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Working Party on Communication Infrastructures and Services Policy

MOBILE COMMUNICATION DEVELOPMENTS IN THE OECD AREA

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FOREWORD

The Working Party on Communication Infrastructures and Services Policy discussed this paper at its meeting in June 2010. The Working Party agreed to recommend the paper for declassification to the Committee for Information, Computer and Communications Policy (ICCP). The ICCP Committee agreed to the declassification of the paper in October 2010.

The paper was drafted by Ms. Kayoko Ido of the OECD's Directorate for Science, Technology and Industry. It is published under the responsibility of the Secretary-General of the OECD.

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MAIN POINTS

This report discusses evolving developments of mobile communications in the OECD area. The main objective is to examine the impact of mobile broadband developments on market dynamism, and to consider their implications for policy makers and regulators. The first section looks at the path from current mobile communication to the next generation of mobile broadband networks. The second part of the report analyses the drivers of mobile broadband development. The paper particularly focuses on several points; new device and application trends; tariff structures; data traffic growth; network operator's financial performance; and a demand side perspective. In the third section, the paper discusses potential influences on policy and regulatory developments. The expected growth of mobile broadband infrastructure and services not only calls for a reconsideration of traditional policy issues but also may raise new regulatory challenges. The key findings of this document include:

- The successful development of mobile broadband infrastructure and services will depend on the availability of spectrum. In particular, wider bandwidth is required in order to fully realise the potential of high-speed connections. An increasing number of OECD countries have introduced market-based approaches for spectrum allocation and assignment for the next generation of mobile broadband networks than was the case for third generation mobile (3G). While in a few cases comparative selection is used, it is less prevalent than in the past. Spectrum harmonisation on a global basis is a key issue for seamless mobility, and the digital dividend provides an opportunity to increase wireless spectrum availability with associated benefits for consumers.

- Mobile broadband goes far beyond telephones and laptops and the recent popularity of certain types of new consumer electronic devices gives equipment manufacturers and application suppliers a stronger bargaining position with mobile network providers. Competition between all suppliers, resulting from customer demand for some types of equipment and applications, can lead to increased consumer choice and lower prices for new services.

- New business models are emerging (*e.g*. "sponsored connectivity" or transaction-based models) in which firms use the wireless network connectivity to provide services to their customers without those users subscribing to a wireless plan, or having a contract, with the underlying infrastructure provider. There is no direct relationship between the customers and the network providers, as the firms directly pay for the network connection and the customers pay for the services via the price of devices and content they purchase.

- Further technological development will open more opportunities for different types of business models, as long as there is robust competition between infrastructure providers. To date, it has been the existing mobile operators that have provided connectivity for sponsored business models or virtual mobile network operators (MVNOs), alongside their traditional retail services. In the future, some firms may expand the wholesale approach, particularly as the range of devices using wireless services expands. In the United States, one new market entrant proposes to limit its own services to the wholesale level as it rolls out a national broadband wireless network.[1] Market growth should be beneficial for all firms that are best able to take advantage of these trends.

- A few mobile operators have recently moved towards permitting their customers to use voice over IP (VoIP) services, provided by third parties, on their networks. They say this attracts and assists them to retain customers, thus growing overall revenue. This trend, most evident in markets that have a higher degree of competition, will continue with mobile broadband, which will be all-IP networks, suitable for packet-based traffic. Such developments, as a result of increasing competition, have benefits for all stakeholders as they decrease the need to consider regulatory remedies when certain issues arise.

- The use of femtocells, a tool primarily used for extending mobile coverage in a limited area, may increase. Mobile operators may also be able to offload traffic from mobile networks to the user's fixed broadband network through femtocells. This aspect is attractive particularly for mobile broadband operators as traffic demand on wireless connections will increase. Optimising advances in the topology of networks, using femtocells, picocells and/or relays bringing the reach of facilities closer to the user, are one of the objectives of the next generation of mobile broadband networks.

- While developments in mobile broadband technologies are attracting justifiable attention, it is important to recognise that fixed broadband networks will also play a vital role in underpinning the goals all stakeholders have for mobile services. Operators will likely try to shift traffic quickly off wireless networks and onto high-speed fixed networks in the vicinity using WiFi and femtocells in order to provide increased bandwidth to users and to reduce congestion in frequency bands. Using fixed networks as backhaul will allow the wired lines to do the "heavy lifting" and will provide additional bandwidth for mobile applications. The offloading of traffic from mobile to fixed networks will not, however, be likely to be sufficient to negate the need for additional spectrum for mobile broadband development.

- Improvement in mobile broadband technologies to provide larger capacity across networks will increase the potential for tethering devices to wireless connections. Tethering describes the ability of users to attach devices, such as laptops and tablet computers, to their mobile wireless phones. In some countries, operators without a licence to sell certain devices directly to their customers, invite their users to tether these devices. This enables users to attach a device of their choice to the service provider of their choice. Some of the benefits may be more attractive access prices for connectivity over which these devices can be utilised, or less expensive devices with similar functionality. Another may be to take advantage of an operator with mobile broadband network coverage in their area over one with an earlier generation network in that area. Finally some customers may prefer to tether devices to existing subscriptions, which include a specified amount of data, rather than pay for a separate subscription for the device of their choice.

- Awareness of the need to transition to Internet Protocol version 6 (IPv6) is increasing, but the take-up in mobile networks has been very limited to date. It is likely that Internet Protocol version 4 (IPv4) and IPv6 will coexist for a considerable time to come, but all stakeholders should be encouraged to consider introducing IPv6 to the mobile broadband networks from the initial stages, to help support a smooth transition from IPv4.

- The further development of mobile broadband networks could play an important role by augmenting the options available for the provision of some aspects of universal service. Some countries have used previous generations of mobile technologies to meet universal service objectives, in those instances when it proved to be the best available option. The increasing capability of mobile broadband networks may enhance this role, although some challenges remain and the definition of services provided under universal service is evolving in a growing number of countries.

MOBILE COMMUNICATION DEVELOPMENTS IN THE OECD AREA

1. THE ROAD TO NEXT GENERATION MOBILE DEVELOPMENT

1.1. Overview of the current mobile market

Mobile telecommunication subscriptions have grown at a rapid rate since the service was first offered. Around the world, the number of mobile subscribers has reached 4.1 billion in 2008, up more than ten times from ten years ago.[2] Growth in very recent years has been led especially by countries in Africa and Asia. Most new subscriptions in these countries are for so called second generation mobile (2G). The worldwide subscription of 3G is gathering pace (Table 1) and some analysts have forecast the number of individual mobile broadband subscribers will soon overtake the number of fixed broadband connections though with different capabilities.[3]

In OECD countries, the number of mobile subscriptions reached 1.1 billion in 2007, almost double 2000. Many countries have achieved penetration rates than exceed 100% suggesting multiple accounts and a relatively mature market for traditional services. Of these, the number of 3G subscriptions is 0.2 billion, accounting for 18.2% of all mobile subscriptions, with access to high-speed Internet services, broadband multimedia services, and data communication services. In contrast to mobile, the fixed phone penetration rate, via public switched telecommunication networks (PSTN), has been decreasing. In OECD countries the penetration rate was 41% in 2007, which was down from 47% in 2000. It is likely that the number of "mobile only" subscribers has been increasing but users are also substituting VoIP services over fixed broadband access networks (*e.g.* over xDSL and cable).

Table 1. Global 3G developments

	Subscription (million)	Networks in service as of January 2010	Countries in service as of January 2010
UMTS	414	318	135
HSPA		301	129
HSPA+		38	24
CDMA2000	512	308	121
IEEE802.16e	2	523	147

Source: GSA, CDMA Development Group, WiMAX Forum, ABI research.
Note: Subscription data of UMTS, HSPA, HSPA+ and CDMA2000 is as of September 2009, IEEE802.16e is as of the end of 2009.

1.2. The scope of next generation mobile

At present, there is no clear consensus with respect to the definition of "next generation mobile". The International Telecommunication Union (ITU) has developed a global standard for mobile broadband referred to as "IMT-Advanced (4G)". It will support low to high mobility applications and a wide range of data rates in accordance with service demands in multiple user environments. It will have capabilities for high-quality multimedia applications with significant improvements over the existing IMT-2000 in terms of performance and quality of service. IMT-Advanced focuses more on worldwide practical usability, cost efficiency, quality of service, user-friendliness, higher mobility and interoperability with other systems (Table 2). The list of enhancements indicates some of the challenging goals IMT-2000 is facing.

Table 2. Key features of IMT-2000 and IMT-Advanced

IMT-2000	IMT-Advanced
High degree of commonality of *design* worldwide *Capability for multimedia* applications, and a wide range of services and terminals Compatibility of services within IMT-2000 and with the fixed networks High quality Worldwide roaming capability	A high degree of commonality of ***functionality*** worldwide *while retaining the flexibility to support* a wide range of services and applications ***in a cost efficient manner*** Compatibility of services within IMT and with fixed networks High quality mobile services Worldwide roaming capability User equipment suitable for worldwide use Enhanced peak data rates to support advanced services and applications (100 Mbit/s for high and 1 Gbit/s for low mobility were established as targets for research) Capability of interworking with other radio access systems

Source: ITU,
Note: Underlined by OECD as they are regarded as additional enhancements specific to IMT-Advanced.

"Generation" is often used as a convenient generic term for categorising mobile technologies. The terms 4G/3G/2G are not used consistently in the mobile industry and are used frequently for marketing purposes. Aside from the marketing uses of the terms, the ITU designation for "IMT-2000" is often referred to as 3G technologies. "Systems beyond IMT-2000" was a temporary name used by the ITU as work proceeded on creating new requirements and procedures for defining radio air technologies that could meet new established technical criteria. A naming resolution was adopted that provided some clarification on ITU terminologies:

- The term "IMT-2000" encompasses also its enhancements and future developments
- The term "IMT-Advanced" can be applied to those systems, system components, and related aspects that include new radio interface(s) that support the new capabilities of systems beyond IMT-2000
- The term "IMT" is the root name that encompasses both IMT-2000 and IMT-Advanced collectively.

Concerning the official designation of IMT-Advanced, the ITU received six candidate technology submissions in response to an open invitation for proposals of candidate radio interface technologies in October 2009.[4] These aligned around LTE-Advanced technology (3GPP LTE Release 10 and beyond) and the IEEE 802.16m technology, detailed descriptions of which are presented in the following sections. These technologies will be assessed as to whether they satisfy ITU-R requirements through an evaluation process. The ITU has indicated that the selected technologies will be accorded the official designation of IMT-Advanced in October 2010.

1.3. Transition path from 3G to next generation mobile

1.3.1. 3G in today's market

- UMTS, HSPA and HSPA+

These are part of the GSM family of technologies. High Speed Packet Access (HSPA) builds on Universal Mobile Telecommunications System (UMTS) with some improvements in data transmission technology. Typical High Speed Downlink Packet Access (HSDPA) networks have capacities to provide from 1.8 Mbps to 14.4 Mbps peak downlink data rates. As technological progress improves end user experience, some operators, such as Vodafone UK's service in high demand areas, are offering 14.4 Mbps.[5] HSPA Evolution (HSPA+) has come up to the market starting in 2009 with further improvements to HSPA with peak rates up to 21 Mbps, although the actual speed which a user experiences may vary depending on a number of conditions. Some operators provide HSPA+ service at higher rates such as Telefónica's O2 in Germany that is delivering up to 28 Mbps for downlinks in Munich. HSPA+ networks were in service in more than 24 countries at the end of March 2010.[6]

- CDMA2000

CDMA2000 has been deployed especially in the Asia-Pacific area and North America.[7] The most advanced commercially launched phase of the CDMA family at this point is called EV-DO Revision B.[8] It can provide 4.9 Mbps for downlinks but is capable of increasing data rates by aggregating more than one carrier, hence the actual available data depends on the number of carriers aggregated. Downlink speed varies from 3.1 Mbps for EV-DO Rev. A single carrier to 14.7 Mbps for EV-DO Rev. B multicarrier (3x). As of September 2009, 308 commercial services are offered in 121 countries and the total number of CDMA 2000 subscriptions has reached 512 million.[9]

- TD-SCDMA

Time Division Synchronous Code Division Multiple Access (TD-SCDMA) has been deployed mainly in China. The theoretical peak rate is 16.6 Mbps for the downlink.[10] The number of subscribers is estimated to be more than 5 million as of the end of 2009.[11] So far, no deployment has been planned on a commercial basis outside of China.

- iBurst

iBurst has been developed for wireless broadband. iBurst-based technology was approved as an IEEE 802.20 standard, but not approved as IMT-2000. Download speed is up to 1 Mbps per user and it supports high mobility with handovers at speeds of over 100km/h. Subscription growth has been lower than other mobile technologies in most OECD countries. Commercial services are offered in the United States, Canada and Norway but a large part of the deployment has taken place in Africa and the Middle East. As of 2007, the number of subscribers had reached 0.14 million worldwide.[12] Due to the larger deployment of other mobile technologies, only a small number of vendors have committed to the technology. It is likely that to date, as a result, iBurst has limited scale economies compared to other mobile technologies.[13]

1.3.2. New technologies coming to the market

- LTE

Many observers believe that Long Term Evolution (LTE) has the most momentum in the development of mobile broadband networks. LTE is an optimised OFDMA (Orthogonal Frequency Division Multiple Access) solution, on the roadmap of 3G evolution, improving spectrum efficiency in wider FDD (Frequency division duplex) and TDD (Time division duplex) spectrum. LTE is a packet-based (all-IP) architecture and is capable of providing high speed data services with low latency. This has been developed by the Third Generation Partnership Project (3GPP). It incorporates many enhancements to achieve spectrum efficiency, high-speed data transmission, quality of service and optimised packet-based traffic. While HSPA+ allows optimal usage of 5 MHz and 10 MHz bandwidth, LTE would be optimum for new spectrum with a wider channel bandwidth of more than 10 MHz, typically 20 MHz that will be available in 2.6 GHz. By aggregating multiple 20 MHz carriers (as considered in LTE-Advanced, see below) or by using 4x4 MIMO, LTE is capable of providing, in theory, over 300 Mbps for downlink and about 90 Mbps for uplink at maximum. Initial deployments will be likely to use 20 MHz and 2x2 MIMO providing a peak downlink rate of up to 150 Mbps.

As at the end of 2009, 54 operators and networks in 19 countries in the OECD area had an intention to commit to LTE (Table 3). It has received wide support, such that the European Union had funded research on LTE with USD 32 million between 2004 and 2007 and also supports further research on the enhancement of LTE with investments of USD 23 million from 2010.

Teliasonera is the first operator to launch commercial LTE service in Stockholm, Sweden and Oslo, Norway in December 2009. The first commercial-based LTE service uses 2.6 GHz band in both countries, which the company won in a spectrum auction. Each licence is valid for 15 years. The initial service is a mobile broadband connection to laptops with USB dongles and subscriptions have a 30 gigabytes (GB) monthly data cap. The advertised expected download speed is up to 50 Mbps and the company is expected to provide up to 80 Mbps in the future.[14]

Table 3. LTE commitments in OECD countries (as of June 2010)

Countries	Operators
Australia	Optus, Telstra, 3 Australia, Vodafone Hutchison VHA
Austria	T-Mobile Austria, Orange, mobilkom, Hutchison 3 Austria
Belgium	Belgacom Mobile/Proximus, Mobistar, KPN Group Belgium/BASE
Canada	Bell Wireless Affiliates, Mobility/DAVE Wireless, WIND/Globalive, MTS Mobility/Allstream, Rogers Wireless Communications, Sask Tel Mobility, Shaw Communications, Telus Mobility, Videotron (Quebecor Media)
Chile	Telefónica Móviles Chile/Movistar, Claro, Entel PCS Telecomunicaciones
Czech Republic	Telefonica O2 Czech Republic, T-Mobile Czech Republic, Vodafone Czech Republic
Denmark	Telia Denmark, Telenor Denmark, TDC Mobil, HI3G Denmark/3
Finland	TeliaSonera, Elisa, Alands Mobiltelefon, DNA Finland, TDC Song
France	Orange France, SFR, Bouygues Telecom
Germany	T-Mobile, Vodafone D2, O2, E-Plus
Greece	Panafon/Vodafone, WIND Hellas, Cosmote
Hungary	Vodafone, T-Mobile/Maygar Telecom, Pannon
Iceland	Vodafone, Iceland Telecom/Siminn, Nova
Ireland	O2, Vodafone Ireland, Hutchison 3, Meteor Communications
Italy	Vodafone Italia, Wind, 3 Italy, Telecom Italia/TIM
Japan	NTT Docomo, KDDI, Softbank Mobile, eAccess/emobile
Korea	LG Telecom, SK Telecom, KTF Corp
Luxembourg	P&T Luxembourg/LUXGSM, Tango, Orange
Mexico	Telefónica Móviles Mexico/movistar, America Movil/Telcel
Netherlands	Vodafone Netherlands, T-Mobile Netherlands, KPN Mobile
New Zealand	Vodafone New Zealand, Telecom New Zealand, 2degrees Mobile
Norway	Telenor Mobil, Netcom/TeliaSonera, Mobile Norway, Hi3G Access Norway
Poland	Orange Poland, Centertel, P4/Play, Polkomtel/Plus, Polska Telefonia Cyfrowa/Era GSM, Sferia/Aero2
Portugal	TMN, Vodafone Portugal, Sonaecom Servicos Comunicacoes
Slovak Republic	Telefónica O2 Slovak Republic, T-Mobile, Orange
Spain	Telefónica Móviles/Movistar, Orange, Vodafone Espana, Yoigo
Sweden	TeliaSonera Sweden, Telenor Sweden, Net4Mobility, Tele2, H13G/3 Sweden
Switzerland	Orange Switzerland, Swisscom Mobile/Natel, TDC Switzerland/sunrise
Turkey	Vodafone, Turkcell, AVEA
UK	Vodafone, T-Mobile, Orange UK, O2 UK, Hutchison 3G/3 UK
USA	AT&T Mobility, Verizon Wireless, T-Mobile USA, Cox Communications, BendBroadband, Cellular South, CenturyLink, CommNet Wireless, Metro PCS, SkyTerra (Harbinger), Stelera Wireless, Terrestar, Aircell (In-Flight Network)

Source: 3G Americas, “LTE Global Deployments Status”.

- IEEE 802.16e

This is part of the WiMAX family and allows high-speed Internet access via portable devices. The technology became a member of IMT-2000 in 2007. IEEE 802.16e employs some advanced technologies so as to increase mobility and capacity for end-users. It is particularly suitable for IP traffic for wireless broadband which is provided to users on the move through handovers across base stations and across operators. Expected download speed is up to 5 Mbps,[15] although the actual speed depends on performance conditions.

WiMAX Forum tracks 523 WiMAX deployments in 147 countries as of the end of 2009, which shows an increase from 408 deployments in the previous year, although the data includes not only mobile WiMAX deployments but also fixed WiMAX.[16] There are very few reliable statistics for the number of mobile WiMAX subscriptions, but mobile WiMAX deployment makes up about 35% of total WiMAX deployments, according to the WiMAX Forum. This is up from 20% in late 2008. It has deployed all over the world, not only in North America and Europe, but also in Africa and South America.[17]

- Similarity and difference between LTE and IEEE802.16e

LTE and IEEE802.16e have a lot of similarities, although they come from different origins. Both adopt many common advanced technologies. Both systems support OFDMA,[18] which is well suited for high data rate systems. Multi-Input and Multi-Output (MIMO), a smart antenna technology, is also easier to support with OFDMA. MIMO use multiple antennas in the base station as well as in user terminals, which increases the peak downlink rate. The support of wider bandwidth is another feature for mobile broadband networks. Wider bandwidth provides not only spectrum efficiency but also greater capacity, which is discussed in the following section. Both LTE and IEEE802.16e can be operated by as wide a bandwidth as possible from 1.25 to 20 MHz. The scalable bandwidth makes it possible to comply with varied worldwide requirements as efforts proceed to achieve spectrum harmonisation in the longer term. Similarities between the two give benefits to vendors, for example, to deploy base stations where 70% of the platform is likely to be common. It is also worth noting that both LTE and IEEE802.16e support FDD and TDD which are ways to transmit downlink and uplink data. This allows both technologies to co-exist, although LTE is mainly focused on FDD while IEEE802.16e is mainly TDD.

The question of which system operators will choose depends on several factors such as:

- Operational efficiencies (*e.g.* available spectrum resources)
- Evolution efficiencies (*e.g.* an easier migration path from the existing system)
- Legacy network support (*e.g.* compatibility with legacy environment)
- Scale economies driven by vendors and uptake in the global market.

1-3-3. IMT-Advanced (4G)

- LTE-Advanced

LTE-Advanced is a further evolved technology of LTE, adding some technology enhancements in particular leveraging advanced network topologies and multicarrier aggregation (40 to 100 MHz) as the radio link improvement is approaching the theoretical limit. The objective of development is to be qualified as IMT-Advanced. As mentioned previously, it was submitted to the ITU for approval as a proposed candidate. Most basic technologies will be based on and evolved from the current LTE approach but it may require wider spectrum bandwidth than LTE to achieve higher speed data transmission. The industry says that peak data rate of LTE-Advanced can reach 1 Gbps by aggregating much wider spectrum.[19] LTE-Advanced is designed to facilitate the transition from LTE so as to have backward compatibility with it. Compatible infrastructures will give operators a great deal of cost savings since the additional investment for a new system can be as little as possible. By May 2010, there was no commercial service available for LTE-Advanced.

- IEEE 802.16m

IEEE 802.16m is an amended version of 802.16e to provide an advanced air interface. The goal of the development is to meet or exceed the requirements of IMT-Advanced. As such, it is another candidate technology submitted to the ITU for consideration as IMT-Advanced. It will support advanced technologies such as OFDMA and MIMO antenna like IEEE 802.16e. As is the case of LTE-Advanced, IEEE 802.16m will support backward-compatibility with IEEE 802.16e for smooth transitioning from the previous version. The performance of 802.16m is targeted to achieve 1 Gbps for the downlink. IEEE 802.16m was not yet in service by May 2010.

1.3.4. Operator positioning and migration path

There are many possible scenarios in moving from 3G to the next generation of mobile broadband networks. The transition from GSM/UMTS to LTE-Advanced or from IEEE 802.16e to IEEE 802.16m seems to be a natural choice since each of them has developed from the same technologies. However, mapping of various operators' positioning is complicated. Even though the technology being adopted today is one of the important factors, operators in the same technology family will not necessarily take the same paths in the future (Figure 1). Many factors influence operator's decision-making such as the competitive landscape in their service areas, expected business model, user demand for mobile broadband, spectrum availability, financial position and other resources.

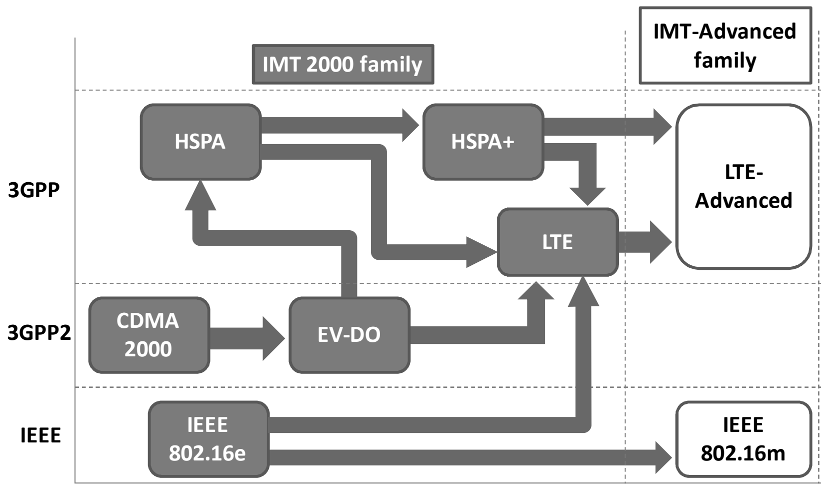
Some expect that operators in the CDMA family will augment their EV-DO networks with LTE simply because UMB, an advanced version of CDMA2000, is no longer available as a migration path from CDMA2000 networks. Leading CDMA operators, such as KDDI, have announced plans to upgrade their network to EV-DO Rev. B. Some CDMA operators, such as Verizon Wireless, are planning to launch LTE service as quickly as possible. The company has already trialled LTE in both the Boston and Seattle markets and intends to have LTE deployed in 25 to 30 United States markets by end 2010, with its entire United States mobile footprint LTE-enabled by 2013.[20] However, others are taking different strategies, *e.g.* Telus and Bell Mobility announcing that they would launch the service based on HSPA first, before the transition to LTE.[21]

Even in the GSM/UMTS family, the migration schedule is not the same for all operators. The leading group is enthusiastic about the early transition to mobile broadband networks, whereas another group is planning to update the existing 3G networks in the interim. Some operators are focusing at this moment on upgrading 3G networks by using HSPA and HSPA+ instead of rushing into the next generation of mobile broadband networks.[22] In terms of return on investment, the longer 3G network equipment has been used, the more the operators have benefited from this investment. If the operator introduced 3G network equipment as a first mover, their network equipment is now becoming more dated. In this case, it may be better to decide on an early migration to next generation technology. They are in a better position to justify new investment as they have exploited their 3G network equipment longer. On the other hand, operators with relatively new equipment would prefer to see a longer return on that investment before moving to the next generation of mobile broadband networks.

Significant future improvements to mobile networks (WCDMA or OFDMA), especially in terms of network capacity, will come from optimising the networks topology, such as adding femtocells and picocells, bringing the transmitters closer to the user, rather than from the air link technology. Optimised advanced topology networks using picocells and femtocells are one of the LTE-Advanced (Release 10) objectives.

The market is moving towards the launch of higher-speed data services. Some argue that this has been influenced by the change of mobile consumption habits, with services now expanding beyond voice services to include Internet access and multimedia content. The introduction of new handsets with larger screens and of netbook, enabling access to a variety of multimedia content, are changing users' behaviour patterns as they consume more and more data services on their personal devices.[23]

Figure 1. Migration path from today's 3G to next generation mobile



1.4. Benefits of next generation mobile

The next generation of mobile broadband networks is expected to be an all-IP based, flat and simplified network such that it achieves higher-speed, larger-capacity and lower-latency wireless access in a more spectrum efficient and a cost effective manner. All of these technology advancements open a wide variety of potential benefits from mobile broadband networks.

- High-speed access

The next generation of mobile broadband networks will achieve higher speed access than current mobile services. It is expected to be comparable to the bandwidth of some entry-level fixed broadband services. Technology enhancements in mobile broadband networks have the potential to improve the end-user experience, such as by offering higher-quality streaming of music and higher-definition video streaming than currently possible. A richer variety of content, including online gaming or movies, can become more accessible as downloading speeds increase with larger bandwidth. The increased uplink data rate enables uploading higher quality video content with lower latency. For example, users may be able to show friends their location in real time by using their mobile handsets.

This also provides a great potential for business use. Sending and receiving large data files with sophisticated smartphones or dongles can boost productivity by allowing employees away from their office to continue working. Live video conferencing, while not yet living up to expectations, may increase, based on economies or generate other efficiencies and environmental benefits.

Mobile broadband networks open a number of interesting possibilities for improving public services such as telemedicine applications.[24] While individual data transfers may not use much capacity, the additive effect of small data transmissions through a household and in a given wireless area will require the bandwidth that the next generation of mobile broadband networks can provide. Applications that require low latency, for example, and relatively intense two-way communication, may face limitations in use on mobile networks. A stable and steady connection may present challenges for using wireless solutions and underline the need for a range of technologies to meet public policy objectives.

- User-friendliness

As the recent boom of smartphones with touch screen interface shows, user expectation is towards more user-friendly handsets. Not only traditional mobile phone terminals, but also other devices, may be capable of functioning as user-friendly terminals, such as vehicles and home appliances with built-in functionality. For example, "ng Connect Program" in which Toyota, Alcatel-Lucent and other companies participate, has demonstrated an "LTE connected car". The vehicle functions as a mobile platform by which information is sent and received through high bandwidth connectivity as well as cloud-based applications including navigation, personal security, entertainment and infotainment services.[25] Other examples include web-browsers, application stores, tablet devices and e-book readers, which users will readily access in their daily activities. User-friendly services may directly connect user handsets with home automation and security systems so as to manage energy control systems such as lighting and heating, or to monitor home security cameras with streaming video.

- Global and seamless mobility

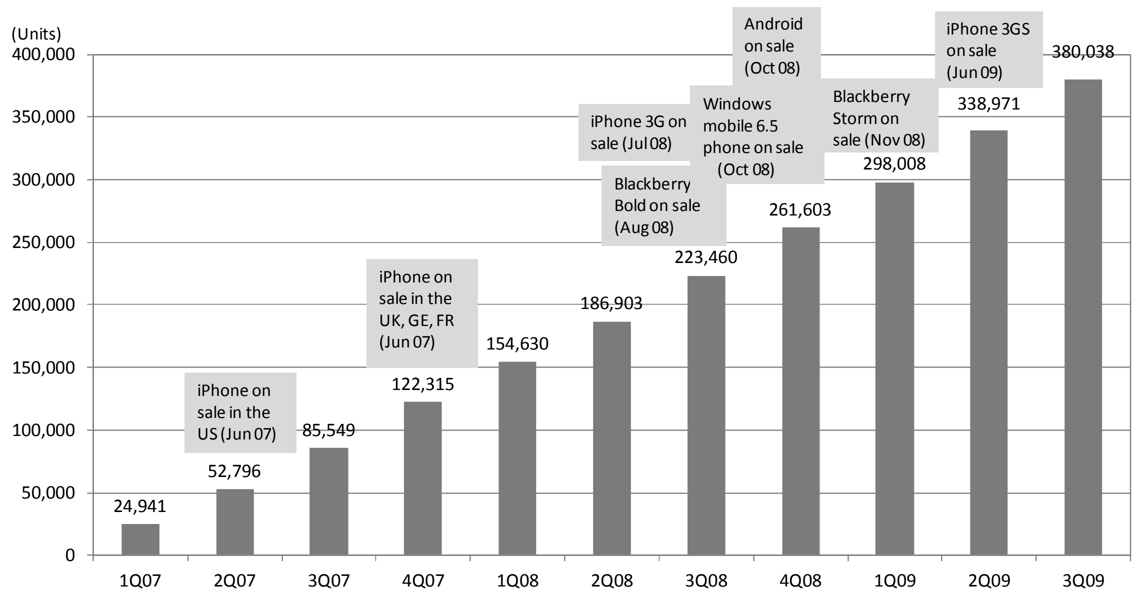
Standardisation on a global basis facilitates seamless mobility, interoperability and may assist in providing economies of scale. As such, one often-highlighted feature of mobile broadband networks is the capability of interworking with other access systems. Indeed handover between different access technologies has some commercial challenges, although it is possible from a technical point of view. One possible challenge would be deployment of multi-mode chipsets with economies of scale. Handsets with multi-mode chipset are capable of handovers from other radio access systems. However, chipset vendors may not supply them if the market is not large enough. In that case, multi-mode handsets will not be available or will be very expensive. Another challenge is implied by ongoing discussion on international roaming. Switching between different access systems or networks and frequency bands may be unfavourable and confusing for users. They may incur unexpectedly high bills, while roaming internationally, even when they subscribe to a flat-rate data plan in their home network.

2. DRIVERS FOR DEVELOPMENT OF NEXT GENERATION MOBILE

2.1. "Smarter" devices and applications

As 3G has rolled out, mobile communications have become available through a wide range of user devices. They include mobile handsets, PC cards, USB modems (dongles), netbooks (mini PCs), portable multimedia players and smartphones among others (*e.g.* e-book readers, cameras, vehicles). Mobile handsets have a large number of default applications, from calculators, stopwatches and calendars to SMS text messaging, music players, movie players, gaming and other entertainment. Certain multimedia applications allow users to download information and content including ringtones, music, pictures and video over the Internet. Smartphone growth in the last few years provides easy wireless Internet access and stimulates the use of wireless data services (Figure 2). In some countries such as Italy, Canada and the United States, smartphones are about one-third of the entire mobile handset market (Table 4). Technology developments have allowed networks to handle more data traffic and consequently to support such a variety of applications.

Figure 2. Worldwide smartphone sales (accumulated units from 2007)



Source: Gartner.
Note: The number of sales before 2006 is not considered.

Table 4. Percentage of install base of smartphones over all mobile handsets in the selected OECD countries (in 2009)

Countries	Italy	US	Canada	Germany	UK	France	Korea	Japan	Global
%	36	32	30	17	17	16	14	4	9

Source: Cisco," Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014", www9.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

2.2. Tariff trends for mobile data

The launch of tariff plans, which include a specified amount of data a user can download, has had an increasing impact on mobile usage trends. In recent years, many operators have adopted this type of pricing to attract more subscribers.[26] Many plans advertised as "flat-rate" still have some sort of download cap. If users exceed the monthly data limit, they are either allowed to continue using the connection by paying an additional fee, or they have a limited connection speed for the remainder of the month. Download caps or other forms of tariff management may help operators avoid network congestion in areas of high usage, make better use of bandwidth during peak periods, and maintain the quality of service they offer. That said, there will be a need to address long-term needs and user demand for better quality of service, based on different pricing techniques for premium services for example.

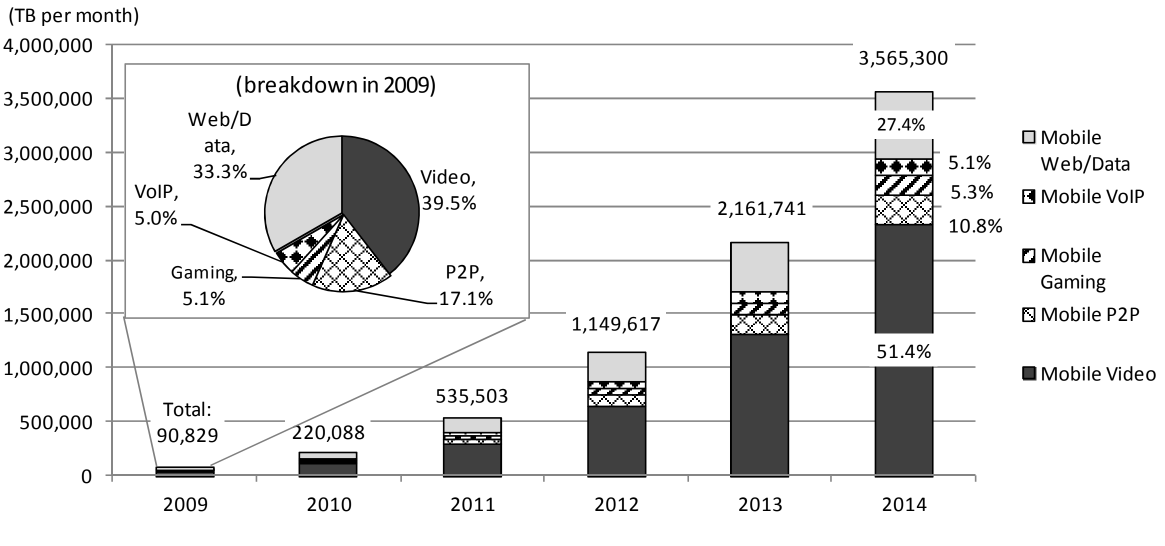
The attractive point of flat-rate pricing for both users and operators is its simplicity.[27] For users, flat monthly subscription fees are often viewed as being transparent and as a way to help them avoid paying more than they expect. For some customers who may not be the direct user of the phone (*e.g.* parents), this is particularly important. For operators, predictable fees reduce their administrative costs of tracking and billing for usage. Recently, some operators have stepped forward to offer unlimited data services without data caps.

Setting tariffs is an important matter for mobile operators. The most important indicator for policy makers is that a range of different tariff plans is available reflecting customer requirements. In a competitive market, operators will strive to meet market demand with prices reflecting that endeavour. The mobile industry has been remarkably innovative in pricing and that will undoubtedly continue with mobile broadband networks. On the other hand, mobile markets suffer from monopoly power over call termination, in markets with calling-party-pays, and these high charges are reflected in higher prices for users. In addition, areas where market forces are limited, due to restrictions on market entry because of spectrum limitations, can also produce high prices for new services. Mobile broadband network advances, especially through new technology and services, may allow policy makers to increase competition and these opportunities should be utilised to their best effect, as they arise, to benefit consumers.

2.3. Traffic growth on mobile network

Advanced devices, applications and new services, as well as more competitive pricing, have generated significant increases in mobile network traffic over recent years. For example, it is estimated that an e-book reader creates as much traffic as two basic phones, utilised for voice and SMS, and a smartphone generates as much traffic as ten basic phones used solely for these traditional services.[28] According to a Cisco study, the entire amount of mobile data traffic is estimated to increase to 3.6 exabytes[29] per month by 2014, with a compound annual growth rate between 2009 and 2014 of 108%. In particular, video is expected to show strong growth. The traffic share of video in overall mobile traffic was 39.5% in 2009 and will be more than 50% by 2014 (Figure 3).[30] Undoubtedly, users have become accustomed to certain services on fixed broadband networks that they would now like to use on wireless networks. This is contributing to the rapid growth in traffic on wireless networks. In addition, wireless services can add value in areas such as location systems or global positioning system (GPS) to develop new services for example in the area of child safety, telematics, or social networking (to name just a few).

Figure 3. Mobile data traffic trends



Source: Cisco," Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014", www9.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

Data traffic volume has been growing rapidly especially in recent years. Many mobile network operators in OECD countries have experienced unprecedented traffic growth (Table 5). As such, one of the key drivers for the development of mobile broadband network technology is the need to handle the high growth in data traffic.

At the same time, it needs to be acknowledged that mobile data is growing from an extremely small or virtually non-existent base. To put this in perspective, the average mobile data user in Hong Kong, China, downloads around 127 megabytes (MB) per month (average over 2G/3G) compared to 22 GB for the average fixed network. While fixed connections tend to be shared by multiple users, and mobile devices by individuals, the different demands placed on fixed and mobile networks can be very large. This underlines the important role which fixed broadband networks will play in supporting mobile broadband networks. Fixed broadband networks are critical to the success of mobile broadband networks in terms of backhaul and in bearing the weight of user demand. The more users rely on fixed broadband networks to do the "heavy lifting", the more efficient use can be made of mobile broadband networks.

In conjunction with the increase in mobile data traffic, a larger proportion of the traffic on Wi-Fi networks is generated by smartphones and other mobile devices. It has been reported that "with the advent of the iPhone and iPad a large percentage of traffic is now moving to wireless Wi-Fi networks. Many public Wi-Fi networks now report that 50% of their traffic is from mobile data sources such as the Android, iPhone and iPad."[31] While this is a relatively new phenomenon and official data is not available, the volume of such traffic is expected to increase as these devices become more common. This underpins the vital role of broadband fixed networks in the future wireless developments.

Table 5. Recent mobile traffic growth of selected network operators in OECD countries

Operators	Experiences
AT&T	Mobile traffic has increased more than 5 000% over the last three years.
Orange	Cumulated mobile data traffic in four European countries (France, UK, Spain and Poland) increased fivefold over 2008.
O2	Mobile data traffic was 18 times higher in 2009 than in 2008.
TeliaSonera	Mobile data traffic in their Nordic and Baltic operation increased by 500% in 2008.
Telstra	Traffic on the wireless network doubles every eight months.
T-Mobile (USA)	Mobile data traffic increased by 45% from Q2/09 to Q3/09.
Vodafone (Europe)	Data traffic has increased more than 300% over the last two years.

The increase in the number of mobile data users has, of course, raised the data traffic volume. Operators, particularly those leading in datacards/USB dongles and smartphone/tablet computer development, have sometimes experienced network congestion. This is because they are designed as a data consuming device and, in a small number of instances, tariff plans may specify unlimited data access. On the other hand, even plans advertised as "unlimited" frequently have caps where users must pay for excess data or tolerate lower data speeds.

If data plans are unlimited and a critical number of users exceed the amount networks are configured to handle, congestion arises. In some cases, users may be relying on their mobile connections to "do the heavy lifting" that would be better suited to fixed networks. This is a salient point to consider for analysts who regard mobile broadband networks as a competitor for data intensive services commonly accessed via fixed broadband networks, though, of course, both have their advantages and drawbacks. In addition, in some of the countries where congestion has been reported, there may be exclusive arrangements, with certain operators, with some types of popular smartphones. In these cases, some may raise the question of whether limited consumer choice means that some networks are utilised more heavily than others due to choices made by suppliers rather than users. Others note that it is still the users who choose to purchase a particular device, knowing it operates on a particular network, and who choose how to use the device.

In the United States, AT&T, the exclusive carrier for iPhone, has been reportedly criticised for substandard services, such as dropped calls, unsteady services, delayed text messages and slow download speeds.[32] On the other hand, there is criticism of mobile coverage and performance in all OECD countries and AT&T may be subject to more scrutiny because it has had exclusive rights over one of the most popular mobile devices yet to reach the market. O2, which until recently exclusively offered an iPhone plan in the United Kingdom, received similar criticisms from mobile users in London.[33]

For its part, AT&T points to 40% of its mobile data traffic coming from just 3% of its smartphone users.[34] If data caps kick-in, these users would pay for downloading this data or, in some countries, experience a reduction in their connection speed. If they do not, the remedy lies with network upgrades, network management, and tariff plans, rather than in the behaviour of users under current arrangements. The primary goal should be to ensure adequate network capacity for all users of mobile networks.

One suggested "congestion culprit" is that smartphone applications automatically update certain features and at a rate neither operators nor users expected in making network and tariff selection. At the same time, the companies that pioneered the introduction of smartphones may have, like everyone else, underestimated their popularity. Over time, as congestion appears to be most serious in markets with high population densities, it should be expected that the market will address these issues. It is noteworthy that at launch, the iPad was initially available with the option of an unlimited data plan in the United States. This suggests that AT&T is confident that its network can support the increasing use that is to be expected.[35] The only restriction on the iPad use, at the time of launch, was that users could only download files up to 20 MB while connected to the 3G network. The previous cap for the iPhones, which was also increased, was 10 MB. Files larger than 20 MB can be downloaded over AT&T's Wi-Fi, the user's own Wi-Fi, or fixed connections.

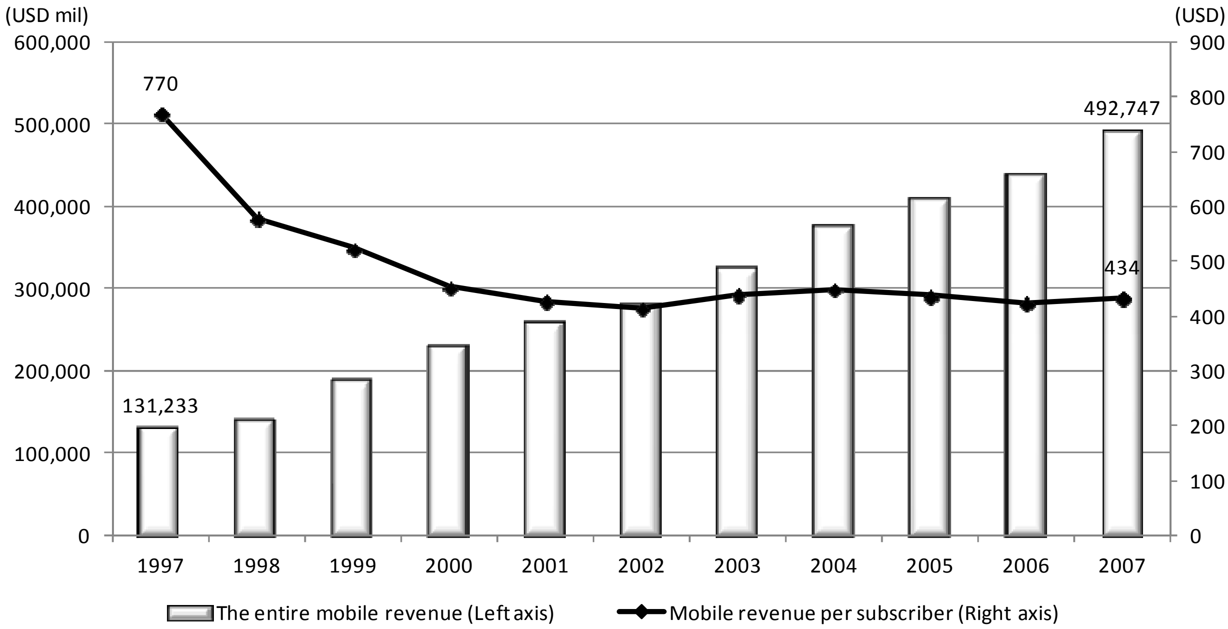
A key question is whether congestion is as much of a problem in markets where there are multiple competitors, vending the most popular smartphones. And, while consumers may complain about their network provider, the uncomfortable conclusion may be that some are trading off congestion with access to certain devices, new features and/or lower prices. In fact, some subscribers accept network congestion in exchange for access to the most popular smartphones, some choose substitute smartphones in exchange for greater network coverage and reliability, while others are willing to forego both the popular smartphones and network coverage and reliability in exchange for lower prices.

Perhaps the most intriguing aspect of some smartphone pricing is that, where exclusive arrangements are in place, the pricing structures would appear to be the result of negotiations between operators and equipment manufacturers. The other salient point is that while the increasing "unlimited" data offers, popular with consumers, have created challenges for network providers, they have stimulated a remarkable amount of innovation. The "unmetered" offers for traditional telephone services and large buckets of minutes for mobile services have historically meant that users, notably in the United States and Canada, have had much higher rates of usage (*i.e.* voice minutes) than most, if not all, other parts of the OECD area. Arguably, the pricing of smartphones and tablet computer access to the Internet, in continuing this tradition, has stimulated tremendous innovation as well as providing new business models for application and content providers.

2.4. Financial pressure on network providers

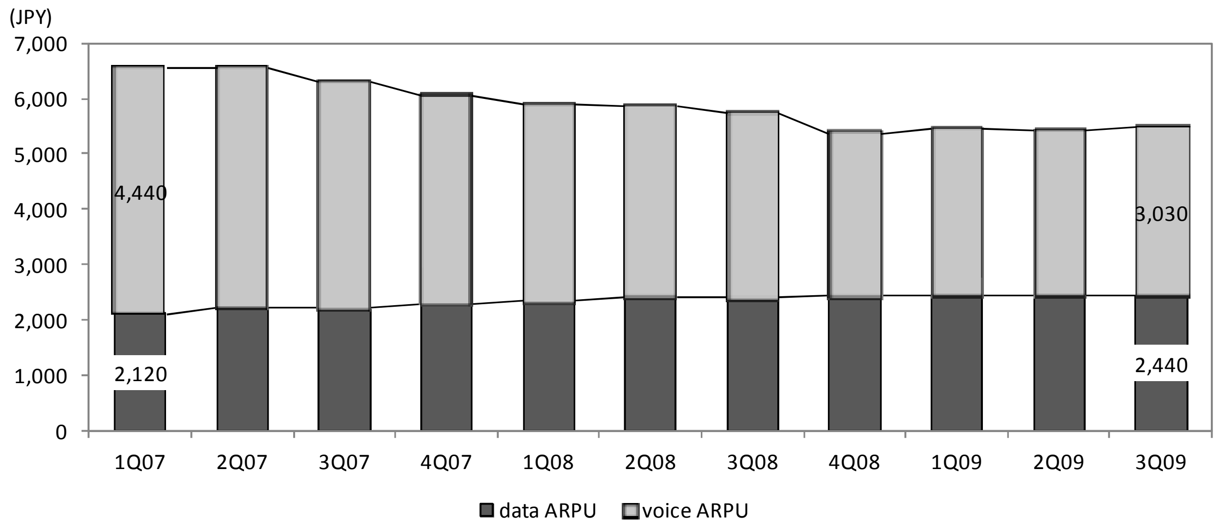
In OECD countries, industry revenue from the provision of mobile services has grown rapidly over the past decade as the number of subscribers has increased. The average mobile revenue per user (ARPU) has remained relatively constant in more recent years (Figure 4). Two factors are influencing ARPU. One is that a large proportion of the initial adopters of mobile communications were business users that had higher ARPU rates. As increasing numbers of consumers adopted mobile communications, including a large number of pre-paid users or in some countries users with two SIM cards, average revenues declined up to the turn of the century. From that time onwards, the industry has been able to maintain ARPUs, including by introducing new services. In recent years, a second factor is that data services have become an increasingly important revenue source (Figures 5 and 6). In the future, the proportion of revenue attributable to data is expected to increase significantly as has been the case for fixed networks.

Figure 4. Mobile revenue trends based on the OECD average data



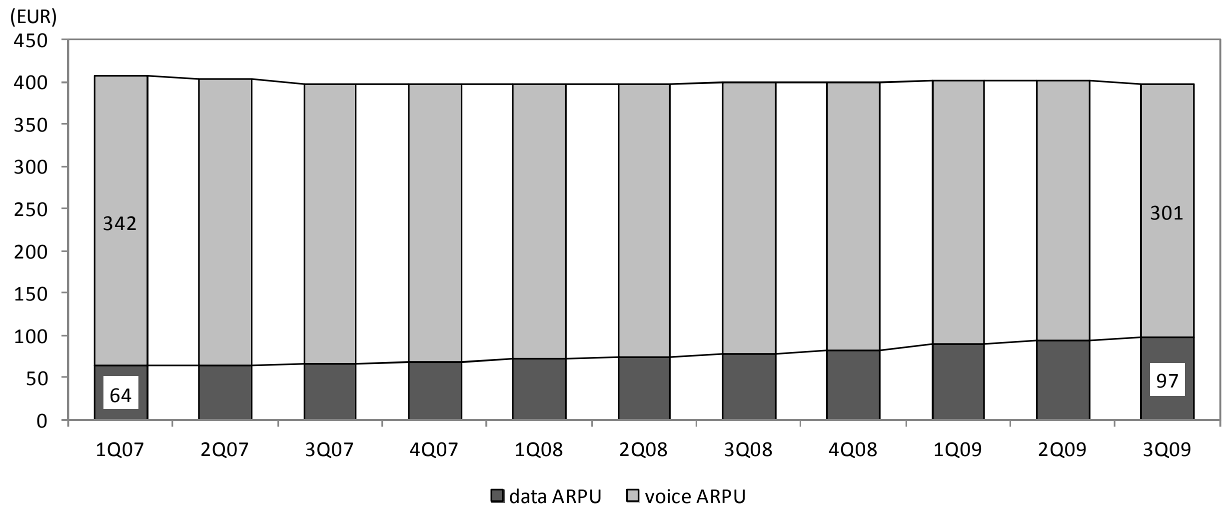
Source: OECD (2009), *Communications Outlook 2009,* OECD, Paris.

Figure 5. NTT docomo's ARPU trends



Source: NTT docomo.

igure 6. Orange's mobile ARPU trends



Source: France Telecom.

The reduction in voice ARPU largely reflects the increasing proportion of consumers and use of pre-paid subscriptions. In some countries, such as the United States, increasingly large bundles of minutes have been included for a fixed monthly fee. Another trend is for larger bundles or unlimited use of SMS to be included as options for customers enabling them to substitute SMS for some voice calls they would otherwise have made. More recently, the use of other data communication services, such as e-mail, and even Facebook and Twitter, location sharing and so forth, may be substituting for voice services. A further factor, in the reduction of voice ARPU, is that operators may have reduced prices to hold or attract customers with the aim of selling them more profitable new services.

The desire to reduce costs is another explanation for the drive towards the development of mobile broadband networks. Operating costs of existing 3G networks account for almost one-third of the total operating expense of network providers.[36] Future mobile broadband networks promise to be very attractive in terms of cost-efficiency, quality of service, and so forth, because they have simple, flat and less hierarchical network architectures that require less cost of network operations, resulting in lower cost per bit than existing mobile networks.

2.5. Demand side perspective

Consumer demand for rich data services is increasing as new devices and applications are made available. For example, geographic-based applications, including GPS capability, help users find information in the particular geographic area where they are. One interesting example is "sekai camera" application for smartphones in Japan. The application lets users share "air tags" or virtual sticky-notes tied to a specific location. When users look through the camera view, they can access pop-up information of texts, photos or voice messages, which are tagged by other users on the screen. In turn, innovative applications appearing on the market also help stimulate the demand for mobile broadband.

3. POLICY CONSIDERATIONS

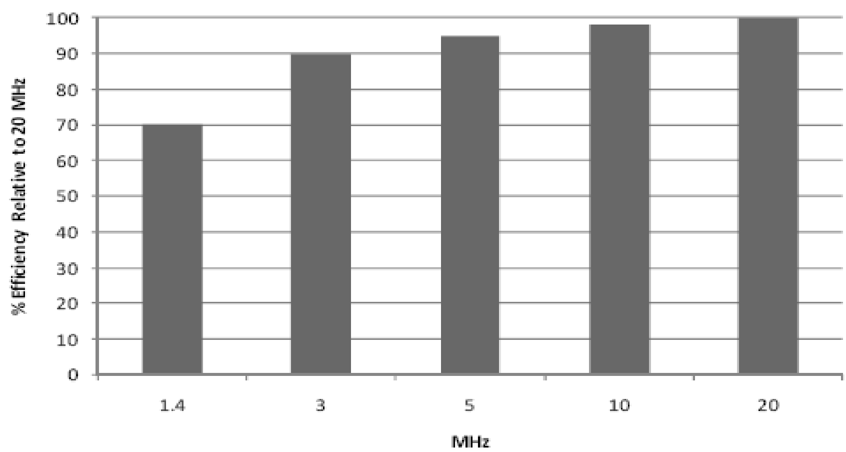
3.1. Spectrum management

3.1.1. Spectrum allocation for next generation mobile

Spectrum is one of the most important issues for the deployment of new mobile systems. How much radio spectrum is assigned and frequency band harmonisation is critical for deployment of mobile broadband services and economies of scale. In many countries, when mobile broadband networks come into view, mobile operators, potential entrants and other stakeholders require more spectrum for new technologies.

As far as LTE and IEEE 802.16e are concerned, both adopt technologies for efficient spectrum use and achieving high peak data rates. In order to take full advantage of high-speed access, they require wider bandwidth than the existing 3G. As discussed earlier, mobile broadband technologies support scalable channel sizes via multi-carrier technology. Spectrum efficiency is different depending on the channel size available. As the largest channel size shows the most efficient result (Figure 7), larger channel sizes have a capacity to handle more bits per unit time, which leads to high data throughput. Using 5MHz, there is only a small performance advantage with mobile broadband networks.[37] In order to fully realise the potential of mobile broadband networks in terms of speed, latency and efficiency, new and additional spectrum allocation would be needed to ensure larger bandwidth. This is likely to significantly increase demand for spectrum from the mobile wireless industry. At the same time, if an operator already has a wide allowance (*e.g.* for their 3G use) and they can re-farm this allowance, they get the same benefit though in practice few operators may have this flexibility.

Figure 7. Spectral efficiency depending on different channel sizes



Source: 3G Americas, www.3gamericas.org/documents/3G_Americas_RysavyResearch_HSPA-LTE_Advanced_Sept2009.pdf.

3.1.2. Spectrum harmonisation

The need to harmonise spectrum use is underpinned by potential benefits from:

- Ensuring interference-free operations: spectrum harmonisation makes harmful interference more readily managed in the radiocommunication systems especially in countries where they are in close geographic proximity.

- Achieving better economies of scale: spectrum harmonisation facilitates the deployment of mobile network infrastructure and handsets on a global basis, which can contribute to seamless broadband and to lower costs. Global competition between mobile vendors imposes further price pressure, stimulates industry innovation, and promotes market growth.

- Lower financial risk for new product development: spectrum harmonisation gives vendors more certainty for new product development and reduces the development costs.

- Facilitating international roaming: spectrum harmonisation gives more potential to handle international roaming with single-mode or single-band terminals. Multi-mode or multi-band terminals can overcome the discrepancy between different technologies or between different spectrum plans, but these multiple radio interface terminals usually cost more to develop and commercialise, so they would be more expensive. In general, costs increase if more bands need to be supported.

3.1.3. Spectrum management approach

As is discussed in previous work,[38] potential approaches to spectrum assignment are a comparative selection model, a market-based model and a commons model (Table 6).

The comparative selection model is the traditional approach in which governments and regulators decide how much spectrum each service would require and assign the spectrum through a selection process. Many OECD countries today limit the use of this approach to situations where regulations prescribe certain spectrum uses to achieve important public interest objectives, such as national defence and emergency services, or to conform to treaty obligations. Governments and regulators in those countries are concerned that the selection process is subjective and less transparent. Some argue that the comparative selection approach does not always result in efficient spectrum use, as large parts of the spectrum are often poorly utilised.[39] Another argument is that this approach is not responsive enough to keep up with accelerating technical development. Others contend that this model facilitates harmonised spectrum use and avoids fragmentation.

The market-based model includes auctions and trading with liberalisation in the secondary market. This approach is now the preferred method to assign spectrum in the majority of OECD countries. For instance, the European Commission encourages member states to introduce market-based approaches to spectrum management.[40] Characteristics are the transparent process, explainable outcome and economic efficiency, as this approach allows applicants who value the spectrum most to use it.[41]

With an auction, the winning bidder should be the firm that values the spectrum the most in terms of its potential returns. Thus, the spectrum will be assigned to the company that can use it most cost-effectively.[42] Opponents claim that this approach will lead to increased prices to consumers and the delay in service deployment.[43] Others argue that auctions may be favourable to dominant companies in the market as they have the financial strength to price out weaker new entrants. On the other hand, it would be expected that profit maximising firms would charge prices that the market will bear, and this will be reflected in their bids or their prices even without auctions. In addition, experience shows that some comparative selection processes have taken much longer than would have been the case for an auction. Finally, auctions can be designed to ensure policy objectives, such as reserving some spectrum only for bids from new entrants, to increase competition.

Trading of spectrum is another dimension of the market-based approach, which makes it possible to buy, sell, aggregate and disaggregate spectrum. Its purpose is to provide whomever needs the spectrum with a way to obtain access to the required spectrum. Some consider that it has provided various companies with opportunities to obtain access to spectrum; others argue that the secondary market does not work effectively as unused or underused spectrum is not being made available to smaller providers.[44] There is also a question as to why firms that were allocated spectrum under a comparative selection process, perhaps many years earlier, should receive a windfall payment as the market determines other users would be more efficient. While the public undoubtedly benefits from any efficiency achieved, others believe that the public should share the increased financial value. In these cases, governments and regulators auction this spectrum and perhaps share the revenue with previous incumbents to encourage their participation.

The commons model allows all users to have free access to the spectrum as long as they abide by the rules in place in the commons, which typically include restrictions on the technologies and power levels that can be adopted. Some argue that this approach promotes greater technological innovation and efficient spectrum use since the regulators could allow multiple re-use of the same spectrum space by limiting the geographical coverage of transmissions. In recent years, the development of Wi-Fi has been a spectacular success from the use of the commons model. On the contrary, others argue that this approach cannot guarantee the quality of transmission and may lead to overuse of the spectrum and excessive interference. In addition, the interference governance structures that may be needed in some applications of the commons model may not be fully developed, and the utility of this approach for mobile or long-range communications may be diminished if co-ordination between multiple real property owners becomes difficult.

Table 6. Spectrum management approaches

Approaches	Merits	Demerits
Comparative selection model	• May be applied to general interest objectives at the national or international level • Facilitate harmonised spectrum use and avoiding fragmentation	• Selection process is subjective and less transparent • Less incentive for efficient use • May slow down technological innovation • Often occupied by previous technologies
Market-based model	• Transparent and readily explainable outcome • Enable efficient and effective management in response to rapid technological change • Encourage efficient spectrum use • Give more flexibility to use	• May be unfavourable to small companies without financial strengths without effective auction design
Commons model	• Lower barriers to access spectrum • Reduce the time-to-market • Stimulate technological innovation	• May lead to overuse of spectrum and excessive interference • Associated costs of the interference governance and co-ordination

A number of OECD countries are moving away from comparative selection to market-based approaches (Table 7). For example, Finland, where spectrum user rights had not been made available for sale, held a spectrum auction for 2.6 GHz band for the first time in 2009. In Korea, the amendment of the Radio Wave Act to introduce spectrum auctions was under legislative process as of May 2009. The first action is likely to be applied to 700 MHz band assignment, and is planned after 2012.[45] The Polish government is considering its first spectrum auction in 2.6 GHz bands.[46] On the other hand, for example in France, both approaches have been followed in recent years.

Table 7. Spectrum management approach for next generation mobile in selected OECD countries

Countries	Spectrum band	Approaches
Austria	2.6 GHz band	Auction
Belgium	2.6 GHz band	Auction
Denmark	2.6 GHz band	Auction
Finland	2.6 GHz band	Auction
Germany	800 MHz band, 1.8 GHz band, 2.1 GHz band, 2.6 GHz band	Auction
Italy	2.6 GHz band	Auction
Japan	1.5 GHz band, 1.7 GHz band	Comparative selection
Korea	800/900 MHz band, 2.1 GHz band	Comparative selection
Netherlands	2.6 GHz band	Auction
Norway	2.6 GHz band	Auction
Portugal	3.4 GHz band	Auction
Sweden	2.6 GHz band	Auction
Switzerland	800 MHz band, 1.8 GHz band, 2.1 GHz band, 2.6 GHz band	Auction
United Kingdom	800 MHz band, 2.6 GHz band	Auction
United States	700 MHz band, 1.7 GHz band, 2.1 GHz band, 2.5 GHz band	Auction

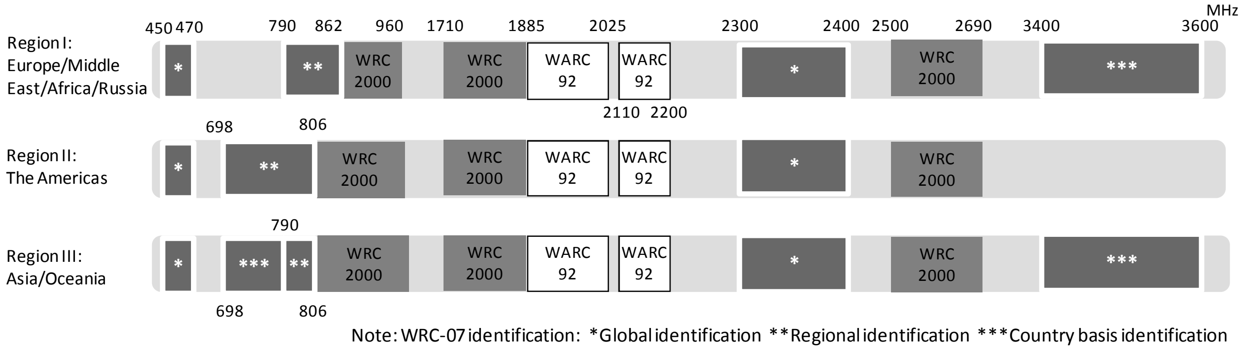
3.1.4. Digital dividend

A switch from analogue to digital broadcasting is taking place across OECD countries. As a result, a significant amount of spectrum will become available for other purposes. The so-called “digital dividend” will create increasing opportunities for innovative wireless technologies and services. This is because the current spectrum allocation plan is typically very tightly spaced and there is little possibility to find additional space without significant changes. Thus, many governments and regulators consider the digital switchover as an opportunity to enhance existing wireless services or to develop new communication services. In this regard, future developments in technologies and consumer demand for services will have a significant impact on the use of the digital dividend. How broad or narrow the band is would also be an important aspect.

Current frequency allocation in OECD countries is based on international agreements at the ITU, and the expected digital dividend will arise from the VHF (very high frequencies) band and the UHF (ultra high frequencies) band.[47] So far, more attention has been paid to the UHF band than the VHF band. The UHF band is better valued due to the attractive propagation features for delivering communication services. It is capable of penetrating buildings effectively and carrying large amounts of data. On the contrary, the VHF band is less preferred mostly because the band is much narrower than the UHF band, less attractive in terms of antenna performance (propagation gain does not offset antenna gain loss), and hence less prone to spectrum scarcity.[48] It is difficult to design antennas for handheld devices at this frequency.

In the international context, a spectrum allocation plan in the UHF band where the potential digital dividend spectrum is located was revised at the most recent World Radiocommunication Conference in 2007 (WRC-07). The spectrum range 790-960 MHz in Region I and Region III, and 698-960 MHz in Region II were identified for the implementation of IMT (Figure 8).[49] In addition, 698-790 MHz was identified specifically in nine countries in Region III.[50]

Figure 8. ITU spectrum identification for IMT



In the regional context, the European Commission issued a technical specification decision for the use of the digital dividend based on a harmonised band plan across member states for electronic communication services, and specifically wireless broadband, other than, and in addition to, broadcasting services.[51] The recommendation highlights potential benefits from harmonised spectrum use including economies of scale, development of interoperable wireless services, lower infrastructure cost, improved geographic coverage, and avoiding market fragmentation resulting in suboptimal use of scarce resources. It also calls for refraining from any action that might hinder or impede the deployment of such communication services in the sub-band. This is a very important point especially for neighbouring countries, because the use of spectrum travels over long distances and may cause harmful interference across the country.

In each country, close attention is being paid to identifying the amount and location of spectrum available (Table 8). Geographical proximity is a significant concern particularly because the propagation characteristics of such a low frequency may increase interference across borders.

Table 8. Digital dividend developments in the UHF band in selected OECD countries

	Countries	Bands	Purpose of use
Region I	Austria	N.A.	Not yet identified
	Czech Republic	790-862	Allocate for mobile telecommunications
	Denmark	790-862	Allocate for mobile telecommunications
	Finland	790-862	Allocate for mobile telecommunications
	France	790-862	Allocate for mobile telecommunications
	Germany	790-862	Allocate for mobile telecommunications
	Italy	N.A.	Not yet identified
	Netherlands	790-862	N.A.
	Norway	790-862	Identified
	Spain	790-862	Allocate for advanced electronic communications services
	Sweden	790-862	Allocate for other than TV services
	Switzerland	790-862	Allocate for mobile telecommunications
	United Kingdom	550-606 790-862	Not yet identified[52]
Region II	Canada	N.A.	Not yet identified
	United States	698-746 746-806	Auctioned and primarily purchased for wireless communications
Region III	Australia	694-820	Not yet identified
	Japan	710-770	Plan to allocate for other than TV broadcasting
	Korea	N.A.	Not yet identified
	New Zealand	694-806	Allocate for mobile telecommunications

Service and technology neutrality have been recent trends in telecommunications policy development. Some countries do not specify the purposes or use of the digital dividend, while others do. Some argue that governments and regulators need to ensure that they should neither enforce the use of a particular type of technology nor discriminate against it, although this does not deny the need to take appropriate action to avoid harmful interference. On the other hand, others argue that market harmonisation by governments and regulators are requisite so as to ensure efficient and effective use of frequencies. They claim this approach can be justified if it helps in achieving certain policy objectives. In any case, governments and regulators generally prefer an efficient and effective spectrum use approach consistent with the maximum amount of service and technology neutrality.

Germany serves as a good example of making the digital dividend valuable for mobile broadband in particular in rural areas. Germany auctioned part of the digital dividend in May 2010. Mobile network operators, who obtained the spectrum, are obliged to deliver broadband services at first in areas up to 5 000 inhabitants that are covered with broadband connectivity (equal to or more than 1 Mbps) of less than 95%. After coverage of at least 90% of those communities, the operators may start to serve at least 90% of those communities of the next priority level (more than 5 000 and up to 20 000 inhabitants, covered with broadband connectivity of less than 95%), until they have achieved the last priority level (more than 50 000 inhabitants). Thus, the goal is to ensure that the digital dividend will facilitate rapid broadband coverage of underserved areas or white spots with a performance of at least 1 Mbps.[53]

3.2. Evolving new business models

3.2.1. Competition among network providers, equipment manufacturers, and application suppliers

A typical mobile value chain includes a variety of different players such as consumer device vendors, backhaul providers, equipment manufacturers, content and applications providers, and platform suppliers.[54] Traditionally, network operators play a central role and influence other parts of the value chain as a vertically integrated mobile service provider. For example, this is sometimes the case when a consumer buys a mobile handset through an operator and has access to services only in the operator's "walled garden". In such a case, the consumer's choice is limited in terms of available handsets and accessible services at the time they select a provider.

However, the recent popularity of new consumer electronic wireless devices, such as smartphones, is likely to have a considerable influence on the conventional mobile value chain in the wireless broadband era. Apple's iPhone is one notable example. The iPhone uses Apple's iTunes App Store, which had been developed prior to its arrival for their previous devices, such as the iPod. The vertically-integrated approach used for the iPhone, is less open than a number of the company's competitors. Apple exclusively provides the operating system, hardware, built-in applications and platforms, although the company allows third-party application development via its approval process.

In response to Apple's success, some mobile network operators, and some equipment manufacturers, have also opened their own application stores. For example, in Korea, KT launched its own e-book content store, which allows various devices including PCs, smartphones and e-book readers to download content. Other examples of application stores include those owned by Google, Research In Motion, Microsoft, AT&T, Vodafone, Orange, Sprint, Telus, Verizon Wireless, Telefónica, Nokia, Samsung, LG Electronics, among others. However, mobile operators at least may face a challenging task. Unlike Apple, they usually depend on outside handset vendors so that they do not have control of the end-to-end system architecture nor any experience in duplicating such architecture.[55] Thus, Apple is uniquely situated as a controller of hardware, software and distribution where network operators used to be the leading player. The closer relationship with Apple and iPhone users builds strong brand loyalty. This might push the conventional mobile operators away to become just infrastructure providers in the mobile value chain. Indeed, the iPad has taken this model a step further in the United States in terms of the customer interface being directly with Apple instead of the operator. It is also worth mentioning that the Amazon Kindle e-book reader and service is another example of a direct relationship between customers and non-network providers. In other countries around the world, it appears the customer interface involves both Apple and mobile operators though the Kindle service has, to date, been more similar to the United States model.

While Apple's success gives it a strong bargaining position with operators, consumer preferences will play a large role in future developments. As long as the iPhone is the dominant mobile smartphone device in the market, operators have to accept a greater share of returns to Apple in order to provide the iPhone. Challenges are coming from Google's Android mobile phones and other attractive mobile devices. If they are competitive enough with the iPhone, network providers can negotiate with equipment manufacturers by using new attractive devices as a leverage, which would lead to increased consumer choice at more affordable prices. Thus, competition between equipment manufacturers and application suppliers will give network providers more bargaining power.

Some global mobile network providers and equipment manufacturers have united to create an open platform to deliver applications to all their mobile phone users. The new alliance aims at creating more competition by offering subscribers access to as many application stores as possible and increasing competition with Apple.

3.2.2. Sponsored connectivity business model

In addition to traditional business models for mobile services, where the customer has a direct billing relationship with the network provider, a number of other firms are developing sponsored connectivity models. Under these models, the firms, non-network providers, use the wireless network connectivity to provide services to their customers. The customers do not have a direct relationship with the network providers, such as via a monthly subscription or pre-paid card. Indeed, they may not know the name of their wireless provider. Perhaps the best known example is the Amazon Kindle e-book reader and service.

Once a Kindle device is turned on (and wireless switched on), it connects to the mobile network automatically. Unlike end-user mobile terminals which require contracts with network operators, Kindle has pre-activated connectivity at the moment of purchase. In this business model, Amazon directly pays for the network connection and the user pays for this service via the price of content purchased from Amazon. In addition, Kindle's international service enables users to roam in many countries around the world. At home or abroad, users will rarely know which operator is providing connectivity. It is possible to determine the operator, but there is no difference in terms of pricing for the operator or country, as there is for most other mobile roaming services.

Unlike traditional mobile services, a user of the "International Kindle" can switch their home country. In other words, a Kindle user in Japan, shifting to live in France, simply changes their home country in their account details. This is enabled by Kindle's use of AT&T's international partner networks. Amazon says "International Kindle" users do not pay separately for content delivery in their designated home country, even though, in terms of the network, they are treated as a roaming customer. An e-book downloaded outside a user's home country incurs an additional fee of USD 1.99 as of May 2010. While the share of revenue from provision of connectivity accruing to each firm (Amazon, AT&T, and partner network provider) is not public, the amount for the mobile providers is likely to be similar to their roaming charges (with due allowance for volume discounts).

If an "International Kindle" user makes a purchase in their designated home country, the connectivity charge is included in the overall price of an e-book. While this charge is not specified separately, if an AT&T partner network charges a rate similar to their roaming wholesale price, it is readily understandable why the model is attractive to mobile operators. In the United States, users can choose from the "International Kindle" (AT&T) or a domestic version that is tied to Sprint's wireless network. The United States domestic Kindle device, using Sprint's network, does not include international wireless roaming.

With sponsored connectivity services, mobile network operators provide the "pipes" for entities such as Amazon. Historically, operators have tended to prefer models where they had a direct relationship to customers. As the infrastructure becomes more effective in terms of speed and network capacity, this type of business model is being opened up to other devices including:

- Game console "Zeebo": this is currently available in Brazil and Mexico. Zeebo's business model is, similar to Kindle, the wireless delivery of game content without the need for Internet access subscription or a mobile service plan. Users can buy game content on line, and the cost of the wireless network connection, which is around USD 10, is included in the price of each game.

- E-mail-only device "Peek": this allows unlimited e-mail and unlimited text messaging for a one-off "lifetime" payment for the device. The device price includes a wireless connection fee so that there is no need for an additional contract with a network provider.

- Navigation service "Tomtom Live Services": this provides real-time information, such as route-around traffic, the best fuel prices, and the latest weather reports, through wireless networks.

Unlike a typical car navigation system, this device has built-in wireless connectivity with a SIM-card. Users pay a monthly service fee, which includes a wireless connection fee to access real-time information services.

- Digital photo frame "Pandigital Photo Mail": this has its own dedicated e-mail address so that users can share that address with others and send photos directly to the frame from their own e-mail account through a wireless network. The price of the device includes the ability to receive 300 photos e-mailed to the frame with no service fee, and additional photo allotments can be purchased.

3.2.3. Mobile advertising

The larger capacity of mobile broadband networks, and their increasing ability to deliver services that can be supported by advertising, will further develop the potential of this market for firms in the value chain. This has produced an increasing amount of corporate activity in respect to the ownership of nascent firms specialising in mobile advertising. In 2009, Google announced it planned to acquire AdMob, a mobile display advertising technology company, for USD 750 million. Soon after Google's announcement, Apple acquired Quattro, a mobile advertising provider, for USD 275 million.[56]

The series of acquisitions of mobile advertising companies suggest that Google and Apple believe there is a promising future for this industry. For its part, Google has demonstrated that advertising is an attractive model for supporting services on fixed networks. Many analysts believe that the most effective advertising platforms have shifted from "traditional media", such as broadcasting and newspapers, to the fixed Internet, and are now shifting to mobile networks. In the past, mobile networks have been limited by capacity constraints (*e.g.* for video advertising) and the lack of integration between applications and advertising (*e.g.* clicking on an advertisement may take a user away from the application and not allow seamless return). Today's 3G networks, and future mobile broadband networks, have encouraged all stakeholders to examine how they can take advantage of advertising as a new source of revenue. Newspapers and magazines, for example, are exploring how they can use applications on devices such as tablet computers and smartphones to generate new revenue.

These changes will provide new business opportunities for mobile advertising platform providers, application developers and network providers. Apple plans to sell mobile advertising, with developers who create the applications to include advertising in the software. The company will take 40% of the revenue from mobile advertising and share it with developers getting 60%.[57] Apple has suggested that 100 million users of iPhones and iPads, averaging 30 minutes a day, watching an advertisement every three minutes, could mean that Apple serves a billion advertisements a day.[58]

A key question mobile operators will be asking, is whether they will share in this revenue. Clearly, popular advertising services will generate traffic and this will benefit operators. Broader efforts by operators to share in such revenue streams may lead to issues similar to fixed networks in terms of traffic prioritisation. On the other hand, the wireless industry has much greater competition than fixed networks in many geographical areas. For example, whereas there may be four or more high-speed mobile wireless networks in some countries, there may only be one or two fixed equivalents. Moreover, operators are free today to choose whether they sell or support smartphones from any manufacturer. Accordingly, the amount of advertising revenue that may alternately be shared by different firms will be a matter for commercial negotiations and the bargaining strength of each actor.

For policy makers these changes, in combination with others being generated by fixed network developments, will likely have significant implications for some of their traditional approaches to media supported by advertising. For example, in 2010, the Australian government decided to rebate licence fees on commercial broadcasters to underpin their support for Australian content requirements for a range of reasons, including the new technology and commercial challenges facing the sector.[59] At the same time, it can be asked why some content, such as books, magazines or newspapers, may attract value added tax on devices, such as Kindles and iPads in some countries, but not for the same content delivered by traditional print media.

3.3. VoIP applications on mobile networks

For a long time, there was little use of independent VoIP service on mobile networks. The rise of smartphones has seen some growth in the use of VoIP over third-party applications. Mobile network operators have often blocked the provision of VoIP services by other entities on their network. This is because some operators fear the impact of VoIP on their voice revenue. As telephony represents part of these operators' revenue, this is understandable. On the other hand, operators that sell large "buckets" of minutes at a fixed monthly price may have less to fear. That being said, VoIP application providers often provide other value-added services that also put competitive pressure on the margins of network operators.

In general, VoIP services provide low prices to consumers and uncharged services for some types of calls. For example, Skype enables users to make outbound calls to non-Skype users at lower per-minute rates, and make calls to Skype users for free. As such, the replacement of conventional voice calls with VoIP can pose a revenue challenge.[60] On the other hand, a few mobile operators have moved towards permitting the use of VoIP services on their network.[61] For instance, AT&T allows VoIP applications for iPhone to run on the wireless network; this was previously limited to use only through Wi-Fi connectivity.[62] Verizon Wireless is also providing a new service, which enables users to Skype VoIP services on its 3G network.[63] Three, one of the first carriers to do so, also carries Skype in eight countries.[64]

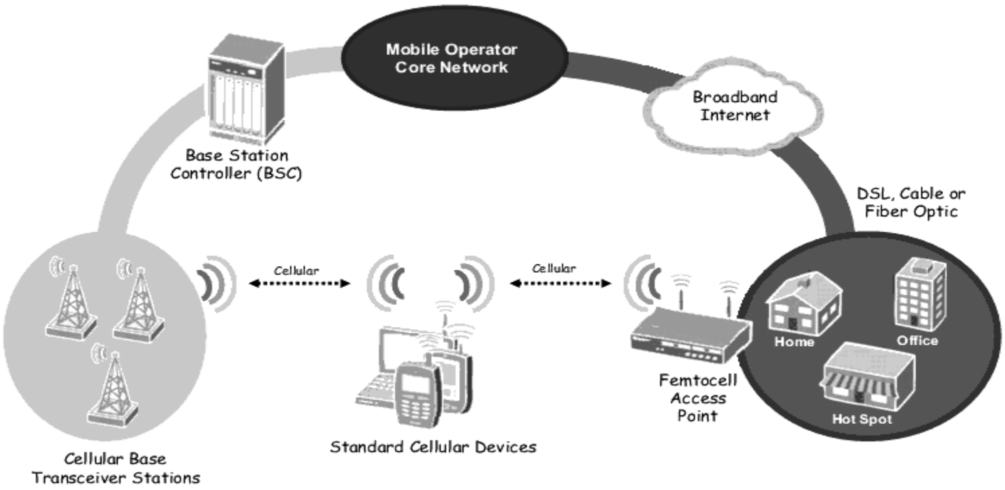
Operators may consider mobile VoIP services as a potential opportunity to attract and hold customers. It also reflects the view, however difficult to acknowledge in terms of traditional business models, that telephony is little different to any other application. At the same time, operators can look forward to growing revenue streams to the extent they can negotiate better deals with firms such as Apple, or together with partners develop competitive services. It is frequently VoIP service providers that introduce new services and, with the advantage of new smartphones and greater bandwidth, they may be able to bring services to the market. In the past, traditional operators have unsuccessfully tried some of these innovations, such as video calls.

The change of some operator's positions regarding VoIP applications could be also a recognition that they wish to head-off concerns about "network neutrality", rather than face potential action by regulators. This issue has not just drawn attention to the position of operators in respect of VoIP, but also to whether some smartphone manufacturers will permit rival VoIP services on their handsets.

3.4. Femtocells

A femtocell is a tool available to extend mobile coverage and augment local capacity by offloading traffic.[65] In principle, it is a very low output power base station capable of covering an area of 100 square meters and handling up to three or four simultaneous sessions from different users. When users make a call at home, a femtocell connects the call to the user's household fixed broadband network, such as DSL, cable or fibre, and then to their mobile operator's network.[66] This is particularly unique when it is compared to traditional 2G or 3G calls which are usually connected directly to a nearby base station/tower and then to the mobile operator's backbone network (Figure 9).

Figure 9. Femtocell access to the core mobile network via broadband Internet



Source: Juniper Networks, www.juniper.net/techpubs/software/aaa_802/imsaaa11/sw-imsaaa-admin/html/Overview3.html.

Any mobile subscriber can use a femtocell service from their operator, as long as they are in the coverage area, which can include private or public spaces. It is possible to restrict to specified users, which is more suitable to residential and small business use. For instance, Sprint's femtocell service allows femtocell subscribers to make a list of up to 50 phone numbers to whom they grant the access to their femtocell, but also enables them to open their femtocell to any Sprint mobile users. However, operators recommend restricted access which prioritises the subscriber's session. When the number of visiting users reaches the capacity of devices to handle the simultaneous session, the subscriber's session will not be possible. As such, the primary target of femtocells is to extend or improve mobile coverage indoors and for small areas.

Some expect open access of femtocell coverage areas, in the same manner as Wi-Fi hotspots, but there are some technical challenges. For example, the current femtocell service usually does not support the handover from the femtocell coverage area to a non-femtocell coverage area, although the reverse is supported. Thus, smooth handovers may be difficult for femtocell because calls initiated in the femtocell area will continue uninterrupted when users move outside of the area. Another challenge is that a femtocell will not function when an Internet connection is not active. As such, it cannot be used in the event of an electrical power outage, a broadband connection failure, when broadband service is terminated or during other service disruptions. When a fixed broadband connection is used simultaneously by other bandwidth-intensive applications, call quality may be affected. For example, Verizon's femtocell service uses network capacity of about 40 kbps for uploads and downloads per call.

By utilising a user's fixed broadband network, femtocells can effectively avoid wireless network congestion, which can occur as the result of a base station being shared by a greater number of users than it is designed to handle. The routing used by femtocells could result in offloading a large amount of traffic from mobile networks to a user's fixed broadband network. This will enable mobile operators to reduce the traffic on their networks and to provide other services by using existing network capacity. The potential savings for mobile operators in terms of backhaul costs may be substantial. A further potential advantage for mobile operators is that femtocells can cost less and be deployed more quickly, to improve coverage, than traditional base stations deployment for some relatively small areas. It may be easier to extend coverage in some areas where approval for construction of additional base stations may be opposed by local authorities or residents. Femtocells use licensed spectrum, unlike Wi-Fi, and accordingly network operators are responsible for complying with any existing regulation.

Some argue that femtocells have no established business model to date, partly because the benefits of today's femtocell are mostly limited to improving service coverage.[67] If this is the case, mobile users may be reluctant to pay for the femtocell service since they already pay a monthly fee for their mobile service. On the other hand, there is a long history in fixed-line telecommunications of users funding extensions to infrastructure to receive or improve service. In some countries, with wireless -at least in the past- users frequently mounted external antennas on vehicles, which were connected to handsets, to boost their reception of any available coverage. A current example is those users who erect external towers to receive various fixed wireless services that would otherwise be out of range.

Some operators who provide femtocell service charge their subscribers for the service, in addition to the monthly fee. For example, Vodafone UK provides femtocell service for a one-off cost of either USD 73 or USD 175 depending on the user plan and, in France, SFR charges a USD 248 one-off fee, both as of May 2010. On the contrary, in Japan Softbank Mobile announced that the company will provide femtocell service for free for their subscribers without good coverage at home or offices. As wholesale prices for femtocells continue to fall, now below USD 100, more operators may begin to give them out for free.[68]

The use of femtocells is likely to increase if only because of their potential to decrease costs for operators and improve services for users. Moreover, users may embrace femtocells if they are rewarded by operators in terms of reduced or unmetered pricing for home access. Although some users may choose fixed phone calls, which are provided for free in some countries, others may have given up their fixed connection or prefer to carry their mobile phone in their home in a way they do not carry portable fixed phones or because of differences in functionality (*e.g.* as from a smartphone). Free femtocells would be unlikely to displace Wi-Fi routers in households with a fixed broadband connection, which are often provided for free or at very low cost in most countries, even though the functionality is not dissimilar for Internet access. The main difference, of course, is that not all services available to the mobile subscriber may be accessible over their Wi-Fi connection. In those countries where operators sell service in large buckets of minutes, the appeal of femtocell to users may still be limited as they would in any case not be charged directly for those minutes. On the other hand, even in those countries, it is easy to envisage models where users are compensated for their contribution to establishing and maintaining a femtocell which is used by other users. This may overcome an understandable reluctance to pay twice for the same call (*i.e.* for their mobile and fixed connection) as well as the cost of receiving a call.

To date, the typical femtocell service applies the same rate plan irrespective of being in the femtocell coverage area or not. It would be expected that competition would promote pricing for calls made from a "home-zone", which a femtocell covers, as they will be charged less than those made outside the home-zone pricing area. These types of services have been available to large businesses equipped with femtocells for some time. This will lead to an increase in mobile use at home and in offices. An additional benefit for mobile operators is that femtocells may enable mobile network operators to compete effectively with fixed network operators as they endeavour to accelerate fixed-mobile substitution for traditional PSTN services.

For operators with both fixed and mobile networks in the same geographical area, there may be fewer incentives to promote femtocells if they lead to a reduction in traditional PSTN voice subscription. On the other hand, this trend is likely to continue irrespective of the introduction of femtocells and these operators would not gain the other benefits of their introduction and be disadvantaged compared to competitors. Fixed operators without mobile networks, or new mobile entrants with a demonstrated record of innovation and price disruption such as Free in France, may seek to utilise the technology in a more competitive manner in combination with their mobile network operator or MVNO businesses or their fixed infrastructure. Indeed, although new mobile entrants are less prevalent today than in past years, femtocells may provide them with a significant way to differentiate their service and attract users. While the experience of fixed networks offering merged fixed and mobile services, in user's homes, has not proved very successful to date (*e.g.* BT's fusion service), this may be less so in future. In part, this was because users also had access to independent Wi-Fi services, over which they could use services such as Skype, but offers may be more attractive if mobile prices were reduced in countries where metered pricing is most prevalent.

Apart from the opportunities that femtocells have for improving outcomes for mobile operators and users, there is one further important point worth noting for policy makers. Femtocells increase the performance of wireless broadband networks, but they also increase the reliance on fixed broadband networks. While most attention is rightly paid to their implications for wireless service, they underline the important role which next generation fixed networks will play in supporting advanced wireless networks.

3.5. Market competition and tethering

The larger capacity of mobile broadband networks will increase the potential for tethering. Tethering allows a wireless handset to work as a modem and to connect other devices such as notebooks, netbooks and MP3 players to the Internet by wire, Wi-Fi or Bluetooth. Some types of smartphones, such as Blackberry and iPhone 3G, officially support tethering. Similar examples are personal mobile hotspots, which work as a portable modem combined with a Wi-Fi hub to access the Internet. These enable network-capable devices to access the Internet easily as long as they are in the mobile coverage area. At the same time, tethering notebooks may lead to a greater consumption of bandwidth on the mobile network, as users may be more likely to access some types of service (*e.g.* video) over larger devices. One trend is that devices will increasingly come equipped to directly attach to a mobile network and therefore not require tethering (*e.g.* e-book readers). On the other hand, there is often a significant price difference between devices that are enabled for network access (*e.g.* 3G or 4G) as opposed to having Wi-Fi access via fixed networks or mobile tethering.

Certain network operators charge for tethering via packet-based billing which is usually far more expensive than fixed monthly data plans. Others do not allow some devices to tether at all. This may be because they fear the effects on other users, or because they wish to sell specific data plans for tethering. Some operators provide little information on tethering, so that their customers may be unaware of the terms and conditions of their subscription. This includes some devices that have the ability to tether, which operators deactivate. On the other hand, a growing number of operators make the use of tethering a selling point for their service.

Some operators allow tethering for particular data plans, with additional fees, or for certain devices. For instance, O2 allows tethering with a monthly fixed payment for iPhone users. AT&T provides monthly data plans for tethering smartphones, except the iPhone. In these cases, subscribers are not allowed to use their monthly bucket of data services for tethering. They have to pay for an additional data plan even if they do not fully consume their monthly mobile phone data allowance. A more user-friendly plan allows part of a monthly data bucket for tethering. In Canada, Rogers offers tethering as a service included in a monthly allowance at no additional fee, for a 1 GB data subscribers. Users have a strong incentive to switch to this type of plan from an operator that does not allow tethering, because they can access the Internet up to the monthly allowance without additional payment. Indeed, from their perspective, they may wonder why they are not permitted to access a service they have paid for with the payment or inclusive options, compared to those operators that permit no tethering. In the future, if operators offer tariff plans which allow connecting any device without restrictions, tethering will not be necessary given that more devices would be connectivity enabled.

In the United States, Sprint has launched a portable mobile hotspot service, which connects any Wi-Fi capable device to the mobile broadband network. Verizon Wireless provides a similar service "MiFi" which also connects Wi-Fi capable devices to the Internet wherever Verizon coverage is available. Three in the United Kingdom and Emobile in Japan also offer this kind of service. Importantly, tethering potentially increases competition among mobile network providers, apart from device-based and application-based competition. Some equipment manufacturers and network providers prohibit tethering of a certain netbook to a certain mobile phone. They would prefer users pay for a per-device monthly data plan, either because of unprepared network infrastructure, or because of their business strategy. By utilising tethering, users can alternatively choose to buy a device without locked data service and use other providers' data services.

When considering competition between fixed and mobile networks, tethering has some significant implications. One is that fixed network users are largely free to "tether" (*i.e.* connect) multiple connections, over any device, to their connections. As long as mobile networks apply restrictions on this capability, wireless services have more limited substitutability for fixed connections than may be apparent at first glance. When the first fixed broadband connections were rolled out, some carriers tried to charge users for multiple connections to the same service. Competition has virtually eliminated this practice and, to the extent that bandwidth permits, is likely to do the same for mobile networks. While the greater number of mobile providers, relative to the number of independent fixed infrastructure network options for most households, makes it less of an issue, the question of "network neutrality" may arise in areas of limited choices. There is a strong argument that tethering should be allowed, particularly when users pay for a certain allotment of data transfer, so as to ensure that consumers can connect and use any lawful devices, as long as they do not harm a network.

3.6. IPv6[69]

One of the challenges when thinking about the future Internet is how to connect a large number of users and devices. The Internet Protocol (IP) specifies how communications take place between one device and another through an addressing system. Each device must have an IP address in order to communicate. IPv4 is the currently used version of the Internet Protocol. However, IPv4 addresses are nearing full allocation, with just 8% of addresses remaining in March 2010 and allocation of all IPv4 addresses expected in 2012. Awareness of addressing constraints seems to be increasing.

Future mobile broadband networks are expected to be based on all-IP networks, which means that more Internet addresses will have to be assigned to new devices. Although awareness is increasing on the need to transition to the newer version of the Internet Protocol, IPv6, which expands the available address space, the take-up of IPv6 in mobile networks has been very slow to date. It is likely that IPv4 and IPv6 will coexist for a very long time. IPv4 support will remain necessary to connect end users to most of the Internet. But companies will need to employ complex and expensive layers of network address translation (NAT) to share scarce IPv4 addresses among multiple users and devices. It is expected that many service providers will deploy IPv6 as well, to take some of the pressure and cost off IPv4. So dual support of IPv4 and IPv6 will likely be the route many operators choose to address the issue from a perspective of both investments and impacts on the existing services for end users. For instance, Nokia indicates that it will take a long time to have truly IPv6-only cellular devices.[70] All stakeholders should be encouraged to consider introducing IPv6 to the mobile broadband networks from the initial stages, to help support a smooth transition from IPv4. For example, Verizon Wireless requires that all devices attached to its LTE network support IPv6, while the support for IPv4 is to be optional.[71]

3.7. Universal service

3.7.1. Next generation mobile as a universal voice service

The development and evolution of wireless broadband could have important implications for universal service policy. The current universal service framework often supposes fixed line service for voice telephony, and satellite or other alternative connections are allowed if necessary. As mobile broadband networks become capable of covering broader areas with better indoor penetration with low frequencies, it could potentially be part of universal voice service.

Therefore, one question raised for wireless broadband is whether mobile should be added as an access medium for universal voice telephony. One concern for regulators, in considering mobile voice telephony in general as a universal service, is its reliability or guaranty of service. Mobile signals travel over radio waves, such that connection may be more easily interrupted than fixed wire lines. Network congestion could also cause degraded service and, while this can occur on fixed networks, is more prevalent on wireless networks. Some argue that universal service should be defined in such a way that it is service-based rather than technology-based so as not to differentiate access technologies. For example, Ofcom says that Universal Service Obligations applying to voice could "evolve to a 'platform neutral' obligation, for which wired or wireless technologies could be used".[72] This could help achieve universal service as economically as possible. The costs of providing universal service are, of course, an important consideration if subsidies are involved. At the same time, some countries see the universal service issue as not being new for mobile broadband networks, but more relevant to the previous generations.

Another concern is how to ensure the reliability of emergency calls and other information which fixed services have supplied to emergency services, such as location. It may not be precise enough to specify where the call is made if the location of the caller's closest cell site only gives general information about the caller's location. In this regard, GPS is a possible solution which provides more accurate information about the caller's location. For instance, Japanese mobile operators are obliged to embed GPS systems in mobile handsets in order to specify the caller's location more precisely.[73] However, GPS has limitations when users are indoors, meaning it may need to be combined with other technologies.[74]

3.7.2. Next generation mobile as a universal broadband service

One question that is arising, and will continue to do so as mobile broadband networks become more prevalent, is whether they should form part of universal service and to what degree. At present, the question includes a rather broader implication as to whether broadband itself should be part of universal service. There are ongoing discussions on this issue in many OECD countries such as in Spain[75] and at the European Commission.[76] Only a few countries have taken legislative approaches to universal broadband access. For instance, in Switzerland broadband Internet access is part of universal service defined as a guaranteed transfer rate of 600 kbps for downlink and 100 kbps for uplink,[77] although mobile voice services would not be considered as such. In Finland, a 1 Mbps Internet connection, regardless of whether it is fixed or mobile, has been defined as a universal service since July 2010.[78] Some noted that, at least for a while, mobile broadband networks may not reach the most remote areas, which are also the least likely to have fixed broadband access, given that current 3G networks do not often reach these areas. That being said, mobile broadband networks may be able to provide superior levels of service to areas that are served by the PSTN but too far from an exchange to be able to use xDSL services. Users in these areas may otherwise have to rely on dial-up Internet access.

3.8. Network coverage related issues

Imposing network coverage requirements is not a new issue, as many OECD countries have already imposed minimum network coverage on mobile operators when awarding 3G licences. Some governments and regulators have also established this obligation for mobile broadband networks. For example, in the Netherlands, the 20-year licences of 2.6 GHz which were auctioned in April 2010 are technology-neutral and subject to service coverage requirements. In Korea, the 10-year licences of 800/900 MHz are attached to a condition which requires 15% of the service area within three years of the award and 30% within five years.

One reason for introducing this to the licence conditions is that it helps regional development by giving network access especially in areas where mobile operators may not deploy the network on a commercial basis.[79] Another reason is to prevent the given spectrum from being unused and rather to promote its use. This is because it would be undesirable if finite resources were underused or just hoarded for speculation in the secondary market. However, it is challenging for governments and regulators to set the appropriate requirement level. This is because if it is set too low, licensees might carry out the requirements and nothing more. In some cases, it has no effect as operators will provide this level of coverage anyway. If it is set too high, potential entrants would be discouraged from providing services or the service launch would be delayed. Even if there are operators to come into the market, it will cause investment in coverage that is uneconomic, which will raise costs for other users. In France, for instance, ARCEP reported that 3G operators were behind in their initial coverage obligations as of August 2009, although the initial goal could have been demanding. Operators agreed on setting new objectives in which 99.8% of the population could be covered by 3G by 2013.[80] Service and technology neutrality can be another challenge. The principle of service and technology neutrality implies that governments and regulators may not know what kind of technologies and services will be offered in advance, which makes imposing minimum coverage requirements difficult.

NOTES

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7 The subscriptions of these areas are about 85% of total CDMA2000 subscriptions as of September 2009.

8 Ultra Mobile Broadband (UMB) was developed from the CDMA2000 family. However, Qualcomm, the leading UMB vendor, had stopped the development and there is little possibility of the commercial launch of UMB.

9 The number includes subscriptions of both CDMA2000 1x and CDMA2000 1x EV-DO.

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19 www.3gpp.org/IMG/pdf/2009_10_3gpp_IMT.pdf.

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46 www.en.uke.gov.pl/ukeen/index.jsp?place=Lead04&news_cat_id=61&news_id=855&layout=1&page=text.

47 VHF is the frequency band from 30 to 300 MHZ and UHF is the frequency band from 300 to 3000 MHz.

48 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0700:FIN:EN:PDF.

49 Region I comprises Europe, the Middle East, Africa and Russia, Region II comprises the Americas and Region III comprises Asia and Oceania.

50 Nine countries are Bangladesh, China, Korea, India, Japan, New Zealand, Papua New Guinea, Philippines and Singapore.

51 http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/legislation/dd_recommendation/en_rec.pdf.

52 The United Kingdom has not identified it for any particular purpose because of its technology-neutral and usage-neutral approach to spectrum allocation in this area.

53 www2.bundesnetzagentur.de/frequenzversteigerung2010/images/DecisionPresidentChamberTenor.pdf.

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55 West, J. and M. Mace (2010), "Browsing as the killer app: Explaining the rapid success of Apple's iPhone", *Telecommunications Policy*, doi:10.1016/j.telpol.2009.12.002.

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66 www.thinkfemtocell.com/System/what-are-femtocells.html.

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70 www.forum.nokia.com/info/sw.nokia.com/id/64fb6b03-5a1d-4048-a849-b68e5a31fc9e/Nokia_Views_on_IPv6_Transition.html.

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