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Fixed and Mobile Networks

SUBSTITUTION, COMPLEMENTARITY AND CONVERGENCE

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Working Party on Communication Infrastructures and Services Policy

FIXED AND MOBILE NETWORKS: SUBSTITUTION, COMPLEMENTARITY AND CONVERGENCE

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FOREWORD

This report was presented to the Working Party on Communication, Infrastructures and Services Policy (CISP) in December 2011. It was recommended to be made public by the Committee for Information, Computer and Communications Policy (ICCP) in March 2012. The report was prepared by Mr. Rudolf van der Berg and Mr. Jaesung Song. It is published under the responsibility of the Secretary-General of the OECD.

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MAIN POINTS

This report examines the convergence of fixed and mobile (wireless) networks and services. It considers these developments against a long standing question of whether they are complementary or competitive. The report concludes fixed and mobile networks are both complementary and competitive. Mobile providers have garnered a very large share of traditional services, such as telephony, over the past decade. Nevertheless, mobile networks are dependent on fixed networks and could not efficiently meet the rapidly expanding demand of users without the contributions made by fixed broadband networks. Managing the differences between networks, and their respective strengths and limitations, is one reason there is still tremendous differences in the pricing of some communication services on these networks.

Fixed mobile convergence or FMC is a specific subset of convergence that focuses on fixed and mobile networks and access to these networks becoming indistinguishable from the perspective of the user and of services. FMC is, for the purposes of this document, defined as a trend in the network that can be seen as a range of possible options. This starts, for example, with the integration of administrative processes, such as for the billing of different services (*e.g.* a single bill), which do not include "network integration" in providing these services. A second level of integration occurs when services can be used on both fixed and mobile networks. A third stage occurs where there is a full integration of fixed and mobile networks and services so that the consumer does not notice where one starts and the other ends. Though this report focuses on the provision of networks and services, convergence can also be seen in end-user devices. The adoption of converged user devices, such as those capable of seamless handover between WiFi and mobile networks and in general of interoperability between fixed and mobile networks, is a key enabler of FMC.

For a user, FMC offers potential access to their data and services anytime and anywhere. This encourages providers to expand service availability from fixed to mobile networks. Technological developments, including use of the Internet and broadband, driven by user demand enable this convergence. Once a service is accessible using the Internet it is independent of the underlying network, meaning that in principle it could be used on either a fixed or a mobile network. This differs significantly from the traditional situation where services were tied to a particular network. At the same time, the increasing demand for mobile services drives operators to bring fixed networks that can carry higher data rates than the mobile network, ever closer to where the consumer will be. The networks, therefore, become more "fixed" and only wireless/mobile in the last few hundred metres.

The main business driver for FMC seems to be competition between network operators. It allows networks to differentiate themselves from competitors by offering a unified or better functioning product. However, the market's willingness to pay for converged services does not seem to be very high. Several FMC products have been introduced and later discontinued. As a result, the interest of telecommunications operators in FMC has been limited, only recently being reinvigorated by the demand to shift mobile data traffic to fixed networks. Shifting data from the mobile to the fixed network promises to save network operators money and improve performance for users. However, greater use of FMC may be slower than otherwise expected if operators do not wish to mix perceived "high value" mobile services with what some customers may equally perceive as "lower value" fixed services.

Technological developments that enable FMC have come in various forms. Changes to billing allow services to be perceived as converged, though the underlying technology and service delivery has not changed. For example, by defining a geographic area in which the mobile phone is used as a "home zone" in which calls are charged at a local rate or a fixed number can be used. This is also known as "home zone" or, in earlier OECD and other reports of the time, fixed mobile substitution. Triple and quadruple play bundled with a mobile component are a similar way of using billing to enable FMC without changing the underlying service.

"Unlicensed Mobile Access", "Wi-Fi offloading" and "Femtocells" are technologies that allow the convergence of infrastructure for voice and data services. Each promise to use the fixed broadband network that users have in their residences to connect to mobile devices, thereby relieving pressure on the mobile network and giving users a better service quality. Further standardisation and integration is still required and governments will have to evaluate the use of these technologies on regulation.

In this report, leading operators from each OECD country were surveyed on the extent to which FMC networks and services were offered. The actual deployment of FMC and services is still limited. Some countries have no FMC offers available to consumers. In many other countries only one or two operators will offer converged services. In some countries converged services like unlicensed mobile access have been discontinued, whereas in other countries there has been strong demand. Consumers, however, do not seem to be willing to pay significantly higher prices for converged networks. Competitive offers that promise some kind of saving seem to be the main driver behind available offers.

FMC is a trend that decreases the traditional differences between fixed and mobile networks. Policy makers and regulators need to monitor these developments because traditional borders between markets blur and approaches may need to be revaluated and altered to be in line with their overall goals. A key question for policy makers and regulators is whether regulation in some way inhibits this move to FMC as it seems in general beneficial to consumers. Another point of attention should be whether in some cases the bundling of services may limit or enhance competition.

While this report does not reach definite and general conclusions regarding the existence of substitution and complementarity between fixed and mobile networks, it is clear that:

- Mobile networks are keenly competitive with fixed networks in terms of voice services.
- Mobile networks increasingly rely on fixed broadband networks to meet customer demand for high-speed data and will do more so in the future.
- Mobile Virtual Network Operators (MVNOs) and fixed networks, without their own traditional Mobile Network Operators (MNO), have the potential to use FMC to compete with MNOs.
- While many envisage a future with MNOs providing more competition to fixed broadband providers, strategically the latter may be in a stronger position and unless MNOs can offer a full bundle they may, in fact be most vulnerable to FMC competition.
- The MNOs with the strongest defensive position will be those with both fixed networks and the widest geographical coverage.

FIXED MOBILE CONVERGENCE

This report examines the convergence of fixed and mobile networks and services across the OECD area. It considers these developments against a long standing question of whether they are complimentary or competitive. It does this to focus attention on areas where convergence is developing apace or faces obstacles in improving services for users. The goal is to determine common factors that stimulate fixed and mobile convergence and the implications for the use of both networks. While most believe fixed and mobile networks are both competitive and complimentary, debate and discussion has never been keener. The conclusions drawn, by stakeholders, will influence decisions on issues ranging from the level of investment and where it is directed, through to how to ensure competitive markets and that there is sufficient availability of spectrum to meet future requirements.

The report concludes fixed and mobile networks are complementary and competitive. Mobile providers have garnered a very large share of traditional services, such as telephony, over the past decade. Today, some users only have a mobile telephone and these devices can offer an increasing range of new services. Nevertheless, mobile networks are dependent on fixed networks and could not efficiently meet the requirements of users without the contributions made by fixed broadband networks. This includes the role fixed networks play in "backhaul" and as "backbone" networks. Moreover, if users transferred all the access demands they place on fixed networks to mobile networks the physical limitations on available spectrum would severely reduce the efficiency of those mobile services.

Managing the differences between networks, and their respective strengths and limitations, is one reason why there is still tremendous differences in the pricing of some services, such as data (*e.g.* consider the prevalence of unlimited access on fixed networks compared to relatively low caps on mobile networks). At the same time many users have given up their traditional fixed subscription in favour of only having a mobile service, for everything from telephony to e-mail. Yet, at the same time, they are increasingly watching video over fixed networks and, a fixed broadband connection will typically serve multiple users and devices in ways that can still be limited on mobile networks. To reach this point, it is necessary to explain how this has developed over the past two decades.

Two decades of fixed and mobile convergence: 1991 to 2011

At the beginning of the 1990s the OECD began to consider the complementary and competitive nature of fixed and mobile networks in the provision of telephony. In 1992, the OECD published "Mobile and PSTN communication services: competition or complementarity?" [1] At that time, there were less than 11 million mobile subscribers in OECD countries, using mostly analogue technology. Today, there are more than one billion digital mobile subscriptions in OECD countries and a further four billion around the world. But, while early expectations for the number of subscriptions have been vastly exceeded, the potential was well recognised:

> "In the decade to come, the prospects are even more exciting as digital technologies are introduced, standards are harmonised and as equipment and usage prices fall. There is the very real possibility that mobile communication services will do for the telecommunication industry in the 1990s what the personal computer did for the computer industry in the 1980s; namely, to bring about a revolutionary change in the way products and services are sold and used."

The key questions raised in that report were:

> "To what extent will mobile communication services eventually compete with, or substitute for, fixed link telecommunication services in terms of tariffs, traffic and subscribers? For how long will mobile communications continue to be regarded as a complementary service to traditional telephony?"

It was recognised, however, that these changes would not occur without liberalisation of communication markets. This led to a statement by the OECD's Committee on Information, Computer and Communication Policy (ICCP) in 1995, "OECD reflections on the benefits of mobile cellular telecommunication infrastructure competition",[2] which stated as its main findings that markets with infrastructure competition, and in particular where there is competition in both fixed and mobile networks, were setting the standard for growth and innovation. The statement also noted that universal service was being enhanced by the application of competition in mobile telecommunication.

Much has changed since the first examination of these issues. Whereas the initial work on fixed and mobile convergence did not consider the Internet, just then being commercialised, it is now a pervasive influence on the development of mobile communications. Just as fixed networks were transformed by technologies that could increase the capacity available to users, so too is broadband transforming mobile networks. The explosion of devices, from smart-phones to tablet computers, is one sign of these developments and this is likely to be intensified as machine to machine communication further expands the types of devices connected to networks.

The OECD has returned several times to examine these changes and the implications they have for policy and regulation. In the late 1990s, the first work was undertaken looking at the introduction of pricing that was beginning to reflect the initial competition between fixed and mobile services. It was noted, at the time, that the strategies for mobile communication pricing structures were starting to diverge from the traditional models used by fixed services. The introduction of prepaid services, for example, was beginning to revolutionise mobile offers but also bring about changes in fixed network pricing (*e.g.* reductions or elimination of the initial connection charges – long a pillar of pricing for joining a fixed network). What became apparent then was that fixed line operators were changing their pricing for national calls so that local and national calls were priced at the same rate, making a mobile call up to seven times more expensive.[3] This was more apparent in countries with high mobile penetration then in countries with low mobile penetration, suggesting a causal link between the two.

In 2006 the OECD published a report entitled "Fixed Mobile Convergence". Which, like this one, was aimed at taking stock of where the market was with regards to fixed and mobile convergence. In many aspects the conclusions of that paper still stand,[4] Though today the emphasis might be on other elements. Technologies that today command less attention than in 2006 are WiMAX and IP Multimedia Subsystems, which were both expected to have a greater future in enabling FMC. FMC has come further, but today is not a universal technology. In some countries virtually no FMC is available.

In 2007, the OECD published a report on next generation access networks and convergence in preparation for the Seoul Ministerial on the Future of the Internet Economy which considered high speed networks and convergence.[5] The report concluded:

> "The current range of wireless networks is not capable of offering high bandwidth connectivity, comparable to wired networks. The extent to which future wireless networking technologies will be a competitive first mile technology is as yet uncertain, and is likely to vary depending on geography and population density. The shared nature inherent to wireless networks also places limitations on capacity availabilities. Even when new spectrum is freed for broadband use, it is not likely that the

> offer will be competitive with existing wired networks. To offer end-users a competitive sustained rate, fibre and street cabinets would have to be brought closer than with VDSL or cable networks. It is therefore most likely that future wireless networks will be built upon available fibre and hybrid networks and will not directly compete, but be part of a converged offer."

The aforementioned report took a position based on the levels of service deliverable by fixed and mobile networks. It was written at time that Apple was just launching the iPhone, a device whose popularity would come to transform the mobile market. Indeed, the success of smartphones and their greater ease of use, and capabilities to make use of data, has caused many to reconsider the competitiveness of mobile services with fixed networks. On the other hand, the experience with the performance of mobile networks, brought on by the popularity of smartphones, reinforced why these networks are complimentary. For example, while some iPhone offers began with unlimited packages for data, these were later withdrawn in favour of caps that are very low compared to fixed networks. In addition many operators prohibited or charged additional fees for tethering further devices even though a user had paid for these data in their existing plans. In short, mobile network operators typically transfer demand from mobile wireless to alternative networks as soon as they can (*e.g.* directly to fixed backhaul or via a combination of Wi-Fi to fixed backhaul) to ensure acceptable levels of service for their users.

Some predictions for fixed and mobile networks have come to pass but others have taken unexpected directions. In 1991, one commentator predicted that by 2010 voice would have switched from fixed networks to mobile networks and broadcasting would have switched from wireless networks to wired networks.[6] This has not proven to be completely accurate to date. Certainly, convergence has vastly increased the use of wireless networks for voice and fixed networks for video services. In recent years, the total amount of voice traffic has been growing, but the share and absolute number of minutes called on the fixed network has declined, whereas on the mobile network it has increased. Voice communication over fixed and mobile networks has also become a digital service not always separately recorded in official statistics as was once the case. Examples include voice communications between users of computer games and Internet messaging services such as Apple's Facetime, and Microsoft's communicator. At the same time, mobile devices carry video services today in ways that few imagined in the 1990s. Moreover digitalisation has given new impetus to over-the-air broadcasting services. Not only that but convergence has reached into all forms of media from music, newspapers and books through to new tools such as twitter and social networks that incorporate communication via text and telephony.

Fundamental to these changes was the emergence of the Internet as a commercial network. From around 1993 onwards the use of the Internet has provided a means that would allow a convergence of services irrespective of the underlying networks. Ever since then, various forms of fixed and wireless convergence have been put forward and standardisation organisations have worked on contributions towards their visions for converged networks. Across the OECD there are different developments around this convergence between fixed and mobile networks. On the other hand, it would hardly be realistic to say that there is a fully converged world; fixed and mobile networks can still be very different in technology, business models and regulation.

Fixed-mobile convergence definition

The term convergence has been used in several OECD reports in the past to denote the merging of services and networks that in the not too distant past used different types of physical networks, network protocols. For example television moving away from CATV, analogue and satellite on to DSL and fibre networks. Fixed mobile convergence FMC is a specific subset of convergence that focuses on fixed and wireless networks becoming one service.

The term fixed-mobile convergence is more a description of a trend than a strictly defined concept. Cisco describes it as:

> "Fixed mobile convergence refers to the ability of telecommunications companies to provide their subscribers with services that interact with and use both the fixed networks of incumbent wireline and/or cable operators and the mobile/cellular networks of mobile operators. For subscribers, fixed mobile convergence offers simplicity: They can access the data, voice, or video services and information they want without concern for how the service is actually delivered and with the trust that they will be charged accurately."[7]

The key aspect of Cisco's definition is that the main driver is to allow subscribers to use various services regardless of the type of network they are on.

The term "fixed" is most often used to describe the traditional wired networks that reach into business and residential properties. The public switched telecommunication network (PSTN) and technologies such as digital subscriber lines (DSL) that enable high speed data transmission, as well as coaxial cable and fibre, are the basis of these networks. Inside premises the network can be extended to personal devices by means of various wired methods (Ethernet, indoor powerline), but also wireless (cordless) networks, like Wi-Fi or DECT. Sometimes point-to-point wireless networks using Wi-Fi, optical and other technologies can be regarded as part of the fixed network. What differentiates fixed from mobile, in fixed mobile convergence, is the lack of mobility that is inherent with fixed networks. Though wireless networks allow a user to walk around an individual room or entire building, mobility is limited to mobile networks. Mobile networks are designed to allow the user to move across large areas at great speeds while remaining connected to a network.

FMC is also used as a term to describe quadruple play offers, where broadband, telephony, television and mobile services are provided by the same telecommunication service provider. In this case it is unclear whether, apart from a single bill, the customer actually makes use of converged services (*i.e.* whether a customer would be able to access the television service using a mobile device or have an integrated telephone service regardless of the network used). As such it might not be correct to call a bundle of services a converged offer, though this is the case in some documents.

Another way of describing FMC is by looking at the technologies that are deployed. Some networks are selling femtocells to their customers. These antennas create a miniature cell of the mobile wireless network where they are installed, and thereby improve the coverage of the network at that location. They use the customer's broadband connection as backhaul to the network of the operator. A similar technology is Wi-Fi-offload which allows a device to use Wi-Fi where it is present instead of using licensed bands, thereby relieving pressure on the mobile operator's network. A later section examines some of these technologies and will further define the term FMC.

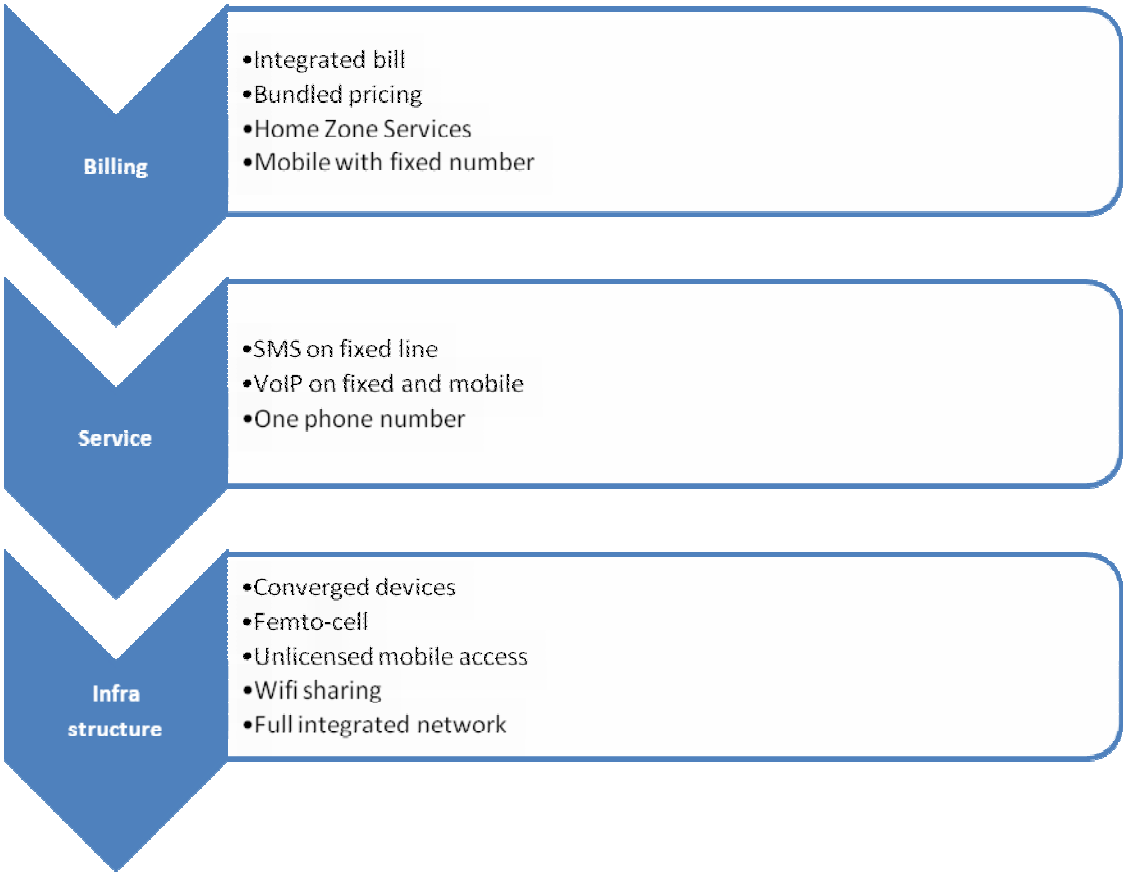
FMC is, for the purposes of this document, defined as a trend that can be seen as a range. FMC can be shown as a range starting with integrated billing where the customer receives one bill, but the networks and services are not integrated (Figure 1). The second step is integrated services, where services can be used on both fixed and mobile networks. The third step is a full integration of fixed and mobile networks and services so that a consumer does not notice where one starts and the other ends. It can be remarked that there is not a strict distinction between the various examples of FMC and so the range should not be seen as successive steps. Furthermore it does not mean that a company has to start with integrated billing, it might be possible to start with services or with the network.

When discussing convergence and competition it can be noted that for regulators there is a difference between substitution and substitutability that is not always clear. Substitution is a more technical and user preference related concept, whereas substitutability has implications from the perspective of a regulators analysis of markets. While this report takes the position that mobile services can substitute for some fixed services a number of regulatory authorities have concluded that they are not fully substitutable. The two positions are not contradictory as market analysis undertaken by regulatory authorities ways up a number of goals set by policy. At the same time, consumers have different requirements and make decisions based on their individual needs. Some households, for example, only have a mobile telephone. Nevertheless, because of the differences in the capabilities of fixed and mobile networks, those same mobile networks may not be able to provide a fully substitutable service that meets the requirements of other users in that geographical area. Currently, Austria is the only country in the European Union and the OECD that has separately integrated the market for retail fixed and mobile voice services and the market for fixed and mobile broadband services separately in its market analysis.

There is also a difference between symmetric and asymmetric substitution, where in the case of symmetric substitution, the two products are equally strong substitutes and an increase in price for A will lead to an increase in demand for B and *vice versa*. There may also be asymmetric substitution, where a decrease in a price for B may result in a switch to B but not vice versa. For example, a switch to broadband may not be reversed by a lowering of prices for narrowband, because users cannot use certain services other than over broadband.

This document does not cover convergence in end-user equipment. In order for a user to be able to make use of a converged service in a network, the device of the user has to support the necessary communication protocols. This may be achieved by installing a suitable application or may need a new device. At the same time, this report assumes that the network is able to support converged service offerings, though this may need upgraded software and equipment.

Figure 1. Range of ways to implement FMC



Drivers for fixed mobile convergence

For many developments in telecommunication there are four drivers that shape the future;

- Customer demand
- Technological development
- Business imperatives from network and service firms
- Regulatory requirements

This is true for FMC as well, though in this case there is less of a regulatory requirement.

Customer demand

It is always difficult to predict customer demand. Many products and services introduced into the communication markets fail or remain only niche services. Others exceed expectations. That being said there are some relatively easily identifiable trends in consumer preferences. With regards to telecommunication networks and services, it has become clear that, in general, consumers prefer services that are not constrained by time and location or whether they are stationary or mobile (*i.e.* anytime and anywhere).

The principle benefit of wireless communication, such as for mobile cellular networks, is that it does not tie users to a specific location. This also allows a device to become more personal than a device

that is tied to a location. A cellular mobile device can be carried anywhere the consumer goes within network coverage or, via roaming agreements, on to other networks. A cordless telephone is a shared device in many households, a mobile telephone is a personal device. The effect also works the other way round, making devices and services more personal has a profound effect on the way consumers want to use these devices and services. It increases the demand for mobility, because a consumer does not wish to be without access to services.

It would be fair to say that, in general, consumers have no particular affinity to fixed or mobile networks. They wish to be mobile but some users wish to have their mobile phones treated in a similar manner, in respect to pricing, when in locations such as homes or offices. They may accept trade-offs (*i.e.* less mobility for a higher speed or vice versa) but would undoubtedly prefer both capabilities at pricing they find attractive. Others may not use mobile services because of any number of reasons (*e.g.* its novelty or perceived health implications) though even here they tend to limit rather than not use services entirely. Some consumers may be willing to go "mobile only" if their voice and data needs can be met by a cellular network and potentially augmented by complimentary access to a fixed network (*i.e.* Wi-Fi at a public or private location). Nevertheless, fixed broadband subscriptions continue to increase across the OECD area in tandem with the rapid growth of smart-phones. In addition the pricing of fixed and mobile data services have, if anything, increased with greater use of data caps on mobile networks. As a result, fixed and mobile connections remain complimentary for data services.

Technological development

Several technological developments push towards FMC. The main one is services convergences as enabled by the Internet. Once a service is accessible using the Internet it has become independent of the underlying network. There are no fundamental constraints to delivering the service to any user, using any device, anywhere in the world. There may be some technical constraints, for example bandwidth, or processing power of a device, however once these are solved the service can be accessed anywhere. The introduction of smartphones has provided users with access to services that were at one time unique to mobile networks like SMS and other messaging using equivalent or better services as provided by Facebook, Whatsapp, Blackberry Messenger or Kaokaotalk on any network they just happen to use, fixed or mobile. At the same time, television in its various forms is more and more liberated from the fixed network and delivered to a wide variety of smart phones using IP technology through the use of Slingbox, Hulu, BBC iPlayer and a variety of cable company provided time and place shifting technologies. Traditional telephony using E.164 numbers is about the only service that has so far not given in to this trend. To date, there have arguably been few significant effects of Internet based services on traditional telephony, except for the use of Skype, and similar services, in international calling.[8] Fixed telephony and mobile telephony so far have not converged in any significant way, given that the use of integrated services like Unlicensed Mobile Access, which will be discussed later, have found limited adoption.

Another technology push is the greater demand for high speed data. Where traditionally different networks were used for different types of services, now every network needs to be able to deliver high speed data. In order to deliver high speed data to the consumer, the backhaul network converges more and more to a single core for both fixed and mobile networks. This network based on fibre optic technology and Ethernet is essentially the same for a DSL network, a high speed mobile network and a cable network. With mobile wireless achieving higher data rates, the size of area that can be covered with these speeds decreases, pushing fibre to almost every location of cellular antennas, whereas in the past fixed wireless connections were used. In effect, mobility is enabled by wireless in the first few hundred meters after which a wired network takes over. This in turn leads to the question why shouldn't every fixed network node support a mobile wireless connection.

A third technology push is standardisation aimed at making seamless connections to different wireless and mobile networks easy. The less a user needs to know, the more the technology will be used. An example is how many smart phones are configured to connect to a consumers Wi-Fi-network when in range. This is now common on any smartphone and saves consumers on their bandwidth bills. There are several standards on the table that make FMC easier. These will be discussed in the next chapter.

Business imperatives from network and service firms

As broadband fixed networks have developed fixed and mobile or FMC convergence may have been expected to occur at a more rapid pace. In other words, it might have been expected that mobile services would have been developed as an extension of the fixed network. Instead, fixed and mobile networks and services have, for the most part, developed separately. Incumbent fixed network operators generally established a separate business unit to run their mobile network. The network, operations and marketing of the mobile unit was often separate from the fixed-line business, sometimes even for the name and branding of the company. In some cases previously distinct branding has been brought together under one name (*e.g.* Orange and France Telecom). On the other hand, there are still distinct differences between fixed and cellular mobile networks and "de-mergers" are not uncommon (*e.g.* BT and MMO2).

Historically some of the splits between fixed and mobile operations were to meet regulatory requirements. This meant that incumbent fixed operators established arms-length subsidiaries, to meet regulatory requirements, to ensure a level playing field for new entrants into mobile markets. Overtime, these separations were reinforced by other developments. In 2002, for example, as a condition of a merger, regulatory authorities required Telia and Sonera to operate their fixed and mobile networks as separate subsidiaries in both Sweden and Finland, and grant third parties non-discriminatory network access. This raises the issue of how easy it would have been, over the past decade, for fixed and mobile incumbents to provide seamless services – had they wished to – and how other stakeholders would have dealt with these developments (*e.g.* regulators, new entrants). Certainly, there has been a development of bundled services, across providers that have multiple networks or through regulatory intervention (*e.g.* local loop unbundling) but there is less evidence of FMC.

Regulation may not, however, have been the primary factor in the development of FMC though undoubtedly market structures influence the starting point and ongoing regulatory requirements have a large effect on commercial strategies. A further factor in FMC developments is that the two products are perceived differently by customers and suppliers. On the fixed network, telephony and Internet data are perceived by consumers as commodities and are often provided through unlimited packages with no perceived marginal cost on behalf of customers. On mobile cellular networks, telephony and Internet data are still perceived by consumers as "high-value services", because of the mobility. This creates challenges for merging these services. Many users do not wish to pay what they regard as higher prices for "mobile services" they access via fixed networks. At the same time, operators do not wish to offer "mobile services" which they regard as having greater value to customers, for "commodity fixed network prices".[9]

The main business driver for FMC seems to be competition between network operators. It allows networks to differentiate themselves from competitors by offering a unified or better functioning product. However the customer's willingness to pay for converged services does not seem to be very high. Several FMC products were introduced in the market and later discontinued. As a result, the interest of telecommunications operators in FMC has been mixed, only recently being reinvigorated by the demand to shift mobile data traffic to fixed networks.

A driver for FMC could be cost savings from making greater use of the fixed network to reduce pressure on the mobile network. Given the increasing demand on mobile networks this would seem a

relatively simple way to save on investments in mobile networks. However, there is still limited evidence of mobile networks promoting offloading to the fixed network. Certainly, mobile operators are increasing the number of proprietary "hotspots" but these offers are generally not FMC (*e.g.* seamless handover of calls between fixed and mobile facilities) as in the case of Wi-Fi-offload and femtocells. This is either because the network demands created by smartphones are either being effectively managed over the existing capabilities of cellular networks or because operators fear that FMC may fundamentally change pricing models for mobile services.

In some ways FMC may be at an inflection point. Established operators with extensive network coverage, and the high levels of investment this requires, would like to maintain higher levels of pricing for mobile than fixed services. As a result they often charge the same for a call over a femtocell as a cellular connection even though a user may be paying for the backhaul via their fixed broadband connection.[10] MVNOs may not face the same incentives. Indeed, the more MVNOs can initiate or offload traffic on fixed network the less they will pay wholesale mobile providers. In the United States, for example, Republic Wireless is a small start-up MVNO using Sprints network.[11] The company has launched an "unlimited" voice, text and data offer for USD 19 (plus tax) per month. While there are "acceptable use policies", in relation to the unlimited usage, the company is relying on being attractive to users that are for the most part in areas covered by Wi-Fi. It only offers one choice of a smartphone which it says is to integrate a more seamless handover between Sprint's network and Wi-Fi. A user moving outside a Wi-Fi area, to one covered by Sprint's network, would hear a "tone" but, Republic Wireless say, the call would not be dropped. It shows that convergence between fixed and mobile networks, in both infrastructure and devices, allows MVNO's new options to compete in the market with MNO's.

There are restrictions on the Republic Wireless offer that may go beyond technical limitations. Users are, for example, not initially permitted to make international calls. This may have more to do with the need to establish commercial relationships for these calls than any technical limitation. There is also a limitation on international roaming due to the use of Sprints CDMA network. In theory, both these limitations could be overcome or would not be an obstacle with other MNO and MVNO partnerships. If the model is successful it may encourage more stand along fixed networks to launch or adapt their existing MVNO offers to provide a more seamless service. And, while Wi-Fi has long been an option for VoIP bypass of international roaming prices, the seamless nature of such a service may at least partially address limitations on substitutability (*i.e.* users could retain their numbers in areas with Wi-Fi coverage while roaming).

Regulatory requirements

In communication markets, regulation can, of course, have a large influence on developments. The separation between fixed and mobile market structure has been driven by the requirements established by regulators to ensure market access and a level playing field for competition. Nevertheless, commercial developments in fixed broadband markets have encouraged bundling, such that quadruple offers are now commonplace, and many believe this has encouraged the overall competitiveness of these markets. A key question today is whether the different treatment of fixed and mobile networks restricts the development of FMC.

TECHNOLOGICAL DEVELOPMENTS IN FIXED MOBILE CONVERGENCE.

Various technologies are available that enable FMC. As FMC is a "trend" rather than a single technology, it can be integrated or made increasingly seamless through billing, services and infrastructure. This section will highlight some of the technologies used by networks to enable a form of FMC.

Billing

Billing (integrated or through bundles) is mostly a business process and does not have a network or services component associated with it. FMC is however sometimes enabled through billing. The technology for providing access, routing or switching in the underlying network or service does not change, but the experience of the user with the product does change (*i.e.* in the marketing and in the billing of the product). [12] This can be further elaborated.

Vodafone New Zealand has a product called "Home Phone Wireless".[13] It is a telephone station with two wireless DECT handsets. The difference from other products in the market is that the telephone is not connected to a fixed line, but instead is connected to the mobile network. Vodafone Germany has a similar product called "Zuhause Festnetz Flat", which is a DECT base-station without telephones. It could be described as a non-portable, mobile telephone. The phone has a fixed telephone number attached to it and is charged accordingly and not at the higher mobile phone rates. It is marketed as a less expensive alternative to the incumbent's fixed line telephone. The technical innovation lies mostly in routing traffic destined for a fixed line over a mobile connection. As it is billed differently than a normal mobile telephone, at rates that are equivalent to a fixed line, it can be regarded as a converged offer.

A mobile telephone that is charged at fixed line rates when it is in the area the consumer lives in is a similar product. This service is often known as home zone or sometimes as Fixed Mobile Substitution (FMS) and was described as FMS in the previous report on FMC in 2006. With homezone the mobile phone operator determines the cellular sites that service the location that the customer defined as their home zone (*i.e.* through the billing address). When the customer places or receives a call in that location the call is treated in the billing process as if it was a call from or to a fixed line. There are many variations of this product available. In some cases it is possible to receive calls on a fixed line number on the device instead of on a mobile number. In other cases it is possible to dial out with the fixed number, so that the person called sees the fixed line number in caller identification. Some offers for business customers enable the business to emulate the same experience as it had with a fixed line personal branch exchange using mobile phones or a mix of fixed and mobile phones. Examples are "Vodafone Zuhause" and "O2 Mobile Flat" in Germany.[14] Other countries have and had similar offers.

Services

Integration of services may not require changes to the underlying network to deliver a new service. It may be that a network that previously could not handle a service, is enabled for that service, or that the service is offered in a way that does not change the underlying functioning of the network. Once a service is deployed over an IP network, by definition it becomes a converged service that can run over any type of network, whether fixed or mobile. It is, therefore, difficult to point out specific fixed mobile converged services.

There have been some attempts to port mobile network specific services like SMS to the fixed network, without using IP based services. This would allow subscribers with compatible fixed-line phones to send and receive SMS-text messages. ETSI ES 201 912 standardises how the SMS signalling data can be sent over the network. Some fixed-line operators have installed SMS-to-voice gateways that will

convert an SMS to a fixed-line to a spoken message after which the service will call the receiving fixed line number and read out the SMS. The uptake of such services has been minimal as many customers do not have a compatible handset at home and not every fixed line or broadband operator supports it. SMS and MMS as messaging services are now facing a competitive threat from convergence through alternative messaging services like "Facebook", "Skype", "Whatsapp", "Kaokaotalk", "iMessage" and others that all offer the same messaging functionality, with additional features and the benefit of working on multiple devices and accounts.

Voice-over-IP (VoIP) in itself allows voice conversation over any type of network, fixed or mobile, it is therefore by definition a converged service. VoIP programmes like Skype, in principal allow VoIP conversations over any kind of supported device. Some fixed-line broadband operators, who offer telephony, allow the use of SIP-based connections over any network to their services. One example is Illiad/Free in France. Where a properly configured mobile phone can also be used as a VoIP phone, sending and receiving telephone calls.

Another way of approaching a fixed mobile converged service is Google Voice, which allows users to use a unique phone number and which is connected to all the devices/numbers a user has. It works independently from the user's other providers of telephony services. A call to the Google Voice number of the user can make all the phones the user has ring, fixed and mobile, or specific numbers based on time of day or callerID. When one of the phone numbers the user has changes or a new one is added, the overlying Google Voice number does not have to change. This service is only available in Canada and the United States, primarily because of the interconnection costs that are charged in other countries.

Infrastructure

Full integration of fixed and mobile networks would mean that the networks are, for all means and purposes, indistinguishable. A user would be able to connect to a fixed or mobile network anywhere where the network is present. The underlying access network would, from the user's perspective, be irrelevant. Such an integrated network is not yet available. It is, however, a goal that some service providers seem to be striving for with various technologies that augment the available infrastructure.

Convergence is occurring first in modern devices. Such as smartphones, tablets and so forth, which come factory-ready for IP-services and carry multiple wireless communication technologies on board. Most devices can be configured to automatically use Wi-Fi when available for data connections, potentially saving the consumer money, because less data is used than on the 2G/3G/4G network, where charges may apply. Not only are these devices capable of using multiple underlying wireless networks, more and more they can also be configured as access gateways. Certain smartphones can be configured as Wi-Fi access hotspots, though some operators prohibit this use, which allows the mobile network to be extended using Wi-Fi to devices that do have Wi-Fi, but not a mobile connection.

Wi-Fi is often used as an "offload mechanism". First of all by consumers who use their home Wi-Fi, but in some countries the Wi-Fi that is integrated into a home broadband router, of their broadband provider, also has a shared Wi-Fi component. This is common with broadband providers in France,[15] but is also supplied by British Telecom in the United Kingdom and Belgacom in Belgium in co-operation with the Spanish FON company.[16] The Wi-Fi access point will send out two identifiers (SSID), one is the user's SSID, the other one is the operators SSID. Other subscribers of the broadband operator can access the Wi-Fi provided they have a valid username and password. This greatly increases the number of Wi-Fi hotspots available in a country. France, for example, has millions of Wi-Fi hotspots that are provided by broadband users.

Using a technology called Unlicensed Mobile Access (UMA) a mobile telephone that is equipped with Wi-Fi and GSM can switch seamlessly from GSM to Wi-Fi, while still maintaining an on-going call.[17] It was first introduced as Fusion by British Telecom in 2005, this version worked with Bluetooth, but was discontinued. Other mobile operators however do offer the service, for example Orange, who calls it Signal Boost in the UK and Unik elsewhere. Other operators who offer it are T-Mobile US and Rogers Canada who call it "Wi-Fi Calling". The main benefit from the system is that the customer may get better coverage in the home and that the mobile network is released from a call. Some operators like T-Mobile and Orange also offer users lower calling rates when using the system at home. Most mobile operators however do not support UMA. It is also not supported on all mobile phones either, for example it is not available on the iPhone, but is supported by most Blackberries, some Android phones and Nokia products.

A drawback with Wi-Fi is that until now it is not seamless to connect to a new network. It requires the Wi-Fi access point to first authorise the connection. This can be done through a username/password, Wi-Fi protected setup or some other method, however for every new device it has to be repeated. This requires user interaction and therefore makes it failure prone. IEEE 802.11u is a new standard, ratified in early 2011. It allows the network to check back to a provider to see if it can authorise access to the access point. This would allow for seamless access to the Wi-Fi network and easier handovers from the 2G/3G/4G mobile network to Wi-Fi and back using the 802.21 standard. This would make usage much simpler for consumers because it would limit their need for intervention.

Femtocells[18] are another tool for FMC[19]. These are miniature base stations for mobile networks that connect to the mobile network via a subscriber's home broadband connection through Wi-Fi, USB or Ethernet. They broadcast a 2G/3G/4G signal which has a limited range, generally only covering a residence or a small business. Their main use is in providing a better signal to the 2G/3G/4G network in and around the home. Some commentators wonder whether femtocells really serve a purpose as Wi-Fi has in this scenario an almost similar range and the femtocell may lead to co-ordination problems with the macrocell. [20] Furthermore the femtocell can generally not be used by anything else than a device registered with the femtocell. This means other people cannot make use of this home broadband connection and it is more limited than if it could be used by other subscribers who happen to be nearby.

Femtocells have so far witnessed limited uptake as they have often been sold for a fee to consumers and carried an additional subscription cost. Some commentators said it was the consumer fixing the problem of the network and paying for it too.[21] However, SFR in France has recently introduced femtocells that are the size of a USB-key and can be plugged into the Wi-Fi-routers given consumers as part of their broadband subscription, which will be free to their customers.[22] Softbank, in Japan, recently handed out free femtocells with free DSL to business owners as part of a push to increase the coverage of its network.

MARKET TRENDS FOR FMC

Voice markets

In the early years of this century revenue from mobile communication voice services began to surpass those for fixed voice services in most OECD countries. Operators reacted to this trend by seeking to integrate fixed and mobile service either to win further market share, in the case of standalone mobile operators, or defend or enhance service offerings in the case of integrated fixed and mobile network operators. Some of the earliest, so called FMC services, [23] were introduced by Denmark's TDC 'Duet' and in the United Kingdom BT's 'One Phone'. It was not, however, until around the middle part of the previous decade that mobile operators began to expand FMC services. Examples include Vodafone Germany, T-Mobile USA, and SFR in France which launched mobile-based home zone services respectively in 2005, 2006 and 2007. In response to this, fixed operators including BT, France Telecom, and Neuf Cegetel started to provide dual-mode single telephone services that were built on their fixed-line infrastructures in 2005 and 2006 to defend their market and enhance services for their customers.

This section provides an overview of how FMC services have developed in OECD countries. To provide an indication of FMC service development, two leading operators from each OECD country (*i.e.* 68 operators in all) were selected, and information gathered from the services available on their websites. In addition, the operators' bundled services that are related to FMC are summarised. It can be noted that there may be some operators that are not included, such as new entrants in the mobile market, "fixed-only" incumbents, cable operators and MVNOs, although a few of these entities are cited by way of example. Though a limited sample and not an exhaustive overview of offers it does give a reasonable perspective on how well established some services have become in the market.

Home zone service

Home zone service, also called Fixed Mobile Substitution (FMS) in a previous OECD report, offer discounted rates for calls placed from a pre-defined zone, which is generally a subscriber's residence. As there is no difference between calls from inside and calls from outside of the zone, in terms of call delivery, users do not need to change their cell phones or the way to make a call to use this service. All the mobile operator has to do is make a change in the billing system. With its ease of use and potential price reductions, home zone benefits customers. From a mobile operator's viewpoint, this service may bring new business opportunities, with relatively low implementation costs, but may also erode their own potential revenue from the fixed voice market. For this reason, home zone has largely been introduced by new entrants who needed to expand their customer base or by incumbents who saw this as an instrument against fixed operators' introduction of a dual-mode single telephone service.

Reviewing the operators' websites identifies 10 out of 68 operators in eight countries as home zone providers (see Table 1). Except for Germany and Spain, there is just one provider in six countries among those covered: Belgium, France, Greece, Korea, New Zealand, and the United Kingdom. All the operators provided this service as an additional option for which the monthly fee varies from USD 1.82 (SK Telecom) to USD 21.22 (Vodafone Spain). On zone setting, while users designate the "home zone" before they use the service, zone sizes may increase up to 2Km radius (Germany) or to a postcode area

(United Kingdom). In a zone, users can make unlimited or up to forty hours free call to fixed lines and/or to on-net mobile lines. T-Mobile and SK Telecom users, however, have reduced call rates instead of an unlimited call plan.

Home zone service is popular in Germany and was first brought to the market by a new entrant. Following O2 Germany's launch of the first home zone service ("O2 Genion") in July 1999, it gained four million subscribers in eight years. In a Home-zone, a two-year Genion M user could make unlimited calls to fixed and to O2 customers for EUR 10 (USD 14.15). Observing the O2's success, Vodafone Germany started to offer a similar service ("Zuhause") in 2005 and gathered 2.4 million subscribers in two years. For its part, T-Mobile also increased the number of its home zone ("@Home") customers reaching 1.85 million in 2007. [24] In Korea, SK Telecom, responding to its rival KT's introduction of dual-mode service in October 2009, offered T-zone and succeeded to attract more than two million customers in less than 10 months. [25]

Table 1. "Homezone" service operators in OECD countries

Country	Operator	Name of Service	Monthly Fee (USD)	Inclusive
Belgium	Mobistar	Always at home	9.90	40 hours free calls to fixed lines
France	SFR	Happy zone	14.00	Unlimited calls to fixed lines
Germany	T-Mobile	T-Mobile@Home Single Centre	7.00	In the 2 km distance of any location designated as home calls to landline USD 0.05
	Vodafone	AT home flat rate	21.22	Free calls to national landlines and to Vodafone
Greece	Cosmote	At home 500	12.70	500 mn./month calls to national landlines
		At home international	19.13	300 mn./month to all National Fixed Networks and International Fixed Networks of 21 - 30 countries
Korea	SK telecom	T-zone	1.82	Fixed call at the same rate as the fixed operators in the zone (KRW 39/3mn.) instead of KRW 18/10sec.
New Zealand	Vodafone NZ	Local Plan	16.41	Unlimited local landline calls
Spain	Mobistar	Movil en Casa	8.49	500 mn./month calls to national landlines
	Vodafone	En tu Casa	21.22	Unlimited calls to national landlines
United Kingdom	O2	Favorite Place	16.12	500 minutes to O2 mobiles and standard UK landlines from a chosen postcode

Source: OECD based on operators' websites

Dual-mode single telephone service

Dual mode telephones provide users with seamless communication services between fixed and mobile networks. With such a device, users can make VoIP calls through Wi-Fi and broadband access networks at a reduced rate if they are in a Wi-Fi zone. If users are outside the zone they can use the device as a normal mobile handset. Unlicensed mobile access technology makes it possible to hand-over calls between Wi-Fi and cellular networks.

Users of dual mode telephone services benefit from lower tariffs with VoIP and from using a single telephone to cover indoor and outdoor communications. Potential drawbacks include the need to "click" a button on a telephone to change modes or the need to activate an application to make a VoIP call. Furthermore users need a broadband line, a home gateway, and a dual-mode telephone beforehand to use this service. The advantage to a fixed broadband operator, with widespread coverage, is that they may be able to better retain customers and reduce the traffic migration to mobile networks by offering this type of convergent service.

The survey undertaken for this report found that eight operators in six countries are offering dual-mode single phone service to their customers (Table 2). The countries were Canada, France, Japan, Korea, Sweden and the United States. Four operators in these countries offer unlimited call plans for home-originated Wi-Fi calls with their basic plans (Orange, T-Mobile USA) or additional monthly fees (Rogers Wireless, NTTDoKoMo). Other operators reduce the price for outbound calls by treating these as fixed calls, although, in fact, these are mobile-originated VoIP calls.

In France, Orange's UNIK service has been cited as one of the most successful cases of a single telephone offer. After launching in October 2006, with prices ranging from EUR 4 (USD 5.66) for unlimited on-net call to EUR 20 (USD 28.29) for unlimited domestic and international calls, the service gained more than one million customers until November 2008. At this time, the average revenue per user

(ARPU), of the UNIK service, was raised by EUR 19 (USD 26.88) among the users of the service and the "churn rate" among UNIK was lower by between 2.6 to 4 times. Following the success of the service, it was expanded to corporate services and to other countries including the United Kingdom, Poland, and Spain. [26] In August 2010, UNIK evolved with the introduction of a quadruple service ("OPEN"), where unlimited call plans are included not as an option but as a default.

In Japan, KDDI has focused its dual mode telephone service on the business market. Since it has various discount options for home users like "au-My Home" discount and Combined Line, it emphasises the convenience that a single telephone can be used as an extension phone in the office and as a mobile phone outside the office. In a similar context in Korea, KT introduced single telephone options for large companies such as Samsung Securities in 2009.[27]

Table 2. Dual-mode single telephone services in OECD countries

Country	Operator	Name of Service	Monthly Fee (USD)	Inclusive
Canada	Rogers Wireless	Wi-Fi calling service	15.12	Unlimited local and long-distance call in Canada, Unlimited evening and weekend calls over the wireless network, 90% discount of IDD calls to over 180 countries
France	Orange	UNIK	Basic Plan	Unlimited calls to fixed and mobile (VoIP)
Japan	NTT DoKoMo	Home U	13.56	Unlimited call to Home U users, 30% off to others
	KDDI au	Office Freedom	-	Rates are the same as regular call prices
Korea	KT	Olleh Wi-Fi Call	-	Rates are the same as calls from fixed *i.e.* KRW 39/3mn to fixed, KRW 13/10sec. to mobile instead of KRW18/10sec.
	SK telecom	FMC	4.55	100 mn. free domestic calls
Sweden	Telia	Home Free	-	Rates are the same as regular call prices
United States	T-mobile USA	Unlimited national hotspot	Basic Plan	Unlimited national calls

Source: OECD based on operators' websites.

Dual-mode single telephone services, with the exception of business markets in various countries and for consumers in France, have not been very successful to date. BT's Fusion, the earliest single telephone service, has not been marketed to individual users since February 2008, leaving an estimated 45 000 subscribers at that time. In the United States, T-Mobile ceased its "@Home service", which provided unlimited national call from dual-mode single telephones for USD 10 a month, in 2010.[28] Instead, the service was integrated into the "Even More Plan" priced at USD 99.99 a month. The major reasons suggested for the low take up of these services are the limited types of handsets, inconvenient ways of making a VoIP call, and the low penetration rate of home gateway boxes.

Bundling service

Service bundling may be advantageous to both consumers and operators. Consumers can use a group of services, potentially at a reduced rate.[29] Operators may be able to retain customer loyalty across a group of services and potentially charge more for some services. Strictly speaking this may not be a convergence of fixed and mobile networks or services as it may not change the perspective of the user on

the service. However, there may be a point where consumers buy the whole package of services, despite these services not having been converged in a practical sense.

Reviewing the operators' fixed-mobile bundling plans distinguishes two types of pricing for bundling: rate or lump-sum discount and flat rates. [30] Among the operators surveyed, five offer discounts by a certain rate or amount for using their bundled services (Table 3). The discount rates are between 10% and 15%.

Table 3. Rate or lump sum discount bundling services in OECD countries

Country	Operator	Name of Service	Benefits
Canada	Rogers Wireless	Bundle services	Up to 15% discount for QPS (fixed voice, fixed broadband, broadcasting, mobile voice bundled)
Germany	Deutsche Telecom AG	Telecom Advantage	Save up to 120 EUR (USD 170)/ year for subscribing totriple play service (fixed, mobile and TV service)
Greece	Cosmote	Smart Play	Up to 10% discount for TPS (fixed voice, fixed broadband, mobile voice bundled)
Korea	SK Telecom	Family Free	For QPS, fixed Internet KRW 20 000 (USD 18.2), mobile KRW 8 000 (USD 7.28) discount respectively per month
Poland	Orange	Combo	Up to 45 PLN/month discount for QPS

Source: OECD based on operators' websites.

A further type of bundled pricing uses flat rates. Four operators had at least one fixed and mobile-included Triple Play Service (TPS) plan, of those surveyed, and five operators had the Quadruple Play Service (QPS) plan(s) (Table 4). Monthly fees vary from USD 56.60 to USD 209.60 for TPS and from USD 31.90 to USD 141.30 for QPS according to the benefits included in the services. Operators in France, Luxembourg and Switzerland among those surveyed, proposed unlimited mobile voice usage in the plans. This "frees" customers from the notion that mobile rates are more expensive than fixed rates and may expedite usage of mobile networks. The other players restrict mobile usage by limiting time or by charging additional call rates, which may generate further costs to the users. Notably, Telecom New Zealand limits data usage on fixed Internet service in its bundling plan.

Table 4. Flat-rate type bundling services in OECD countries

Country	Operator	Name of Service	Fee (USD)	Inclusive				
				Fixed Internet	TV	Fixed Voice	Mobile Voice	Mobile Internet
Austria	A1	TV combi	35.2	8Mbps	110 ch.	Connection only	Connection only, 5 cents/m to all network	not included
Belgium	Mobistar	Starpack	94.8	16Mbps	Basic	Unlimited calls to fixed lines	1 hour call to any network, 125 SMS	not included
France	Orange	Open 24/7 Special	134.3	20Mbps	140 ch.	Unlimited to all fixed lines in France, over 100 destinations (VoIP), 1 hour to mobiles	Unlimited to all fixed and mobile operators in France SMS/MMS unlimited	500MB
		Open 1	77.7	20Mbps	140 ch.	Unlimited to all fixed lines in France, over 100 destinations (VoIP)	1 hour, SMS/MMS unlimited	500MB
	SFR	Absolu	141.3	20Mbps	HDTV	Unlimited calls to fixed and mobiles	Unlimited calls to fixed and mobile	3GB
Greece	Vodafone	Mobile, fixed, ADSL	56.6	6Mbps	not included	local & long-distance call: 200 mn., call to mobile: 20mn, International call to 47 countries: 20 mn.	Unlimited to Vodafone, 30mn to others	60MB
Korea	KT	Olleh	31.9	50Mbps	140 Ch.	Inbounds: free Outbounds: standard tariff	KRW 9 000 (USD 8.2) discount per line	not included
Luxembourg	Tango	Complete	104.7	20Mbps	not included	Unlimited national calls to fixed and mobile	Unlimited national calls to fixed and mobile, 50% discount for international calls	not included
New Zealand	Telecom NZ	Total Home Mobile	89.4	20GB data	not included	14c per minute for national landline calls	29c per minute for calls to fixed and mobile	not included
Switzerland	Sunrise	Combined Offer	209.6	15Mbps	not included	Unlimited free calls to fixed and to mobile	Unlimited free calls to fixed and mobile	not included

Source: OECD based on operators' websites

Although there are a number of operators providing mobile-integrated TPS or QPS, these packages are not very common across the OECD area. In Europe, a survey on e-communications confirmed that just 4% of households in 27 European Union countries use mobile-related TPS or QPS in the first quarter of 2011.[31] By way of contrast, Orange's QPS Open is exceptional in the French market. Subscribers to the package reached 509 000 in the first quarter of 2011, showing a 70% rise year-on-year basis.[32] Also, the company expects half of its customers to use its QPS service by 2015.[33] The entry of a fourth mobile operator into the French market, due to commence in 2012, may be one factor stimulating developments as the existing players seek to sign customers to longer term deals.

On the future of bundled services, Strategy Analytics forecasted high growth opportunities for multi-play bundling in Austria, Italy, and China, each expected to double the percentage of multi-play homes by 2016.[34] What happens will depend on the level of competition in each country but the development of new devices more attune with convergence (*e.g.* smartphones, tablet computers) may overcome some of the drawbacks with initial offers via bundling or single mode telephones.

Effect of the services on fixed-mobile relationship

The traditional fixed voice market has witnessed increasing substitution by mobile services in recent years. Data informing the development of this trend is available for 31 OECD countries (Table 5). Some notable features are that more than eight calls out of ten came from mobiles in Austria, Finland, Turkey and the Czech Republic in 2009. In most OECD countries, the proportion of mobile is bigger than that of fixed, however in New Zealand and Germany fixed is still twice as large as mobile. France is the only country where the ratio of mobile usage per line to fixed voice usage per line decreased in the five-year period. (Greece and Hungary saw a decline in 2009, but this is probably due to the use of data from BEREC/European Commission, which has similar but slightly different numbers to the OECD).

Under the seemingly apparent trend of mobile substitution in the voice market, fixed operators in France have successfully maintained their traffic and subscribers. The mobile traffic share in France had gone up the least, by just 5% among OECD countries, over the previous five years (Table 5). In addition, the share of households in France, which have mobile telephone access but do not have a fixed telephone is quite low. At 15%, in 2010, the rate in France can be contrasted to an average of 27% for other European Union countries.[35] This preservation of the fixed market was contributed too by the transition to VoIP services on fixed broadband networks. France is a leading country in VoIP penetration with a rate at over 70%.[36] The most common broadband packages include "free" domestic and international calls to fixed lines and "free" calls to domestic mobile numbers. The introduction of FMC services, such as UNIK may also have played a role in absorbing some fixed traffic that may otherwise have been initiated on mobile networks.

Table 5. Share of mobile voice traffic in domestic (fixed+mobile) voice traffic

Country	2005	2006	2007	2008	2009
Australia					
Austria	-	67.9%	75.6%	80.5%	83.5%
Belgium	42.1%	47.6%	49.5%	52.7%	55.1%
Canada	-	-	-	-	-
Chile	29.0%	34.5%	44.8%	54.3%	60.2%
Czech Republic	48.1%	61.7%	67.0%	76.9%	80.2%
Denmark	32.8%	40.3%	47.7%	54.6%	60.6%
Estonia	56.6%	65.3%	70.9%	72.8%	74.6%
Finland	59.2%	70.0%	76.8%	82.7%	86.7%
France	48.5%	52.3%	53.9%	53.6%	53.5%
Germany					32.1%*
Greece	38.1%	44.2%	49.5%	54.7%	52.5%*
Hungary			74.3%	78.2%	74.5%*
Iceland	41.3%	45.1%	51.3%	56.9%	58.7%
Ireland	48.9%	55.1%	62.4%	68.8%	69.0%
Israel					58.4%
Italy				54.0%	56.8%
Japan	47.3%	51.4%	55.6%	61.2%	65.4%
Korea	59.8%	62.7%	66.7%	70.9%	75.8%
Luxembourg				53.0%	57.7%
Mexico	22.8%	27.2%	31.5%	46.5%	52.6%
Netherlands	-	-	50.3%	53.1%	55.3%
New Zealand				26.4%	30.9%
Norway	34.2%	44.8%	54.4%	62.8%	69.0%
Poland	38.6%	54.1%	64.4%	71.5%	76.9%
Portugal	-	66.2%	68.7%	71.5%	74.0%
Slovak Republic	42.7%	46.1%	50.0%	54.8%	60.1%
Slovenia				69.9%	75.4%
Spain	48.5%	53.6%	57.0%	57.8%	56.9%
Sweden	22.2%	30.7%	39.4%	47.0%	53.6%
Switzerland	30.3%	34.7%	39.5%	45.6%	49.9%
Turkey				75.5%	84.4%
United Kingdom	24.5%	32.5%	41.5%	47.1%	50.4%
United States					

*= BEREC/European Commission.

A number of regulatory agencies have looked at FMC. BEREC, the Body of European Regulators for Electronic Communications, in its analysis of the share of mobile traffic in domestic (fixed+mobile) voice traffic cautions against taking general conclusions, without regards to local situations.[37] It says:

"The number of households having at least one mobile telephone access is rather high and homogeneous – from 82% to 96% (average 89%) - across Europe. On the other hand, fixed line penetration is extremely heterogeneous: fixed access is very high in countries such as Sweden, the Netherlands (89%) and France (87%) whereas no more than 17% of the Czech households are connected [to a fixed line]. This heterogeneity is also striking looking at mobile only households (from

2% to 81%) and dual access (from 15% to 94%) Based on this observation, the substitution of fixed-voice by mobile voice services should be assessed on a case by case basis."

BEREC cites the "E-communication household survey (2011)" as it identifies different patterns demonstrated (Figure 2):

a. Countries with low and decreasing fixed line penetration, offset by an increasing number of mobile only households (Czech Republic, Finland) (Pattern A)

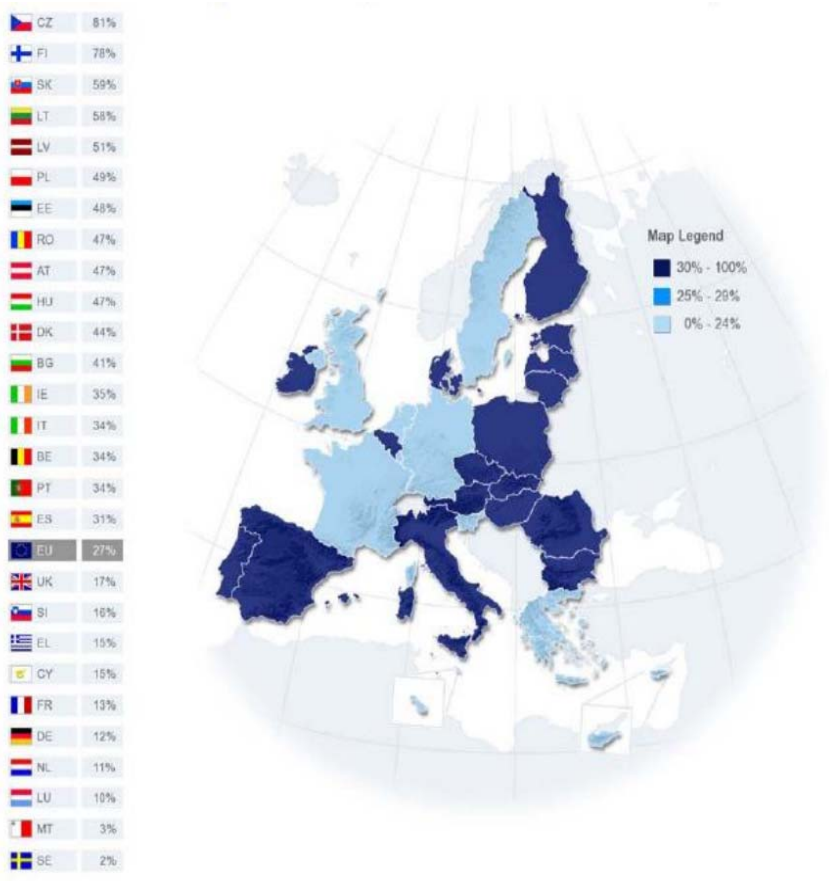
b. Countries with high and steady (or growing) fixed line penetration, and a large majority of dual access households (France, The Netherlands). (Pattern B)

BEREC considers the hypothesis that in Pattern A (Dark Blue) countries substitution may be more prevalent and in Pattern B countries (Light Blue) complementarity might be more prevalent. More work is however needed to analyse these patterns. For example for countries in pattern the question may be whether the quality and pricing of fixed voice and broadband networks is an issue that needs to be evaluated. Another question worth investigating is whether competition in the mobile and fixed voice market is of influence in the shares of voice calls initiated (or terminated) on a fixed or mobile network.

For regulators, there is a difference between substitution and substitutability that is not always

Figure 2. Households having mobile access but no fixed telephone access

Source: E-Communication Household Survey (2011)



clear from these numbers. Substitution is a more technical and user preference related concept, whereas substitutability has implications from the perspective of a regulators, analysis of markets. For this analysis countries resort to competition analysis tests (for example the SSNIP test). As noted, Austria is the only country in the European Union to date that has integrated the market for retail fixed and mobile voice services and separately the market for fixed and mobile broadband services. In their report, BEREC goes into more detail on which elements regulators may need to consider in their analysis of these markets.

Convergence of fixed and mobile network data

One of the key differences between the current environment, and previous times at which the OECD has examined FMC has been the growth in the use of smartphones. In 2007, the release of the iPhone in many ways began a new period for mobile devices characterised by new interfaces and applications that have proven popular with users to access data over mobile networks. In addition, there has been a trend toward greater flexibility in tariff options more applicable to the use of smartphones and reflecting user demand. The greater use of smartphones, however, has brought challenges for some networks where the increasing demand taxes the available capacity. While smartphone users pay for these services, and have a reasonable expectation of being able to use their new capabilities, the stunning growth in their popularity may have caught some operators by surprise. As it takes time and considerable investment to upgrade networks, the demand placed on facilities may in some cases have outstripped their ability to meet the new requirements being placed on them. In turn, this can negatively affect all users of the network irrespective of whether they are using smart phones (*e.g.* dropped calls).

All the available evidence points to a continuing increase in the demands placed on mobile networks by smartphones. The use of a range of mobile devices that may encourage greater use of data, such as tablet computers, is likely to contribute to this trend. In addition, applications that interact with "the cloud" or automatically update data at regular intervals introduce usage patterns that differ significantly from tradition telephony and text services. There is, however, a range of options available to network operators to meet greater demand from their users and some of these options involve FMC.

Some of the options available to meet increasing demand for mobile services include tariffs that regulate demand; new technological developments that increase network efficiency (*e.g.* compression) or upgrading network capabilities through new investment. Nevertheless there will always be limitations on the amount of spectrum and capital that is available for mobile networks. This is why mobile network operators will seek to leverage the capabilities of fixed networks to do much of the "heavy lifting". In other words, mobile operators will seek to shift traffic from mobile networks to fixed networks and FMC will play a critical role in this development. It makes little sense, for example, for users to be placing demands on 3G or LTE spectrum in their places of work, leisure and residence if options such as Wi-Fi or Femtocells can be used to shift traffic to the far greater capacity available on fixed networks. It will enhance their experience as well as for users that are only connected to a regular mobile network.

Wi-Fi offloading

As a means of data offloading, Wi-Fi has the advantages of being widely available where there are large numbers of users. In contrast to some of the first FMC devices, many communication and computing devices today including smartphones, tablets and laptops integrate Wi-Fi as a default option and automatically log on when in a "known network". In addition, the pricing of Wi-Fi compared to mobile wireless networks provides an incentive for users to make use of them when they are available. While there are also drawbacks to the use of Wi-Fi (*e.g.* mobility) and, in some cases, users may experience the same limitations as any wireless network (range, quality of service and decreased capacity through shared use), it is expected that both operators and users will make greater use of them.

To offload mobile broadband traffic, many mobile operators across the OECD area are expanding the number of hotspots available to their users. For example, in the United States, Verizon partnered with Boingo Wireless, a Hotspot provider, to offer free Wi-Fi access at hotspots to its broadband subscribers in July 2009.[38] In turn users are making much greater use of this Wi-Fi access. In the same country AT&T acquired a Wi-Fi company (Wayport) in 2008. AT&T reported in October 2011 that its users then made 100 million Wi-Fi connections per month across 29 000 hotspots nationwide. This exceeded the total connections made by its users in all of 2009 and was five times the total connections they made in 2008. [39]

Fixed network broadband providers are also expanding the availability of Wi-Fi services across their networks with shared use among subscribers. Users who agree to share their Wi-Fi service with other users of the same network provider, are able to access Wi-Fi at an increasingly wide range of locations. The world's largest Wi-Fi sharing network, Fon, provided connectivity to over four million Fon hotspots worldwide as of May 2011.[40] FON does this through people who volunteer their home broadband connections. As mentioned in the previous section most broadband networks in France offer shared Wi-Fi as part of their broadband service, giving the user access to millions of Wi-Fi access points.

Femtocell offloading

Femtocells have strengths in potential for coverage improvement, security and network handovers. Operators widely promote the ability of femtocells to boost signals in areas where the regular network signal is weak or cannot be reached. This can improve the experience for users, economically expand network coverage and encourage a shift of demand from regular mobile networks to a fixed network. As femtocells are a kind of base station, harmonised with regular mobile network stations, they provide the same degree of security and ability to handover traffic.

The femtocell market is in the lively but relatively nascent stage. The onset of greater network demand created by smartphones has undoubtedly given operators increasing incentive to consider their use. Prior to this requirement some may have believed that femtocells may have resulted in less revenue if they diverted traffic from one type of tariff to another. At the same time, users questioned why they were in some cases paying the same rates for services where they were contributing to the cost of service through their payment for the fixed network connection. Nevertheless an increasing number of operators offer femtocells.

Some 14 operators, including Vodafone in ten markets, are operating femtocells for individuals and enterprise market in 15 countries of the operators reviewed for this report (Table 6). All but Sprint's services began after 2009 and 11 among 23 services commenced in 2011. While most operators offer the service with a one-time upfront fee costing from USD 18 to USD 373 for residential consumers, Japanese, French and Spanish operators supply a free femtocell to their users. In addition operators have begun to offer tariffs that reflect the contribution made my users. Optus and Sprint, provide two notable examples with femtocell offers that bundle unlimited call plans.

Table 6. Femtocell service providers in the OECD

Country	Operator	Service Name (Network)	Launch Date	Price (USD)	Monthly Fee (USD)
Australia	Optus	Homezone(3G)	April 2011	AUD 360 (USD 373.1)	AUD15 (USD 15.5) (Unlimited calls)
	Vodafone	Expand	May 2011	N/A	-
Czech Republic	Vodafone	Private 3G Zone	July 2011	CZK 3377 (USD 185.7)	-
Italy	Vodafone	Booster	May 2011	EUR 129 (USD 182.5)	-
France	SFR	Home 3G (UMTS/HSPA)	Nov. 2009	EUR 199 (USD 281.5)	-
	Orange	Extra Signal (Enterprise)	May 2011	EUR 500 (USD 707.3)	-
Greece	Vodafone	Access Gateway	July 2010	EUR 150 (USD 212.2)	-
	Cosmete	Perfect Signal	Oct. 2011	EUR 90 (USD 127.3)	-
Ireland	Vodafone	Sure Signal	Feb. 2011	EUR 49 (USD 69.3)	-
Japan	Softbank	Femtocell (WCDMA)	June 2010	-	-
	NTT DoCoMo	My Area (UMTS/HSPA)	Nov. 2009	-	USD 10
	KDDI	Au Femtocell (CDMA)	July 2010	-	-
Hungary	Vodafone	Mini Bazis	May 2011	N/A	-
Netherlands	Vodafone	Signaal Plus	Oct. 2011	N/A	-
New Zealand	Vodafone	Sure Signal	Jan. 2011	NZD 349 (USD 286.3)	-
Norway	Network Norway	Full Dekning	Feb. 2011	NOK 99 (USD 17.5)	-
Portugal	Optimus	Sinal On (UMTS)	Dec. 2009	EUR 99.9 (USD 141.3)	EUR 7.8 (USD 11.0)
Spain	Vodafone	Voz y Datos Premium Oficina (WCDMA)	June 2010	-	EUR 15 (USD 21.2)
	Movistar	Mi Cobertura Movil	Aug. 2010	-	EUR 9 (USD 12.7)
United Kingdom	Vodafone	Sure Signal	July 2009	GBP 50 (USD 80.6)	-
United States	AT&T	3G Microcell	Sep. 2009	USD 159	-
	Verizon	Network Extender (CDMA)	Jan. 2009	USD 249.99	Free
	Sprint	Airave (CDMA)	Sep.2007	USD 129.99	USD 4.99 (Unlimited calling: 10)

Source: Femto Forum.[41]

Effect of data offloading on fixed-mobile convergence

Data offloading is expected to grow steadily in the near future using both Wi-Fi and Femtocells. The dependency of mobile networks on fixed broadband for data traffic management confirms the relationship between fixed and mobile data markets is complementary. While mobile networks have increasingly acted in a competitive manner to traditional services on fixed networks, such as telephony, the two networks have tremendous benefits when used in parallel for operators and consumers. An indication of why fixed and mobile networks are complimentary comes from traffic data reported by Ofcom. In March 2011, the average residential fixed broadband connection in the United Kingdom, used 17 gigabytes of Internet traffic. By way of contrast, the average mobile data usage per 3G connection was 0.24 gigabytes.[42] In other words, the demands placed on fixed networks were, on average, 71 times higher on fixed than mobile networks. Shifting all fixed network traffic to the mobile network would put a significant

strain on the mobile network. Shifting mobile traffic to the fixed network however would result in a marginal increase in traffic for the fixed network.

Overall, FMC is developing but it still has some way to go. Given the potential to improve service for users and potential financial and performance advantages for mobile network operators, the market will drive developments in a positive way as long as there is sufficient competition. In the voice market, there have been telephone services that covered fixed and mobile markets in several countries, but their influence was, at best, modest and in most cases they were not successful. In part this may have reflected a desire not to "cannibalise" traditional revenue streams. By way of contrast, the demand for data over mobile networks is driving the industry toward greater FMC offerings and the forthcoming expected increase in the use of "cloud services" is likely to further intensify this trend.

POLICY IMPLICATIONS OF FMC

FMC is a trend that decreases the traditional differences between fixed and mobile networks. Policy makers and regulators need to monitor these developments because traditional borders between markets blur and approaches may need to be revaluated and altered to be in line with their overall goals. A key question for policy makers and regulators is whether regulation may in some way inhibit this move to FMC as it seems in general beneficial to consumers. Another point of attention should be whether in some cases the bundling of services may impact competition in the market. This section will explore some of these questions.

Regulation as a possible barrier to FMC

As noted, in previous sections, fixed and mobile networks have taken different commercial and technical directions during their evolution. Regulatory authorities have also treated these networks differently for a variety of reasons. While policy makers and regulators aim for technological neutrality, as a central principle, around which they develop policy and regulation, many rules carry differences in the ways in which fixed and mobile networks are regulated. Some of these differences relate to decisions taken many years ago, for specific reasons, but have practical influences on the development of FMC.

The main area where developments around FMC are influenced is in numbering and associated pricing related issues. In most OECD countries, except the United States and Canada, mobile telephones have numbers, from a specific range, that identifies them as mobile numbers. This has underpinned one of the main differences between the pricing of these services in Canada and the United States relative to the rest of the OECD. In most OECD countries, calls to mobiles are paid at a different and higher rate (wholesale as well as retail) than calls to fixed lines. This is not the case in Canada and the United States (where either wholesale charges for terminating to mobile do not exist, or are very low and equal to termination rates on fixed networks). As a result, the retail price to call a mobile network from a fixed network, has tended to be more expensive than fixed to fixed calls or mobile to mobile calls, in countries outside of Canada and the United States.

In recent years regulators have been reducing mobile termination charges.[43] As a result fixed networks have begun, in some countries to bundle domestics calls to mobile networks in a fixed price, in the same way they have previously done for wireline calls. This raises the question as to whether, prior to intervention by regulators to reduce termination fees, treating numbering differently for fixed and mobile networks locked in higher prices as a basis for the total package offered to consumers. In other words, if

there had not been a difference between the numbering for mobile and fixed voice services, would companies have treated them similarly – as was the case in Canada and the United States.

Some mobile networks offer mobile telephones a fixed number, with the associated lower termination rate as a replacement for a fixed line. These networks find the competition with fixed lines more important than the associated termination revenue. For regulators, this should be an important signal not just on termination rates, but on the nature of competition between the networks. For a consumer a fixed number often relates to a household and a mobile number to an individual and not a specific service. For a consumer, a service is more important than the type of network used. By removing differences in regulation between fixed and mobile networks, the playing field for competition between networks could be levelled.

Google, through Google Voice and competing services "Phonebooth" and "Ringcentral", offer services to consumers in Canada and the United States, that are not available elsewhere. From the perspective of a consumer, these companies offer a fixed and mobile service at the same time. This is because these services enable a single telephone number to be reachable on whatever device or operator the customer defines. This raises the question of why this FMC service, is not supported in other OECD countries. The answer, according to Google, is that high termination rates in other countries make the service uneconomical. In most OECD countries high mobile termination rates effectively prohibit such an offer in the market unless Google was prepared to charge its own customers accordingly.[44]

Another element to consider is that the use of Wi-Fi-offload, UMA and Femtocells practically means that a proportion of calls to a mobile effectively do not leave the fixed network until the final metres. This may have positive effects for the customer, who has a better signal, and the service provider, who gets less customer complaints and can unburden the mobile network. For fixed networks the use of VoIP allows nomadic use of the service and the telephone may therefore not be at the address for which it is registered. This factor needs to be taken into account by regulators, in considering whether maintaining differences between fixed and mobile is warranted, given the way some market parties route traffic to an increasing degree over fixed networks. It might not influence the current rules on numbering of fixed and mobile services, but it may have an influence on the way countries deal with calls to emergency services, where the location is respectively derived from the address or the cell site. With the introduction of new services it might be necessary to use a more technology neutral way of assessing location in case of emergency calls.

The question that needs to be asked is whether voice service, with an associated telephone number on a fixed network, is different in a relevant way than a voice service on a mobile network. If authorities aspire for regulation to be technology neutral or service neutral, then should the regulator explicitly distinguish between the two networks in an area such as numbering? In other words, to what extent are current regulations maintaining the differences between the two networks? An example is the current distinctions in numbering (*i.e.* fixed versus mobile) and geographical distinctions. These distinctions are a result of historical technical choices and regulation, but do not reflect technical requirements. Experience from Canada and the United States suggest that having a geographical number for a mobile telephone can provide a viable market[45] – and some value added services which support the Internet economy and benefit consumers are being developed there which are not yet available in other OECD countries. If differences, in areas such as numbering and interconnection, lock in behaviours then removing such differences, to the extent possible, may assist in making more competition and support innovation.

The influence of FMC on competition

FMC appears to have a positive impact on competition in networks and services. Companies cannot expect a market position in one type of infrastructure to be the basis for future performance in another. Accordingly, FMC can spur innovation as companies will have to find a fixed or mobile component to their strategies. This, in turn, will stimulate them to improve their offers to consumers.

Regulators need to be aware that there is a possibility that the bundling of fixed and mobile services may lead to challenges to maintaining competition. Where competitors cannot replicate a bundle, but consumers want the full bundle, they have to weigh up how to maintain sustainable levels of competition. In order to evaluate this, countries will have to evaluate both the fixed and mobile markets separately and as a whole. A limit on competition in either market may lead to a limit in the other market if bundling is an important element. In the following paragraphs some (hypothetical) examples of how FMC may either benefit a fixed network or a mobile network, in the case of bundling, are explored.[46]

In countries where local loop unbundling and wholesale broadband access is used, consumers may have a choice between more broadband providers then mobile network providers. It is true that because of spectrum limitations there are more regulatory barriers to entering mobile than fixed markets. However, in terms of networks with their own infrastructure it may be the case that there are more mobile networks in a particular location than fixed networks. The alternative presumption tends to be made because the rules that apply to fixed networks do allow much more freedom for new entrants in how they configure the pricing of services for users (*e.g.* through local loop unbundling). Compare this to a service such as international mobile roaming where MVNOs are limited to the wholesale arrangements made by MNOs. Thus, the ability of operators to offer a complete fixed or mobile bundle is likely to be determined by the level of regulation applied to facilities-based providers as much as how many entities have their own infrastructure.

While it is not true in every case, due to local loop unbundling, many countries have more retail fixed line operators than MNOs. If each mobile operator has a fixed line operation, any fixed line operator without a mobile service is at a disadvantage. This does not have to be negative as it may spur further innovation and creativity – and if entities wishing to complete a bundle can become MVNOs they may be able to compete on an equal basis. However, it could potentially lead to a situation where having a mobile license and being a fixed network operator become mutually dependent, effectively limiting entering the market to obtaining a spectrum license. While there is little indication that there is a restriction of competitive market access, over and above the physical limitations imposed by spectrum availability, this needs to be monitored by regulatory authorities.

Another element for competition may be access to the home gateway. 802.11u allows seamless connections to Wi-Fi. Most consumers have a Wi-Fi access point in their DSL, cable or fibre router that is under the control of the operator. The question then is who determines what devices and services can make use of this seamless connection. For users it would be preferable if as many services and devices as possible can make use of this mechanism. Or even that users can control what devices are associated with their subscription. It could be imagined that an employee with a company-issued device automatically gets access to a Wi-Fi access point by authentication with the company the user works for. The question is whether flexible arrangements will be possible or if the access point is locked to the services of one operator and there is no flexibility in who can provide authentication.

Policy makers and regulators aim to facilitate the expansion of the global Internet economy, but if historical decisions, such as with numbering, are restraining FMC developments this needs to be addressed, taking into account all the issues at stake, in particular the ones related to emergency services. While it is clear that FMC is beneficial for users it is not always clear that regulation is allowing this to proceed apace.

The best way for FMC decisions to be taken is for them to be taken by the market which will most efficiently respond to demand. That being said there are limitations on market entry, such as those determined by the availability of spectrum, which means that competition may also be limited in some respects. This underscores the role MVNOs may need to play, and how vital it will be for them to have the flexibility to do so, in ensuring that fixed network providers can supply bundles that integrate FMC.

While this report finds that fixed and mobile networks are competing and complementary it is clear:

- Mobile networks are competing with fixed networks in terms of voice services.
- Mobile networks increasingly rely on fixed broadband networks to meet customer demand for high-speed data and will do more so in the future.
- MVNOs and fixed mobile networks, without their own traditional MNO, have the potential to use FMC to compete with MNOs.
- While many envisage a future with MNOs providing more competition to fixed broadband providers, strategically the latter may be in a stronger position and unless MNOs can offer a full bundle they may, in fact be most vulnerable to FMC competition.
- The MNOs with the strongest defensive position will be those with both networks and the widest geographical coverage.

NOTES

1 *www.oecd.org/dataoecd/11/32/2091307.pdf,* for market forecasts see page 27.

2 www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=OCDE/GD(96)42&docLanguage=En

3 OECD, Cellular Mobile Pricing and Trends", DSTI/ICCP/TISP(99)11/FINAL http://www.oecd.org/dataoecd/54/42/2538118.pdf

4 OECD, "Fixed-Mobile Convergence: Market Developments and Policy Issues", DSTI/ICCP/CISP(2006)4/FINAL, http://www.oecd.org/dataoecd/20/26/38309911.pdf

5 OECD, "Developments in Fibre Technologies and Investment", DSTI/ICCP/CISP(2007)2/FINAL

6 Nicholas Negroponte, the so called Negroponte flip.

7 *www.cisco.com/en/US/netsol/ns519/networking_solutions_solution_category.html,* retrieved 13 October, 2011

8 *www.telegeography.com/products/commsupdate/articles/2012/01/10/international-call-traffic-growth-slows-as-skypes-volumes-soar/*

9 Whether or not the marginal costs of a mobile minute is higher than that of a fixed minute is difficult to ascertain as fixed lines often carry a fixed monthly charge irrespective of the number of minutes called, might incur long distance charges that mobile calls traditionally did not have etc. Furthermore the cost of building the physical network are higher for a fixed network than for a mobile network.

10 See for example Vodafone's femtocell offer where the call is charged at the same rate.

11 Similar models are being tested by SFR in France, and used by Free Mobile in France using EAP-SIM

12 It may require updates to networks to allow the measurement of what is billed and ways to effectuate that what is paid for is delivered and what is not paid for is not available.

13 *www.vodafone.co.nz/home-phone/wireless/* for product description, terms and conditions. retrieved 4 November.

14 O2 Mobile Flat was called Genion.

15 See the offers by SFR *www.sfr.fr,* Free *www.free.fr* and Bouygues *www.bouyguestelecom.com.*

16 *www.btfon.com/*

17 3GPP TS 44.318 Release 11 is the latest version. The 3GPP calls it Generic Access Network (GAN), however UMA is the marketing term that is mostly used commercially.

[18] The size of the coverage of a cell in a mobile networks is described by the words macro, micro and pico. A macro site covers a whole region, whereas a micro site may cover a small area in that macro region. A pico site is aimed at a specific location *i.e.* a busy railway station or part of that railway station. As femto is the next smallest in the international system of units, it was chosen to denote coverage in even smaller sites, *i.e.* in the home or business.

[19] Standardised by the 3GPP, they are also known as Home Node B or Home eNode B. For an in depth analysis see: ***Error! Hyperlink reference not valid.***

[20] *www.ericsson.com/res/thecompany/docs/publications/ericsson_review/2011/heterogeneous_networks.pdf* , Heterogeneous networks – increasing cellular capacity, Landström *et. al.,* Ericsson Review 1-2011.

[21] *www.theregister.co.uk/2011/04/11/optus_launches_femtocell/ a*nd *http://shop.vodafone.co.uk/shop/mobile-accessories/vodafone-sure-signal*

[22] *www.rethink-wireless.com/2011/09/26/sfr-offers-europes-free-femtocells.htm and www.thinkfemtocell.com/Femtocell-Operator/softbank-offer-free-femtocells-and-free-dedicated-internet-broadband.html*

[23] In this report, the term 'Fixed Mobile Convergence(FMC) services' is used in a broader perspective, meaning Dual-mode single telephone service and Fixed Mobile Substitution (FMS) service. In some other documents, FMC service refers to only single telephone service.

[24] SK Telecom, press release, 21 October 2009, "FMS/FMC service provision plan".

[25] SK Telecom, press release, 15 September 2010, *www.sktelecom.com/jsp/n_prcenter/NewsView.jsp?f_rk=1&f_reportdata_seq=3624*

[26] Webinar on UMA & Femtocells: Complementary technologies, 20 November 2008. *www.smart-wi-fi.com/podcast/Orange_UMAToday_webinar_081120.pdf* .

[27] *www.zdnet.co.kr/news/news_view.asp?artice_id=20090907093252&type=det*

[28] *http://support.t-mobile.com/docs/DOC-2931*

[29] OECD (2006) *Multiple Play: Pricing and Policy Trends.* Paris: Organisation for Economic Cooperation and Development. DSTI/ICCP/TISP(2005)12/FINAL. *www.oecd/dataoecd//47/32/36546318.pdf*

[30] For the purpose of the report, only mobile-included triple and quadruple services were reviewed.

[31] European Commission (2011), E-Communications Household Survey. *http://ec.europa.eu/information_society/ digital-agenda/scoreboard/docs/pillar/studies/eb_ecomm/final_reports/reporteb751sp362infsoecommunications_en_final.pdf*

[32] *www.wirelessintelligence.com/analysis/2011/05/orange-defends-mobile-lead-in-france/*

[33] *http://marketpublishers.com/lists/9924/news.html*

[34] *www.strategyanalytics.com/default.aspx?mod=pressreleaseviewer&a0=5081*

[35] European Commission (2011), E-Communications Household Survey. *http://ec.europa.eu/information_society/ digital-*

agenda/scoreboard/docs/pillar/studies/eb_ecomm/final_reports/reporteb751sp362infsoecommunications_en_final.pdf

[36] *http://point-topic.com/content/dslanalysis/BBAvoipq410.html*

[37] BEREC Report on Impact of fixed-mobile substitution in market definition BoR (11) 54 Draft as published on BEREC website.

[38] *http://gigaom.com/mobile/verizon-offers-boingo-wi-fi-macs-need-not-apply/*

[39] *www.att.com/gen/press-room?pid=21806&cdvn=news&newsarticleid=33140&mapcode=consumer|mk-att-wi-fi*

[40] *http://blog.fon.com/en/archivo/uncategorized/fon-community-now-enjoys-4-million-fon-spots-worldwide.html*

[41] *http://femtoforum.org/fem2/resources.php?id=194*

[42] See Figure 8 and Figure 15, http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/bbspeeds2011/infrastructure-report.pdf

[43] "Developments in Mobile Termination", OECD Digital Economy Papers, No. 193, OECD Publishing. http://dx.doi.org/10.1787/5k9f97dxnd9r-en

[44] It could well be that even the fixed line termination rates are too high for such a business model.

[45] See for example Google Voice, which is available in North America, but not elsewhere. It should also be noted that in the United States as a result of number portability and the use of VOIP services the number may not be as closely associated with a particular geography as in the past.

[46] For example, bundles could make it more complicated to change provider, while the transferability of services and applications between different devices and networks, fixed and mobile, raises questions about how far proprietary (non- transferable) content is a legitimate, desirable, competitive ploy and when it becomes counter-productive. These issues are highlighted, for example, in the OECD report "The Development and Diffusion of Digital Content (DST/ICCP/CISP(2011)9/Final}.