Siemens U10 handsets are available in a selected number of Mobilkom Austria's shops, but it is expected that a wide range of 3G handsets from different vendors, which will allow interoperability between 2G and 3G, will be available in the future. Between 2001 and 2002, Mobilkom invested EUR 72 million (USD 85 million) in 3G network deployment.[148] As of May 2003 the network covered 42% of the population in the 54 largest cities.[149] As of December 2003, Mobilkom acquired about 1 500 users.[150]

In May 2003, Hutchison 3G Austria (3 Austria) launched 3G services. The company covered about 35% of the population by May 2003, which substantially exceeds the obligation in its license (25% of the population by the end of 2003). The parent company Hutchison Whampoa is prepared to invest EUR 1.2 billion (USD 1.3 billion) in its Austrian operation.[151] As of December 2003, H3G Austria had about 17 000 subscribers.[152]

The Spanish license holder Telefonica Moviles decided to pull out of the Austrian 3G market before starting commercial services in March 2002.[153] Since then, a number of operators have shown an interest in the unused frequencies that Telefonica had. For example, Mobilkom Austria and T-Mobile expressed a strong interest in the license. In December 2003, Mobilkom finally acquired a second UMTS license from Telefonica Moviles.[154]

Belgium

The technical launch of Proximus's UMTS networks was in July 2003. It was testing future mobile telephony applications such as mobile video telephony and video streaming, but announced the

commercial launch of its 3G services targeting business customers in April 2004.[155] Proximus intends to provide its customers with comprehensive mobile services regardless of the type of technology they use, *i.e.* 2G, 2.5G, and 3G. Mo9bistar and KPN Orange are also planning to launch 3G services during 2003.

Canada

Several operators have started 3G services using CDMA2000 1X technology with limited data rates. For example, Bell Mobility launched 3G services using CDMA2000 1X technology in the Greater Toronto area in February 2002, and it has expanded the coverage since then. The network is capable of supporting peak data speeds of up to 163.2 Kbps.[156] Telus Mobility launched 3G services using CDMA2000 1X technology in June 2002. The network has a speed of 144 Kbps under optimal conditions while achieving average speeds of about 60 Kbps. The company had about 2.6 million subscribers at the time of the launch growing to about 3 million as of March 2003.[157] Aliant Mobility launched 3G services using CDMA2000 1X technology in November 2002.[158] The services were first introduced in the Greater Halifax Metropolitan Area and then expanded in other major centres. The network has maximum data speeds of up to 144 Kbps and average speeds of about 86 Kbps.[159] MTS Mobility also launched 3G services using the same technology in November 2002.[160] The main three service plans include Warp I (data speeds of up to 28 Kbps, CSD 30/USD 22.4 per month), Warp II (data speeds of up to 46 Kbps, CSD 50/USD 37.3 per month), and Warp III (data speeds of up to 86 Kbps, CSD 80/USD 59.7 per month).[161]

The government auctioned 2300 MHz and 3500 MHz band spectrum in February 2004.[162] Twenty-two companies made successful bids and are eligible to receive licenses upon final payment, which might pave the way for further development of commercial 3G services in Canada.

Czech Republic

Although no commercial 3G services have been launched, Eurotel and T-Mobile Czech are supposed to start services by January 2006.

Denmark

Hutchison 3G (3 Denmark) launched 3G services in October 2003.[163] The network coverage was from launch 45% of the population and will be 50% by the end of the year. H3G Denmark expects that the 3G network will expand to 80% of the population much before the end of 2008[164], which is the requirement in the license. Through a roaming agreement with TDC, 3 Denmark covers 100% of the population with voice and SMS services. All H3G's 3G services are accessible as long as the user is within H3G's network coverage.

Finland

Since January 2002, TeliaSonera Finland has operated test 3G (UMTS) services in the Greater Helsinki area, Tampere, Turku and Oulu. In December 2003, TeliaSonera Finland started pre-commercial operation of 3G services together with the companies that need the network for their own service development.[165] The network will first be used by selected business customers who develop mobile services of their own. TeliaSonera estimates that the total costs of building the UMTS network will amount to approximately EUR 500 million (USD 556 million) from 2000 to 2009.[166]

France

Orange France and SFR planned to launch their commercial 3G service around the third quarter of 2004. Packet switched services will offer data rates of up to 144 Kbps for uplink and 384 Kbps for downlink. The network is expected to cover 30% of the population including major cities, and the service

will be available to 98% of the population in the mid-term.[167] In September 2003, Orange France had been working for 18 months on developing *"Villes Orange"* in Toulouse and Lille and building 3G capabilities.[168] In February 2004, Orange France started trials of the 3G services with 4 000 subscribers in order to test the customer experience of 3G.169 In April 2004, the company launched pre-commercial 3G services in Toulouse using a W-CDMA network.[170] Similarly, SFR started trials in several cities in France. Subsequently SFR launched commercial 3G services for business users in May 2004 and for residential users in the city regions of Paris, Lyon and Toulouse in June 2004.[171] The first 3G deployment by Bouygues Telecom will be in December 2004.

Germany

In January 2003, T-Mobile launched a test project in Nuremberg to spur adoption of 3G services targeting business users.[172] This initiative will demonstrate how business users can benefit from 3G services and integrated end-to-end business applications. T-Mobile planned to start rolling out 3G networks by the end of 2003.[173] In September 2003, however, T-Mobile abandoned this plan due to insufficient handset supplies and unresolved technical problems.[174] In February 2004, it was reported that T-Mobile would launch commercial data-only 3G services soon.[175] In March 2004, it was reported that T-Mobile would launch commercial UMTS services in Germany as well as in the United Kingdom and Austria in May 2004.[176] O2 launched 3G (UMTS) services in July 2004.[177] Vodafone Germany started nationwide 3G services in February 2004. Subscribers have a download speed of 384 Kbps and an upload speed of 64 Kbps.[178]

Greece

In July 2003, the Greek operator Telestet made the first public W-CDMA 3G call in the country over a network ready for commercial use.[179] Vodafone Greece expects its network to be ready by the end of 2003.[180] Cosmote Mobile Telecommunications S.A. announced in June 2003 that it selected Ericsson as its main vendor for the first phase of 3G deployment. It will invest EUR 35 million (USD 40.1 million) in 3G networks by the end of 2004.[181] STET Hellas telecommunications launched 3G (UMTS) services in January 2004, which were initially available in the greater Athens and Thessaloniki areas.[182]

Hungary

Although no commercial 3G services have been launched, Pannon GSM and Nokia demonstrated the first public W-CDMA 3G operator call in October 2003. These two companies have made an agreement whereby Nokia may provide full W-CDMA 3G network equipment for Pannon GSM for future commercialisation.[183]

Ireland

Hutchison Ireland is unlikely to provide a full commercial 3G service until the end of 2004. This delay is mainly due to limited network coverage as well as a shortage of handsets.[184] O2 Ireland was planning to start testing 3G service in early 2004 and to launch commercial services in late 2004 at the earliest.[185] However, it commenced limited 3G services among selected business and individual customers in December 2003.[186] It announced that its 3G network covered more than 35% of the population including major urban centres such as Dublin, Cork, Limerick, Galway, Waterford and Kilkenny. Vodafone Ireland started a 3G service in May 2003 which provides data speeds of up to 144 Kbps.

Italy

In March 2003, Hutchison 3G Italy launched 3G services. By mid December 2003, H3G Italy had reached 340 000 mobile subscribers while it has completed coverage through the acquisition of

approximately 4 000 sites.[187] While lack of handsets had been a problem, H3G Italy stated in September 2003 that 80% of the technical problems with 3G handsets were solved.[188]

In September 2003, Vodafone Italy announced that it would launch commercial UMTS services in mid-2004.[189] Telecom Italia Mobile is expecting to launch 3G services in 2004 after testing the services in the second half of 2003.[190]

Japan

In October 2001, NTT DoCoMo launched its 3G service, FOMA, using the W-CDMA standard. FOMA currently offers a maximum speed of 384 Kbps with a variety of applications such as 'i-motion mail' (to send video files with a voice message) and visual communications (TV phones). NTT DoCoMo announced in September 2003 that the service area for its 3G would cover 99% of the population in the Kanto-Koshinetsu region. It also announced that DoCoMo's eight regional subsidiaries would expand the service area to 96% of the population nationwide by the end of September 2003. FOMA is scheduled to cover the same service area as the PDC network in the Kanto-Koshinetsu region and for PDC in populated areas nationwide by the end of March 2004.[191] It further announced that the number of FOMA subscribers exceeded 1 million in September 2003.

In June 2003, NTT DoCoMo launched WORLD WING, an international roaming service for its FOMA handset users.[192] This service was available in 73 countries and regions as of October 2003. FOMA subscribers can make and receive calls outside Japan by inserting a smart card that comes with their 3G handsets. DoCoMo will charge no monthly fee or commission for this roaming service.[193] In addition, as noted earlier, NTT DoCoMo announced in September 2003 that it would launch a new 3G videophone service to make international videophone calls and 64 Kbps data transmission to the United Kingdom in co-operation with H3G UK. With this service, subscribers can make face-to-face contact via videophone and dial directly into private LANs via data transmission costing JPY 72 (USD 0.64) per 10 seconds.[194] Reportedly, NTT DoCoMo is also considering a strategy for 3G services in Chinese Taipei, where it already provides i-mode services through an alliance with KG Telecommunications.[195] In August 2003, the company developed technology that enables much faster data rates than presently available on FOMA. The technology uses spectrum by allocating it to specified users, allowing for a maximum speed of 14 Mbps. DoCoMo plans to undertake testing in 2003 and put them in service in 2005.[196]

KDDI launched 3G services using a CDMA2000 1X standard in April 2002. By the end of 2002, after nine months of service, it had 4 673 500 subscribers and as of February 2004 it had acquired 12 766 000 users. It also launched new 3G services using the CDMA2000 1xEV-DO standard in November 2003. Targeting frequent users and aiming at attracting 450 000 users by the end of March 2004, it offered services initially only in metropolitan areas and will expand service to 90% of the population by September 2004. The data rate of the CDMA2000 1xEV-DO services is up to 2.4 Mbps.[197] The services include location-based services, MMS, video distribution and high-speed Internet access. After the introduction of CDMA2000 services, KDDI's data average revenue per user (ARPU) grew to 20% of total ARPU.

KDDI announced in March 2004 that it would start an international roaming services of CDMA2000 1X voice and packet with SK Telecom of Korea, and it plans to expand its roaming area to other countries.

Vodafone K.K. (former J-Phone) rolled out 3G services to its customer base through Vodafone Global Standard (VGS) in December 2002 with coverage of about 71.1% of the country's population.[198] It offered dual-mode handsets (W-CDMA/GSM) from NEC and Nokia.[199] In August 2003, Vodafone announced that it would launch new Vodafone live! services on VGS after early October. The main features of this service include fast download speeds, CD-like quality ring-songs and video clip downloads as well as

access to 'sha-mail' picture messaging, Movie Sha-mail video messaging and Internet content for customers when they roam on GSM networks abroad.[200] In October 2003, Vodafone announced that it would sell 3G handsets that enable subscribers to watch TV over the mobile from December 2003.[201] Despite these services, the number of subscribers has not met the company's target yet. Vodafone acquired only 83 000 3G subscribers between its service launch in December 2002 and September 2003.[202]

Korea

Following the launch of a CDMA-based PCS service using 1800 MHz (reverse 1 750~1 770 MHz, forward 1 840~1 860 MHz) in September 1997, KT Freetel (KTF) provided wireless data services to subscribers by using CDMA2000 1X network and launched 'MagicN Multipack' service, a multimedia downloadable service with icons on a handset based on CDMA2000 1X in May 2001. KTF has provided 3G service with a maximum speed of 2.4 Mbps based on CDMA2000 1xEV-DO standard from May 2002.[203] Also KTF launched the high-speed mobile multimedia communication service branded as 'Fimm',[204] which stands for 'First In Mobile Multimedia' and offers 3G mobile multimedia services such as MMS, streaming video images (VOD), real-time TV viewing, video phone communication and MOD based on CDMA2000 1xEV-DO. VOD services bring subscribers streaming video images like TV, movies, music videos, and sports events through the graphic channel and MMS service allows subscribers to transmit a wide range of attached multimedia data via mobile phone or e-mail. The data includes long text (up to 1 000 words), photos, pictures, music, streaming video and so forth. As of December 2003, KTF had 7.4 million CDMA2000 subscribers, including 1.8 million CDMA2000 1xEV-DO subscribers out of a total 14.4 million subscribers.[205]

In March 2001, KTF obtained a license to launch W-CDMA 3G services in Korea. KTF merged KTICOM, a subsidiary of KT for W-CDMA 3G business in March 2003. For the first time ever, KTICOM demonstrated international video roaming between W-CDMA networks in Korea and Japan in co-operation with a Japanese mobile operator, J-Phone, in June 2002 during the 2002 World-Cup.[206] KTF provided W-CDMA trial services from September 2003 and launched the commercial W-CDMA 3G service in nine metropolitan areas including Seoul from December 2003 with a maximum speed of 384 Kbps.[207] KTF has continually developed a variety of value-added services and applications of W-CDMA 3G services and has negotiated in order to extend its global roaming coverage with other global mobile operators based on the W-CDMA standard.

Following the commercialisation of the world's first CDMA cellular phone service using 800 MHz band (824-849 MHz, 869-894 MHz) in 1996, SK Telecom became the first in the world to commercialise a CDMA2000 1X network in October 2000. In addition, SK Telecom launched CDMA2000 1xEV-DO in January 2002. The company decided to roll-out a CDMA2000 EV-DO network in 23 cities first and then extend its coverage to 83 cities and nationwide highways that year. As of January 2004, CDMA2000 1xEV-DO covers 90% of the population. As 2G subscribers actively migrated to CDMA2000 1X and EV-DO network, total usage of data services increased. Data service usage of CDMA2000 1X subscriber was about 30% higher than that of 2Gs. The numbers of CDMA2000 1X subscribers of SK Telecom and CDMA2000 EV-DO are almost 11 million are almost 4 million respectively. In October 2003, CDMA2000 EV-DO subscribers accounted for 12% of the company's total revenue.

SK Telecom obtained the business license as a W-CDMA service provider in March 2001 and started W-CDMA commercial service in December 2003. At the initial stage, dual band and dual mode (W-CDMA and CDMA2000) services were available.

LG TeleCom was incorporated in July 1996 as the telecommunications service provider of CDMA technology. Following the launch of its commercial operation of Personal Communications Service (PCS) in October 1997, LG TeleCom started countrywide CDMA2000 1X service in May 2001. As the first in

the world to develop Java Station, a Java technology used in CDMA phones, the company has also been a leader of Korea's wireless Internet technology. In April 2002, LG TeleCom initiated a new era of mobile financial transactions by launching the world's first infrared payment service that allows purchasing via PCS phones. LG TeleCom was the first in Korea to provide the new mobile banking service, "BankOn", which is based on a smart chip, as from September 2003.

Based on its advanced technology, data services and deployment of CDMA2000 EV-DV in PCS frequency band as well as 2 GHz band, LG TeleCom will promote a 2 GHz band CDMA2000 service.

Luxembourg

In May 2003, Tele2 AB announced that Tango, Tele2 AB's mobile operator in Luxembourg, launched its 3G network. Tele2's 3G network covers 90% of the population and 70% of the territory of the country. It uses Tango's 2G (GSM) network as a base.[208] In June 2003, P&T Luxembourg launched its first UMTS services in accordance with its 3G license awarded in May 2002. Initially, the network covered two principal cities: Luxembourg-City and Esch-S-Alzette.[209]

Mexico

Grupo Iusacell announced the launch of commercial 3G services in January 2003 using CDMA2000 networks with an access speed of up to 144 Kbps.

Netherlands

Following an announcement from BT and Deutsche Telekom in September 2001 that they had signed a deal over 3G network expenditure sharing in Germany and the United Kingdom, KPN announced that its E-Plus subsidiary would share German network costs with group 3G.[210] KPN plans to launch services in 2004, although it has put emphasis on increasing the number of subscribers to its 2G i-mode service during 2003. In September 2003, however, KPN announced that it would increase the investment in 3G technology by contracting with Lucent Technologies.[211] In March 2004, KPN announced that it would start offering commercial 3G services in June 2004.[212]

In September 2003, Vodafone Netherlands started to test 3G services in a project called MobiHealth at the technical University Twente in the city of Enschede.[213] Vodafone's 3G networks covered Amsterdam, Rotterdam, Den Haag, Utrecht and the connecting roads in the Randstad as of September 2003. Outside of the Randstad, Vodafone has coverage in Maastricht, Enschede and Eindhoven.[214] In June 2004, Vodafone Netherlands launched consumer 3G (UMTS) services that include the offer of video telephony, live television, film trailers and music and sport clips.[215]

New Zealand

Telecom New Zealand launched CDMA2000 1X services in July 2002 following the migration of their TDMA network to cdmaOne. Vodafone New Zealand announced in August 2003 that it would deploy a 3G network in partnership with another operator; this is due to be completed within 18 months.[216]

Norway

Telenor began testing its 3G network in December 2001. It is only providing for voice transmission at this point, but sees the service as a first step before deploying extensive 3G networks.[217] NetCom is also testing its 3G network. Hutchison 3, which obtained a 3G license in Norway in September 2003, is planning to build its 3G networks as an extension of its plan to construct a 3G network in Denmark.

Through its Hi3G joint venture, Hutchison paid NOK 62 million (EUR 7.64 million) for the license.[218] It is required to provide at least 30% of the population with 3G services within six years.[219]

Poland

Sferia launched 3G services using CDMA2000 1X technology in November 2002.[220] In July 2003, the Polish 3G license holders asked the regulator URTiP to delay the launch date for 3G services until 2004. They claimed that their heavy debt burdens and unreliable UMTS equipment was holding back their investment.

Portugal

In May 2001, Oni Way began testing 3G transmission in Portugal.[221] Although it was supposed to start commercial 3G services by the end of 2001, due to financial problems it asked for the repeal of its UMTS license in December 2002. The repeal was then granted in January 2003. There are currently three 3G operators in Portugal.

In July 2001, Telecel, a Vodafone affiliate, signed an agreement with Nortel Networks to supply 3G services in Portugal.[222] In January 2004, Vodafone announced that it would launch 3G services to a limited number of users in Lisbon and Porto for the first phase. The services will offer various applications including video telephony and high-speed mobile Internet connections up to 384 Kbps.[223] The company launched a 3G data card service in February 2004 and voice and video services in May 2004. It also launched 2G and 3G services in the underground stations of Oporto Metro in June 2004.[224]

Optimus launched 3G (UMTS) services in June 2004. The company plans to invest EUR 300 million (USD 367 million) in its network by 2009.[225]

Spain

Vodafone met the regulatory requirements for functionality and coverage of their 3G services in Spain in June 2002 with network coverage in 23 cities and 98 towns across the country.[226] In addition, it completed live 3GPP UMTS roaming calls between Spain and Japan's J-Phone in 2001. Vodafone plans to launch commercial 3G services in the fourth quarter of 2004. Meanwhile, Xfera Moviles plans to launch 3G services by December 2004. It downsized its 3G business plan to one-tenth the size of the original when 3G licenses were awarded in March 2000. It is reportedly in talks with one of its shareholders about the deployment of UMTS networks in Madrid and Barcelona.[227] In December 2003, Xfera obtained governmental approval for a delay in the deployment of its 3G network.

Telefonica Moviles is working on a UMTS pilot network deployment with Lucent.[228] It officially presented 'Oficin@ MoviStar UMTS', the first pre-commercial UMTS service in Spain, together with its plans for the 3G project in October 2003. Telefonica planed to launch commercial 3G services in 2004 subject to the availability of handsets, and announced the launch of data-only UMTS services for EUR 1 (USD 1.25) per Megabits of transmitted data in February 2004. It also plans to invest about EUR 1 billion in 3G infrastructure between 2003-2006 and to have coverage in the 52 provincial capitals in the country by the end of 2003 as well as between 7 000 and 8 000 UMTS base stations in 2005.[229] In relation to this, it has also been reported that four Spanish 3G license holders including Telefonica Moviles, Vodafone, Amena and Xfera will invest EUR 800 million in UMTS technology between December 2003 and September 2004.[230]

Sweden

In May 2003, Hutchison 3G (3 Sweden) announced the launch of 3G (UMTS) services under the brand name 3.[231] H3G's network will initially cover Stockholm, Gothenburg and Malmo as well as some small cities. The network is likely to cover approximately half of the population, and Hutchison is attempting to increase the coverage to 70% by the end of 2003.[232] This coverage will be achieved by the extension of a 3G Infrastructure Service (3GIS) network, which is a joint venture established by 3 Sweden, Vodafone Sweden and Orange in order to share network infrastructure during the deployment of 3G networks in rural areas.[233] However, other operators may be slowing their deployment of 3G networks. For example, TeliaSonera warned in January 2004 that the deployment of its 3G network in Sweden would be delayed unless the company is allowed to use EDGE technology as an alternative to UMTS technology.

Switzerland

Swisscom announced it would offer 3G services for business customers in the first half of 2004. 3G services for residential customers from three operators (Swisscom, Orange, Sunrise) are expected to start during 2004. In March 2004, Swisscom Mobile announced its plan to deploy a nationwide broadband network that combines UMTS, EDGE and wireless LAN technologies by the beginning of 2005.[234]

Three 3G licensees (Swisscom, Orange, Sunrise) are actually building up their networks. Despite tight environmental regulations as well as difficulties in getting building permits for radio base stations, it is expected that they will manage to cover 50% of the population by the end of 2004 (license obligations). The fourth licensee Telefonica shows no activities regarding 3G network deployment.

Turkey

Although no commercial 3G services have been launched, it has been reported that 2G operators Turkcell and Telsim are preparing to enter the 3G market.

United Kingdom

Although licensed operators had been slow in launching 3G services,[235] many of them have finally started commercial services in recent years. In March 2003, Hutchison's 3G network was officially launched with both Motorola and NEC phones. From early on, the network provided urban and main artery 3G coverage throughout the country, and approximately 70% of the population is currently covered. In September 2003, Hutchison 3G UK launched an international video calling service, with subscribers enjoying UMTS services by Hutchison companies in Australia, Austria, Italy, Japan and Sweden.[236]

Vodafone UK started commercial 3G data card services in February 2004. With its Vodafone Mobile Connect 3G/GPRS data card, the company provides its subscribers with data rates of up to 384 Kbps. The data card will be available in some other European countries including Germany, Italy, the Netherlands, Portugal, Spain, and Sweden. Vodafone UK originally planned to launch commercial 3G services in the spring of 2004, by which time it expected to cover about 30% of the population, but the 3G voice services have been delayed.[237]

T-Mobile UK started 3G services in February 2004, although the network is only accessible via PCs and at the time of the writing, customers were not able to use telephone handsets. As of March 2004, the 3G networks were being used by selected customers using 2.5G and 3G data cards in PCs with automatic roaming across the company's seamless network. However, T-Mobile UK plans to launch 3G handsets and services on a wider basis.[238]

Orange UK will not launch 3G services until March 2004 at the earliest,[239] although the company started commercial trials of its 3G services in February 2004.[240] The company expects to provide 3G coverage of 40% of the population in ten major cities, on rail routes and at airports on full launch.[241]

On the Isle of Man, Manx Telecom introduced UMTS services in December 2001 after voice test calls in May 2001 and a public video call in June 2001.[242]

United States

Although a number of operators have started 3G services since 2001, most of them used CDMA2000 1X technology and hence the data rate was relatively limited. For example, Verizon Wireless launched 3G services using CDMA2000 1X networks averaging speeds of between 40 Kbps and 60 Kbps under the brand name Express Network in January 2002.[243] Sprint also launched a 3G network using CDMA2000 1X technology in selected markets in August 2002. This network provides peak speeds of up to 144 Kbps with average user speeds of 50-70 Kbps.[244] MetroPCS launched 3G services using CDMA2000 1X technology in Florida in February 2002 with a data rate of up to 153 Kbps. The company offered basic voice services at a monthly flat rate of USD 35,[245] and extended coverage in 2003.[246] EDGE (Enhanced Data Rates for Global Evolution) is already a commercial reality following the launch by Cingular Wireless in June 2003.

In recent years, however, some operators have increased the data rate in commercialising 3G services. For example, Verizon Wireless commercially launched its 3G (CDMA2000 1xEV-DO) networks called BroadbandAccess in September 2003. The network uses CDMA2000 1xEV-DO technology and promises the average user a download speed of 300 Kbps to 500 Kbps (up to 2 Mbps) with a monthly rate of USD 80. The service is available first on the East Coast as well as in a region of Southern California.[247] The company also plans to provide services to attract users away from DSL or cable providers. They are supposed to complement its 2.5G and 3G networks with Wi-Fi access in a partnership with a WLAN operator Wayport. In January 2004, Verizon announced its plan to expand the 3G network beyond the two regional markets, investing USD 1 billion between 2004 and 2006.[248]

As of October 2003, there were no truly nationwide commercial 3G networks that have a level of data rates equivalent to Verizon's CDMA2000 1xEV-DO networks in the United States. However, there are a number of regional limited networks operated by smaller providers. For instance, Monet Mobile Networks is offering commercial broadband using CDMA2000 1xEV-DO wireless data networks in Duluth, Minnesota.[249] This service is designed for broadband mobile Internet access with a flat monthly rate. UbiquiTel also announced that they launched a data-optimised CDMA2000 1xEV-DO trial network in Boise, Idaho in November 2002. This network provides selected enterprises and government entities with mobile access at speeds of up to 2.4 Mbps.[250] The following table summarises 3G (CDMA2000) carriers in the United States.

Table 10: 3G operators in the United States as of December 2003

Operator	Service launch date	Frequency bands	Pre-IMT-2000 technology
Western Wireless	July 2001	800 MHz	TDMA, cdmaOne
Monet Mobile Networks	October 2001	1900 MHz	N/A
Leap Wireless	December 2001	1900 MHz	CdmaOne
Verizon Wireless	January 2002	800 and 1900 MHz	AMPS, CdmaOne
MetroPCS	February 2002	1900 MHz	N/A
Sprint	August 2002	1900 MHz	CdmaOne
Cellular South	September 2002	800 MHz	AMPS, TDMA
NTELOS	Third quarter 2002	1900 MHz	CdmaOne
US Cellular	October 2002	800 and 1900 MHz	AMPS, TDMA
Kiwi PCS	November 2002	1900 MHz	CdmaOne
Illinois Valley Cellular	January 2003	800 MHz	TDMA
Midwest Wireless	January 2003	800 MHz	TDMA
ALLTEL	March 2003	800 and 1900 MHz	CdmaOne, TDMA

Source: CDMA Development Group

Other large operators are also gradually becoming active in the 3G market. For example, AT&T Wireless initially announced in December 2002 that it would launch 3G services using W-CDMA standard by the end of 2003 in co-operation with Japan's NTT DoCoMo, but it is now delaying commercialisation.[251] In order to meet the contract with NTT DoCoMo, AT&T Wireless plans a commercial launch of 3G services in four cities: San Francisco, San Diego, Seattle, and Dallas, by the end of 2004.[252] It has been conducting a trial of W-CDMA technology in Dallas for several months.[253] The announced services will complement AT&T Wireless's national high-speed EDGE network.[254] In October 2003, AT&T Wireless deployed a 3G W-CDMA trial network in the greater Miami area in order to evaluate mobile voice and high-speed data services.[255]

VI. PRICING OF 3G

6.1 Main pricing issues

The level and structure of prices is expected to be one of the most important factors in the adoption and diffusion of 3G services. Indeed, a survey indicated that 85% of European mobile users thought that price was the key reason to switch mobile operator.[256] Pricing models for 3G services normally consist of combinations of the two essential basic rates: a monthly flat rate based on connection speed as well as quality of service and an added component for premium services.[257] Given the use of flat rates for broadband Internet access through fixed networks (DSL and cable), 3G operators need to find an appropriate balance between the demand for services and the constraints imposed by network capacity.

Charging per minute or per packet (or per byte) will prove expensive for a number of users. 3G access speed varies depending on the speed at which a user is moving as well as the extent of voice traffic congestion, so that some users may feel that they are not getting full value for their money. This has not deterred operators from per minute charging. In Japan, for example, NTT DoCoMo offers packet charges of JPY 0.2 (USD 0.002) for data communications unless users choose "packet pack" services.[258] If users pay a monthly rate of JPY 8 000 (USD 68), for example, the packet charges are reduced to JPY 0.02 (USD 0.0002).

Flat rate pricing is more likely to be an incentive for the uptake of 3G services. It also has a potential to encourage existing customers to upgrade to more feature-rich mobile phones. Increasing numbers of operators are beginning to provide flat-rate services. In the United Kingdom, for instance, 3's VideoTalk 500 provides customers with 500 voice minutes to any network at any time for GBP 25 (USD 40) per month. VideoTalk 750 also provides customers with 750 voice minutes to any network at any time for GBP 35 (USD 55) per month. For the first three months, the package will include a GBP 20 (USD 32) per month allowance for video calling, video messaging and content.[259] As already mentioned, however, some are concerned that 3G operators will not have the capacity if they acquire too many customers and too much traffic because of the flat rate. This aspect increases in importance in view of the possibility that quality of service is likely to become a problem if operators do not charge for traffic volumes in an 'always-on' environment.

Another pricing problem is that it is not easy to determine how much to charge to each 3G application. This holds true in comparison with 2G pricing. For example, data services over 3G networks differ significantly from those provided by 2G networks in that they are offered in the form of packet-mode services and that the rates are higher. Pricing among different types of 3G applications is also difficult to differentiate. For instance, sending e-mail is priced at much less than holding a videoconference.[260] Charging high prices for videoconferencing reflects to some extent the higher resource utilisation of this application, but it could be risky if operators do not know how much demand there is in the market for this application. Some argue that pricing for messaging, content and entertainment services, such as instant messaging, games, music and video clips, could have a dramatic effect on overall mobile revenue and average revenue per user (ARPU).[261] From this perspective, it is estimated that revenue for these services will rise to USD 35 billion, 23% of total mobile revenues by 2008. However, some still emphasise that consumers are more interested in 3G applications that are useful while they are on the move such as traffic information rather than 'luxurious' capabilities such as downloading music and multi-media applications.

In a situation where pricing models have not been established, operators may have to find alternative means to ensure profits. For example, revenue sharing with content providers could be a way for operators to set up a pricing model. In Germany, T-Motion is providing a package of wireless services including sports, music and news with a monthly flat rate of USD 9, and it will share up to half the revenues with its content providers.[262]

Despite the generally expensive 3G prices, some companies are offering free services in a limited market. In the United Kingdom, for example, Hutchison 3G UK announced in August 2003 that it offered football fans the chance to follow three months of the new Barclaycard Premiership season for free on their video mobile phones.[263] Moreover, H3G VideoTalk 500 and 750 subscribers could send and read e-mail and view selected online content for free until August 2003.[264] In Austria, Mobilkom's 3G service was free from its launch in April 2003 to October 2003. In Sweden, 3 Sweden launched two pricing options named 3Fri (3Free) in September 2003 with 60 or 300 minutes of calls for free and the same rates to all mobile and fixed networks in that country 24 hours a day.

It is interesting to find that some operators set lower charges for 3G than those for 2G. In Japan, for example, NTT DoCoMo charges USD 0.44 for voice calls with 2G networks but just USD 0.26 with 3G. Similarly, a thousand packets of data cost USD 2.53 with 2G but just USD 0.17 with 3G. This is because of the increased efficiencies for the network as well as phone equipment.[265] In Sweden, 3 Sweden claims that video calls via its 3G services cost less than many people pay for voice communication and that this fact will drive a number of subscribers who want to share emotions to choose video calls. Its MoVi (video calls) services cost SEK 2.50 (USD 0.3) per minute.

There are also a number of reduced rate plans. In Japan, for example, NTT DoCoMo offers the Yu Yu Call discount plan, which applies a reduced rate of up to 30% towards designated phone numbers. Although this discount plan was limited to 2G and 3G voice calls with a basic monthly fee of JPY 180 (USD 1.5), it was extended to include 3G videophone communication as well in October 2003.[266] In the United Kingdom, 3 UK provided new customers who subscribed to its 3G services between October 2003 and December 2003 with the benefit of the same price for video calls as for voice calls for three months beginning on their registration date.[267]

Some operators link the extent of service plans with the availability or price of handsets. In Austria, for example, 3 Austria subscribers can get a handset free if they choose VideoPlus 800 priced at EUR 69 (USD 76) per month while the handset will cost EUR 149 (USD 165) if they choose VideoPlus 500 charged at EUR 49 (USD 54) per month.[268] In Italy, 3 Italy differentiates the type of 3G handsets in accordance with the prices of flat-rate plans.

Reduced 3G prices can be a threat to fixed telephony services, although this point is just as valid for any wireless or mobile technology as long as it is priced competitively with wireline services. In the United Kingdom, for example, Hutchison reduced prices of 3G voice calls to less than half of those of other operators. Some operators such as Vodafone also recognise that 3G can be a means to undermine the fixed telephony market.[269] If other 3G operators follow this move, operators might recognise that one of the important applications of 3G would be voice calls, which will promote competition on price reduction and will encourage the shift from fixed to mobile voice telephony.[270]

6.2 Examples of 3G pricing

This section provides an overview of pricing levels and structures being implemented by 3G operators. The diffusion of 3G is at an early stage so it can be expected that as diffusion accelerates and competition develops between national operators prices will change. As for 3G services, operators are beginning to offer a range of pricing packages to meet different customer demands.

Mobilkom Austria

Mobilkom Austria provides two data-centric packages. Data Package 7 is priced at a monthly flat rate of EUR 7 (USD 8.2) and EUR 2 (USD 2.4) per additional 7 Mbps of data exchange. Data Package 50 costs EUR 50 (USD 58.8) and EUR 1.50 (USD 1.8) per additional 50 Mbps of data exchange.[271]

Hutchison 3G Austria

Hutchison 3G Austria provides three types of rate packages as summarised in Table 11. VideoPlus plans require a 12 month contract whereas 3 Basic and 3 Power have no minimum contract period.

Table 11: H3G Austria's 3G tariff plan

Plan	Monthly charge	Service	Other features
VideoPlus 250	EUR 25 (USD 28.7)	This service includes 66 video minutes, 99 e-mails, 33 MMS (Multimedia Messaging Service) and video messages, 99 information service requests, and 250 minutes of national voice calls.	This tariff is available in combination with an NECe606 or an NECe808 handset, which retail for EUR 299 (USD 343.7) for one and EUR 499 (USD 573.6) for two.
VideoPlus 500	EUR 49 (USD 56.3)	This service includes the same service as VideoPlus 250 but with 500 minutes of national voice calls.	This tariff is available in combination with a NECe606 or a NECe808 handset, which retail for EUR 149 (USD 171.3).
VideoPlus 800	EUR 69 (USD 79.3)	This service includes the same service as VideoPlus 250 and 500 but with 800 minutes of national voice calls.	This tariff is available in combination with an NECe606 or an NECe808 handset, which is available for free.
3 Basic	EUR 19 (USD 21.8)	This service includes the same service as VideoPlus 250 but with 133 minutes of national voice calls.	This tariff is available in combination with a NECe606 or a NECe808 handset, which retail for EUR 576 (USD 677.7).
3 Power	EUR 39 (USD 44.8)	This service includes the same service as VideoPlus 250 but with 333 minutes of national voice calls.	This tariff is available in combination with a NECe606 or a NECe808 handset, which retail for EUR 576 (USD 677.7).

Source: Hutchison 3 Austria.

Hutchison 3G Italy

Hutchison 3G Italy initially launched services with flat rate plans known as 'Top 3 Executive' and 'Top 3 Privilege.' These plans have a monthly charge of EUR 85 (USD 94) without the handset and EUR 140 (USD 155) including leasing of the handset, respectively. With these amounts, subscribers will receive:

- 10 hours a week of national calls to fixed and mobile networks.
- 10 hours a week of national videocalls to 3 subscribers.
- 150 national and international SMS a week.
- 50 MMS a week.
- 100 e-mails a week.

- 100 multimedia events downloaded from 3 Mobile Portal a week.

The main difference between the two plans is in the type of handsets. Top 3 Privilege will allow subscribers to acquire the NEC e606 (EUR 780) handset with the possibility of replacing it once a year from a list of 3's handsets whereas Top 3 Executive will allow subscribers to acquire the Motorola A 830 (EUR 570) or the NEC e606 handset. According to 3 Italy, the most successful tariff plan is the Top 3 Privilege, which was chosen by about 70% of the subscribers' base. Such a tariff plan has been successful because of the fact that for the first time in the Italian communication market an operator offered leasing of handsets. The most popular service is video calling.

In March 2003, Hutchison 3G Italy launched prepaid services together with postpaid services. The tariff plans for both services are:

- Voice calls: EUR 0.15 per minute.
- National video call: EUR 0.55 per minute.
- National SMS: EUR 0.15 per minute.
- MMS and video message: EUR 0.55 per minute.

These plans include a bonus rate when subscribers spend more than EUR 50.

In September 2003, Hutchison 3G Italy launched a new tariff plan 'TUA'. This plan provides two possibilities: either the subscriber receives a free handset paying a one-off initial fee of EUR 99 or the subscriber buys the handset. For both possibilities, there is a requirement for the subscriber to fulfil the monthly threshold of 60 minutes of incoming traffic and EUR 30 of outgoing traffic. Moreover, if the subscriber buys the handset and meets the above threshold, he/she will receive a bonus of up to EUR 30 a month.

Furthermore, Hutchison 3G Italy announced that it would initiate a prepaid videophone service in September 2003. This offer requires users to sign up for an offering called Tua and a free video-enabled handset, which will be upgraded at no extra charge. Although the phone is free, the sign-up charge is EUR 99 (USD 113.8) in addition to a minimum monthly usage fee of EUR 30 (USD 34.5). Voice calls will cost EUR 0.3 (USD 0.34) per minute (EUR 0.15 (USD 0.17) to other 3's mobiles) whereas video calls to 3's mobiles will cost EUR 0.45 (USD 0.52) per minute.[272]

NTT DoCoMo (Japan)

At the launch of 3G services, NTT DoCoMo set the basic pricing principles: (1) tariff structure suitable for the age of mobile multimedia – a comprehensive subscription package allowing the use of all communications modes and cheaper packet charges suitable for high-speed and large volume transmission; (2) facilitate a smooth migration from 2G – charges for voice communications will be similar to 2G; (3) communications charges are set to better align with the charges in Europe and the United States and to set simplified time zones.[273]

As of September 2003, NTT DoCoMo provides five packages and one data-only package plan. These plans can be combined with packet communications packages called 'packet pack.' The following tables summarise the detailed tariff plans.

Table 12: NTT DoCoMo's 3G package tariff

	Monthly basic usage fee	Proportion of toll-free communications
FOMA Plan 39	JPY 3 900 (USD 33.4)	JPY 750 (USD 6.4)
FOMA Plan 49	JPY 4 900 (USD 42.0)	JPY 2 050 (USD 17.6)
FOMA Plan 67	JPY 6 700 (USD 57.4)	JPY 4 050 (USD 34.7)
FOMA Plan 100	JPY 10 000 (USD 85.7)	JPY 7 350 (USD 63.0)
FOMA Plan 150	JPY 15 000 (USD 128.5)	JPY 11 650 (USD 99.8)
FOMA Data Plan	JPY 2 200 (USD 18.8)	JPY 0 (USD 0)

Source: NTT DoCoMo.

Table 13: NTT DoCoMo's 3G tariff for packet communications (JPY)

	Flat communication rate	Packet pack communication rate			
		Below 0.15 million packets	0.15-0.6 million packets	0.6-2 million packets	More than 2 million packets
No packet pack	-	JPY 0.2	JPY 0.1	JPY 0.05	JPY 0.02
Packet pack 20	JPY 2 000 (USD 17.1)	JPY 0.1		JPY 0.05	JPY 0.02
Packet pack 40	JPY 4 000 (USD 34.3)	JPY 0.05			JPY 0.02
Packet pack 80	JPY 8 000 (USD 68.5)	JPY 0.02			

Source: NTT DoCoMo.

KDDI (Japan)

KDDI's 3G services using the CDMA2000 1xEV-DO standard, branded CDMA 1X WIN, offer four types of tariff plans as shown in Table 14. KDDI's CDMA 1X WIN also offers five types of packet communication tariff plans as shown in Table 15.

Table 14: KDDI's 3G (CDMA2000 1X WIN) voice and data tariff plans

	Monthly basic usage fee	**Proportion of toll-free communications**	**Communication fee per 30 seconds**
Plan L	JPY 10 000 (USD 91.3)	JPY 6 600 (USD 60.2)	JPY 12 (USD 0.10)
Plan M	JPY 6 900 (USD 63.0)	JPY 4 200 (USD 38.3)	JPY 14 (USD 0.13)
Plan S	JPY 4 900 (USD 44.7)	JPY 2 100 (USD 19.2)	JPY 16 (USD 0.15)
Plan SS	JPY 3 900 (USD 35.6)	JPY 1 000 (USD 9.1)	JPY 20 (USD 0.18)

Source: KDDI

Table 15: KDDI's 3G (CDMA 1X WIN) packet tariff plans

	Monthly fee	**Bundled number of packets**[274]	**Communication fee per packet**
EZ Flat	JPY 4,200 (USD 39.7)	Unlimited[275]	Applicable only to access for Ezweb and email from handsets
Basic	JPY 300 (USD 2.85)	None	JPY 0.2 (USD 0.002)
Packet-wari WIN	JPY 1,200 (USD 11.4)	12 000	JPY 0.1 (USD 0.001)
Packet-wari WIN middle	JPY 4,000 (USD 37.9)	160 000	JPY 0.025 (USD 0.0002)
Packet-wari WIN super	JPY 7,500 (USD 71.0)	500 000	JPY 0.015 (USD 0.0001)

Source: KDDI

Vodafone K.K. (J-Phone)

Vodafone K.K.'s 3G pricing plans and discount services are the same as its 2G services. The following table summarises the tariff plans for both voice calls and video telephony. The company announced a new discount service called Vodafone Happy Time starting in October 2003. This package has a uniform rate of JPY 5 (USD 0.05) per minute for calls to other Vodafone customers during Saturdays, Sundays and national holidays. In addition, two new price plans and a new discount service were added. One of them was aimed at heavy users with a basic monthly charge of JPY 20 000 (USD 173.3) and JPY 17 000 (USD 147.3) worth of calls. Another one was suited to economy users with a basic monthly charge of JPY 5 900 (USD 51.1) and JPY 2 700 (USD 23.4) worth of calls. A new discount service called Vodafone Happy Bonus, which was limited to subscribers with a two-year contract, provided a 15% discount on basic monthly charges and free basic monthly charges for two months out of every ten months of use. Those who registered for Vodafone Happy Bonus before March 2004 qualify for music, restaurant and shopping prizes.[276] Vodafone K.K. also introduced a packet data discount service, Vodafone Happy Packet, for 3G subscribers, in December 2003.

Table 16: Vodafone K.K.'s 3G and 2G tariff plans

	Monthly basic usage fee	Proportion of toll-free communications	Communication fee per minute (after 7 a.m./ after 1 a.m.)
Value Pack Premium	JPY 20 000 (USD 173.3)	JPY 17 000 (USD 147.3)	JPY 15/10 (USD 0.13/0.09)
Value Pack Platinum	JPY 14 500 (USD 125.6)	JPY 10 000 (USD 86.7)	JPY 15/10 (USD 0.13/0.09)
Value Pack Gold	JPY 9 800 (USD 84.9)	JPY 5 400 (USD 46.8)	JPY 20/15 (USD 0.17/0.13)
Value Pack Silver	JPY 5 900 (USD 51.1)	JPY 3 000 (USD 26.0)	JPY 30/20 (USD 0.26/0.17)
Value Pack	JPY 3 900 (USD 33.8)	JPY 2 000 (USD 17.3)	JPY 40/30 (USD 0.35/0.26)

Source: Vodafone K.K.

SK Telecom (Korea)

SK Telecom's 3G services called June provide several package plans. The packages, with their monthly tariff, vary according to the amount of content that users can download via 3G. For example, June 95 users can download up to eight music files whereas June 500 users can download as many as 170 files with the fixed monthly charge.

Table 17: SK Telecom's 3G package tariff

		June 95	June 150	June 250	June 350	June 500
Monthly charge		KRW 9500 (USD 8.0)	KRW 15 000 (USD 12.8)	KRW 25 000 (USD 21.3)	KRW 35 000 (USD 29.8)	KRW 50 000 (USD 42.6)
Proportion of toll-free communication		35 100 (USD 29.9) (13 500 kilobytes)	71 500 (USD 60.9) (27 500 kilobytes)	195 000 (USD 166.0 (75 000 kilobytes)	351 000 (USD 298.8) (135 000 kilobytes)	650 000 (USD 553.3) (250 000 kilobytes)
Charge rate exceeding the proportion of toll-free communication		50% of basic charge	70% of basic charge	80% of basic charge	85% of basic charge	90% of basic charge
Content to be down-loaded	VOD	4 kinds of sounds	6 kinds of sounds	10 kinds of sounds	15 kinds of sounds	20 kinds of sounds
		2 kinds of images	3 kinds of images	5 kinds of images	10 kinds of images	15 kinds of images
		-	4 music files	10 music files	15 music files	20 music files
		1 music video	2 music videos	5 music videos	10 music videos	20 music videos
		2 new movie clips	4 new movie clips	5 new movie clips	10 new movie clips	20 new movie clips
		-	-	5 broadcasting programmes	10 broadcasting programmes	20 broadcasting programmes
	Music	8 kinds of sounds	14 kinds of sounds	20 kinds of sounds	35 kinds of sounds	50 kinds of sounds
		8 music files	17 music files	50 music files	90 music files	170 music files

Source: SK Telecom.

Table 18: Basic charge of SK Telecom's 3G services

	Charge per 0.5 kilobytes
Multi-media (VOD/MOD)	KRW 1.3 (USD 0.001)
Text	KRW 6.5 (USD 0.006)
Small amount of multi-media (GVM, SK-VM)	KRW 2.5 (USD 0.002)
Internet access	KRW 1.5 (USD 0.001)

Source: SK Telecom.

Hutchison 3G Sweden

Hutchison 3G Sweden offers three sets of tariff plans. Subscribers can choose between the Blue and Green plan for standard use and the Red plan which includes video services (MoVi).

Table 19: Hutchison 3G Sweden's 3G tariff plans

	Blue	Green
Monthly charges	SEK 349 (USD 42.3)	SEK 679 (USD 82.4)
Voice calls to the 3 and fixed networks	400 minutes	1 150 minutes
Voice calls to other operators	50 minutes	100 minutes
MoVi (MMS)	50	100
SMS	50	100
MoVi (Video calls)	50 minutes	50 minutes
E-mail	100	100
Services 3	SEK 100 (USD 12.1)	SEK 100 (USD 12.1)

Source: IDATE NEWS.

Hutchison 3G Sweden simplified pricing by offering 3Fri, which includes free minutes to call anyone, anytime of the day in the country. 3Fri 60 includes 60 minutes of calls and a charge of SEK 2 (USD 0.25) per minute for calls above this limit, while it costs SEK 1.50 (USD 0.18) per minute for calls above 150 minutes. 3Fri 300 includes 300 minutes of calls as well as 50 Mbps of data transmission with SEK 1.30 (USD 0.16) per minute for above the 300 minute limit, while it costs SEK 0.90 (USD 0.11) per minute for calls above 600 minutes.[277]

Hutchison 3G UK

When the service was launched Hutchison 3G UK offered three types of bundled services (Table 20).

Table 20: Hutchison 3G UK's initial tariffs of bundled 3G services

Service	Tariff plan
The basic formula	A prepaid formula requiring no monthly subscription. Calls to other 3 subscribers priced at GBP 0.05 (USD 0.08) per minute. Other voice calls were more expensive starting at GBP 0.10 (USD 0.16) per minute. Video file transfers were priced at GBP 0.50 (USD 0.79) per minute, and each video download was priced at GBP 0.50.
Kit On3	Monthly rate of GBP 59.99 (USD 95.31) for 1 000 voice calling minutes, 100 video file transfers, 250 SMS and 50 downloads.
Caboodle	Monthly rate of GBP 59.99 (USD 95.31) for 1 000 voice calling minutes, 100 video file transfers, 250 SMS and 50 downloads.

Source: IDATE NEWS.

Subscriber growth was slow so that the company reduced its rates introducing several new tariff plans, which are essentially aimed at package users (Table 19).

Table 21: Hutchison 3G UK's tariffs of Videotalk services

Price plan	Monthly charge	Calls made		Messages			Content and E-mail
		Calls	Video	Video	Picture	Text	
VideoTalk 500	GBP 25	500 minutes	GBP 10 worth		0	25	Free until August 2003
VideoTalk 750	GBP 35	750 minutes	GBP 20 worth		0	50	Free until August 2003
VideoTalk 1000	GBP 60	1 000 minutes	50 minutes	50	50	150	25 events
VideoTalk 2000	GBP 100	2 000 minutes	100 minutes	100	100	300	50 events

Source: Mobiles Online.

International video calling services were launched in September 2003 and all customers video calling from the United Kingdom pay a flat rate of GBP 1.5 (USD 2.4) per minute to make an international video call, and GBP 2.0 (USD 3.2) per minute to make a video call when roaming overseas.[278]

With a view to meeting the goal of having 1 million customers by the end of 2003, 3 UK drew up several new price plans from October 2003.[279] Table 20 summarises the plans.

Table 22: Hutchison 3G UK's new price plans

Price plan	Monthly charge	Calls made	Content and email
VideoTalk 100	GBP 15 (USD 25)	100 minutes	
Football 500	GBP 30 (USD 50)	500 minutes	Unlimited football highlights and text alerts
Video for Voice	This is a promotion plan which allows customers that signed up with any of 3 UK's VideoTalk price plans to enjoy the benefit of video calls within the United Kingdom for the same price as voice calls. For three months, new customers can make video calls for the cost of voice calls and use video calls as well as voice calls from their monthly bundle. The offer applies to the initial 3 months of a 12 month contract.		

Source: 3G Newsroom.

In addition to the new price plans, in October 2003 3 UK also introduced a range of add-ons which are designed to provide subscribers with the flexibility to customise their mobile package.

Table 23: Hutchison 3G UK's add-ons

	Monthly charge	Service
Add Text	GBP 5 (USD 8.3)	Designed for text users, this service covers 75 text messages to reduce the cost per text to GBP 0.067, a reduction of one-third from GBP 0.1.
Add Football	GBP 5 (USD 8.3)	This service provides customers with unlimited access to football content, including Barclaycard Premiership and UEFA Champions League video clips, video and text alerts and team news.
Add Entertainment	GBP 5 (USD 8.3)	This service provides customers with unlimited access to 3's movies, classic comedy, and showbiz content.
Add Unlimited	GBP 10 (USD 16.7)	This service provides customers with unlimited access to content including football, showbiz, movies, comedy, news, weather, location-based content, and horoscopes as well as video content from MTV.

Source: 3G Newsroom.

6.3 Average revenue per user (ARPU)

Average revenue per user (ARPU) provides a benchmark measure for mobile operators. ARPU includes revenues from traffic and does not include revenues deriving from handsets or advertisements. An analysis undertaken in May 2001 predicted that ARPU would increase from USD 20 to 30 for voice and limited data capability in 2001 to USD 80 to 100 in a 3G multimedia world. On the other hand, some forecasts have predicted a decrease in 3G ARPU with some estimates foreseeing a 15% drop in mobile ARPU by 2005 and major business consolidation.[280]

In recent years, mobile operators have for the most part had a declining ARPU, and some operators have had less ARPU in 3G business than in 2G. In Japan, for example, NTT DoCoMo generated less ARPU in March 2003 from customers on FOMA than those on 2G i-mode services, presumably because it charges less for 3G than for 2G services. Although DoCoMo's monthly 3G ARPU was JPY 10 400 (USD 88.8) from October to December 2001, around 25% higher than 2G i-mode ARPU of JPY 8 500 (USD 72.6), it declined to JPY 8 300 (USD 70.9) in 2002 as the novelty of video communications wore off while i-mode ARPU remained static.[281] However, some analysts believe that in the longer term 3G subscribers will generate significantly higher revenue, up to 50% more than 2G subscribers.[282]

A number of industry analysts believe that voice will continue to produce most revenues in the medium term although access to data and other services will become increasingly important.[283] Pricing structures of some operators appears to support this view. For example, the fact that 3 UK slashed voice tariffs to GBP 0.05 per minute or less in June 2003 seems to be based on the assumption that 3G will prove profitable based on lower costs for voice services alone.[284]

In most 3G applications, it is likely that volume rather than high prices will create revenue from 3G business in the future. In other words, increased bandwidth as well as enhanced capabilities from devices along with content will drive usage for 3G services. From this perspective, some argue that CDMA2000 1xEV-DO will create much higher ARPU than CDMA2000 1X because the speed of the former is much higher, which will allow an increasing traffic volume.[285]

VII. RELATIONSHIPS WITH OTHER WIRELESS TECHNOLOGIES

7.1 Linkage with 2G/2.5G

The deployment of 3G networks is, in some cases, playing a role in strengthening 2G and 2.5G services. This results mainly from the delay in 3G commercialisation. For example, in France Bouygues Telecom provided EDGE technology for mobile multimedia services in October 2003 because 3G networks were not commercially available.[286] In the United Kingdom, Vodafone, Orange UK, T-Mobile and mmO2 continued to place emphasis on existing GSM networks in 2003 rather than launch 3G services immediately despite the fact that their rival 3 UK had already launched its 3G networks.

At the same time, it is important to note that 2.5G technology is defining some of the 3G applications and services. This fact might also discourage operators to move to 3G businesses. In other words, the main challenge for 3G is to persuade 2G and 2.5G customers that it is worth the upgrade.

One of the main problems for operators is how to migrate subscribers from 2G to 3G. There is also a risk for 3G operators that customers transferring from 2G to 3G decide to change company. In order to avoid customer churn pricing structures and levels play an important role. Indeed, some operators have set prices of 3G voice and data services cheaper than 2G. This becomes possible because of the technological efficiency of 3G. In Japan, for example, NTT DoCoMo charges less for 3G than 2G services for voice and data services.[287] In the United Kingdom, 3 UK's plan called VideoTalk 100, which brings video mobile services within the reach of low-end contract users, is priced cheaper in comparison with other similar 2G/2.5G packages offered in the United Kingdom, as shown in the following table.[288]

Table 24: Competitive mobile call prices in the United Kingdom

Package	Monthly price	Inclusive minutes	Average price per minute
3 UK VideoTalk 100	GBP 15 (USD 25.4)	100	GBP 0.15
T-Mobile Everyone 100	GBP 21 (USD 35.6)	150	GBP 0.14
Orange UK 120	GBP 25 (USD 42.4)	120	GBP 0.208
Vodafone 100 Anytime	GBP 22 (USD 37.3)	100	GBP 0.22
mmO2 100	GBP 25 (USD 42.4)	100	GBP 0.25

Source: 3G Newsroom

As a consequence, the emergence of 3G services will inevitably affect 2G/2.5G pricing. Some operators have been obliged to reduce 2G prices in order to compete with 3G services. In Germany, for example, a number of 2G operators have introduced massive price cuts to stimulate consumer demand for mobile data applications in preparation for the arrival of 3G.[289] In addition, it is interesting to find that some mobile operators are linking 2G/2.5G with 3G services to attract customers. In the United States, for example, Verizon Wireless 2G subscribers with a monthly service plan over USD 35 may enjoy 3G data services for an additional monthly charge of USD 30.[290] In Germany, T-Mobile has recently announced the introduction of a data card supporting GPRS, UMTS, and wireless LAN.

But, although the delay in commercialising 3G may be leading some operators to strengthen their 2G and 2.5G offerings this is also in turn helping to strengthen 3G. This is because some of the new applications that 2G and 2.5G are providing raises user expectations and increases demand for better multimedia service on mobile networks. An example is the development of i-mode, Japan's mobile Internet service provided by NTT DoCoMo. This service played an important role in demonstrating that there is a market for wireless Internet access and increased the demand for the services. With the popularity of i-mode, the number of 3G subscribers in Japan grew dramatically over the last few years.[291] In the Netherlands, KPN Mobile has also promoted the use of i-mode in Belgium, Germany, and the Netherlands. Along with its plan to begin rolling out 3G network during 2003, KPN is still targeting a combined i-mode subscriber base of one million users in the three countries.[292] Presumably, Vodafone Group PLC's new consumer-oriented service 'Vodafone live!' has come from the competition with i-mode.[293] Some operators are using 2G to expand the 3G market. In i-mode's case, for example, it has been adopted by KPN-owned operators in Benelux and Germany as well as Bouygues in France. In addition, it has been introduced in Spain by Telefonica Moviles as well as in Italy by Wind in 2003 and signed up almost 700 000 users across Europe as of September 2003, whereas Japan had 39.5 million i-mode subscribers then. This has placed pressure on the United Kingdom operators as the only major European country without an i-mode provision and encouraged co-operation between NTT DoCoMo and 3 UK.[294]

7.2 Linkage with Wireless LANs

Along with the development of 3G, in recent years OECD countries have developed a number of services using Wireless Local Area Networks (WLANs) for Internet access in selected local areas (access points), normally called hot spots, such as hotels, airport lounges and coffee shops. Analysts have forecast that the global WLAN market will grow from USD 1.5 billion in 2002 to USD 3.1 billion in 2007.[295] Another estimate predicts that the number of WLAN enabled notebook users will reach 58 million by 2008.[296] However, some OECD countries seem to be lagging behind in the implementation of WLANs. In the United Kingdom, for example, as of August 2003 56% of all companies had no plans to implement WLANs.[297]

WLANs and 3G could be viewed by some as competitive services in the wireless telecommunications market. While some analysts see WLAN and 3G as complementary technologies, other analysts have argued that developments in WLANs can be a threat to 3G. For example, one estimate is that WLANs could take as much as 64% of 3G revenues in the next four years.[298] Other research undertaken by Deutsche Telekom implies that 90% of data applications viewed as a potential market for 3G (UMTS) can be provided more efficiently by WLANs.[299] This research also suggested that the problem lies in the fact that WLANs are competing with 3G exactly in the key areas in which the 3G deployment was supposed to start first. A conclusion from this analysis is that 3G has a comparative advantage over WLANs only in rural areas where hot spots may be harder to develop. It has also been argued that 3G might not be necessary because consumers will opt to use WLANs in hot spots such as at airports or hotels when they are away from home.[300] There are, however, both similarities and differences between 3G and WLANs.

Similarities

Both 3G and WLANs share similarities in that they are wireless technologies that enhance various degrees of mobility as well as enable users to use services without cabling. From the users' perspective, interface devices are needed to use services in both 3G and WLANs in spite of their wireless features. For 3G, PC cards will be needed. For WLANs, PC cards or PCs equipped with a wireless network interface card will be necessary.

At the same time, they are also technologies that provide broadband Internet access and can be alternatives to wired broadband networks, although speed may be lower than some wired broadband technologies such as fibre-optics. However, some WLANs have offered speeds much higher than cable modem or DSL connections. Both services will support 'always on' connection, which is an important factor particularly from users' perspective. Some also expect that these technologies can be a solution to the 'last-mile problem' in local areas. While 3G is an extension of 2G, whose main feature is end-to-end voice communication, enhanced performance in 3G allows access to broadband Internet services.[301]

Differences

There are a number of differences between 3G and WLANs. The first difference relates to the business model. As already noted, 3G is an upgrade of existing mobile services such as 2G and 2.5G, and thus its business model is a telecommunications service model in which operators own and manage the network infrastructure and provide services to customers on the basis of the infrastructure with charges. However, WLANs came out of the data communications industry, a by-product of the computer industry, in which the primary business model is that equipment makers sell boxes to users. Users of closed-community WLANs are often not charged directly, and the costs of providing wireless access are subsidised by the community. Sufficient business models for WLANs are still in development.

The way in which networks are rolled out is also different. The deployment of 3G networks is generally implemented in a top-down and centralised manner, whereas the deployment of WLANs often takes the form of bottom-up and decentralised. There is considerable difference in the time and costs required for the network deployment as well. While it normally takes several years for operators to deploy their 3G networks which can be nationwide, the roll-out of WLANs is in most cases fairly speedy, which is expected for small hot spots. For example, Wi-Fi Metro, a wireless Internet access provider, launched a number of Wi-Fi hubs for wireless Internet access in Northern parts of California in only a few months.[302] This contrasts with the majority of 3G operators that delayed the deployment of the network. WLANs require less deployment costs than wired networks, and providers can piggy-back on the existing WLAN equipment, although coverage is small compared with 3G deployment. In contrast, the deployment of 3G networks by new entrants requires a great deal of investment, although existing mobile operators can use much of the 2G infrastructure. In this context, some wireless operators might start to consider extending access points (hot spots) if they can obtain sufficient spectrum because they believe that 3G revenues may not come quickly. However, the most important cost item for WLANs is not the upfront capital cost but the ongoing operating expenditure to support access points.[303] Most WLAN operators have to establish increasing numbers of access points in order to widen wireless broadband coverage, which will incur a large amount of backhaul costs.

In terms of deployment, 3G is currently being rolled-out at an increasing rate in a number of OECD countries, but some OECD countries have yet to begin investing in this technology. However, an increasing numbers of wireless operators have launched WLAN services. Some companies seem to be hesitating to start 3G services but are launching WLAN operations. In the United States, for example, AT&T Wireless launched Wi-Fi hot spot services in five US airports while it cut its initial 3G deployment schedule for 2004 from 13 cities to highly populated areas of 4 US markets.[304]

Unlike 3G, WLANs are not originally targeted at end-to-end services, whereas 3G has its roots in wireless voice telephony networks, and hence an integral part of it is voice calls between end-users. In contrast, WLANs are basically designed as a consumer data communications network, but are evolving to provide end-to-end services such as Wi-Fi telephony using IP technologies.

In terms of services, one of the most critical differences between 3G and WLANs is the data transmission rate. Normally, WLANs are capable of providing much faster transmission speeds than 3G,

and most WLANs provide speeds of 2-11 Mbps and some (for example 802.11g) are evolving to deliver speeds of 54 Mbps.[305] As a consequence some 3G operators might consider WLANs as an additional tool to make use of wireless content.[306]

The coverage of services also essentially differs. Although WLANs were designed as a local area technology and do not cover wide areas, 3G is a wide-area mobile broadband technology, allowing users to access services without finding a hot spot. While it could be possible that increasing numbers of hot spots may reduce the relative advantages of 3G wide-area services, the wide-area technology can offer services that will not be available with WLANs, particularly for voice services and mobile Internet access. Nevertheless, it may be important to note that WLANs are increasing and thus the coverage difference might be less important in the future. For example, some community groups are linking satellite connections to WLANs in remote areas where DSL and cable are not readily available.[307] However, such a solution would require significant computing resources for handoff, billing and authentication. Nevertheless, a number of service providers are attempting to use WLANs as a basis for wireless broadband access over broad geographical areas.

From a regulatory perspective, one of the most important differences is the asymmetric regulations between 3G and WLANs. Namely, 3G uses licensed spectrum whereas WLANs normally use unlicensed spectrum.[308] The cost of obtaining 3G licenses is often high and the number of licences limited so that there are barriers to entry in the market in contrast to WLANs. For 3G an important role of licenses is to protect service providers from interference from other operators. In contrast, there are no license requirements for WLANs and the risk of interference is higher, which may explain why WLANs would like to begin implementation in the 5GHz band rather than further deployments in the 2.4 GHz band.

Unlike 3G, WLANs provide opportunities for 'third parties' to use the network free of charge, even though Internet access using 'third-party' networks may violate the providers agreement with the WLAN network provider. Although users and subscribers are normally the same in 3G, any potential user passing by the vicinity of the signal can, in a number of public hotspots, access WLANs without payment. This has created security concerns which are being addressed through standards.

In addition, WLANs have the following disadvantages compared with 3G:

- Few or no roaming possibilities both nationally and internationally.
- Voice over IP (VoIP) is not as developed as the mobile standards.
- Difficulty for seamless handover between networks when on the move.
- Low penetration of WLAN-enabled handhelds compared to mobile phones.
- Few in the WLAN business can afford to subsidise terminals on the scale that has been seen on the mobile markets.[309]

Implications

While there would be no doubt that WLANs will be a complementary technology to 3G, the argument that these services will endanger 3G business plans appears premature. Rather it is expected that 3G and WLANs will be able to coexist and provide complementary services. 3G is ideally suited for wide-area, mobile environments while WLANs are suited for lower mobility and higher data transmission rates (often on private networks such as enterprises, campuses and homes). The fact that operators could offer high-

speed wireless access when a user is near a WLAN hot spot but provide 3G technology over a wider range will allow such complementary services.

Technological developments will also allow for the coexistence of 3G and WLANs. For example, Lucent Technologies announced successful seamless roaming of a wireless data call from WLANs to 3G (UMTS) networks in September 2002.[310] In December 2002, Nortel Networks also demonstrated integrated solutions for wireless operators which will link WLANs and 3G.[311] HP and Transat technologies announced in February 2003 that they would combine their technologies into a powerful solution in order to enable their mobile operators to link their own 2.5G and 3G networks with public WLANs.[312] In March 2003, Ericsson conducted a demonstration of seamless 2G, 3G, and WLAN roaming using IPv6 as a part of the European Union's IPv6 Wireless Internet Initiative (6WINIT) launched in 2001.[313] With this linkage, users will be able to have voice and data services from a single provider even if they are on the move or in a hot spot. Microchip makers Broadcom and Royal Philips Electronics also announced in September 2003 that it developed new microchips for WLAN that will accelerate the use of wireless networking on high-profile portable devices including 3G. These microchips create promising uses for the 802.11b standard and open the door for devices that combine WLANs and 3G by overcoming some of the key obstacles in integrating WLANs on portable devices. While it is likely that the integration of 3G and WLANs will be a gradual process, the development of hardware that can support both 3G and WLANs would be a significant step.[314]

These capabilities will not only allow the coexistence of 3G and WLANs but also have a great deal of applicability especially in the enterprise market. For example, roaming between WLANs and 3G will allow an employee to download large files from a WLAN at a hot spot outside his office and continue to receive the information via 3G on his way back to his office. With ubiquitous coverage, employees can stay connected without worrying whether they are covered by WLANs. At the same time, technology will address the necessity for combined billing for both 3G and WLAN services without restructuring existing network architectures. A report predicts that a combined mobile/WLAN strategy can increase revenue by approximately USD 676 million worldwide in 2006 rather than by providing WLANs alone in hot spots.[315]

There will be cases where developments in WLANs are stimulated by improvements of 3G. For instance, emerging wireless technologies of 802.16e and 802.20 standards will join 802.11 WLAN series in order to rival 3G technologies for mobile data services.[316] 802.16e is under development to add mobility to stations that support fixed wireless networking in the 2 to 6 GHz bands, and 802.20 is specified for the 500 MHz to 3.5 GHz range for full mobility. Handoffs between existing WLANs (802.11) and 802.20 networks have already been successfully demonstrated. However, issues of roaming, handset availability, reliability and availability still need to be addressed.

At the same time, it is interesting to find that some wireless operators are concentrating on a single technology instead of pursuing both and use WLAN services by partnering with other wireless operators. For instance, Vodafone announced in September 2003 that it would focus on 3G services without installing WLAN hot spots on its own. Instead, it will provide support using billing capabilities through SMS messages to bill accounts.[317] On this basis, Vodafone UK signed an agreement with BT Openzone that provides WLAN services in September 2003. Vodafone considers that the BT Openzone WLAN network will complement its existing 3G network and ensure that users can connect using the most appropriate network available.[318]

In the future, standards developed for systems beyond IMT-2000 will accommodate various levels of mobility and data transmission services. Some operators are planning to combine 3G with WLAN services. In the United States, for example, Verizon Wireless plans to complement its 3G networks with WLAN access by partnering with Wi-Fi operator Wayport.[319] In Germany, T-Mobile announced its plan to combine its WLAN and 3G services into a single high-speed data network in February 2004.[320]

7.3 Linkage with digital television

Along with 3G, digital television will play an important role in providing broadband access to the Internet to provide interactive audio-visual services in the near future. While there are still some challenges for the diffusion of digital television such as the management of switch-over from analogue to digital transmission, creation of interactive services, and viable business models, a number of OECD countries have already set the time frame to move to digital television.[321] Hence it is increasingly necessary to promote open technological platforms for 3G and digital television.[322] In this context, some recent policy initiatives are important. For example, the European Commission adopted a Communication on interoperability of Information Society services, designed to promote open platforms for 3G and digital television in July 2003.[323] Since precise capabilities will differ between 3G and digital television even if 3G is used as a tool to receive video service, individual customers will use the service differently. It will be critical to follow developments in this rapidly evolving field.

NOTES

[1] OECD, *OECD Communications Outlook 2003*, p.13

[2] http://www.itu.int/ITU-D/ict/statistics/at_glance/cellular02.pdf, http://www.itu.int/ITU-D/ict/statistics/at_glance/main02.pdf

[3] http://www.telecom.paper.nl/index.asp?t=a&i=35103&n=920

[4] With regard to the definition of broadband audio-visual services, see OECD, "Broadband Audio-visual Services: Market Developments in OECD Countries", DSTI/ICCP/TISP(2003)6/FINAL.

[5] http://www.wirelessnewsfactor.com

[6] http://telephonyonline.com/ar/telecom_overcoming_stress_gshdsl/index.htm

[7] For example, see http://www.3gtoday.com/.

[8] IS-95 standard was developed by Telecommunications Industry Association (TIA) and is technically TIA/EIA/IS-95 (superseded by TIA/EIA/IS-85-A). CdmaOne* is a registered trademark of the CDMA Development Group.

[9] As of June 2004, there were 217 commercial CDMA networks.

[10] http://www.gsmworld.com/index.shtml

[11] The standards are interoperable to the extent that users can place phone calls to each other (via the PSTN) without having to use the standards of another user.

[12] http://www.trillium.com/assets/wireless3g/white_paper/8722019.pdf

[13] Those mobile technologies that have a *maximum* speed of 128 Kbps are excluded from the category of 3G in this paper because they usually offer speeds of around 60-70 Kbps.

[14] CDMA2000 is a registered trademark of the Telecommunications Industry Association (TIA) in the United States.

[15] UMTS is a registered trademark of the European Telecommunications Standards Institute (ETSI). See http://www.etsi.org/t%5Fnews/0002%5Frel.htm.

[16] ITU, ITU-D, Guidelines on the Smooth Transition of Existing Mobile Networks to IMT-2000 for Developing Countries (Annex to Doc. 8F/TEMP/34(REV.1), October 15 2003.

[17] http://www.mobilkomaustria.com/CDA/frameset/sec_frame/1,3150,890-966-html-en,00.html. Upgrade to CDMA2000 from cdmaOne is replacement of software and introduction of a channel card.

[18] http://www.trillium.com/assets/wireless3g/white_paper/8722019.pdf

[19] Migration is a very controversial issue and the matter is currently being considered in the marketplace.

[20] http://www.3g.co.uk/PR/Feb2003/4927.htm

[21] See http://www.3gnewsroom.com/3g_news/oct_03/news_3816.shtml. However, many TDMA operators are deploying CDMA2000 as their IMT-2000 migration path. In addition, many TDMA carriers operate in 800 MHz for which there is no W-CDMA solution.

[22] http://www.itu.int/ITU-D/imt-2000/documents/IMT-2000%20Handbook_Web_1.pdf

[23] http://home.intekom.com/cellular/technologies/3g/3g.htm

[24] http://www.3g.co.uk/PR/November2002/4468.htm

[25] http://www.3gnewsroom.com/3g_news/jul_03/news_3594.shtml

[26] http://www.cdg.org/technology/3g.asp

[27] Unlike interoperability issues with the GSM to W-CDMA upgrade, CDMA2000 1xEV-DO handsets are backward compatible. Therefore, some estimate that the adoption rate will remain higher among CDMA users for CDMA2000 1xEV-DO technology even though W-CDMA subscribers are likely to surpass those for CDMA2000 1xEV-DO over time.

[28] Reportedly, China plans to introduce TD-SCDMA in a few years. See *International Herald Tribune*, February 23 2004, p.14.

[29] http://matsushita.co.jp/mtj/v4706/pdf/p0202.pdf

[30] Telecom.paper, February 26 2004. See http://www.telecompaper.com/index.asp?t=a&i=41661&n=906.

[31] Some analysts may categorise EDGE as '2.75G'.

[32] The term 4G has not officially been recognised by the ITU or some OECD countries, and there has been no universally accepted definition that has been identified for 4G services. The governments of Japan and Korea have used the term 4G to describe some of the R&D being conducted in their countries.

[33] http://home.intekom.com/cellular/news_2003/060503-docomo_to_trial_4g_system.htm

[34] According to NTT DoCoMo, however, commercial '4G' services would not be available until 2013. See http://www.3gnewsroom.com/3g_news/oct_03/news_3842.shtml.

[35] http://www.3g.co.uk/PR/November2002/4462.htm

[36] For example, SK Telecom will test a high-speed mobile system beyond IMT-2000 with Flarion. See http://www.3gnewsroom.com/3g_news/dec_03/news_4054.shtml.

[37] http://www.3g.co.uk/PR/November2002/4468.htm

[38] *Nihonkeizai shimbun*, June 7 2003, p.10

[39] http://www.soumu.go.jp/s-news/2003/030307_1.html

[40] http://www.mobile.commerce.net/print.php?story_id=923

[41] http://www.3g.co.uk/PR/July2003/5619.htm

[42] http://www.nordicwirelesswatch.com/wireless/story.html?story_id=3256. In addition, world mobile phone sales for 2003 are expected to reach 504 million units according to Strategy Analytics. See http://www.telecom.paper.nl/index.asp?t=a&i=37906&n=556.

[43] http://www.3g.co.uk/PR/April2003/5309.htm

[44] http://www.3g.co.uk/PR/August2003/5738.htm

[45] http://www.3gnewsroom.com/3g_news/sep_03/news_3763.shtml

[46] http://www.3gnewsroom.com/3g_news/sep_03/news_3703.shtml

[47] http://www.3g.co.uk/PR/August2003/5747.htm, http://www.nttdocomo.co.jp/p_s/dcmm/index.html

[48] http://www.3gnewsroom.com/3g_news/oct_03/news_3845.shtml

[49] http://www.3g.co.uk/PR/July2003/5687.htm

[50] http://www.3gnewsroom.com/3g_news/may_03/news_3440.shtml

[51] 3 Italy has also aquired football rights for the Champions League 2003-2004.

[52] http://www.3gnewsroom.com/3g_news/sep_03/news_3734.shtml

[53] http://www.3g.co.uk/PR/August2003/5694.htm

[54] http://www.3gnewsroom.com/3g_news/feb_03/news_3053.shtml

[55] http://www.3g.co.uk/PR/Sept2003/5776.htm

[56] *Tokyo Shimbun*, July 11 2003, p.9.

[57] Since system architecture is based on many factors that have implications for build-out cost, there would be some exceptions. While 3G services are being deployed in 800 MHz, 1900 MHz, and 450 MHz, more cell sites are required for those offering services from a lower frequency band to a higher frequency band.

[58] http://www.3gnewsroom.com/3g_news/jun_03/news_3519.shtml

[59] http://news.com.com/2100-1095-1019617.html

[60] CdmaOne operators who migrated to CDMA2000 were able to re-use their existing infrastructure with small upgrades in software at the base station controller and the mobile switching center, new channel cards and software at the base stations, and a new packet data support node. As a result, the migration from cdmaOne to CDMA2000 requires relatively small capital investment. In the United States, for example, Sprint invested USD 800 million to migrate their nationwide network to CDMA2000 1X.

[61] For example, A Base Station Test Set, introduced in January 2003 by Agilent Technologies, is one of the most comprehensive, single-box base station testers on the market. See: http://www.3g.co.uk/PR/Jan2003/4799.htm.

[62] Delays and refusals for planning permissions are primarily caused by public concerns about the health effects of Electromagnetic Fields (EMF). These public concerns are in contrast to a number of independent

experts' views which conclude that there is no convincing scientific evidence of a link between public exposure to low level radio signals generated by mobile telecommunications systems and adverse human health effects. The mobile communications industry acknowledges that there is a responsibility to address community concerns about the sites of radio base stations.

63 http://www.nttdocomo.co.jp/new/contents/03/whatnew1001.html

64 http://www.scigen.co.uk/what/consultancy/whatis3G.pdf

65 http://telephonyonline.com/ar/telecom_gm_delivering_conversational/

66 Neil Gandal, David Salant, Leonard Waverman, *Standards in Wireless Telephone Networks*, Telecommunications Policy 27 (2003), pp. 325-332.

67 See http://www.cdg.org/technology/cdma_technology/shosteck/defining.asp

68 http://www.coleago.com

69 For example see http://www.3g.co.uk/PR/Jan2003/4801.htm

70 http://www.telecom.paper.nl/index.asp?t=a&i=33476&n=006

71 On a worldwide basis, however, the majority of countries have yet to provide 3G licenses. The contrast is particularly clear between developed and developing countries.

72 http://www.telecom.paper.nl/index.asp?t=a&i=35544&n=570

73 http://www.3gnewsroom.com/3g_news/oct_03/news_3865.shtml

74 Both Orange and SFR spent about EUR 5 billion (USD 5.8 billion) for the license, respectively.

75 http://www.3gnewsroom.com/3g_news/oct_03/news_3865.shtml

76 Initial license terms for this spectrum will be for 15 years and renewal terms will be 10 years. The spectrum will be auctioned using geographic area licensing and symmetrically paired spectrum blocks with the pairings being composed of different bandwidths. The FCC has adopted a non-exclusive licensing approach for these bands in which traditional frequency co-ordination between users will not be required. Instead, each path will be registered in a database and entitled to interference protection on a link-by-link basis, with the priority being set based on the data of link registration. The FCC will issue an unlimited number of non-exclusive, nationwide licenses authorising non-Federal Government entities to use the entire 12.9 GHz of spectrum in these three bands.

77 http://www.3gnewsroom.com/3g_news/oct_03/news_3863.shtml

78 http://www.europemedia.net/shownews.asp?ArticleID=8019

79 http://www.telecoms.com/NASApp/cs/ContentServer?GXHC_gx_session_id_=cb648ce779f7b493&pagename=telecomsportal/render&var_element=content/article_simple&auth_pubcode=informatelecoms&var_article_id=1034683583792&display_channel=home&rdsl=true

80 http://www.itsweden.com/docfile/37521_3g_rollout_status.pdf

81 See http://europa.eu.int/information_society/topics/telecoms/radiospec/mobile/commission_doc/index_en.htm

[82] Some might argue that infrastructure sharing implies only network sharing, which should be distinguished from collocation of other facilities such as antennae sites. However, this paper broadly takes this term to include both.

[83] Network sharing will accompany several levels such as core networks and sites, and each level could have a different extent of regulations. In this context, it would be helpful to refer to the EU Competition Directorate that ranks the levels as sites, base stations, radio network controllers, core networks, and frequencies.

[84] http://www.itsweden.com/docfile/37521_3g_rollout_status.pdf

[85] http://www.theregister.co.uk/content/64/30531.html

[86] Even apart from this regulatory requirement, it is technically difficult to handle roaming from non-shared parts to shared parts of the network.

[87] http://www.3gnewsroom.com/3g_news/jan_04/news_4071.shtml

[88] Telecom.paper, April 16 2004.

[89] http://www.europemedia.net/shownews.asp?ArticleID=5770

[90] http://www.nordicwirelesswatch.com/wireless/story.html?story_id=3245

[91] http://www.3gnewsroom.com/3g_news/jul_03/news_3584.shtml

[92] http://www.mobilein.com/what_is_a_mvno.htm

[93] See:
http://europa.eu.int/information_society/topics/ecomm/doc/all_about/todays_framework/public_resources/i_10820020424en00330050.pdf.

[94] See:
http://europa.eu.int/information_society/topics/telecoms/regulatory/new_rf/documents/l_10820020424en00070020.pdf.

[95] See Delibera AGCOM 544/00/CONS.

[96] http://www.europemedia.net/shownews.asp?ArticleID=16226

[97] http://www.vodafone.ie/aboutus/company/press/2003/release010503.jsp

[98] http://www.3g.co.uk/PR/Jan2003/4780.htm

[99] http://www.au.kddi.com/seihin/kinobetsu/index.html

[100] http://www.3g.co.uk/PR/Sept2003/5841.htm

[101] http://www.3gnewsroom.com/3g_news/jul_03/news_3533.shtml

[102] In addition to these figures, it should be noted that Hutchison 3G has reached a subscriber base of 660 000 from zero market presence during March-December 2003.

[103] See http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param%5bno%5d=380

[104] Telecom.paper, March 26 2004.

[105] http://www.bbj.hu/user/article.asp?ArticleID=186925

[106] http://www.telecom.paper.nl/index.asp?t=a&i=35629&n=530

[107] http://telephonyonline.com/ar/telecom_pricing_showstopper/index.htm

[108] See: http://news.bbc.co.uk/1/hi/business/1692220.stm

[109] The phone froze when it accessed some Web sites incorporating certain site-construction specifications.

[110] http://telephonyonline.com/ar/telecom_ntt_docomo_recalls/index.htm

[111] http://www.3g.co.uk/PR/Jan2003/4801.htm

[112] http://www.telecom.paper.nl/index.asp?t=a&i=33670&n=912

[113] http://www.itudaily.com/home.asp?articleid=3101501

[114] http://www.europemedia.net/shownews.asp?ArticleID=17038

[115] http://www.mobile.commerce.net/story.php?story_id=2694

[116] http://www.3gnewsroom.com/3g_news/dec_03/news_4064.shtml. As of December 2003, German regulator RegTP is likely to re-sell the 3G spectrum of Quam and MobilCom in 2004. It will confiscate the two licences and then re-sell the spectrum allocated for around EUR 100 million for each permit (USD 119.11 million). See http://stefan.blogs.com/techblurbs/2003/12/spectrum_of_fai.html.

[117] http://www.3gnewsroom.com/3g_news/jul_03/news_3552.shtml

[118] http://www.telecomflash.com/default.asp?journalid=5&func=articles&page=070313&year=2003&month=7&srchexpr=3g#hls1. As of December 2003, Telefonica is in talks with Mobilkom Austria to sell its Austrian 3G license following the Austrian regulator RTR's approval to sell. It also does not plan to return its German 3G license as agreed with regulators and will instead seek a way to sell the license even though current German laws prohibit the sale of 3G licenses or trading of frequency spectrum. See http://www.telecom.paper.nl/index.asp?t=a&i=38848&n=650.

[119] http://www.3gnewsroom.com/3g_news/jan_04/news_4112.shtml

[120] http://www.3gnewsroom.com/3g_news/jan_04/news_4067.shtml

[121] http://www.vodafone.com/article_with_thumbnail/0,3038,OPCO%253D40000%2526CATEGORY_ID%253D201%2526MONTH%253D1%2526LANGUAGE_ID%253D0%2526CONTENT_ID%253D214962%2526YEAR%253D2004,00.html

[122] http://www.theregister.co.uk/content/59/35899.html

[123] http://www.3gnewsroom.com/3g_news/sep_03/news_3773.shtml

[124] http://www.3gnewsroom.com/3g_news/sep_03/news_3768.shtml

[125] *Tokyo shimbun*, July 11 2003, p.9.

126 http://www.3g.co.uk/PR/Sept2003/5835.htm

127 http://www.3gnewsroom.com/3g_news/may_03/news_3437.shtml

128 http://www.3g.co.uk/PR/April2003/5233.htm

129 http://www.3gnewsroom.com/3g_news/sep_03/news_3756.shtml

130 In addition, consumers can roam seamlessly between 2G and 3G coverage in their CDMA networks.

131 http://www.europemedia.net/shownews.asp?ArticleID=15068

132 http://www.nwfusion.com/news/2003/0520docomtoof.html

133 http://www.ipwireless.com/press_062503.html

134 http://www.nwfusion.com/edge/news/2002/0114edge.html

135 http://www.europemedia.net/shownews.asp?ArticleID=17072

136 http://www.europemedia.net/shownews.asp?ArticleID=16946

137 This partnership was also joined by Orange, although it has subsequently pulled out of the market. See: http://uk.gsmbox.com/news/mobile_news/all/28487.gsmbox

138 http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_3G_Article280703

139 The data rate will be limited to 64 Kbps. See: http://www.telecom.paper.nl/index.asp?t=a&i=34241&n=806

140 http://www.telecom.paper.nl/index.asp?t=a&i=34269&n=170

141 http://www.3g.co.uk/PR/October2002/4270.htm

142 http://www.telecom.paper.nl/index.asp?t=a&i=28621&n=506

143 http://www.3gnewsroom.com/3g_news/jul_03/news_3535.shtml

144 http://www.3gnewsroom.com/3g_news/jan_04/news_4115.shtml

145 http://www.3g.co.uk/PR/December2002/4521.htm

146 http://www.3gnewsroom.com/3g_news/nov_03/news_3971.shtml

147 http://www.3gnewsroom.com/3g_news/jul_03/news_3606.shtml

148 http://www.mobilkomaustria.com/CDA/frameset/start_frame/0,3149,892-988-62933-1-html-en,00.html

149 http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_PR_Article070503

150 *International Herald Tribune*, February 23 2004, p.14.

151 http://www.mobile.commerce.net/print.php?story_id=3033

152 *International Herald Tribune*, February 23 2004, p.14. Also see http://www.3gnewsroom.com/3g_news/sep_03/news_3716.shtml.

153 http://www.finanzas.com/id.3489907/noticias/noticia.htm

154 http://www.3gnewsroom.com/3g_news/aug_03/news_3681.shtml

155 Telecom.paper, April 8 2004, http://www.3g.co.uk/PR/July2003/5680.htm

156 http://www.nortelnetworks.com/corporate/success/ss_stories/wireless/collateral/nn_102580.11-07-02.pdf

157 http://www.mobilecomms-technology.com/projects/3g_telus/

158 http://www.alianttelecom.ca/1xRTT/

159 http://www.3gnewsroom.com/3g_news/aug_02/news_2407.shtml

160 http://ebusiness.mts.mb.ca/mtsapplications/css/home.nsf/prod/Data%20to%20Go%20solutions?opendocument&~v1=wl~v2=Wireless%20Data~

161 http://ebusiness.mts.mb.ca/mtsapplications/css/home.nsf/prod/Data%20to%20Go%20solutions%20-%20Warp%20Speed?OpenDocument&ExpandSection=1&~v1=srch~v2=Warp%20I~v3=#_Section1

162 http://www.ic.gc.ca/cmb/welcomeic.nsf/261ce500dfcd7259852564820068dc6d/85256a5d006b9720852256e3f006ac9d5!OpenDocument

163 http://www.telecom.paper.nl/index.asp?t=a&i=33644&n=670

164 http://www.3g.co.uk/PR/August2003/5714.htm

165 The services initially operated primarily on the 2.5G (GSM/GPRS) on account of the technological delay. After several months, they were based also on UMTS network. See: http://www.3g.co.uk/PR/Sept2002/4001.htm

166 See http://www.sonera.com/CDA.COM.ArticleFrame/0,1395,articleId=10258&expandSize=2&expandLevelId=637_616_&hierarchyId=637,00.html, http://www.sonera.com/CDA.COM.ArticleFrame/0,1395,articleId=17046&expandSize=2&expandLevelId=637_616_&hierarchyId=637,00.html

167 http://www.lucent.com/livelink/0900940380030b8f_Newsletter.pdf

168 http://www.3gnewsroom.com/3g_news/sep_03/news_3748.shtml

169 http://www.theregister.co.uk/content/59/35769.html

170 http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_3G_Article300404

171 Telecom.paper, June 17 2004.

172 http://wirelessnewsfactor.com/perl/printer/20513/

173 http://www.telecom.paper.nl/index.asp?t=a&i=33125&n=002

174 http://www.3gnewsroom.com/3g_news/sep_03/news_3698.shtml

175 http://uk.biz.yahoo.com/040219/80/emgfp.html

176 http://www.3gnewsroom.com/3g_news/mar_04/news_4329.shtml

177 http://www.3gnewsroom.com/3g_news/sep_03/news_3731.shtml

178 http://www.telecom.paper.nl/index.asp?t=a&i=38053&n=970

179 http://www.europemedia.net/shownews.asp?ArticleID=17008

180 http://www.telecom.paper.nl/index.asp?t=a&i=33038&n=560

181 http://www.3g.co.uk/PR/June2003/5527.htm

182 Telecom.paper, January 22, 2004.

183 http://www.3gnewsroom.com/3g_news/oct_03/news_3835.shtml

184 http://www.3gnewsroom.com/3g_news/oct_03/news_3799.shtml

185 In addition, Vodafone Ireland launched limited 3G services using Nokia 6650 handsets and made Ireland's first '3G calls' in May 2003. The services are available to a selected group of customers across the country. However, the data speed is limited up to 144 Kbps, and thus they do not fit in the 3G category in this paper. As larger volumes of handsets become available, Vodafone intends to make its service available to all customers with a new range of services. See:
http://www.telecom.paper.nl/index.asp?t=a&i=28610&n=932 and
http://www.3g.co.uk/PR/April2003/5317.htm.

186 http://www.telecom.paper.nl/index.asp?t=a&i=38313&n=910

187 http://www.3g.co.uk/PR/April2003/5306.htm

188 The distribution of UMTS handsets by 3 Italy has been dependent on the availability of imported handsets and existing handset replacement with new models. Also see
http://www.telecom.paper.nl/index.asp?t=a&i=33670&n=912.

189 http://www.telecom.paper.nl/index.asp?t=a&i=34466&n=556

190 http://www.3gnewsroom.com/3g_news/sep_03/news_3771.shtml

191 http://www.3gnewsroom.com/3g_news/sep_03/news_3701.shtml

192 See http://www.nttdocomo.co.jp/p_s/world/worldwing/index.html?did=,
http://www.3gnewsroom.com/3g_news/may_03/news_3406.shtml

193 http://www.nwfusion.com/news/2003/0520docomtoof.html

194 No application for this service is necessary. FOMA subscribers simply dial the designated number followed by the 3 UK mobile phone number. See
http://www.3g.co.uk/3GForum/showthread.php?s=37af89941b7f06c9a80c3425a7b69f97&threadid=854

195 http://www.telecom.paper.nl/index.asp?t=a&i=32067&n=31672. KG Telecommunications does not hold a 3G license after withdrawing from Chinese Taipei's auction of 3G licenses in December 2001.

196 http://it.nikkei.co.jp/it/news/newsCh.cfm?i=2003082407366j0&h=1

197 See: http://www.kddi.com/corporate/news_release/2003/1022/index.html

198 http://wirelessnewsfactor.com/perl/printer/20311/

199 Chris Pearson and Vicki Livingston, "UMTS to Mobilize the Data World", February 2003, http://www.3gnewsroom.com/html/whitepapers/year_2003.shtml

200 http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_3G_Article180803c

201 http://headlines.yahoo.co.jp/hl?a=20031001-00000295-jij-bus_all

202 http://www.3gnewsroom.com/3g_news/oct_03/news_3804.shtml

203 http://search.hankooki.com/times/times_view.php?terms=KTF+KTF+code%3A+kt&path=hankooki1%2Fkt_tech%2F200205%2Ft2002050918163945110.htm

204 http://search.hankooki.com/times/times_view.php?terms=KTF+KTF+code%3A+kt&path=hankooki1%2Fkt_tech%2F200205%2Ft2002050918163945110.htm

205 Source: CDMA Development Group.

206 http://search.hankooki.com/times/times_view.php?terms=roaming+code%3A+kt&path=hankooki1%2Fkt_tech%2F200206%2Ft2002062617193245110.htm

207 http://search.hankooki.com/times/times_view.php?terms=02+02+CDMA+code%3A+kt&path=hankooki3%2Ftimes%2Flpage%2Fbiz%2F200312%2Fkt2003122618021911910.htm

208 http://www.3g.co.uk/PR/April2003/5311.htm

209 http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_3G_Article300603a

210 http://www.europemedia.net/shownews.asp?ArticleID=5770

211 http://japan.internet.com/allnet/20031001/12.html

212 Telecom.paper, March 17 2004.

213 As of February 2004, Vodafone Netherlands will launch the Vodafone UMTS Mobile Connect Card for EUR 0.75 (USD 0.94) per Megabits.

214 http://www.telecom.paper.nl/index.asp?t=a&i=33625&n=502

215 Telecom.paper, June 16 2004.

216 http://australianit.news.com.au/articles/0,7204,6950730%5E15306%5E%5Enbv%5E,00.html

217 http://www.3g.co.uk/PR/1496.htm

218 http://www.3gnewsroom.com/3g_news/sep_03/news_3696.shtml

219 http://www.3g.co.uk/PR/Sept2003/5794.htm

[220] http://www.wirelessdataforum.org.nz/article.php?sid=632&catid=355, http://www.sferia.com.pl/

[221] http://www.europemedia.net/shownews.asp?ArticleID=3546

[222] http://www.3gnewsroom.com/3g_news/jul_01/news_0911.shtml

[223] *CTIA Daily News*, January 5 2004, http://www.wow-com.com/news/daily_news/pub_view_site.cfm?pub_id=1&issue_id=1542&type=html&issue_date=1/5/2004

[224] Telecom.paper, June 11 2004.

[225] Telecom.paper, June 4 2004.

[226] Chris Pearson and Vicki Livingston, "UMTS to Mobilize the Data World", February 2003, http://www.3gnewsroom.com/html/whitepapers/year_2003.shtml

[227] http://www.3gnewsroom.com/3g_news/jul_03/news_3542.shtml

[228] Chris Pearson and Vicki Livingston, "UMTS to Mobilize the Data World", February 2003, http://www.3gnewsroom.com/html/whitepapers/year_2003.shtml

[229] http://www.telecom.paper.nl/index.asp?t=a&i=36209&n=310, http://www.3g.co.uk/PR/Oct2003/6021.htm

[230] http://www.telecom.paper.nl/index.asp?t=a&i=37818&n=580

[231] In Scandinavia, H3G is a joint venture between Hutchison Whampoa (60%) and Investor AB (40%).

[232] http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_PR_Article070503

[233] Orange has pulled out of the Swedish market. See: http://www.3gnewsroom.com/3g_news/oct_03/news_3876.shtml.

[234] Telecom.paper, March 24 2004.

[235] For example, MmO2 already delayed the launch of 3G services until the second half of 2004.

[236] http://www.3gnewsroom.com/3g_news/sep_03/news_3755.shtml

[237] Vodafone UK's 3G network was deployed in major urban areas as of January 2004. See: http://www.3gnewsroom.com/3g_news/jan_04/news_4124.shtml.

[238] http://www.theregister.co.uk/content/64/35603.html, http://www.silicon.com/networks/mobile/0,39024665,39118441,00.htm

[239] Vodafone announced in September 2003 that most service launches in Europe would not be achieved until October 2004 although it planned to launch low-key services in the United Kingdom in spring 2004. See: http://www.3gnewsroom.com/3g_news/sep_03/news_3792.shtml

[240] http://www.theregister.co.uk/content/59/35769.html

[241] http://www.telecom.paper.nl/index.asp?t=a&i=34239&n=840

[242] http://www.umts-forum.org/servlet/dycon/ztumts/umts/Live/en/umts/News_PR_Article070503, http://www.nwfusion.com/research/2001/0806feat.html

[243] http://www.mobilecomms-technology.com/projects/verizon_3g/

[244] http://www.3g.co.uk/PR/August2002/3882.htm

[245] http://www.3g.co.uk/PR/1709.htm

[246] http://www.cdg.org/news/latest_news.asp?hnYY=2002&hnMM=10

[247] http://www.nwfusion.com/news/2003/0317verizonwifi.html

[248] http://www.3gtoday.com/news/wirelesswk010804.html

[249] http://www.3g.co.uk/PR/October2002/4321.htm

[250] http://www.3g.co.uk/PR/November2002/4450.htm

[251] http://wirelessnewsfactor.com/perl/printer/20336/

[252] Chris Pearson and Vicki Livingston, "UMTS to Mobilize the Data World", February 2003, http://www.3gnewsroom.com/html/whitepapers/year_2003.shtml

[253] http://telephonyonline.com/ar/telecom_att_wireless_formalizes/

[254] EDGE services were available to 220 million people living in more than 6 500 cities and town across the country. See Telecom.paper, March 23 2004.

[255] http://www.3gnewsroom.com/3g_news/oct_03/news_3839.shtml

[256] http://www.3gnewsroom.com/3g_news/oct_03/news_3847.shtml

[257] See: http://www.unstrung.com/document.asp?doc_id=41001, http://www.telecom.paper.nl/index.asp?t=a&i=34812&n=782, http://telephonyonline.com/ar/telecom_pricing_showstopper/index.htm

[258] For details see: http://foma.nttdocomo.co.jp/fee/fee_02.html

[259] http://www.3g.co.uk/3GForum/showthread.php?s=15db76b0063dc1ac8df2c03f637535c6&threadid=284

[260] E-mail normally uses 9 kilobytes whereas a high-quality audio weighs in at 5 megabytes, or more than 555 times as large as e-mail.

[261] http://www.cellular-news.com/story/9176_print.shtml

[262] T-Motion was established as a joint venture between T-Mobile International and T-Online International to deliver mobile online services to the Deutsche Telekom family. For details, see: http://www.portal.com/news_events/press_releases/release_2001/t-motion.htm.

[263] http://www.3g.co.uk/PR/August2003/5694.htm

[264] http://www.3g.co.uk/3GForum/showthread.php?s=15db76b0063dc1ac8df2c03f637535c6&threadid=284

265 http://news.com.com/2100-1095-1019617.html

266 http://www.3gnewsroom.com/3g_news/sep_03/news_3717.shtml

267 http://www.3gnewsroom.com/3g_news/oct_03/news_3810.shtml

268 http://www.handyversand.at/index.htm?hutchison_3.htm

269 *Wall Street Journal Europe*, August 13 2003.

270 This paper does not intend to imply that a main application of 3G services is voice because it is too premature to judge. However, some argue that that the killer application still seems to be voice in that IMT-2000 technologies that are deployed (both CDMA2000 and W-CDMA) have more capacity for voice than 2G systems.

271 http://www.idate.fr/an/qdn/an-03/IF270/index_a.htm

272 http://www.3gnewsroom.com/3g_news/sep_03/news_3777.shtml

273 http://www.mobiletechnews.com/info/2001/09/04/060403.html

274 One packet delivers 128 Kbps of data.

275 Monthly Ezweb and e-mail service access fees of JPY 300 (USD 2.8) apply in addition to the above tariff.

276 http://www.3gnewsroom.com/3g_news/sep_03/news_3758.shtml

277 3 Sweden also launched the 3Fri Kvall & Helg (3Free Evenings and Weekends) for SEK 50 (USD 6.2) extra per month, which includes 1 000 minutes of voice calls in Sweden to the fixed network and on the network during evenings and weekends. See: http://www.3gnewsroom.com/3g_news/sep_03/news_3728.shtml.

278 http://www.3gnewsroom.com/3g_news/sep_03/news_3755.shtml

279 http://www.3gnewsroom.com/3g_news/oct_03/news_3798.shtml

280 http://www.trp.hku.hk/papers/2002/deconstructing3g.pdf

281 http://www.3gnewsroom.com/3g_news/mar_03/news_3196.shtml

282 http://www.3g.co.uk/PR/Oct2003/5899.htm

283 http://www.3gnewsroom.com/3g_news/sep_03/news_3714.shtml

284 http://www.3gnewsroom.com/3g_news/sep_03/news_3714.shtml

285 http://www.itudaily.com/onlinenews/home.asp?articleid=3100302

286 http://www.telecom.paper.nl/index.asp?t=a&i=34074&n=700

287 http://www.3gnewsroom.com/3g_news/jul_03/news_3533.shtml

288 http://www.3gnewsroom.com/3g_news/oct_03/news_3798.shtml

289 http://www.3gnewsroom.com/3g_news/sep_03/news_3731.shtml

290 http://www.nwfusion.com/news/2002/01283gverizon.html

291 The number of DoCoMo's 3G subscribers grew from 50 000 in January 2002 to 150 000 in January 2003 and swelled to more than 1 000 000 in September 2003. See: http://news.com.com/2100-1095-1019617.html.

292 http://www.3g.co.uk/PR/Jan2003/4775.htm

293 http://www.3g.co.uk/PR/Jan2003/4775.htm

294 For the details of this co-operation, see the chapter on 'Market Developments of 3G.'

295 http://www.telecom.paper.nl/index.asp?t=a&i=32067&n=32287

296 http://home.intekom.com/cellular/news_2003/062703--coexist.htm

297 http://www.telecom.paper.nl/index.asp?t=a&i=33459&n=060

298 http://www.wired.com/news/wireless/0,1382,50689,00.html

299 http://www.europemedia.net/shownews.asp?ArticleID=15608

300 This might imply that 2G would be sufficient for mobile voice communications. See: http://telephonyonline.com/ar/telecom_mobile_datas_new/index.htm.

301 However, a wired broadband backbone network may be necessary to support the wireless workstations.

302 Wi-Fi Metro implemented the wireless networks mainly in coffee shops and restaurants. See: http://www.wired.com/news/wireless/0,1382,50689,00.html

303 http://www.nwfusion.com/news/2003/0808wideless.html

304 http://www.nwfusion.com/newsletters/wireless/2003/0113wireless1.html

305 However, additional enhancements to 3G are being standardised to increase the data transmission rate.

306 http://telephonyonline.com/ar/telecom_mobile_datas_new/index.htm

307 http://news.com.com/2102-1071_3-954609.html

308 There are some WLANs that use licensed spectrum such as IEEE 802.20.

309 http://www.3gnewsroom.com/3g_news/may_03/news_3418.shtml

310 http://www.europemedia.net/shownews.asp?ArticleID=12672

311 http://www.3gnewsroom.com/3g_news/dec_02/news_2806.shtml

312 http://www.3g.co.uk/PR/Feb2003/4835.htm

313 http://www.nwfusion.com/news/2003/0203ericstests.html

314 http://news.com.com/2100-1039_3-5073056.html

315 http://telephonyonline.com/ar/telecom_nortel_links_wifi/

316 http://www.nwfusion.com/newsletters/wireless/2003/0421wireless1.html

317 http://www.telecom.paper.nl/index.asp?t=a&i=34742&n=792

318 http://www.telecom.paper.nl/index.asp?t=a&i=34819&n=220

319 http://www.nwfusion.com/news/2003/0317verizonwifi.html

320 http://www.theregister.co.uk/content/59/35899.html

321 For example, in Sweden digital terrestrial television first started in 1999 and has already reached 90% penetration as of March 2003. The Swedish parliament decided in May 2003 that the switch over to digital television will be completed by February 2008. See OECD, "Broadband Audio-visual Services: Market Developments in OECD Countries", DSTI/ICCP/TISP(2003)6/FINAL.

322 http://www.3g.co.uk/PR/July2003/5608.htm

323 http://www.europemedia.net/shownews.asp?ArticleID=17038