Analysis on the Profitability of Mobile Broadband Flat Rates

Mª Ángeles Martínez Fernández (dragon@tid.es), Laura Mateo Quero (lmq@tid.es), Santiago Andrés Azcoitia (sandres@tid.es)

Department of Network Techno-Economic and Regulatory Analysis

Telefónica I+D, Madrid, Spain

***Abstract*— Data traffic flat rates are becoming increasingly popular among mobile users. Comfortable for the users, they contributed to popularize fixed broadband and recently, with the help of new versatile handsets, they are expected to boost data traffic in mobile networks. Moreover, fixed to mobile broadband substitution phenomenon is also taking place once flat rates have been introduced in the market. Nevertheless, there are significant differences between fixed and mobile networks in terms of cost sensitivity to traffic. Should mobile operators be worried about the long term profitability of these flat rates? Cost modeling is used to measure this sensitivity and to find out that mobile networks are much more cost sensitive to traffic than fixed networks, discussion is made on how fixed mobile substitution and continuous increment of data traffic in the network may impact in network cost and flat rate margins and measures that operators might take to protect against it are proposed and analyzed.**

***Index Terms*— Cost modeling, mobile broadband, flat rate**

I. Introduction

CURRENT use of mobile data services such as Internet access, instant messaging, email or multimedia is increasing significantly worldwide. This growth can be attributed to several factors, including faster network link speeds, the implementation of new technology, availability of user friendly handsets, the development of new and more sophisticated applications and services or an increase in the number of mobile clients. However, fall in prices and the introduction of flat rates in mobile broadband that have been recently experienced seem to be the main reasons for this global growth.

As mobile data use grows, subscribers expect to receive mobile broadband services at prices and speeds which are similar to a fixed broadband connection that they are already used to. In some cases, fixed broadband substitution for mobile has been detected and is commercially powered by some operators. If mobile operators want to continue being competitive, not only should they provide greater capacity in their networks but also, they need to reduce their data tariffs or, even, offer a flat rate. And all of this has to be achieved without losing their current profits.

Charging for traffic introduces incentives to save in data traffic both for service developers and customers. These incentives are not present in flat rate services which lead to heavier usage profiles. In the past, the use of flat rates in fixed broadband showed that this type of tariff encourage customers to use as well as service providers to develop more data services. A similar massive growth in data traffic is expected in mobile networks if flat rates become popular. Moreover, a progressive substitution of fixed lines to mobile ones can take place as it is pointed out in Figure 1. In fact, in the early stages of mobile broadband flat rate introduction, it is reported that most of the data traffic in UMTS networks is originated in laptops rather than in smartphones, by customers with usage profile closer to ADSL medium / light users.

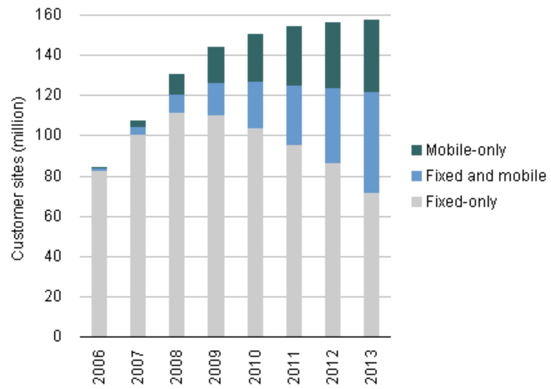

Fig 1. Broadband equipped sites in Europe, split into fixed only, fixed and mobile, and mobile-only, 2006-2013 by Analysys Mason. [1]

Forecasts about how data traffic in mobile networks is going to evolve in the following years show a strong growth, as it can be appreciated in Figure 2.

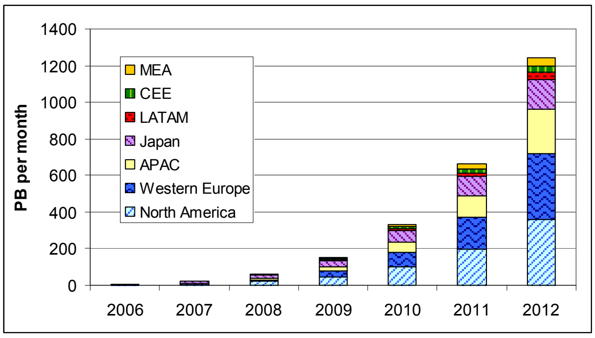

Fig. 2. Forecast of mobile data traffic by Cisco Systems [2]. Cisco projects a very strong growth for mobile data from 2007 to 2012, where traffic will roughly double every year.

It has to be noticed that fixed and mobile networks have different cost sensitivity to traffic. Mobile network cost is much more sensitive to traffic than fixed network cost. In this paper, a cost model is used to build an efficient mobile network, calculate its cost and measure sensitivity of this cost to increments in demand, in order to analyze the growth of traffic, inherent to flat rate schemes, that operator is able to tolerate maintaining a reasonable margin of benefits.

The paper is structured as follows; the second section exposes the cost model that has been developed in order to study the traffic sensitivity. The third section makes a comparison between the cost structure of fixed and mobile operators. The fourth section analyzes the cost sensitivity to traffic in the radio access network. The fifth section shows the behavior of margins with an increment of the number of users and the traffic consumed per user. The sixth section studies what would happen if fixed broadband is substituted for mobile broadband. The last section presents the conclusions of the study.

II. Cost Model

In order to study the cost structure of fixed and mobile operators, bottom-up long run incremental cost (LRIC) scorched earth cost models have been implemented for both fixed and mobile operators. Planning exercise has been done for a hypothetical national incumbent operator, taking into account public Spanish geographic and population data.

Specifically, a LRIC bottom-up cost model is a techno-economic model that determines the costs associated to a theoretical network that would be necessary to develop in order to provide certain services according to an expected demand. It is supposed that the operator uses the best technology available at the best price and that it is not affected by past decisions.

The structure of the model is shown in Figure 3:

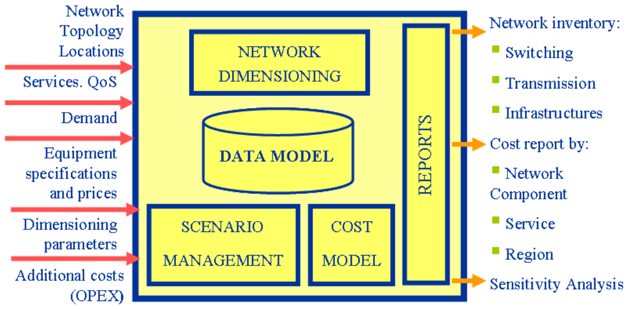

Fig. 3. Cost model structure

The following assumptions are taken:

- Fixed and mobile operator offers voice, videoconference and data services.
- Reference demand is for main Spanish mobile operators in 2007. [3], considering both UMTS R99 and HSPA demand.
- UMTS radio network deployment for the main cities in the country in the 2100 MHz band.
- Single failure link/node protection considered.
- Typical dimensioning and QoS parameters.

As a result the model generates the following reports for a given scenario:

- Network inventory.
- CAPEX per network element for a greenfield deployment.
- Annualized cost per network element considering typical asset life parameters.
- Annualized cost per service, by allocating network element cost among services using causal cost drivers based on the usage that each service does of each network element.

Different simulations have been processed in order to measure the sensitivity of the network cost to increasing data traffic demand.

Network has been divided in different parts, as it is shown in Figure 4, in order to study the sensitivity of each of them to the increment in demand. The following parts have been considered:

- Customer Premises Equipment (CPE)
- Access Network
- Access Node
- Backhaul
- Backbone & Interconnection
- Service Platforms

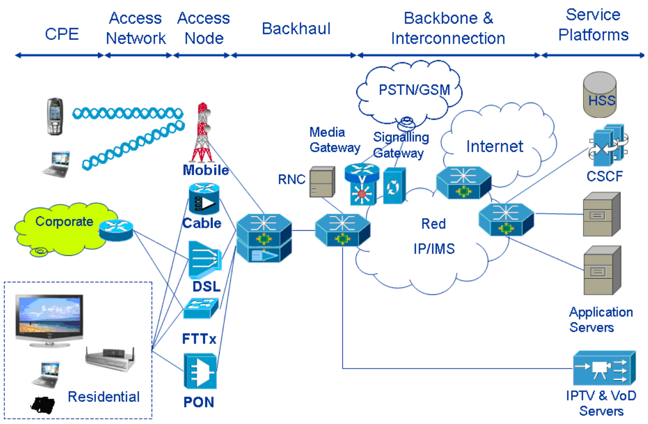

Fig. 4. Different network segments considered by the cost model.

III. Network Cost of Fixed Operators vs Mobile Operators

There are significant differences in cost structure by network element between fixed and mobile operators. Fundamentally, cost sensitivity of radio access network to increments in demand is high whereas fixed access cost is almost constant regardless of network usage by the customers. In order to provide a deeper insight on this, cost models as described in the former section have been built for both fixed and mobile incumbent operators. Figures 5 and 6 show CAPEX structure by network element for both cases, supposing networks are efficiently built from scratch.

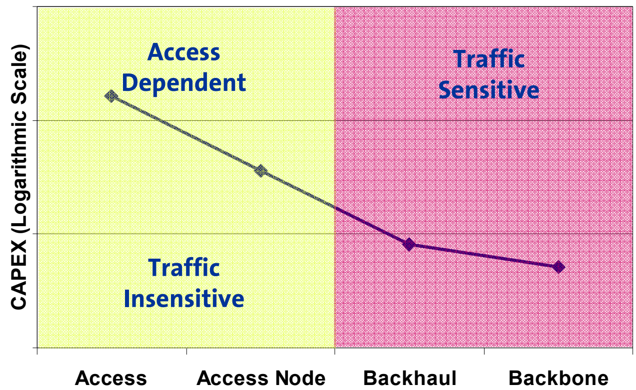

Fig 5. CAPEX structure for different network elements for a theoretical efficient fixed incumbent operator. Please note that CAPEX scale is logarithmic. Horizontal lines show x10 scale (see [4])

Suppose a fixed operator which owns a network dimensioned to cope with a certain demand. If this demand duplicates over a year due to heavier usage by customers, this fixed operator will not need to invest in additional access infrastructure (as long as demand do not exceed fixed access capabilities), but only in the backhaul, backbone, interconnection and service platforms. In this case the most important part of the network cost (access infrastructure & access nodes) remains constant. Thus, it is reasonably easy for a fixed operator to satisfy an increasing bandwidth demand of the end users by investing in backhaul and backbone infrastructure, as long as access infrastructure do not pose a bottleneck and forces a costly upgrade as it is currently being the case of worldwide FTTx deployments.

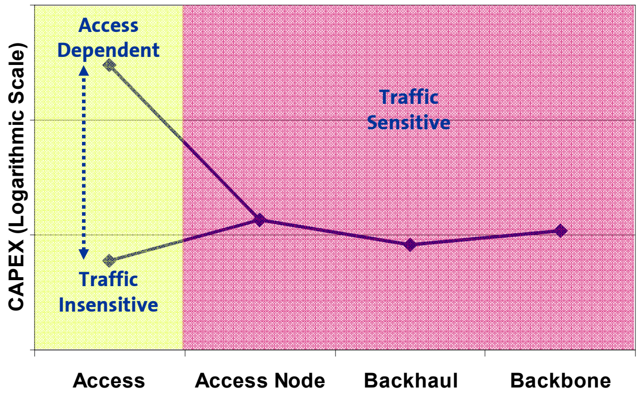

Fig 6. CAPEX structure for different network elements for a theoretical mobile operator. Access cost depends on the country (cost of UMTS licenses and spectrum usage charges). Please note that CAPEX scale is logarithmic. Horizontal lines show x10 scale.

On the other hand, let us suppose a mobile operator which owns a network dimensioned to cope with a certain demand. If this demand duplicates over a year due to heavier usage by the customers, this mobile operator will report that base stations cannot cope with the increasing demand. In this case the operator has at least the following choices:

a. Add carriers to existing GSM or UMTS base station, which is the cheapest solution as long as there is free spectrum.
b. Add new access nodes (for instance, use microcells in locations with highest traffic density) in order to increment the capacity of the radio access network. In this case, new sites would be necessary to locate new access nodes.
c. Maintain access network infrastructure and degrade QoS (percentage of lost calls/sessions, effective bit rate per user) which may eventually increase churning and affect the operator income statement.

As a result, typically a mobile operator has much more CAPEX sensitivity to increments in demand than a fixed operator. Could this sensitivity affect margins of flat rates supposing the operator invest to maintain QoS?

IV. Radio Access Network Cost Sensitivity to Traffic

In order to show cost sensitivity of radio access network to traffic, an exercise using an UMTS LRIC cost model has been performed, with the assumptions summarized in section II. Afterwards, some alternatives for operators to reduce this cost sensitivity are given.

A. *Measuring Cost Sensitivity*

To measure radio access network cost sensitivity to increments in demand the cost model described in section II has been applied to a 3G mobile operator for a country like Spain. The operator's network is deployed on a geographical area that has been divided into five types according to population:

- Dense urban, for areas with more than 700K inhabitants. Trisector base stations are used in these areas.
- Urban, for areas with less than 250 K inhabitants. Trisector base stations are used.
- Suburban, for areas whose population is between 250 K and 20K inhabitants. Trisector base stations are used.
- Roads / Highways. Bisector base stations are used.
- Rural, for areas whose population is less than 20 K inhabitants. Omni directional base stations are used.

In each type of area different parameters of radio propagation features and coverage provided (deep indoor, light indoor, incar) are applied.

Traffic demand and number of users have been estimated using the known reference demand of Spanish operators, taken from public data reported by the regulator (see [3]). Typical radio dimensioning parameters have been considered.

Simulating an exponential growth in data traffic as it is expected for the following five years (see Figure 2), the network costs evolve is shown in Figure 7. All the values in this graph are referred to Data Backbone Cost in the year of reference (t=0). According to this picture, the main cost increment is related to the radio access network, while increments in Data Backbone are not so significant. Increments in the number of data service users or in the traffic per user cause an important increase on the number of access nodes needed (see Figure 8). This increment is even more important when demand is for high bit rates. Breathing 3G cells makes cell capacity, and then the number of cells to maintain QoS, be very dependent on the number of active users and the mixture of their services. In fact, as demand increases in real scenarios, operators are finding out that their access networks do not meet the expected coverage.

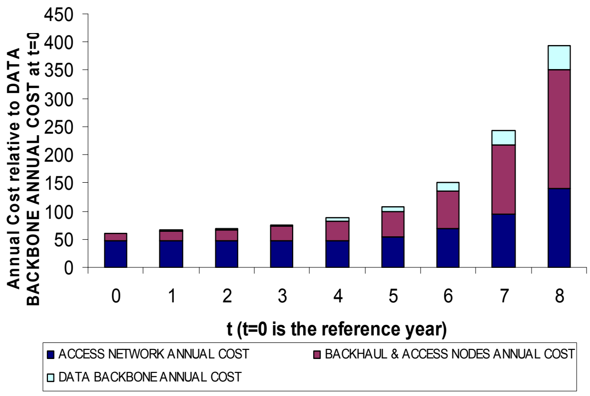

Fig 7.- Cost Sensitivity to an exponential growth in data traffic.

The simulation has been made with the following assumptions:

- Available spectrum is limited. It has been supposed that a 2x5MHz block in 2,100 MHz spectrum is used for macrocells level and another 2x5MHz block in 2,100 MHz spectrum is used for microcells level.
- 3G only mobile operator. No site sharing with GSM / DCS base stations.
- Data services only.
- Microcells are used when macrocells' radio that guarantees a value of load factor under a maximum is smaller than a threshold. In that situation, a percentage of data traffic is supposed to enter the network using the microcells level.

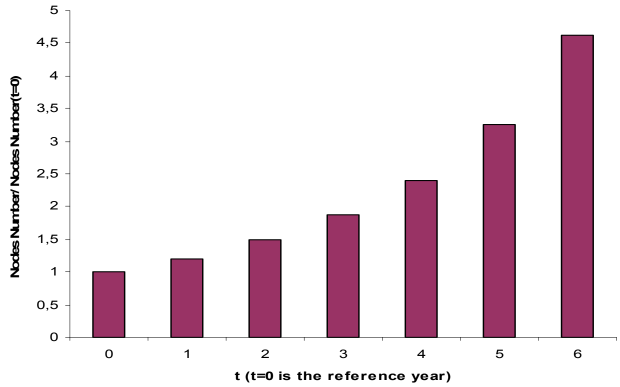

Figure 8.- Growth in the number of base stations in five years time from the reference year t=0.

B. Controlling Cost Sensitivity of Radio Access Network to Traffic

There are several alternatives available for mobile operators in order to reduce radio access costs:

Using more spectrum

As a result more carriers would be used in macrocells level. This solution reduces the number of base station sites and microcells needed, but the radio frequency is a finite and increasingly precious resource that needs to be managed effectively. Thus, the vast majority of the radio spectrum is regulated by national governments in most cases and. only part of the available spectrum is assigned to each mobile operator.

Deploying UMTS in lower frequency bands

One of these solutions consists of deploying 3G over the 900 MHz spectrum band (900 MHz refarming). The advantages of UMTS in 900MHz band are:

- The coverage- driven rollout advantage of larger cells (especially in urban environments).
- The improvement of data rates and indoor coverage.

The greatest obstacle to UMTS 900MHz deployment has been regulators' practice of assigning 900MHz bands to GSM. Tasked to handle heavy GSM traffic loads, the band frequently has little or none remaining capacity available for 3G. Now regulators are beginning to see the benefits of 900MHz bands. Countries such as France and Finland have already considered this option given the fact that a migration of GSM users to UMTS is expected.

The UHF band is appearing as another alternative band for UMTS.
Although there are benefits in using lower frequency bands, the availability of these bands depends on the national regulation so each operator must analyze the savings of growing its network using these bands.

Evolving Backhaul Network
Backhaul network cost is significant for mobile operators. A change in the architecture of mobile backhaul infrastructure is needed to be able to provide effectively the huge rise in capacity as new bandwidth data services grow in popularity. Evolving backhaul network to a packet-based network should be the mobile operator goal. In addition, this solution could simplify network and business processes bringing flexibility for service providers.

Establishing different QoS
Traditionally, mobile and fixed operators have taken a different approach to QoS. Fixed operators do guarantee performance of voice services whereas data services are "best effort". On the one hand, mobile operators have traditionally guaranteed both, voice and data service. To reduce cost, mobile operators may adopt the same mechanism of fixed operators offering premium services whose performances are guaranteed and are paid by traffic and best-effort services where flat rates are applied. These policies allow mobile operators to deploy a smaller network but also facing dramatically growth of data service. On the other hand, decreasing QoS might cause a customer loss towards operators with better performance.

Applying Traffic Caps
Establish traffic cap that once it is exceeded, maximum rate for this user is reduced, somehow controlling the traffic growth inherent to flat rates.

Downloading traffic to fixed wireless
Taking into account that a significant amount of traffic is originated or destined to certain places where the user spends more timer (home, office), mobile radio traffic (voice, data or both) maybe redirected in these cases to fixed wireless access using WiFi. This will alleviate traffic in the radio access network.

Mobile operators must bear in mind all these measures to keep the cost of services they provide lower than the revenue they receive from their final users. Setting the focus on the data service, although the network cost per unit of data services decreases as the global traffic increases (see Figure 9), the total cost per user will increase as the traffic per user grows and this may eventually end in network cost exceeding revenues from flat rates in the medium-term and, thus threatening profitability of flat rate data services. The following section describes this effect.

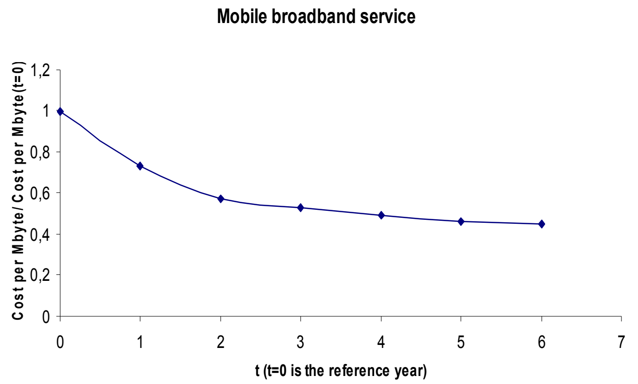

Fig. 9. Decrease of the network cost of mobile broadband service as traffic increase exponentially every year.

V. Traffic Sensitivity of Data flat rates margin

Taking the former results, it is straightforward to display the effects of an increment of the mean user demand (Kbps) in the margins of flat rates. Figure 10 represents unit cost and revenue per user supposing mean demand per user (Kbps). Flat rates disincentive traffic control both for end users and service providers and thus it is expected that mean demand per user increases in time. If no control on the users is implemented and the operator tries to maintain QoS, this increment would raise network cost as new investments, especially in the access, are needed.

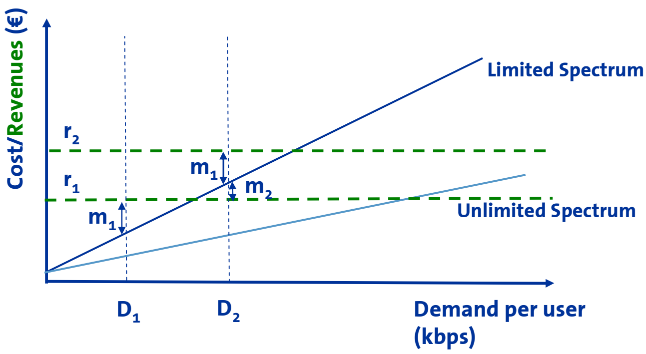

Fig. 10. Unit revenue and unit cost (for the case of limited and unlimited spectrum) as a function of transmission demand per customer (Kbps). Fixed cost is expected to be low or even negligible as long as the operator is already offering data services.

Suppose that at time t_1 a mobile operator with limited spectrum reports mean demand per user D_1. With a flat rate r_1 unit margin per customer would be m_1 as it is concluded from the graphs. If unit demand increases in t_2 up to D_2, unit margin would become negative (m_2) if flat rate is maintained in r_1. Operator would have to increase the flat rate to r_2 to maintain margins.

To illustrate this effect Figure 11 shows the evolution of mobile broadband service costs and revenue versus traffic consumption per user considering different rates. Nowadays, there are a lot of users being charged per data traffic volume and consequently their traffic per user is lower than it would be if they had a flat rate. Consequently, the current working area of the cost curve would be traffic near to 0. In this situation, considering that all users pay a flat rate, the mobile operator would obtain an important reasonable profit margin. If users increase their traffic (which is the current situation of customers paying a mobile broadband flat rate), it would be necessary to increase the price of the flat rate in order to guarantee user traffic being served and allow operator to maintain its profit margin. Operators may control the growth of traffic and cost of heavy users by limiting throughput or charging for traffic if traffic per user exceeds a threshold.

Different flat rates may be established, with different traffic caps or thresholds in order to create customer segments and make sure using these control mechanisms that traffic per user does not exceed a certain threshold. These new rates can be rate 2 or 3 in the figure 11 depending of the traffic per user.

Fig 11. Mobile broadband service revenue and cost per user for the period of time analyzed

In a scenario of unlimited spectrum, cost sensitivity to traffic increment is lower, as it is shown in the former figure, especially due to lower cost in base station sites.

The introduction of new technologies with improved spectral efficiency (such as LTE) is expected also to reduce the sensitivity of radio access network to traffic and eventually, increase the amount of traffic per user needed for cost to exceed flat rate revenues.

VI. A Wireless World

If substitution of fixed lines by mobile becomes more and more common, it is straightforward to wonder: will mobile broadband be able to completely substitute fixed broadband access one day?

It is possible to think of a completely wireless network. However, in order to carry traffic of every service with the QoS that users require, it will be necessary that they install an individual access point in every home and enterprise (the so called femtonodes). Otherwise, if several customers are connected to the same base station, the access node will represent an important bottleneck at the time of enjoying the most bandwidth consuming services, such as HDTV, HD video on demand.

Even in this case, it has to be noticed that interference problems may arise as access sites at home become popular. This would require additional spectrum and power control for these access nodes. Available bandwidth will eventually impose a limit in the maximum throughput that an end-user would experience.

Moreover, if handover policy does not make any difference between femtonodes and macro or microcells, handover signaling traffic would increase, as more and smaller cells are deployed. This effect may be solved by preventing handover to femtonodes except in case the femtonode is familiar to the handset. Thus, macro and microcells may be used only for mobility traffic while picocells and femtonodes would be reserved for heavy and traffic consuming, fixed or nomadic services.

From a cost point of view, this network would resemble an integrated mobile and fixed wireless network, and thus conclusions on cost structure given in section III would still be valid. In fact, *design and cost of a mobile network when traffic demand tends to infinite is equivalent to design and cost of both a fixed wireless layer for fixed and nomadic bandwidth consuming traffic and a macro and micro mobile layer for high mobility traffic.*

In conclusion, a wireless world is possible, although it should be studied whether wireless access adds value to certain bandwidth consuming services such as HDTV or HD video on demand which may cause congestion on mobile access nodes and would perform better using wire line access.

VII. Conclusion

Until recently, mobile broadband use has been sporadic and exclusive of business customers. However, it is expected that this traffic grows exponentially in the following years, reaching the residential market, owing to both the appearance of revolutionary handsets that allow the user to take advantages of new mobile data services, and affordable offers from the mobile operators.

In this scenario, operators will face an important investment in their access network in order to maintain QoS offered to the users as the mobile broadband traffic increases. This effort will not always be rewarded with higher revenues, especially when traffic demand increases and the customer base remains constant. Taking into account that sensitivity to demand of mobile network costs is steeper than in the case of fixed access, flat rates margins as well as service QoS should be carefully watched by mobile operators, which may in turn apply a mix of the measures suggested in section IV and V in order to assure that their mobile broadband offer is both useful for the user and profitable for them.

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