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State of the Art Mobile Internet Connectivity and its Impact on e-Commerce

NOTE

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Abstract

Mobile broadband usage is growing thanks to the popularity of Internet-enabled smart phones and tablets. Mobile data networks are becoming faster and more capable. Europeans increasingly depend on mobile data applications, when at home and when under way. This briefing note considers whether the high price of mobile data roaming inhibits the use of mobile applications; the degree to which the 2012 Roaming Regulation addresses these concerns; and what further measures if any should be taken.

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LIST OF ABBREVIATIONS

DSL	Digital Subscriber Line
EDGE	Enhanced Data rates for GSM Evolution, a technical standard for wireless data communications
EPC	Evolved Packet Core
Gbps	Gigabits (billion bits) per Second
GSM	Global System for Mobile Communications, a technical standard for wireless communications
home network (HN)	The network with which a roamer has a customer relationship.
home routing	A form of mobile roming where traffic is routed through the home network before being sent to or from the end destination.
HSPA	High Speed Packet Access
IP	Internet Protocol
local breakout (LBO)	A form of mobile roming where traffic is routed directly from the visited network, without being routed through the home network, before being sent to or from the end destination. The use of this term in BEREC documents BoR (12) 67 and BoR (12) 68 goes somewhat beyond that of the definition in UMTS standards.
LTE	Long term Evolution, a technical standard for high speed wireless communications.
M2M	Machine-to-Machine
Mbps	Megabits (million bits) per second
MIMO	Multiple Input Multiple Output
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NRA	National Regulatory Authority
UMTS	Universal Mobile Telecommunications System, a technical standard for wireless communications
visited network (VN)	The network that is providing service to a roaming user at a particular moment of time.
VoIP	Voice over Internet Protocol
VoLTE	Voice over Long Term Evolution
WiFi	A form of WLAN that used licence exempt spectrum
WiMAX	Worldwide Interoperability for Microwave Access, a technical standard for high speed wireless communications
WLAN	Wireless Local Area Network

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EXECUTIVE SUMMARY

Mobile broadband usage is experiencing significant growth, driven primarily by the wide dissemination and availability of Internet-enabled smart phones and tablets as well as dongles that enable mobile Internet access to laptops. Mobile data traffic is estimated to grow at a stunning compound growth rate of 78% per year for the period 2012-2016; by contrast, total Internet Protocol traffic (including fixed) is expected to grow at a compound rate of just 29% per year for the period 2012-2016.

The introduction of high speed 4G networks (e.g. LTE) is an enabler of new applications and greater traffic, but it is also a response to this traffic increase. This migration enables higher speed (greater bandwidth) for mobile connections; indeed, LTE offers a maximum theoretical downstream speed of 300 Mbps, while the future LTE-Advanced is projected to offer a further increase in theoretical maximum downstream speed to 1 Gbps.[1] This greater speed is in part due to the higher spectral efficiency (e.g., more bits/s per Hz of spectrum) of LTE, achieved in part through the use of MIMO (Multiple Input Multiple Output, i.e. the use of multiple antennas in both mobile terminal and mobile network). Another rather substantial part of the increase in speed is simply a result of the larger amount of spectrum that is expected to be available for LTE.

LTE also greatly reduces the delay ("latency") that IP packets will experience on their path through the network. This is important for many uses of the network, including two-way voice and video.

These wireless services are used by travellers; while under way close to home; and increasingly from home as a true substitute for fixed broadband connections.

The use of smart phones has significant implications for the design of applications. Applications may need to accommodate smaller screen sizes, and may need to be location-aware. At the same time, the rapid adoption of smart phones and tablets, together with use of PC dongles, enables applications to be invoked while mobile that in the past would have been unthinkable except from a fixed location. A range of forward-looking mobile applications are emerging in areas such e-Health, transportation, and e-Government. At the same time, a great many everyday applications are especially important to travellers, including:

- Navigation applications, such as maps with pointers to local facilities and services, and turn-by-turn navigation.
- Information on public transport and plane schedules, online check-in services.
- Weather forecast services.
- Restaurant, shopping, art, music, hotel, culture, and city guide applications that complement and/or replace paper travel guides.
- Radio and TV applications that provide the consumer with the possibility to tune into their home programmes.
- On-line translation tools, which are rapidly replacing the classical paper travel dictionaries.
- Internet banking, as the default way (and for many Europeans today also the only way) to keep track of credit card payments.

[1] Mbps are millions of bits per second; Gbps are billions of bits per second. Realistically achievable speeds, particularly under load, are substantially less than these theoretical maximum values.

When a European is travelling, his or her need for data is likely to be *greater*, not less, than when at home. Indeed, the use of mobile data while roaming increased roughly 120% year over year from 2010 to 2011.[2] If prohibitively high mobile data roaming costs were to effectively inhibit or prevent Europeans from using mobile data while travelling, there could be real socio-economic costs to Europe. This is a Single Market issue. Potential scale economies that are being lost today would continue to be lost; consumer welfare would be directly impacted as a result; and to some degree European competitiveness would be negatively impacted relative to certain of the larger integrated areas with which we compete, including the US, China, and perhaps even India.

It is instructive to note that the problem of high domestic roaming prices was solved in the United States by the unilateral actions of a single MNO (AT&T Wireless) that had both a nationwide mobile network, and the willingness to disrupt existing arrangements in the hopes of gaining market share. For a number of reasons, a similar development in Europe seems unlikely, but perhaps not impossible.

The new Roaming Regulation seeks for the first time to address high prices for mobile data roaming by imposing retail price controls as of 1 July 2012. These will presumably be effective, but still imply data roaming prices that are much higher than domestic data prices, and that are thus probably still high enough to depress many forms of data usage.[3]

The Roaming Regulation of 2012 also includes structural measures that seek to establish competition for roaming, with the goal of achieving lower prices without regulation. BEREC has just released consultation guidance; thus, it is now possible to comment on two concrete proposals that appear to be actionable.

- Our feeling is that the first of BEREC's proposals, "Single IMSI", may possible lower the "spread" between wholesale costs and retail prices, but does not represent a radical break.
- The second BEREC proposal, Local Break-out (LBO), is modest in and of itself but might be effective if combined with complementary measures.

Looking ahead, implementation of "roam like at home" would imply substantial challenges. It is hard to see how prices to the user could be constant when costs in the various Member States are not. A "Roam like a native" solution seems to be more sustainable in a Europe where underlying costs will continue to differ among the Member States.

The "Local Break-out (LBO)" that appears in the same BEREC proposed guidelines could be viewed as a "roam like a native" approach. It could be truly promising if supported by complementary measures, and innovative business practices. Potentially complementary initiatives could include (1) moves by service aggregators or by smaller, aggressive MNOs to pool packages of offers together that span multiple Member States; and (2) regulatory initiatives to strengthen the ability of users to invoke Voice over IP (VoIP) in the handset, possibly coupled with initiatives from LBO service providers to actively support VoIP.

[2] BEREC Benchmark Data Report (2012), pages 37 and 38, WIK computations.

[3] We estimate an increase in aggregate payments to MNOs for intra-EEA mobile data roaming, despite the substantial reduction in the regulated price.

Key findings and recommendations for the European Institutions

- Ensure proper implementation of the Roaming Regulation of 2012.
- Maintain contact with market players so as to minimise any policy impediments to innovative offers that might effectively give force to the Local Break-Out (LBO) solution.
- Be alert to any opportunities for a disruptive player to establish a pan-European presence, and if so weigh carefully the balance between competition issues and regulatory policy issues.
- Monitor the ongoing evolution of mobile data services over time to see if any blockages develop (or remain).

1. INTRODUCTION

KEY FINDINGS

- The growth of mobile data has important implications for European consumers, and for the European Parliament as an instrument for achieving European objectives.
- We were asked to study how the evolution of wireless Internet data (especially LTE and WiFi off-load) are changing the ways in which consumers use the Internet, and whether any impediments (notably including mobile data roaming) might impede that natural evolution.

The key issues presented by the study are:

- How is the evolution of wireless Internet data (especially LTE and WiFi off-load) changing the ways in which consumers use the Internet? What are the implications of these changes?
- Do current arrangements as regards mobile data roaming impact consumer benefits that would otherwise flow from increased use of mobile data, and thus inhibit the desirable evolution of mobile data?

The growth of mobile data has important implications for European consumers, and for the European Parliament as an instrument for achieving European objectives. Mobile data could play a key role:

- As a means of providing consumers with ubiquitous IP-based access to data and applications anytime, anywhere, whether moving or stationary.
- As a means of achieving ubiquitous broadband coverage, even to remote or hard-to-reach areas, and thus achieving the objectives of the Digital Agenda for Europe in a technologically neutral way.
- As an alternative to fixed high speed broadband access, even in areas of moderate density, subject to constraints of capacity and demand.

In this note, we briefly consider key usage trends for mobile broadband (section 2), key technology trends for mobile broadband (section 3), the impact of roaming on use of mobile applications (section 4), the implications of the 2012 roaming regulation (section 5), and ideas for addressing roaming challenges that we might explore in the course of the study (section 6).

2. USAGE TRENDS FOR MOBILE BROADBAND

KEY FINDINGS

- Mobile broadband usage has experienced significant growth, driven primarily by the wide dissemination and availability of Internet-enabled smart phones and tablets as well as dongles that enable mobile Internet access to laptops.
- Mobile data traffic is estimated to grow at a stunning compound growth rate of 78% per year for the period 2012-2016; however, the rate of growth is declining over time, as is typical in the adoption of any new technology.
- In contrast, total Internet Protocol traffic (including fixed) is expected to grow at a compound rate of just 29% per year for the period 2012-2016.
- Mobile Internet Protocol (IP) traffic represented only about 2% of total IP traffic in 2011; however, given the rapid growth of mobile traffic, this will grow about 10% of total global IP traffic in 2016.
- The use of smart phones has significant implications for the design of applications. Applications may need to accommodate smaller screen sizes, and may need to be location-aware.
- An increasing portion of mobile traffic is expected to be offloaded onto the fixed network via WiFi or femtocells. In 2016, 22% of mobile traffic could be offloaded.
- The introduction of high speed 4G networks (e.g. LTE) is an enabler of new applications and greater traffic, but is also a response to greater traffic.

Mobile broadband usage has experienced significant growth, driven primarily by the wide dissemination and availability of Internet-enabled smart phones and tablets as well as dongles that enable mobile Internet access to laptops. An increasing number of applications (particularly cloud applications) as well as an increasing variety and volume of content have developed alongside the dissemination of mobile access devices. Moreover, average mobile network connection speeds have increased significantly, making the use of mobile devices more attractive. These developments have spurred explosive growth in mobile broadband traffic.

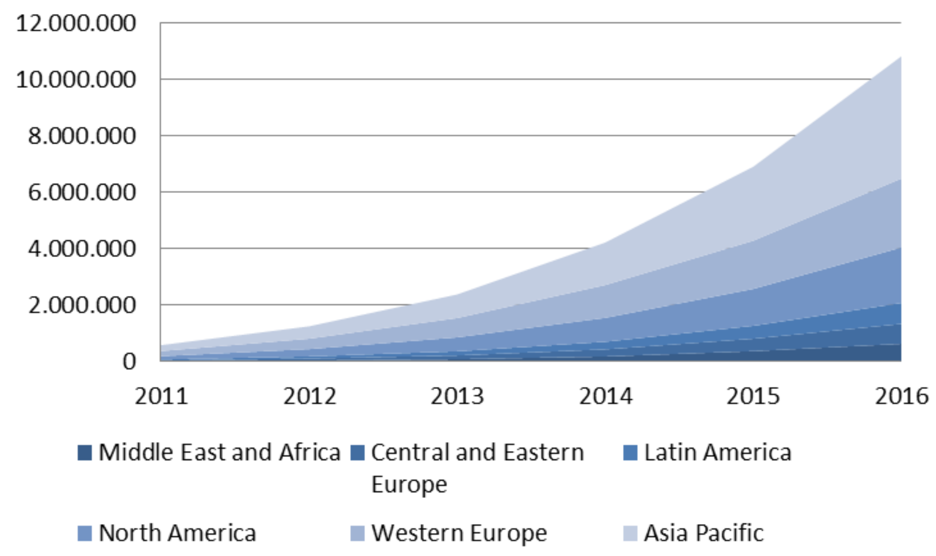
Cisco Systems publishes a respected annual analysis of the expected growth of fixed and mobile data traffic over the Internet.4 Based on their 2012 analysis, several key trends are evident that underscore the growing importance of mobile data:

- Mobile data traffic is estimated to grow at a stunning compound growth rate of 78% per year for the period 2012-2016; however, the rate of growth is declining over time, as is typical in the adoption of any new technology.
- Mobile Internet Protocol (IP) traffic represented only about 2% of total IP traffic in 2011; however, given the rapid growth of mobile traffic, this will grow in the years to come. Projected mobile data traffic of 10,804 Petabytes per month in 2016 represents about 10% of total global IP traffic.
- Total Internet Protocol traffic (including fixed) is expected to grow at a compound rate of 29% per year for the period 2012-2016; however, this rate of growth is also declining.

[4] CISCO (2012): "Cisco Visual Networking Index: Forecast and Methodology, 2011–2016", White paper, 30 May 2012; and "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2011-2016", 14 February 2012. Note that *Internet Protocol (IP)* traffic includes not only traffic on the public global Internet, but also traffic that remains on a single network.

Figure 1 shows projected global mobile data traffic in TB per month, by region for the period 2011-2016. The growth of mobile data traffic in Western Europe substantial, but is notably less than in other regions of the world, and also less than in Eastern Europe. Asia Pacific, North America and Western Europe show highest traffic volumes followed by Latin America, Central and Eastern Europe, and the Middle East and Africa. Compound annual growth rates for 2011-2016 are highest for the Middle East and Africa at 104%, followed by Asia-Pacific at 84%, Central and Eastern Europe at 83%, and Latin America, North America and Western Europe at 78%, 75% and 68%, respectively.

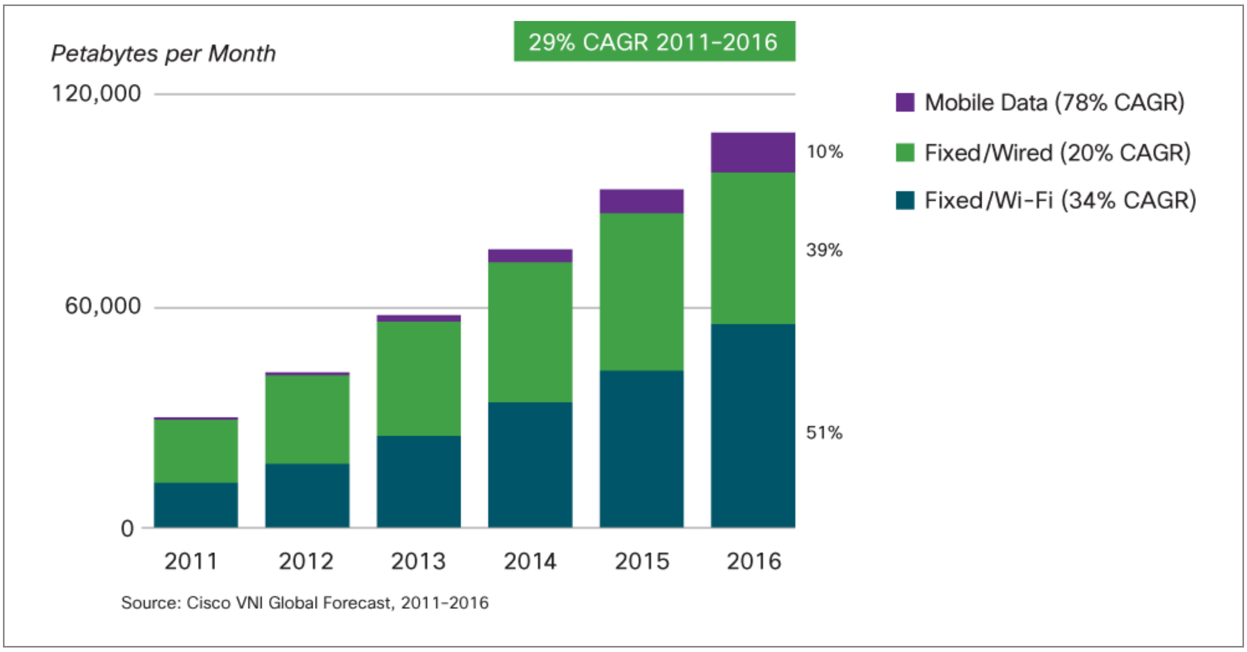
Figure 1: Global mobile data traffic (TB/month), by region (2011-2016)



Source: Cisco (2012), WIK calculations

An increasing fraction of traffic is wireless. WiFi is also wireless, and reflects a convergence of the fixed and mobile network (see Figure 2).

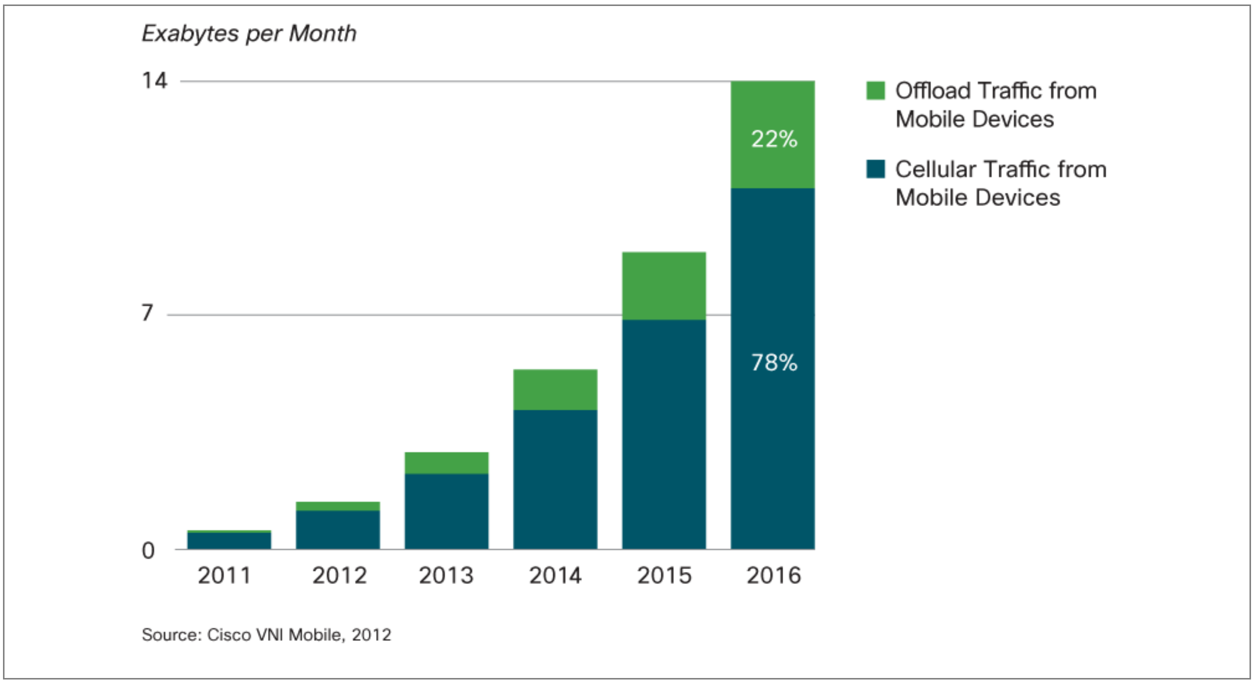
Figure 2: Mobile, fixed / wired, and fixed / WiFi data



Source: Cisco VNI (2012)

An increasing portion of mobile traffic is expected to be offloaded onto the fixed network via WiFi or femtocells. Cisco estimated that in the absence of mobile data offloads, the compound annual growth rate of mobile traffic would be just 84% instead of 78%.

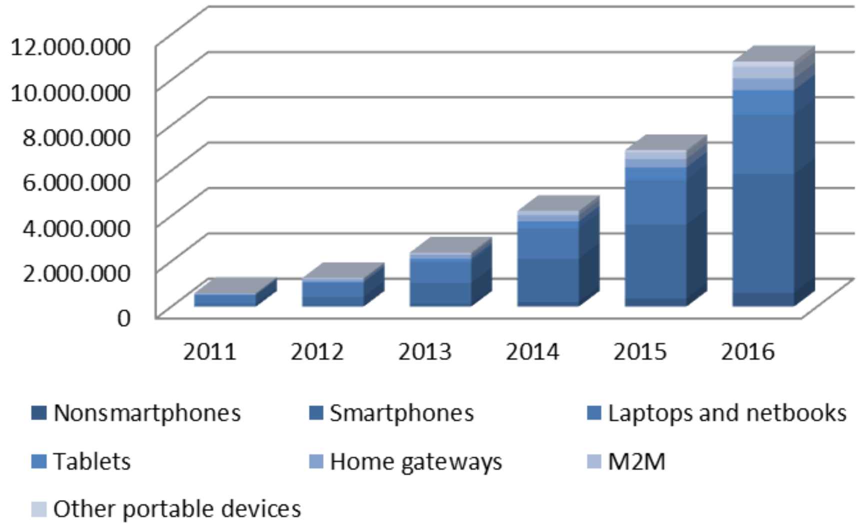
Figure 3: Offload of mobile data traffic to WiFi, femtocells and picocells



Source: Cisco Mobile VNI (2012)

Smart phone usage has increased significantly and is estimated to nearly triple from 2012 to 2013. Figure 4 shows mobile data traffic estimates by device for the period 2011-2016. Smartphones and laptops lead traffic growth, followed by tablets and other devices.

Figure 4: Mobile data traffic by device, 2011-2016



Source: Cisco (2012), WIK calculations

Based on Cisco data, the average amount of traffic per smart phone in 2011 was 150 MB per month, up from 55 MB per month in 2010. While mobile traffic generated by laptops was 3.5 times higher in 2011 than mobile traffic generated by smart phones, Cisco estimates that traffic generated by smart phones will have outstripped traffic generated by laptops by a factor of 2 in 2016. The average smart phone is estimated to generate 2.6 GB of traffic per month in 2016, which represents a 17-fold increase over the 2011 average of 150 MB per month. Total mobile traffic generated by smart phones in the period 2011-2016 is estimated to grow at a compound annual rate of 119%. As regards tablets, Cisco estimates that tablets will generate almost as much traffic in 2016 as the entire global mobile network in 2012.

The growing take-up of smart phones has been stunning, and has been a key driver in the growth of mobile data. The use of smart phones has, however, significant implications for the design of applications.

The first and most obvious has to do with screen size. Browsers, for example, adapt automatically to the size of the screen; however, as most of us have come to recognise, a *small screen* smart phone is unlikely to perform satisfactorily in accessing a web-based application that was designed for a *large screen* (laptop, netbook, or tablet).[5]

Location awareness is another key requirement, and a key enabler, for certain mobile application classes. For applications like navigation, tracking and tracing, and emergency services, location awareness is a key requirement. Without it, the application loses much or all of its value.

There are also many examples in which location information is an enabler that helps to make applications more valuable for users by providing more relevant information and options. Location has always been a relevant criterion for people navigating the real world, and the incorporation of location information in mobile applications firmly introduces the same logic in the navigation of the wealth of information on the internet and in

5 In the longer term, it is conceivable that technological developments including wearable devices (such as the augmented reality head-mounted displays being produced for Google's Project Glass) and speech recognition might partly compensate for the limitations of a small form factor; however, they are likely to imply application re-design of their own.

applications. Location information in applications introduces a natural ordering in the information and options presented to people. There are many examples that can be mentioned here, from localised weather predictions and traffic information to localised search results for restaurants and for social network buddies.

Food for thought 1: Mobile data applications provide real value.

"Sight-seeing in Lübeck is a dream!" exclaimed Sabine. "So different from Bonn, Germany, where we live. But I am a little turned around now, with these narrow streets. Which way to our hotel?"

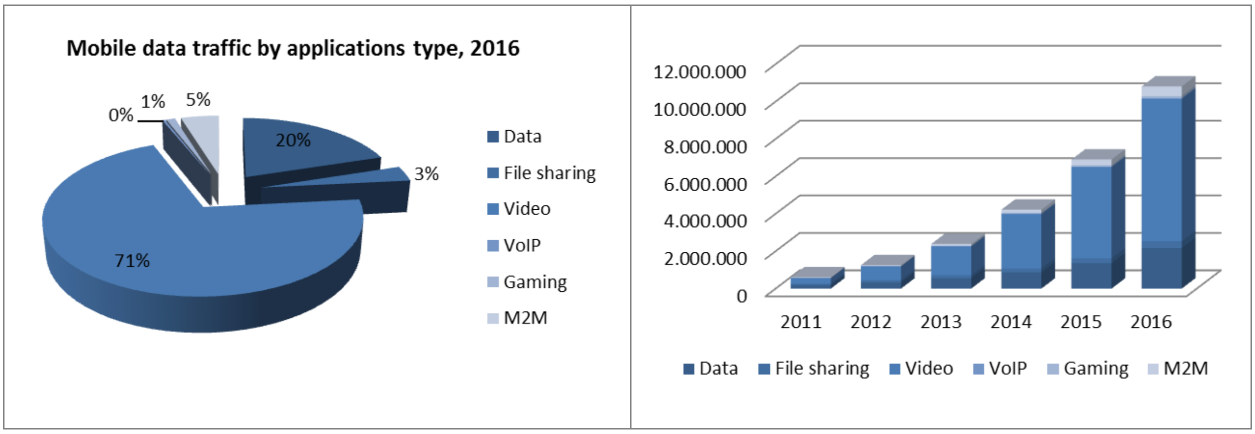
"Oh, drat!" said Werner. "I left the city map in the hotel. But no problem! My smart phone has GPS, and a navigation application. Wait a minute … Yes, look there, Sabine. That blue arrow is us, and that's the direction in which we are walking."

"Very nice, Werner, but after all that sight-seeing, I'm starving. Can your magical new toy cook us up something good to eat?"

"Well, no, but I can pull up a list of nearby restaurants. Hold on …"

As regards types of applications, more than two-thirds (70%) of the world's mobile data traffic is expected to be video by 2016. Even though a great many devices are expected to be capable of machine-to-machine (M2M) communication in the future, the share M2M traffic is estimated at about 4% in 2016. This is shown in Figure 5.

Figure 5: Mobile data traffic by application type (2016 and 2011-2016)

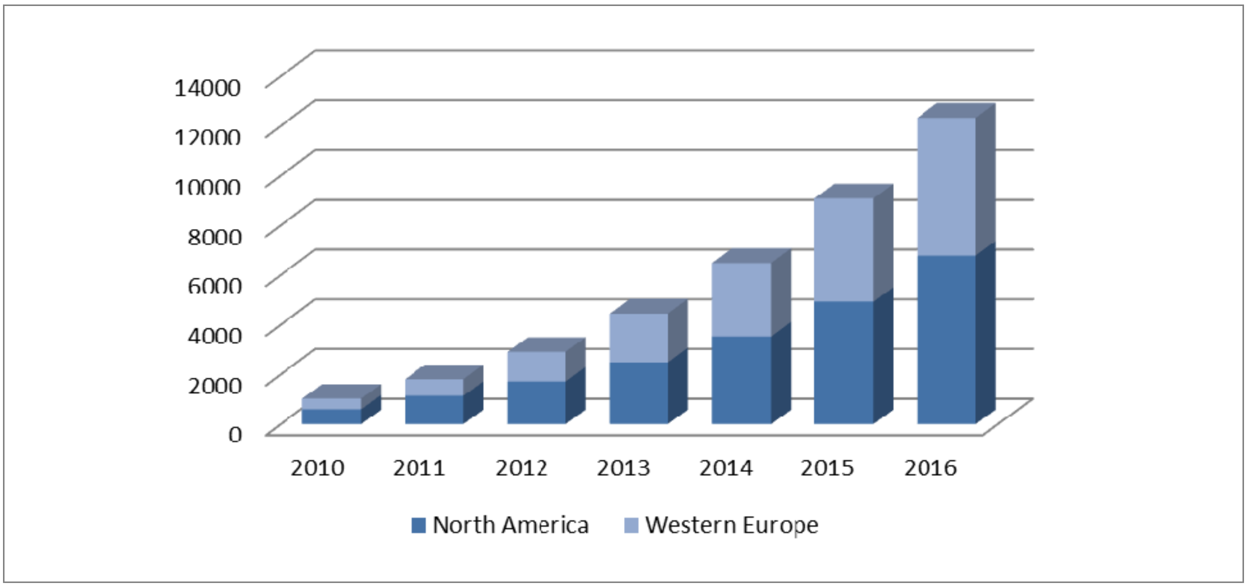


Source: Cisco (2012), WIK calculations

Given the limitations of mobile devices in terms of speed and memory, content consumption and resulting traffic growth have also been spurred significantly (1) by the introduction and evolution of cloud application services such as YouTube, Netflix, Padora and Facebook, which generate far more traffic than email and normal web-based applications; and (2) by the increase in mobile network connection speeds (with the premise that an increase in network connection speeds will lead to an increased uptake and usage of high-bandwidth applications).

Mobile network connection speeds are expected by Cisco to increase 9-fold by 2016 mainly due to the introduction of 4G networks (e.g. LTE). Increased use of mobile data is both a cause and effect of 4G deployment – network operators need the upgrade in order to keep up with customer demand. Although mobile network connection speeds in Western Europe averaged only 667 kbps in 2011, they are estimated to increase to 5.5 Mbps by 2016, because 4G connections generate significantly (Cisco estimates currently 28 times) more traffic than non-4G connections. Even though 4G connections only amount to 0.2% of mobile connections today, they already account for 6% of traffic. This proportion will move to 6% of connections and 36% of total traffic in 2016. Projected average mobile network connection speeds (in kbps) for Western Europe and North America are shown in Figure 6.

Figure 6: Projected average mobile network connection speeds (in kbps) for Western Europe and North America



Source: Cisco (2012), WIK calculations

3. KEY TECHNOLOGY TRENDS FOR MOBILE BROADBAND

KEY FINDINGS

- The evolution of mobile network technology has been going on for many years, from GSM (2G) to EDGE (2.5G), UMTS (3G), HSPA (3.5G) and now on to LTE (4G, starting from 3GPP Release 8). Each stage of this migration brings an increase in the bandwidths (speeds) that can be obtained over mobile connections.
- The higher bandwidths in LTE come from its higher spectral efficiency (e.g., more bits/s per Hz of spectrum), achieved in part through the use of MIMO (Multiple Input Multiple Output, i.e. the use of multiple antennas in both mobile terminal and mobile network). Another rather substantial part of the increase in bandwidth simply comes from the larger amount of spectrum that will be available for LTE.
- LTE also greatly reduces the delay ("latency") that IP packets experience on their path through the network. This is important for many uses of the network, including two-way voice and video.
- Satellite communications could potentially play a complementary role to terrestrial wireless LTE.
- If mobile data users are to benefit from the increased bandwidth over the radio interface, the LTE antenna sites will need to have a high-capacity backhaul connection (typically be a fibre connection) to the mobile core network.
- LTE is expected to further evolve to LTE-Advanced, which will offer a substantial further increase in transmission speeds. LTE-Advanced also enables a more prominent role for femtocells.
- The technical basis for data, voice and SMS mobile roaming is complex. In general, there are two technical options available: home routing (through the subscriber's network in the home country) and local break out (LBO, where traffic is dealt with in the visited country).[6]

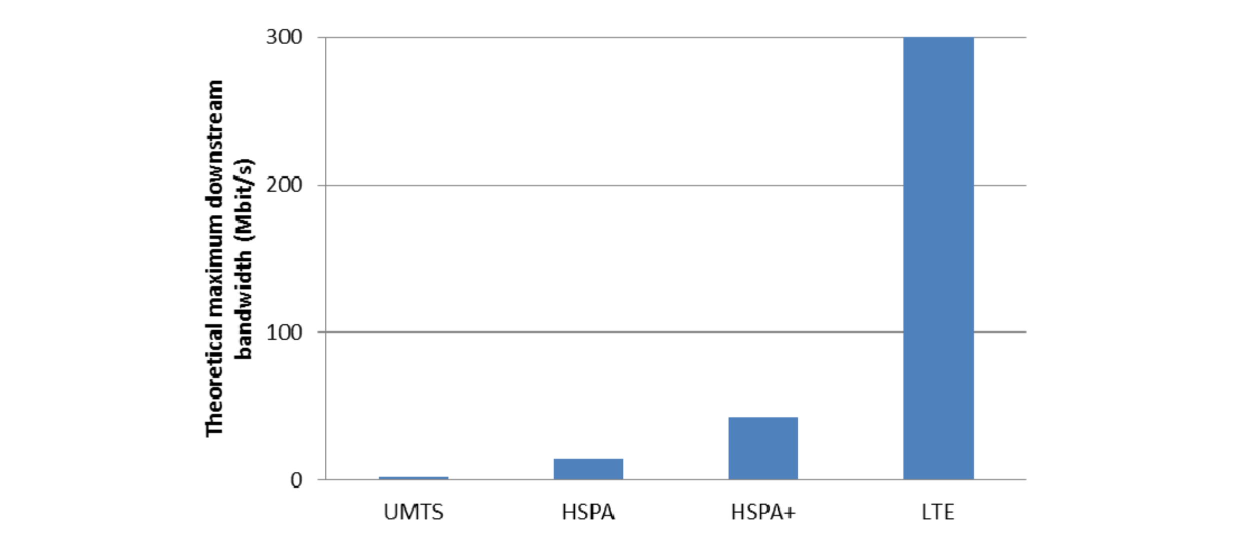
This section of the briefing note discusses the technical evolution to LTE, further migration to LTE-Advanced, and the technical basis of mobile roaming.

3.1. Technical evolution to LTE

The technical evolution to LTE is largely a response to the growth in consumer demand for mobile data. The migration to progressively more advanced forms of LTE is clearly a key development. It is the next stage in the evolution of mobile network technology that has already been going on for many years: from GSM (2G) to EDGE (2.5G), UMTS (3G), HSPA (3.5G) and now on to LTE (4G, starting from 3GPP Release 8). Each stage of this migration brings an increase in the bandwidths (speeds) that can be obtained over mobile connections. The theoretical maximum bandwidth that can be achieved with LTE over 20 MHz of spectrum is 300 Mbit/s downstream and 75 Mbit/s upstream, which is a substantial improvement over HSPA+ with 42 Mbit/s downstream and 11 Mbit/s upstream (Figure 7).

[6] We are referring here to LBO as defined in UMTS standards. BEREC's use of the term LBO in documents BoR (12) 67 and BoR (12) 68 builds on the UMTS definition.

Figure 7: Theoretical maximum downstream bandwidth for successive mobile technology generations



Source: TNO based on 3GPP specifications

Maximum bandwidth numbers like these should be interpreted with care. The actual bandwidths that can be obtained in practice are determined by many factors, such as the mobile operator's decisions in network dimensioning and radio planning in particular. For an individual mobile data customer, the bandwidth is also strongly dependent on the data consumption of the other mobile data users active in the particular radio cell he happens to be in. For LTE, the typical downstream bandwidth can be expected to be in the range between 10 and 100 Mbit/s, depending on the network dimensioning and network load. This represents a substantial increase compared to HSPA and earlier mobile technology generations (Table 1). Preliminary results from the first live LTE networks have confirmed that LTE can indeed provide substantially more bandwidth than UMTS/HSPA.

Table 1: Typical maximum downstream bandwidths for successive mobile technology generations

Mobile technology generation	Range of typically achievable maximum downstream bandwidth (Mbit/s)
HSPA	2-5
HSPA+	5-25
LTE	10-100

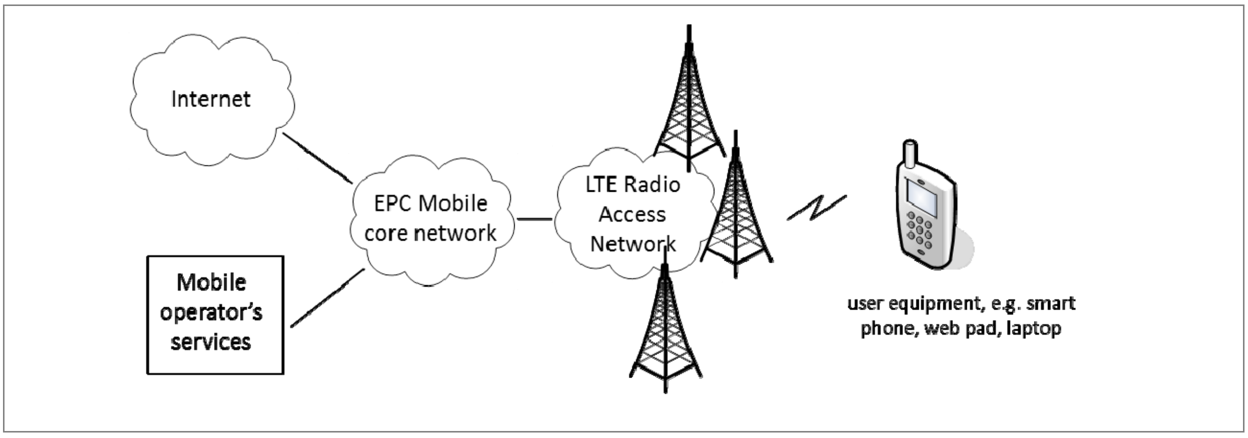
Source: TNO estimates

The higher bandwidths in LTE come from its higher spectral efficiency (e.g., more bits/s per Hz of spectrum), achieved by a number of technical elements such as a more extensive use of MIMO (Multiple Input Multiple Output, i.e. the use of multiple antennas in both mobile terminal and mobile network). Another rather substantial part of the increase in bandwidth simply comes from the larger amount of spectrum that will be available for LTE. In particular the spectrum available for LTE in the 800 MHz band is a valuable, as it provides better indoor coverage than the higher frequency bands, such as the 1800 MHz, available for UMTS and HSPA today.

The increase in bandwidth offered by LTE is important, but it is not the only improvement over UMTS/HSPA. Broadband is about more than just bandwidth, and this is also reflected in the design of LTE. A key design goal has been to reduce the delay (“latency”) that IP packets experience on their path through the network. For real-time applications, like two-way voice or video, small delays are crucial for guaranteeing a proper Quality of Experience for customers. Here, it is important to note that in parallel and in close alignment with LTE, a new generation of the mobile core network has been developed: the *Evolved Packet Core (EPC)* (see Figure 8). A clear improvement over earlier generations of mobile radio and core networks is the consistent and streamlined All-IP design of the LTE radio access network and the EPC. This brings an improved set of Quality of Service classes, to the benefit of applications that have specific requirements for the quality of mobile data connections. Another improvement in the EPC is that is has been designed from the start to support multiple access technologies. Specifically, the EPC standards contain the functions and interfaces to integrate services over LTE and WiFi/WLAN networks.

Studies show that there is also potential to support satellite communications (Satcom) networks.[7] In this approach, the satellite network is treated as an access network and connected to the EPC. Satcom networks have already shown their value in providing Internet connectivity in remote rural areas. Linking Satcom networks with the EPC offers the opportunity to move away from the traditional Satcom stove pipe (e.g., Satcom access combined with a specific Satcom core network and Satcom service architecture) and integrate it more closely with mobile and fixed networks and services.

Figure 8: Mobile network operators can use the combination of the LTE Radio Access network and the EPC mobile core network to provide Internet access and other services



Source: TNO

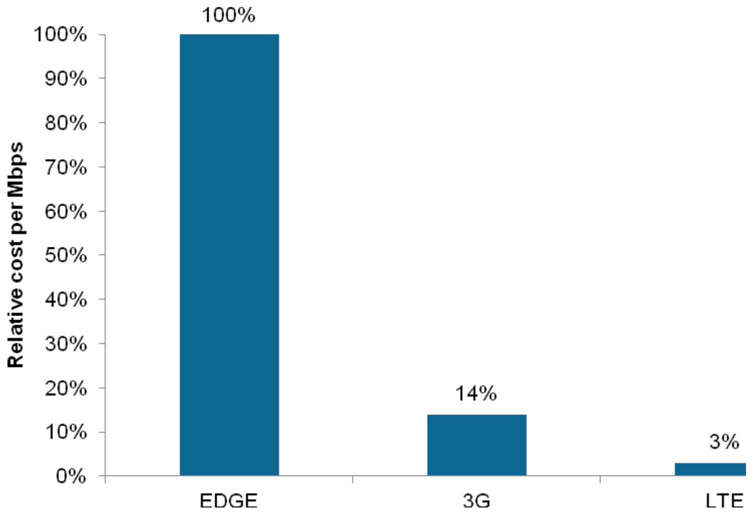
It is important to note that fast mobile data connections such as LTE increasingly depend in several ways on fast fixed networks. First, in order for mobile data users to benefit from the increased bandwidth over the radio interface, the LTE antenna sites need a high-capacity backhaul connection to the mobile core network. This will typically be a fibre connection, with microwave links as an alternative in situations where fibre connections are difficult to install or prohibitively expensive.

7 M. Cano, T. Norp and M. Popova, Satcom Access in the Evolved Packet Core, in Venkatasubramanian, N. et al (Eds.), Mobile Wireless Middleware, Operating Systems, and Applications, Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, 2012, Volume 93, Part 3, 107-118.

Second, despite the increased radio capacity offered by LTE, it will be attractive and even necessary in many situations to off-load mobile traffic to fixed (e.g., DSL, cable and fibre) networks to reduce the traffic load on the mobile network. As can already be seen today, a substantial part of the data from wireless devices (e.g., smartphones, tablets and laptops) is not carried by mobile networks, but is instead transferred to fixed broadband networks via WiFi or possibly by femtocells (see Figure 3 in Section 2). Thus, the further uptake of wireless devices and applications stimulates the development of both mobile and fixed network infrastructures, but it is also dependent on a constructive interaction between the two.

The enhancements that LTE offers in bandwidth, together with the reduced complexity of LTE networks in terms of number of components and the effort to manage them, also reduce the unit cost (unitised in regard to data carrying capacity) of operating a mobile network, as shown in Figure 9.

Figure 9: Relative total cost of ownership for the same capacity (normalised to EDGE)



Source: Booz & Co. (2009), p. 4.[8]

The importance of these progressive technological improvements has been perhaps most visible in Austria, where mobile broadband frequently represents an economic *substitute* for the fixed broadband access, rather than an economic *complement* (i.e. something that would be used in addition). The RTR, the Austrian NRA for electronic communications, has recognised this evolution by treating fixed and mobile broadband as a single market for purposes of regulatory analysis.

The roll-out of LTE in Europe has started, with commercial deployments in Germany, Sweden, Poland, Portugal and a number of additional countries. In other countries, such as Spain, France and Italy, there are no commercial LTE roll-outs at this time, but the 800 MHz band has already been auctioned. For large-scale (nationwide) LTE roll-outs, this is an important band as the 800 MHz signals can carry for long distances, and can also provide good indoor coverage compared to the relatively high frequency bands such as 2600 Mhz.

[8] Booz & Co. (2009): "LTE: Delivering the Future of Wireless", White Paper, www.booz.com/media/uploads/LTE_Delivering_Future_of_Wireless.pdf.

The pace of the roll-out is determined by the mobile operators, based on the business cases that they develop, the availability of attractive terminals (handsets) suitable for European frequency bands, and the (expected) behaviour of their competitors. In a number of countries, such as Germany, France, Italy and Spain, the licence conditions include coverage obligations for rural areas.[9] These obligations guarantee a certain specified availability of LTE in those countries, also in areas where the mobile operator business case may be negative.

3.2. Further Technical evolution to LTE-Advanced

After LTE, the evolution of mobile access network technology will continue with LTE-Advanced, starting with 3GPP Release 10. LTE-A is projected to offer a (theoretical) maximum downstream speed of 1 Gbit/s, which is a substantial increase above the 300 Mbit/s of LTE. This increase is obtained through a combination of approaches, including:

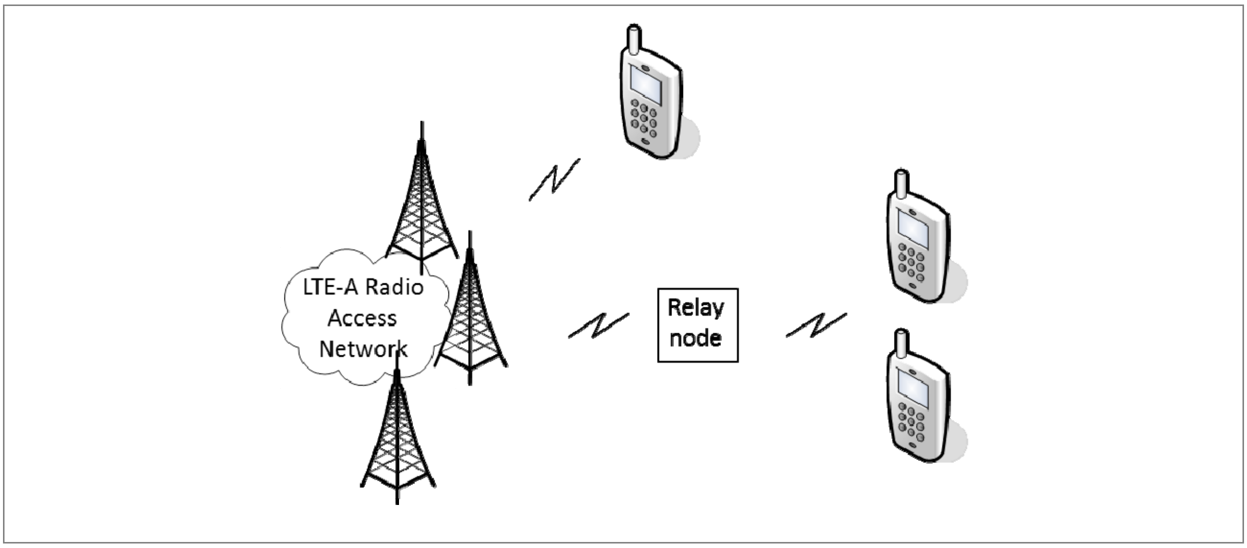
- More flexible use of available spectrum bands. LTE-A has been designed to combine spectrum from a number of bands, such as 800, 900, 1800, 2100 and 2600 MHz. The 900 and 2100 are typically used for 2G and 3G networks today, but when these networks are phased out in the future, the spectrum can be used in LTE-A networks.
- Some further improvements in spectral efficiency.
- More extensive use of MIMO (Multiple Input Multiple Output)

Similar to LTE, LTE-A access networks are designed for connection to the Evolved Packet Core (EPC). There are also a number of architectural changes in LTE-A compared to LTE:

- There is a more prominent role for femtocells. Apart from the use of more spectrum, the deployment of a larger number of smaller cells is traditionally the most powerful way to increase mobile capacity. Femtocells are small cells, typically installed in customers' homes, that connect to the mobile network over fixed broadband connections. They can be used to provide additional in-door coverage with high capacity, thus removing part of the load from the larger ("macro") cells. Removing traffic from the macro cells can also be achieved over WiFi, commonly known as WiFi offloading. The difference between femtocells and WiFi offloading is that femtocells use spectrum licenced to the mobile network operator, thus creating a more controlled environment for the offloading, while WiFi uses unlicensed spectrum.
- LTE-A has so-called relay nodes. A relay node serves as an intermediate node between the antenna in the mobile access network and the mobile terminal. The key characteristic of a relay node is that it has an LTE-A radio connection to the mobile network that serves as a backhaul. The mobile terminal connects to the relay node in the same way as it connects to a regular base station, see Figure 10. One of the benefits expected from relay nodes is the potential to provide extended LTE-A coverage at relatively low cost, for example in rural areas. The cost advantage comes from the use of LTE-A radio connections in the backhaul, which are expected to be cheaper than alternatives like fixed fiber and microwave links.

[9] LTE Spectrum and Network Strategies, Arthur D. Little, Telecom & Media Viewpoint, 2012, available at www.adl.com/LTESpectrum (accessed 14 June 2012).

Figure 10: The use of relay nodes to achieve extended mobile coverage



Source: TNO

3.3. Roaming

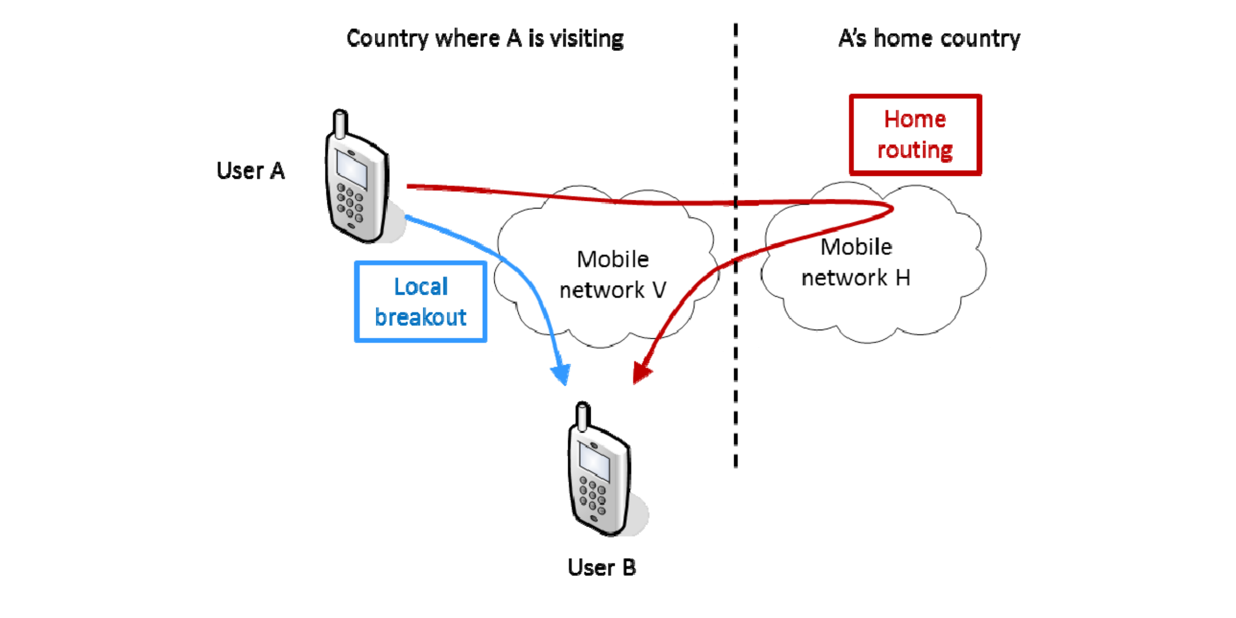
As a preparation for the discussion on roaming tariffs and regulation in later chapters of this report, this section summarises the technical arrangements for voice and data roaming that are available in the successive mobile technology generation. The focus is on a European user using his mobile phone for voice calls or to access the Internet while travelling in another European country.

Figure 11 shows voice roaming for the case of a classical circuit-switched voice call over GSM (2G) or UMTS (3G). There is an important distinction to be made between two scenarios. In the local breakout scenario,[10] indicated in blue in the figure, the visited network V originates the call to User B, much as if User A were its own customer. In the home routing scenario, indicated in red in the figure, a voice circuit is set up from the mobile network in the visited country (mobile network V) to the mobile network in the users's home country (mobile network H), even if the user is making a call to another user who is in the same country. In order to establish a connection between user A and user B, the voice circuit is extended back to a mobile network in the visited country.[11] The local breakout scenario avoids the need for the voice circuit to go from network V to network H and back in the case where the called user is in the visited country. The call is routed directly to user B without the need to leave the visited country.

[10] We are referring here to local breakout LBO as defined in UMTS standards. BEREC's use of the term LBO in documents BoR (12) 67 and BoR (12) 68 builds on the UMTS definition, both in terms of technical capabilities and business arrangements.

[11] User B is depicted here as being on the same mobile network in the visited country, but this need not be the case. For that matter, User B might be in a third country, or in the User A's home country.

Figure 11: Local breakout and Home routing scenarios for roaming for classical circuit-switched voice in 2G/3G networks



Source: TNO, based on 3GPP specifications

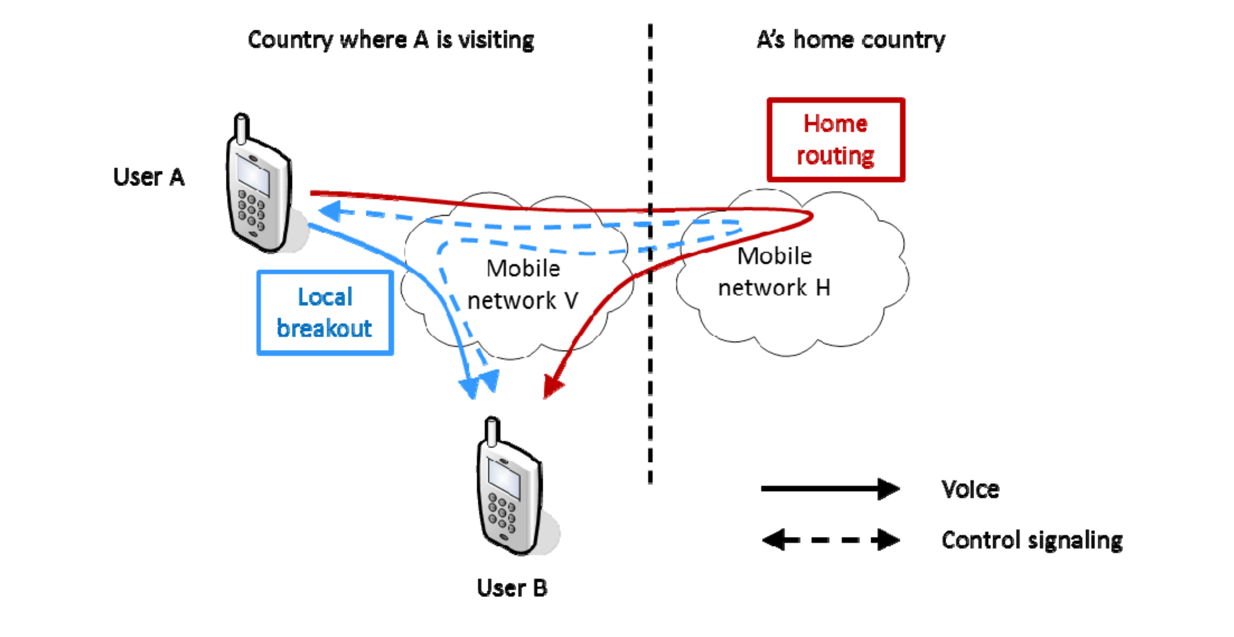
It is clear that with local breakout, the costs of the (international) connections between the visited network and the home network can be avoided. Both the local breakout and the home routing scenarios have been used for many years in international voice roaming over 2G/3G and are still in place today. Local breakout is the default approach for voice roaming, and is widely used. Home routing could be used in a number of specific situations, for example if the configuration of a pre-paid platform in the home network requires the voice circuit to pass through it. Home routing can also be found in certain "dial like home" arrangements, in which users travelling abroad can use the national numbering plan of their home country that they are familiar with, i.e., they can dial numbers from their phone's contact list without the need to add the country code, e.g. +44 for UK numbers.

In LTE, all services, including the voice service, are packet switched. Thus, circuit-switched voice no longer exists in LTE. Instead, voice is transported as Voice over LTE (VoLTE), which in essence is a Voice over IP (VoIP) service within 3GPP's IP Multimedia Subsystem (IMS). Figure 12 shows roaming for VoLTE. As in the case of 2G/3G above, the two main scenarios are the local break-out and the home routing scenario. For VoLTE, the home routing scenario is the default scenario. However, the GSM Association (GSMA) has the requirement that the routing in VoLTE roaming must be at least as optimal as in circuit-switched roaming.[12] Another GSMA requirement is that it must be possible for the charging model for circuit-switched voice roaming to be maintained in VoLTE roaming. Therefore, at the request of the GSM Association, the local breakout scenario for VoLTE roaming has also been developed and standardised. As a result, both the home routing and the local breakout scenarios are described in the IMS reference architecture,[13] bringing the desired alignment of roaming scenarios between VoLTE and circuit-switched voice.

[12] GSMA IR.65 *IMS Roaming & Interworking Guidelines*, Version 8.0, 9 May 2012.

[13] E.g. 3GPP TS 23.228 V11.4.0 (2012-03) *IP Multimedia Subsystem (IMS); Stage 2* (Release 11), 3GPP TS 23.401 V11.1.0 (2012-03), *General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access* (Release 11).

Figure 12: Local breakout and home routing roaming scenarios for VoLTE in LTE/EPC networks



Source: TNO, based on 3GPP specifications

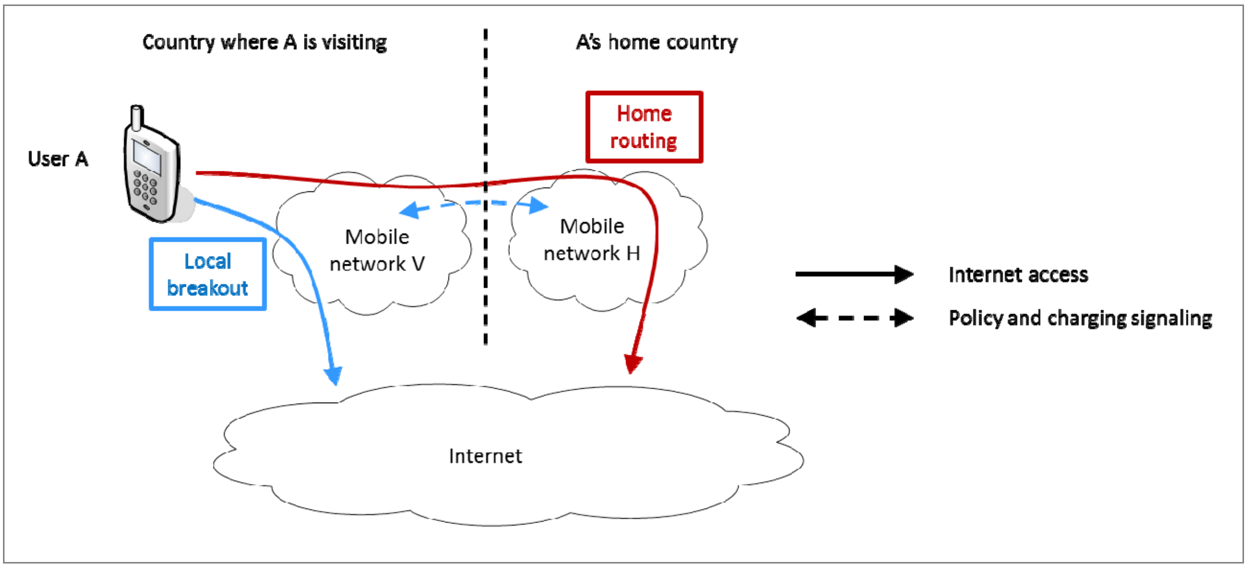
A characteristic of the VoLTE local breakout scenario is that although the voice itself only passes through the visited network, the so-called signaling messages that are used to establish the call do pass through the home network. As a result, the home operator that has the commercial relation with user A has a direct insight in the call details that are used in its retail charging: called numbers, call duration, and so on. In the widely used circuit-switched version of local breakout (Figure 11), this type of information is not directly available to the home operator, so the home operator relies on the information provided to it by the visited operator in a separate, off-line process.

Figure 13 sketches the scenarios for data roaming. Data roaming is of relevance for users who want to access the Internet while traveling abroad. Again, the standards support both the local breakout and the home routing scenarios. Generally, users are not expected to have a preference for the geographical location at which their data are transferred onto the global Internet[14]. Therefore, both scenarios are technically suitable for providing Internet access. Home routing has been the default for data roaming in 3G networks until now, and is very widely used. The local breakout scenario is also used, but less frequently. With local breakout, the costs of transferring the data to the home network and then back to the visited network can be avoided; however, we have analysed these avoided costs, and consider them to be de minimis.

[14] There can be exceptions. For example, in the local breakout scenario, user A is likely to receive an IP address from the mobile network operator in the visited country. As a result, he may no longer be able to access certain content from his home country that is protected by so-called geo blocking. Geoblocking based on IP addresses is often used to restrict the audience of streaming video services to specific countries for which the content rights have been acquired. Another example is a website where the IP address of the users is used to determing the default language settings. A German citizen traveling in Greece might thus receive a Greek language front page for a website that would appear in German at home.

In the basic local breakout scenario, the home operator bases its retail charging on the call details delivered by the visited operator in the off-line process. The 3GPP's Policy and Charging Control architecture (PCC[15]) contains the option to provide the home operator with a direct insight into the call details of roaming customers that it can use to monitor data consumption, e.g., to inform the user and block traffic when spending limits are reached. The direct insight can be obtained through the exchange of so-called usage monitoring information between the home and visited networks, denoted by the dashed blue line in Figure 13.[16]

Figure 13: Local breakout and home routing roaming scenarios for Internet access in LTE/EPC networks



Source: TNO, based on 3GPP specifications

In summary, both the home routing and the local breakout roaming scenarios are technically feasible for voice and for data, over both 2G/3G networks and over LTE. For circuit-switched voice and for data, both scenarios are also applied in practice. For LTE, it can also be expected that both scenarios will be used for voice, and also for data.

[15] 3GPP TS 23.203 V11.5.0 (2012-03) *Policy and charging control architecture* (Release 11).

[16] This information exchange would occur over the S9 interface between the home and visited PCRFs (Policy and Charging Rules Function), see TS.23.203 and GSMA IR.88 *LTE Roaming Guidelines*, Version 6.0, 31 August 2011.

4. THE IMPACT OF ROAMING ON USE OF MOBILE APPLICATIONS

KEY FINDINGS

- The great advantage of international mobile data roaming is that it works nearly everywhere, and is usually simple and problem-free.
- The great disadvantage is that international mobile data roaming can be dreadfully expensive compared to domestic use of data!
- For voice, alternatives to the Euro-tariff benefit some users, but on average tend to represent a price increase. They do not provide a general solution.
- Highly motivated consumers – business travellers, for instance – have always had work-arounds to avoid the high cost of international mobile roaming. No mass market solution to date fully addresses the high cost of international mobile roaming to normal consumers.
- Mobile applications will become increasingly important to consumers. Some are futuristic; others are increasingly commonplace and taken for granted.
- Applications such as navigation are potentially important every day when travelling.
- It would be unfortunate, and potentially costly to Europe, if high roaming prices were to make valuable applications effectively unusable for reasons of cost precisely when consumers need them most, because they are far from home.

Mobile roaming is the ability to use a mobile device in a country other than that in which the service has been obtained. The great advantage of international mobile data roaming is that it works nearly everywhere, and is usually simple and problem-free. The great disadvantage is that mobile data roaming can be dreadfully expensive compared to domestic use of data!

Highly motivated consumers – business travellers, for instance – have always had work-arounds to avoid the high cost of international mobile roaming. For instance, a business traveller who is normally in one or two foreign countries might purchase a pre-paid SIM for that country, or might even use a dual-SIM handset or a multi-IMSI SIM to simplify transition from one country to the other. None of these work-arounds are trouble-free, all involve expense and bother. No mass market solution to date fully addresses the high cost of mobile roaming.

As mobile data plays an increasingly central role in the lives of Europeans, it is a safe bet that more applications will become available by means of mobile data, and that an increasing fraction of those applications will in some sense be important – be it for commerce, health, or safety of life or property. Examples of application areas include:

- E-health, often called M-health when provided over mobile data connections. For patients, E-health applications like remote examinations and remote monitoring can be attractive as they can reduce the number of doctor and hospital visits. Apart from being more convenient for patients, there is also an expectation that E-health can contribute to more efficiency in health care. The availability of proper mobile data connections is important in E-health: if the E-health services are restricted to fixed locations, such as the patient's own home, the freedom of movement for patients tends to become restricted as well.

- Mobility and Intelligent Transport Systems. The transportation sector faces a substantial challenge to become more efficient, cleaner and safer. In Intelligent Transport Systems, applications are built that contribute to these goals. For example, based on information from user's navigation systems, roadside sensors and smart phones, dynamic traffic management systems are developed, which can feed information back into individual user's navigation systems. These applications are clearly dependent on mobile data connections.
- Remote collaboration. In remote (or "virtual") collaboration, people work together on a task or project without being in the same office. Working from home is already becoming commonplace, as it saves travel time and can also lead to higher productivity. Now that working from home is established, people take the opportunity to work from other locations as well. But virtual collaboration is not restricted to desk work. There are also many examples of remote collaborations that connect technicians in the field to subject matter experts at other locations to analyse and resolve complicated problems. Mobile data connections clearly have a role to play here.

These application areas are expected to show substantial growth in the next years. But there are already many applications and information services on the Internet today that are of direct relevance for Europeans travelling abroad, many of which depend on mobile data:

- Navigation applications, such as maps with pointers to local facilities and services, and turn-by-turn navigation. Travelling abroad almost immediately introduces a need for these types of navigation applications, as users have grown used to extensive use of navigation applications in their home country.
- Information on public transport and plane schedules.
- Online check-in services.
- Online-shopping mobile applications.
- Weather forecast services.
- Restaurant, shopping, art, music, hotel, culture, and city guide applications that complement and/or replace paper travel guides.
- Radio and TV applications that provide the consumer with the possibility to tune into their home programmes.
- Information services, typically web-based, providing explanations on consumer rights. Such information can be key to providing consumers the reassurance and trust they seek to overcome doubts they may have when purchasing products or services abroad.
- On-line translation tools, which are rapidly replacing the classical paper travel dictionaries.
- Customer support services for various types of electronic equipment.
- Internet banking, as the default way (and for many Europeans today also the only way) to keep track of credit card payments.
- E-government services, needed when making personal or business arrangements involving the local or home country authorities, e.g. in real estate or for travel documents.

If prohibitively high mobile data roaming costs were to inhibit the use of mobile data applications when a European is travelling, this is likely to negatively impact applications developers. Needed applications will not appear, or will not be adapted to European needs and interests. This risks percolating through the value chain.

Food for thought 2: High mobile roaming fees effectively make some mobile applications unavailable when travelling.

> "The Cathedral here in Palma de Mallorca is beautiful!" exclaimed Sabine. But these streets are horribly confusing. Do you know where we are, Werner?"
>
> Werner started to reach for his smart phone.
>
> "No, wait!" said Sabine excitedly. "You did that in Rome last year, it cost us nearly € 50!"
>
> "Umm, I guess you're right," said Werner sheepishly as he put his smart phone back into its case. "The price should be less than it was a year ago, thanks to the new Roaming Regulation, but probably still more than I would care to pay. What shall we do? Go back to the hotel and ask them for a map? First, we would have to find our way to the hotel."

A number of mobile operators now offer special or discounted roaming packages. These packages typically offer a flat rate for some amount of call minutes and some volume of data while roaming for a day or for a month. Used judiciously, these packages could probably reduce costs and increase certainty for consumers. BEREC data strongly suggest that the average consumer is likely to pay *more,* not less, with special voice roaming packages than with the standard EuroTariff, and the same is likely to hold true for data roaming packages.[17] They are an important development, but by no means a panacea, by no means a cure-all.

That alternative packages lead on average to higher prices is neither a market defect, nor an indication of consumer irrationality. If informed consumers are willing to pay a premium for greater predictability of their bill, or for greater flexibility, or for any other reason, policymakers should in general respect the will of the knowledgeable consumer.

Food for thought 3: Discounted roaming data packages may help, but not always.

> In the back seat of the car, Werner's young cousin was quietly listening to his favourite television programme over the Internet on his smart phone. "I have no idea how he can watch for hours on end," said Sabine, "but it's nice to be able to talk with you without interruptions."
>
> "ummm … Aunt Sabine, what does this message mean?"
>
> "Oskar, the 200 megabyte roaming data package that we bought for you was supposed to last a month! What on earth have you been doing?"

[17] Cf. BEREC Benchmark Data Report (2012), page 6.

BEREC data show unambiguously that the use of roaming data is growing rapidly. Growth in roaming traffic for Q3 and Q4 of 2011 (note that there is strong seasonal variation) is up 116% and 128% over that of the prior year, corresponding to a Compound Annual Growth Rate (CAGR) since 2008 of 63% or 58% for Q3 and Q4 respectively. These very robust growth rates are broadly consistent with the increase in mobile data traffic generally, as shown in Section 2 of this Briefing Note.[18]

When a European is travelling, his or her need for data is likely to be *more*, not *less*, than when at home. If prohibitively high mobile data roaming costs were to effectively inhibit or prevent Europeans from using mobile data while travelling, there could be real socio-economic costs to Europe. This is a Single Market issue. Potential scale economies that are being lost today would continue to be lost; consumer welfare would be directly impacted as a result; and to some degree European competitiveness would be negatively impacted relative to certain of the larger integrated areas with which we compete, including the US, China, and perhaps even India.

[18] BEREC Benchmark Data Report (2012), pages 37-38, WIK computations. The publicly released data do not appear to be sufficient to permit detailed analysis of the relationship of retail price to data consumption (demand elasticity), nor of the relationship between overall mobile data growth to roaming mobile data growth.

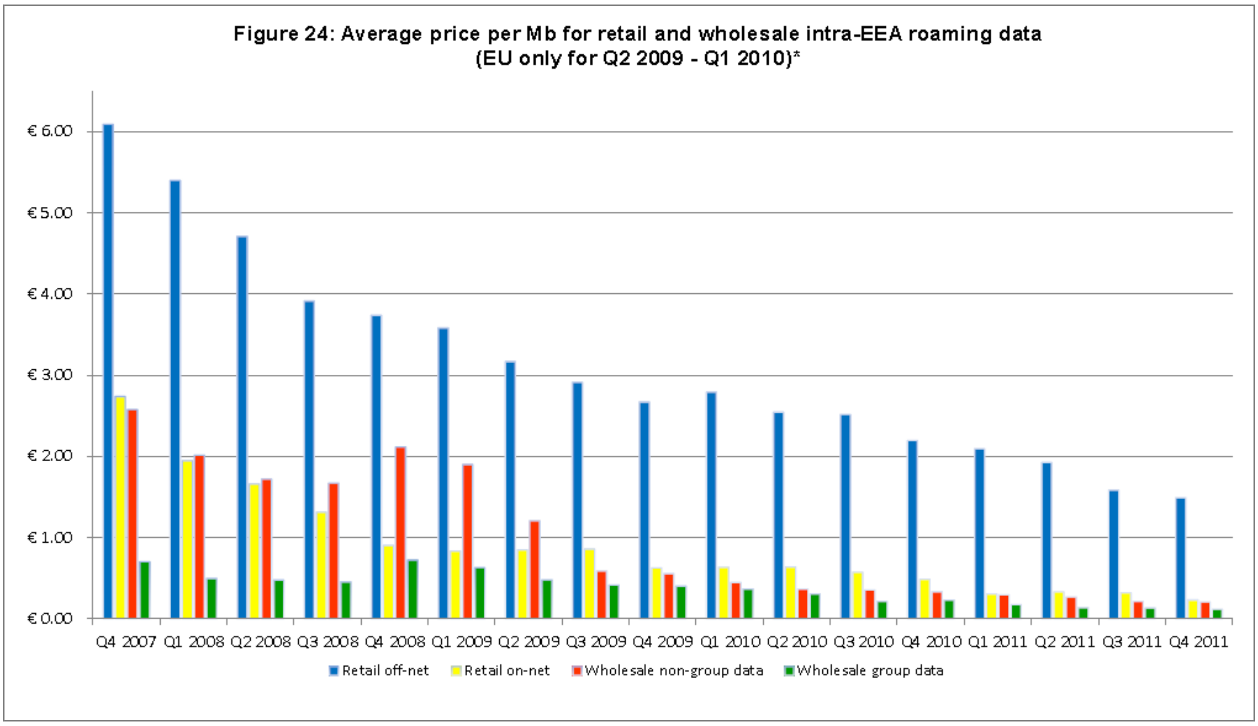
5. THE IMPLICATIONS OF THE 2012 ROAMING REGULATION

KEY FINDINGS

- The new Roaming Regulation seeks for the first time to address high prices for mobile data roaming by imposing retail price controls as of 1 July 2012.
- These will presumably be effective, but still imply data roaming prices that are much higher than domestic data prices, and that are thus probably still high enough to depress many forms of data usage.
- The Roaming Regulation of 2012 also includes structural measures that seek to establish competition for roaming, with the goal of achieving lower prices without regulation.
- BEREC has just released consultation guidance; thus, it is now possible to comment on two concrete proposals that appear to be actionable.
- Our feeling is that the first of BEREC's proposals, "Single IMSI", may possibly lower the "spread" between wholesale costs and retail prices, but does not represent a radical break.
- The second BEREC proposal, Local Break-out (LBO), is modest in and of itself but might be effective if combined with complementary measures.

As was previously noted, mobile data roaming can be dreadfully expensive. The BEREC has been collecting data on roaming since the first Roaming Regulation was implemented in 2007. These data demonstrate that not only is mobile data roaming expensive in comparison with domestic prices, but it is also remarkably expensive in comparison with wholesale prices for mobile data roaming, i.e. its *retail price* is hugely in excess of its *wholesale cost*.

Figure 14: Average price per MB for retail and wholesale intra-EEA roaming data



Source: BEREC, May 2012

Note, too, that retail off-net prices (prices where the visited network is not part of the same corporate group as the home network) are far higher than retail prices than on-net (where home and visited networks are in the same corporate family). This cannot be solely a result of wholesale payments between the *Mobile Network Operators (MNOs)*.

5.1. Retail and wholesale price controls on mobile data roaming

The Roaming Regulations of 2007 and 2009 have established caps at both wholesale and retail levels for both voice and (later) SMS; for data, however, the 2009 Regulation established an advisory cap only at wholesale level. Wholesale prices have declined to levels well below those of the cap, in sharp distinction to voice and SMS (where wholesale IOT charges are only marginally less than the regulated cap). Nonetheless, as some critics feared, retail prices remain greatly in excess of wholesale. The caps to date may have had some effect on how profits are distributed among MNOs, but they have perhaps done little to prevent egregiously high prices on the part of the MNOs.[19]

The new 2012 Roaming Regulation that comes into force on 1 July 2012 will for the first time establish caps on retail pricing for mobile data roaming. This will mitigate somewhat the problem with high prices for roaming data, but should by no means eliminate concerns.

[19] An argument could, however, perhaps be made that even these high prices are an appropriate and welfare-enhancing manifestation of Ramsey-Boiteux pricing.

Table 2: Wholesale and retail price caps for mobile roaming data under the proposed new Roaming Regulation

	Current	1 July 2012	1 July 2013	1 July 2014
Retail price cap per MB (excluding VAT)	None	€ 0,70	€ 0,45	€ 0,20
Wholesale price cap per MB	€ 0,50	€ 0,25	€ 0,15	€ 0,05

Source: WIK, based on materials published by the Commission

Under the new rules, consumers will receive information about roaming charges not only when they travel EU/EFTA countries (as is already required today), but also when they travel to countries outside the EU/EFTA. This should help them to avoid "bill shocks" when using their smart device outside the EU. As from 1 July 2012, people travelling outside the EU are to receive a warning text message, email or pop-up window when they are nearing €50 of data downloads, or their pre-agreed level. Consumers will have to confirm they are happy to go over this level in order to continue their data roaming.

5.2. Opening networks up to resellers

The new 2012 Roaming Regulation also seeks to address the high cost of roaming at its source by opening up the networks to virtual operators and resellers. For reasons that we explain shortly, it is difficult to judge at this point whether these provisions will be effective. Key provisions of the Roaming Regulation[20] include:

- From 1 July 2014, customers will have the option to sign up with an Alternative Roaming Provider (ARP), which may be different from their domestic mobile provider, for a separate mobile contract for roaming whilst keeping the same phone number.
- MVNOs and resellers will have the right to access other EU/EFTA mobile network operators' networks at regulated wholesale prices in order to provide roaming services (together with national services) to their customers.
- Neither domestic nor roaming providers shall prevent customers from accessing regulated data roaming services provided directly on a visited network by an alternative roaming provider. In other words, providers in a visited Member State cannot be prevented from offering data roaming services to consumers with a subscription in a different Member State.

BEREC has been tasked with establishing guidelines as to how all of this should work. In documents BoR (12) 67 and BoR (12) 68, they have described two basic mechanisms:

- A “Single IMSI” solution in which the subscriber has a single network identity. The Home Network (HN) resells its roaming capabilities, including its roaming arrangements, to resellers or MVNOs.
- A “Local Break-out (LBO)” solution with local provision of data services (but not voice or SMS) directly by a visited network operator.

BEREC advocates implementation of both solutions, but in rather basic versions, in order to have capabilities available covering voice, SMS and data by July 2014 as required by the Regulation.

5.3. Likely effects of the Roaming Regulation of 2012

The new retail price caps on mobile data will generate immediate reductions in the price of off-net mobile roaming data. This will somewhat ameliorate the concerns raised in Section 4 of the Long Briefing Note.

The maximum permissible retail price of € 0.20 per MB in 2014 is four times higher than the maximum permissible wholesale price of € 0.05. Experience suggests that off-net retail prices are unlikely to be much lower than the price cap. This price, even though an order of magnitude lower than today’s prices, is still likely to be high enough to deter usage below desirable levels.

Based on BEREC data provided in the Commission’s 2011 Impact Assessment of the proposed roaming regulation of 2012,[21] roughly 300 million MB of roaming data were consumed in 2009. At an average retail price of € 1,77 per MB, this comes to some € 530 million for intra-EU/EFTA traffic in 2009. Based on the rates of traffic growth identified in BEREC document, we can assume that 400 million MB of intra-EU/EFTA roaming data were consumed in 2010, and 900 million MB in 2011. Extrapolating forward at the present rate of growth of mobile roaming data traffic of roughly 60% per year, one can expect nearly six thousand million MB of intra-EU/EFTA data in 2015, and 9,5 thousand million in 2016. If all were charged at the regulated European maximum retail charge of € 0,20, this represents € 1,1 thousand million in 2015, and € 1,9 thousand million in 2015. The rate of traffic growth is somewhat faster than the regulated rate at which prices are declining.[22] Unless the ARP or data roaming services provisions prove to be effective, the aggregate cost of mobile data roaming to Europeans is likely to increase over the next few years. The mobile data roaming issue is unlikely to go away solely as a result of price regulation.

At the same time, we would caution against a simplistic interpretation of these estimates. For consumers to pay more in aggregate is not necessarily a defect if they receive far more service in return for those payments. Further, any comparison to domestic prices is difficult – it is quite likely that pure flat rate retail domestic packages that include data will be phased out over the next few years, a development that is already visible in the United States. The real question, as already noted, is whether retail prices for mobile data roaming will continue to be high enough to inhibit the use of mobile data services in comparison with domestic use. That will need to be watched carefully over the years to come.

As a practical example of the effects of the Roaming Regulation, consider once again the use of navigation applications. Within one's own Member State, the cost of data for an application such as Google Maps is often effectively included within a data flat rate; if not, it is still small enough that the consumer typically does not notice it. When roaming in another EU Member State in 2011, with average prices of roughly €1,60 per off-net MB, it was a different story – it was not unusual for a consumer to be stunned to receive a bill of €50 or more for an activity that seemed quite trivial at the time.

Today, with the Roaming Regulation of 2012 in place, that charge of €50 falls to €22, €14, or €6, respectively, after July 1 of 2012, 2013, and 2014. This represents very substantial progress, and makes the use of basic applications far more practical when roaming than they are today; nonetheless, the price (together with *uncertainty* regarding the price) is likely to depress use somewhat, even for basic applications.

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[20] See particularly Articles 3, 4, and 5.

[21] European Commission (2011), see page 85. They found that 276 million MB were consumed in EU Member States, ignoring Austria, Ireland, Denmark, Luxembourg, and Sweden due to data quality issues.

[22] This analysis glosses over many details. We use BEREC’s 3Q growth rates for 2009, 2010, and 2011. Traffic growth is not independent of price; lower prices would tend to lead to a faster increase the volume of traffic due to *demand elasticity*. Also, while the price for off-net (i.e. non-group) traffic is likely to be close to the regulated cap (unless the structural solutions are effective), on-net prices may be less than the regulated cap.

Video and more complex services are particularly unlikely to be used as much as they deserve to be used while roaming if the off-net price to the consumer remains at these levels.

Continued use of the transparency features of the Regulation will ameliorate consumer concerns with "bill shock", but consumer response is nonetheless likely to lag the introduction of lower prices for mobile data roaming until consumers gain confidence with the new price structures.

The unbundling option that provides consumers with a choice of a visited network data provider seeks to generate enhanced competition in mobile roaming, ideally resulting in lower prices, and greater usage of the roaming service. Even assuming widespread and successful implementation, it is not clear that a sufficient number of consumers will adopt this service. A key reason why there is a problem with mobile roaming in the first place is that consumers seem to appreciate being able to buy a full bundle of mobile services from one provider, and they base their decision primarily on features, handset support, and domestic pricing – not on the price of mobile roaming.

Business users (who travel frequently) have always had ways to get around high roaming costs, and have made some use of them; for most consumers, however, the available work-arounds have been more trouble than they were worth. If the resale capabilities serve only to provide yet another option to those who already have options, their effect might well be limited.

BEREC itself has expressed doubts. "BEREC considered that while the policy of decoupling represents a clear attempt to stimulate much more intense retail competition for the benefit of end users, there are no guarantees that it will work well in practice. The reasons for caution identified by BEREC in its earlier papers remain equally valid today."[23]

Our assessment is that the Single IMSI solution is not a "game changer". Crucial objectives of the new Roaming Regulation were to institute structural mechanisms that would in time obviate the need for regulation, and would drive roaming prices close to those of domestic services (i.e. "roam like at home"). Single IMSI, in and of itself, does neither of these. Since the reseller or MVNO depends on the HN to implement the roaming service through its wholesale arrangements with other MNOs, it is difficult to see how the wholesale price to the HN could ever fall below the maximum price that the HN has to pay, namely the IOT. Key observations are:

- Single IMSI cannot eliminate the need for regulation, except ideally at retail level. Indeed, Single IMSI crucially depends on regulation at wholesale level.
- Single IMSI appears to do nothing to contain wholesale prices.
- Single IMSI could have a positive impact by introducing competition at retail level, thus reducing the mark-up of retail price above the wholesale IOT. For data, this has been a serious problem, so this positive might prove to be important. At the same time, the imposition of retail price controls on mobile data roaming has just been put in place, and addresses the same problem. Whether the Single IMSI solution provides substantial additional benefits commensurate with its cost of implementation remains to be seen.

[23] BEREC document BoR (12) 68.

The data-only Local Break-out (LBO) option appears to be more promising, particularly in the context of the e-commerce issues that are at the core of this study. The proposal as drafted by BEREC seems to be rather limited in scope; however, our feeling is that, combined with complementary initiatives, and used in creative ways by providers of LBO services, it is conceivable that LBO might ultimately re-shape roaming in Europe (and perhaps beyond). We explain at length in the next chapter.

6. ADDRESSING DATA ROAMING CHALLENGES GOING FORWARD

KEY FINDINGS

- Implementation of "Roam like at home" would imply substantial challenges. It is hard to see how prices to the user could be constant when costs in the various Member States are not.
- A "Roam like a native" solution seems to be more sustainable in a Europe where underlying costs will continue to differ among the Member States.
- We are not convinced that the "single IMSI" envisioned in BEREC's proposed implementation guidelines for the 2012 Roaming Regulation would have much effect.
- The "Local Break-out (LBO)" that appears in the same BEREC proposed guidelines could be truly promising if supported by complementary measures, and innovative business practices. Potentially complementary initiatives could include (1) moves by service aggregators or by smaller, aggressive MNOs to pool packages of offers together that span multiple Member States; and (2) regulatory initiatives to strengthen the ability of users to invoke Voice over IP (VoIP) in the handset, possibly coupled with initiatives from LBO service providers to actively support VoIP.

It is clear that the growth of mobile data holds great promise for Europe. It is equally clear that continuing mobile data roaming challenges could potentially impede Europe's ability to benefit from mobile data as it should.

We consider it more likely than not that mobile roaming, including mobile data roaming, will continue to be a problem going forward. In WIK's 2010 study of mobile roaming for the European Commission,[24] we considered various structural solutions, but did not identify any that we considered to be workable and effective (including the MVNO-like separation that the Commission subsequently put forward). At the risk of painting a gloomy picture:

- We found no "silver bullet" in 2010 that would provide a long term solution to the challenge of mobile roaming.
- Implementation of "Roam like at home" would imply substantial challenges. It is hard to see how prices to the user could be constant when costs in the various Member States are not.
- We are not convinced that the "single IMSI" envisioned in BEREC's proposed implementation guidelines for the 2012 Roaming Regulation would have much effect.
- The "Local Break-out (LBO)" that appears in the same BEREC proposed guidelines could however be truly promising if supported by complementary measures, and innovative business practices.

[24] WIK (2010), "Options for addressing competition problems in the EU roaming market".

6.1. General observations on "roam like at home"

It is worth noting that mobile roaming challenges have been addressed in other regions, and in at least one instance the solution has proven to be durable. In 1996, *domestic* roaming in the United States represented 14% of all mobile revenues – far more than international roaming in Europe represents today. This was solved, not by a regulatory intervention, but rather by unilateral action on the part of one disruptive market player. AT&T Wireless (the recently acquired McCaw) offered Digital OneRate, a flat rate bundle with nationwide coverage including calls to all domestic networks, a large number of minutes, and no domestic roaming charges. This popular offer enabled AT&T Wireless to rapidly gain market share at the expense of its competitors. Domestic roaming charges practically disappeared in just a few years. AT&T's unilateral move forced competitors, even large competitors, to complete their own national footprint through mergers and alliances in order to compete. In other words, it forced the emergence of pan-US mobile operators, much as we are seeking to foster the emergence of pan-European networks.[25]

In Europe to date, we have not witnessed the emergence of an MNO group that simultaneously has both (1) a network presence in a sufficiently large number of Member States, and (2) the willingness to embark on a path that potentially disrupts existing arrangements to that degree.[26]

Indeed, a tension is visible in European policy. The Framework Directive calls on Member State NRAs to "…contribute to the development of the internal market by … encouraging the establishment and development of trans-European networks and the interoperability of pan-European services …" Concretely, however, when Vodafone merged with Mannesmann (Germany) in 2000, the Commission restricted the ability of the merged entity to offer European roaming packages.[27] Clearly, there is (or was) a tension between competition policy objectives and electronic communications regulatory objectives.

This issue of a (nearly) Europe-wide network presence may bear some clarification. A stated goal of European policy is to achieve "roam like at home" – a price for mobile roaming that is no different than that for normal domestic services. This implies substantially uniform ***prices*** throughout Europe, which cannot be achieved without also achieving substantially uniform ***costs***.

In the US, Digital OneRate clearly achieved altogether uniform prices, but AT&T Wireless had its own network with nationwide coverage. It confronted only its own true costs, not the wholesale charges imposed by other operators. This is important, in the sense that the interests of MNOs are not aligned – there is a tendency for both home and visited network operators to take high mark-ups, thus introducing an economic failure known as *dual marginalisation*.[28] Dual marginalisation tends to result in prices to end users that can be even higher than the level that would be preferred by an integrated monopolist, and can depress usage to highly inefficient levels (which is exactly our concern about the effect that mobile data roaming charges could have on e-commerce).

[25] J. Scott Marcus, "Call Termination Fees: The U.S. in global perspective", 4th ZEW Conference on the Economics of Information and Communication Technologies, Mannheim, Germany, July 2004. Available at: ftp://ftp.zew.de/pub/zew-docs/div/IKT04/Paper_Marcus_Parallel_Session.pdf.

[26] It is also worth noting that US wholesale arrangements typically result in an MTR of zero among MNOs, which greatly facilitated the implementation of Digital OneRate.

[27] See the notification of 14 January 2000 to Case No COMP/M. 1795 Vodafone Airtouch/Mannesmann.

[28] Dual marginalisation occurs when two monopolists in vertically related market segments both try to take a monopoly mark-up. The consumer sees the combined effect of both mark-ups. The very high prices that result can depress usage to levels even below those that a unitary monopolist would prefer.

This implies that a pan-European network offering roaming service at the same price as domestic mobile service is unlikely to appear until at least one MNO confronts costs across all, or substantially all, Member States that are not significantly different from those which a domestic MNO confronts. But that has an important implication as well, and one that has not been generally appreciated: At that point, ***the roaming service would not compete just with other roaming services; it would compete head to head with all domestic mobile services as well.***[29]

In other words, if "roam like at home" were ever to be fully implemented, "roam ***while*** at home" would become cost-effective.

This implies in turn that, if one were to attempt to achieve "roam like at home" by means of wholesale arrangements, great care would need to be taken in setting the wholesale prices for roaming MVNOs or resellers. If they were set too low, they could encourage inefficient entry and inefficient competition by MVNOs that may not even have invested in infrastructure in the country in question; however, if set too high, the MVNO alternative provider of roaming service will not succeed. This is not a fundamentally different problem from the setting of access prices for fixed networks, but it is possible that considerable complexity lurks beneath the surface.

These concerns are not relevant to either of the primary BEREC proposals. Single IMSI does not appear to come remotely close to achieving "roam like at home"; Local Break-out potentially leads to prices similar to those of domestic services in the visited Member State, and thus avoids the arbitrage risk and potential problems of wholesale/retail mis-match that would flow from "roam like at home".

6.2. "Roam like a native"

The Local Break-Out option presented in the BEREC proposed guidelines does not seek to achieve "roam like at home"; rather, it seeks to achieve, or at least approach, prices that are typical for domestic service in the Visited Member State. We would characterise this as "roaming like a native" of the visited Member State.

There are reasons why this might be effective. One economic perspective is that the presence of high mark-ups both at wholesale and retail contributes strongly to high roaming prices. Economists speak of *double marginalisation* – where two firms with pricing power operate in vertically related market segments, the combined effect of two large mark-ups results in a price to the end-user that exceeds even the price that an informed monopolist would choose. It suppresses demand to an extent that is inefficient both for the consumer and for the producer. The LBO solution completely removes the Home Network from the value chain for data roaming, thus solving the double marginalisation problem.

That might not be enough to result in prices at the level of domestic prices in the Visited Member State, but it is a good start. Some additional mark-up over domestic prices may be appropriate, since the LBO service provider has additional costs and (at least initially) substantial additional risk in comparison to a conventional domestic provider.

Prices at the level typical for the Visited Member State could reflect legitimate differences that exist among costs in each Member State. This is economically rational, and reduces the risk of unwelcome arbitrage.

[29] This is, of course, visible in the United States. Domestic roaming is no longer distinguished to any great degree from normal domestic service. The consumer is usually not even aware of the distinction.

In our 2010 study for the Commission, two concerns were identified with setting prices at the level of the Visited Member State. The first is that consumers would have to understand individual price structures in each Member State that they visited. A second related concern is that they would have to educate themselves about arrangements in each visited Member State, and develop confidence in a service provider in each Member State. These concerns are in principle fully relevant to the LBO service – if LBO services were sold no differently than visited country SIMs are sold to vacationers in airports and train stations today, then take-up would likely be no greater than that of SIMs by vacationers today.

These are clearly challenges, but upon reflection we see the potential of market players creatively addressing these challenges. Aggregators of services might for instance resell services in multiple Member States, providing something approaching one-stop shopping and offering their own assurances of quality. Some of the smaller MNOs, especially those that are data-centric and those that operate in multiple Member States, might form alliances in order to offer roaming packages with business terms that were somewhat harmonised.

The BEREC consultation documents raise a number of valid concerns about configuration complexity. Again, these problems are probably not insurmountable. The LBO service provider could offer a downloadable application at the time that the service is procured, for instance.

Once the doors are open to LBO offers, market players ought to be able to find solutions.

The immediate concern as regards LBO is that it addresses data roaming, but leaves voice and SMS roaming unchanged. Our focus in this Briefing Note is on data, not on voice, but even this problem would not appear to be insurmountable.

Voice over IP has always been technically feasible on sufficiently intelligent handsets, but mobile operators have often put price or non-price barriers in the way of its use. This has long been recognised as a network neutrality challenge – one of the few that might be serious enough to warrant a tailored remedy.

Voice over IP is widely used over WiFi in order to bypass high mobile roaming charges. Many travellers use VoIP, even relatively unsophisticated travellers. This is an excellent solution for one's hotel room; however, it has not been practical when one is walking down the street.

If roaming data were available at prices approaching those that are typical of domestic services, then VoIP over the mobile data service becomes much more interesting. Under current technology, this is an imperfect solution, because the latency of the wireless connection is too great.

This could become much less problematic over time. Voice should be easy to solve once LTE deploys. In an LTE network, the voice is carried over IP in any case; thus, a technical solution to enable VoIP over the LBO service becomes relatively easy at a technical level. Equally important, LTE's improved latency characteristics make VoIP far more attractive over LTE than it is over current mobile technology.

Food for thought 4: There are opportunities for market players to turn BEREC's Local Break-Out (LBO) into an effective option.

"Goodness, Werner, is that what came in the package today? Why do you need another smart phone? You already have a smart phone!"

"Sabine, this is not just any smart phone. It is provided – at a good price, by the way – preconfigured to make it easy for us to use inexpensive data services in five of the countries where we most often vacation."

"Will it be hard to use, Werner?"

"I don't think so. It uses the same operating system as my other smart phone, but it's supposed to do all of the set-up for me when I want to use data roaming."

"Oh! Well, OK for data. Maybe we can let Oskar use it the next time he wants to watch television over the Internet when we're on vacation. But how am I supposed to reach you if you're away on a business trip? How do I call?"

"No problem! I just pop the SIM from my old handset into this one, and boom! I have the same phone number I always had. For you, the call is charged just a local call, like always."

"But you still pay for receiving the call?"

"Well, yes. No worse than today. But the handset comes with VoIP software pre-installed, Skype I think, so for a longer call I can call you back."

"It can't really be that easy, can it?"

"Well, maybe not. The devil is in the detail. But let's give it a try."

6.3. Concluding thoughts

The roaming problem has been challenging and seemingly intractable for a long time. One should not expect it to be "solved" overnight.

We think that it is much too early to suggest that LBO offers a comprehensive solution, but it is the first option in a long time that seems to offer the possibility of a real break with the past. There may be a tendency to under-rate LBO, inasmuch as it is a data-only solution; however, for reasons that this briefing note has hopefully made clear, a data-centric solution is likely to look better and better with each passing year. The economic properties of LBO could prove to be markedly better than other approaches we have seen.

With that in mind, we offer the following recommendations to the European institutions:

- Ensure proper implementation of the Roaming Regulation of 2012.
- Maintain contact with market players so as to minimise any policy impediments to innovative offers that might effectively give force to the Local Break-Out (LBO) solution.
- Be alert to any opportunities for a disruptive player to establish a pan-European presence, and if so weigh carefully the balance between competition issues and regulatory policy issues.
- Monitor the ongoing evolution over time of mobile data services to see if any blockages develop (or remain).

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