Business Innovation Strategies to Reduce the Revenue Gap for Wireless Broadband Services

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Abstract: Mobile broadband is increasing rapidly both when it comes to traffic and number of subscriptions. The swift growth of the demand will require substantial capacity expansions. Operators are challenged by the fact that revenues from mobile broadband are limited, just a few per cent of APRU, and thus not compensating for declining voice revenues, creating a so called "revenue gap". Concurrently, mobile broadband dominates the traffic, set to grow strongly. In this paper we analyze the potential of different strategies for operators to reduce or bridge the revenue gap. The main options are to reduce network costs, to increase access prices and to exploit new revenue streams. The focus in the paper is on cost & capacity challenges and solutions in the network domain. Operators can cooperate and share sites and spectrum, which could be combined with off-loading heavy traffic to less costly local networks. In the network analysis we illustrate the cost impacts of different levels of demand, re-use of existing base station sites, sharing of base stations and spectrum and deployment of a denser network. A sensitivity analysis illustrates the impact on total revenues if access prices are increased, whether new types of services generate additional revenues, and if it fills the revenue gap. Our conclusion is that the different technical options to reduce the revenue gap can be linked to business strategies that include cooperation with both other operators as well as with non-telecom actors. Hence, innovations in the business domain enable technical solutions to be better or fully exploited.

Key words: Wireless Internet access, data traffic, revenues, network costs, spectrum, deployment strategies, HSPA, LTE, operator cooperation, value added services, NFC, B2B2C.

The usage of Internet is currently changing from primarily being a service consumed in fixed and known locations to becoming a service used ubiquitously. People bring their Internet behavior outside homes and offices as part of daily life activities. Public wireless broadband access is based on two different development paths: 1) WLAN based local networks and systems, and 2) Wide area networks using cellular technology (UMTS, HSPA, and LTE), in this paper denoted mobile broadband (MBB).

In this paper we address this traffic, and cost & revenue problems for mobile operators offering MBB services. The data traffic is increasing substantially calling for network upgrades, while revenues are growing at a very low level. The operators are facing a number of challenges related to the scalability and cost structure of cellular systems, guaranteeing high data rates, especially indoors, the use of flat rate subscriptions, and the changes in the business landscape. We analyze the potential impact of different strategies to reduce or bridge the revenue gap. The main options are to reduce network costs, to increase access prices and to find new sources of revenues. The paper is organized as follows. The following section describes the problem area and research questions supported by relevant statistics. Related work is found in the section after. The methodology, models and assumptions are covered in the following section. Then a number of operator challenges are described, and potential strategies to cope with these challenges are elaborated. The cost & capacity analysis is conducted in the subsequent section. Then the potential and impact of increased revenues are described. We then summarize the different types of cooperation cases for mobile operators, followed by conclusions in the last section.

■ Problem description

Development of data traffic and revenues

Mobile data usage is rapidly increasing in both handheld devices and laptops. In several European countries the number of Mobile Broadband subscriptions has shown an annual growth of several hundred per cent. In Sweden the number of MBB subscriptions will surpass 1 million during 2009 (~10% penetration). Mobile operators have traditionally based their business on providing voice services to a continuously growing customer base. The primary traffic generator was illustrated by data from a Nordic operator voice service until 2007 when mobile data surpassed voice. Mobile data generated 16% of the total traffic in 2006 which increased to 79% in 2008, while its share of revenues went from 0.1% in 2006 to 1.9% in 2008. SMS generated 0.2% of the traffic, while the share of revenues increased from 5.4% in 2000 to 11.6% in 2008. A decisive factor behind the rapid development of MBB services is the introduction of flat rate subscriptions with a monthly fee typically in the range of €10-20. This type of pricing scheme has some consequences for the operators. The price per transferred MB is significantly lower for data services compared to voice (and SMS) services, €0.01 per MB compared to €1-2. Subsequently,data traffic dominates the networks as 70-80% of all traffic is from data usage, while only a small fraction of the revenues are derived from data services, typically 5-10%. In addition, the amount of data per user is increasing, like in Sweden going from 0.5 GB per user in 2007 to 1.8 GB by 2008. However, there are large differences between operators ranging from 0.8-4.5 GB per month and user (PTS, 2009).

Some findings from the current development

Mobile broadband unable to drive revenues

The data points underscores that the revenue stream from the voice business is pivotal for operators. It requires less network capacity compared to mobile broadband as MBB users on average consume 130 times more traffic, while paying only 1% of the price per MB compared to voice. This asymmetry is unsustainable, although low utilization in the networks initially can handle the increased load.

Operators forced to look for new revenue streams

The mobile voice business has stagnated as the influx of new customers is declining as penetration rates on mature markets have passed 100%, with an average of 119% in Europe. This indicates multiple SIM cards in combination with intense competition making it challenging for operators to raise prices. This implies that the basic voice business is subject to the risk of a decline. This forces operators to launch new value added services to compensate for a deteriorating voice business. However, customers have so far shown limited interest for mobile videoconference, mobile-TV, and mobile gaming.

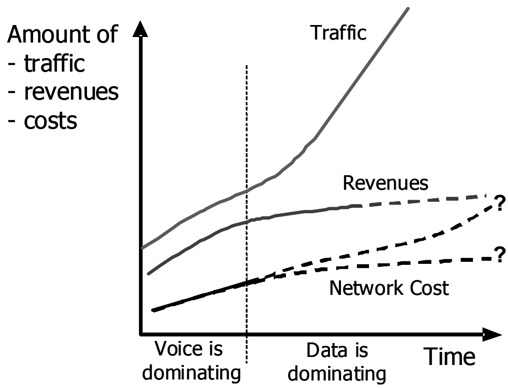
Lower free cash flow restricts capex

The financial crisis has placed the focus on the balance sheet making operators more cautious on capex and prioritizing free cash flow as it improves the financial flexibility. But the operators' ambition to expand on mobile broadband requires capex upgrades. Given that mobile broadband gives no support to cash flow it weakens operators financially at a time when investors are favoring financial stability. This forces operators to explore new business models.

The overall problem - the revenue gap

As MBB generates 70-80% of the traffic while only contributing with 5-10% of revenues operators are facing a problem - a revenue gap, see Figure 1. Due to the flat rate charging for MBB the increased data usage does not automatically translate into increased revenues which are the case for voice services generally charged per minute of use. The minimal impact on revenues from MBB gives a low contribution to cash flow, which limits the funding for increased investments. The total traffic will continue to grow and the operators will need to invest in order to enhance network capacity. Hence, the profitability of the "networking business" will depend on the costs for the network build out.

Figure 1 - Traffic and revenues for increasing data volumes



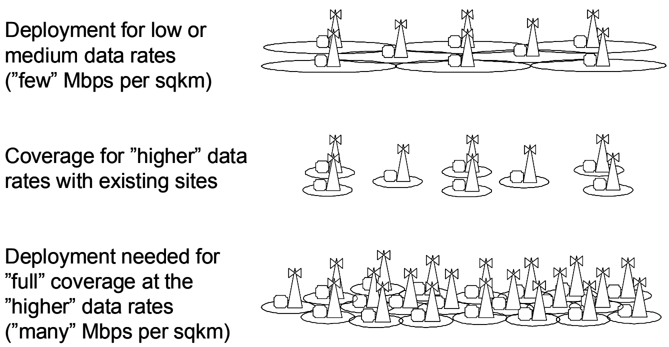
Pictures similar to Figure 1 have frequently been used during the last year. The major telecom vendors claim that new technology, like further development of HSPA and the introduction of 3G Long Term Evolution (LTE), will "solve the problem", i.e. to align the revenue curve with the traffic curve. We argue that it is not technology as such and/or the allocation of more spectrum that will solve the problem. The gains that can be achieved by new technology and additional spectrum depends on demand levels, the possibility to re-use existing base station sites, the deployment strategy, e.g. sharing of networks and spectrum, use of national roaming and offloading of heavy data traffic to low cost local networks. Several of these strategies are based on cooperation between different market actors.

■ Operator challenges

Scalability and cost structure of cellular systems

The increasing demand requires that more network capacity is deployed. One challenge is the cost of capacity in terms of base stations and the amount of radio spectrum. For a specific amount of spectrum and for the same type of Radio Access Technology (RAT) the deployment of N times more capacity will imply N times higher network costs, see Figure 2.

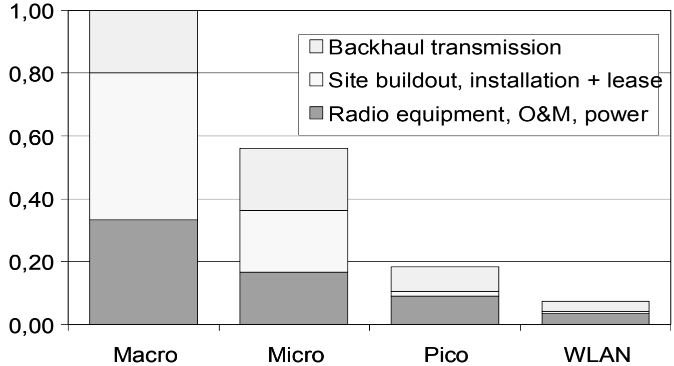
Figure 2 - More capacity per area unit implies denser networks and higher costs



The cost is proportional to the number of users, the demand per user, the service area and also a function of quality (ZANDER, 1997). Development of new technology with lower cost and increased spectrum efficiency will improve the case, but the basic scalability problem will remain. Operators have licensed spectrum at different bands, e.g. at 900, 1800, 2100 and 2600 MHz. The more bandwidth that can be used at one site the better the capacity - cost ratio.

Investments for the radio access network include not only costs for the radio equipment but also costs for transmission and site buildout, see Figure 3. Site costs include both capex and opex, comprising costs for towers, power, installation, site survey & planning and site leases. For outdoor deployment (macro and micro base station sites) the site costs are substantial (JOHANSSON, 2007). For indoor systems the radio equipment and transmission dominates. The transmission to the sites must be upgraded as transmission using 2 Mbps leased lines (E1) is not sufficient to support HSPA or LTE data traffic.

Figure 3 - Example of base station cost structure including capex and opex for greenfield deployment, base on data from (JOHANSSON, 2007)



The cost of the radio equipment for a site depends on the type of radio technology, if sectorization is used and on the operating bandwidth. For WCDMA the number of radio transceivers (TRXs) depends on the number of 5 MHz carriers used, e.g. a WCDMA system using three sectors and 10 MHz of bandwidth will require six transceivers. It should be noted that the price erosion has a significant impact on the costs for the radio equipment as electronic equipment follows Moore's law resulting in an improved performance to cost ratio over time. However, the costs for sites are also depending on steel prices and labor costs most likely to increase over time.

Using outdoor systems to provide indoor coverage and capacity

The majority of the calculations on range are made for outdoor conditions while an increasing share of the traffic is indoors. For voice this share has been estimated to be in the range of 70 - 80 % and for mobile data an even higher share. When calculating the required coverage and number of macro base station sites it is decisive to take into account the indoor penetration loss. A large number of measurements have been carried out where the results show large variations in path losses caused by different types of walls (HOLIS & PECHAC, 2008). The figures show about 10 dB for wooden houses (typical in rural areas) and between 20 and 40 dB for concrete or brick walls (common in suburban and urban areas). The impact of the wall penetration is calculated using Okumura-Hata propagation model for urban macro cells (HATA, 1980). Table 1 below shows the reduction in range (R) and how much denser the network need to be (N) in order to compensate for various values of penetration losses due to wall attenuation (W). Already for a fairly moderate loss of 15 dB the number of base stations has to be increased by a factor of seven. For indoor usage the reduction of achievable data rates occurs already close to the base station. This results in a requirement for an increased number of sites in order to provide both coverage and capacity. Hence, macro cell systems may be complemented by indoor solutions.

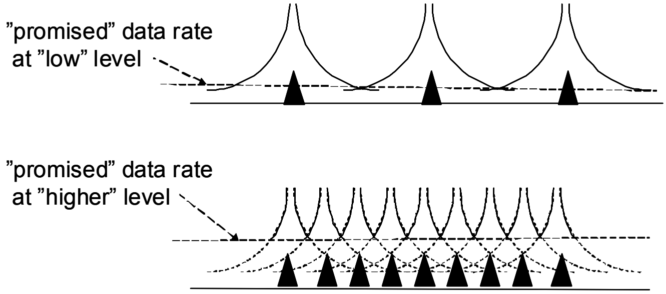
Table 1 - Range R of a base station, N is a "multiplication factor" indicating how much denser the network need to be in order to to compensate for the wall attenuation W

W(dB)	*R(km)*	*N + 1*
0	0.56	1
5	0.4	2
15	0.21	7
25	0.11	25

Marketed offers, user expectations and network costs

MBB services are commonly marketed in terms of "peak rate". Current offers are e.g. up to 7.2 -14.4 Mbps and future "4G offers" are presented as "up to 150 Mbps". This maximum data rate, or close to it, is possible to achieve only if the user is very close to the base station and is alone in the cell. The achievable data rate is considerably lower at the cell borders. The use of more bandwidth and "new" technology with higher spectrum efficiency will give some support, but the underlying problem with dis-satisfied users that are not receving as high data rates as expected will remain. For operators it will be very costly to build networks where peak rates can be guaranteed over large areas. Since the data rates are reduced when the distance to the base station increases more base stations are required to be deployed, resulting in higher network costs, see Figure 4.

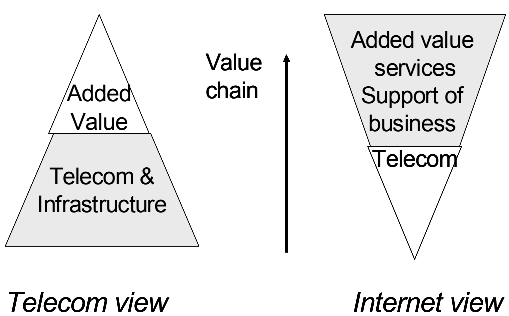
Figure 4 - Data rate guarantees over large areas implies denser networks



Changes in the business landscape

The deployment and operation of telecommunication networks have traditionally been an oligopolistic infrastructure business closely connected to network properties. Long term customer relations (subscriptions with post-paid bills) are very common. Large companies with solid financial resources make long term commitments when networks are deployed and upgraded. However, with the introduction of Internet based services the business landscape has changed. "Any" actor connected to the Internet can start to do business, even with very low investments. For mobile and broadband access the service "itself" is closely related to the network and the related characteristics, e.g. bit rate, and coverage. For internet based services there are other company assets and capabilities than the network that enable an actor to enter and succeed in Internet based business. In addition to value added services other assets can be customer or billing relations, local presence, payment and billing support. There is an ongoing transition from the "telecom view" to the "Internet view" (WHITE, 2008), see Figure 5. Using the telecom view the main aspect is the infrastructure; the services are added "on top of" the networks. Using the Internet view the networks are seen as a basic asset similar to roads, railways, water supply and schools that are needed in order to make markets, companies and the society function as expected. New types of actors make increasing efforts in order to obtain a share of the internet business and to connect customers more closely, like Google, Yahoo!, and Microsoft. Such players are strong contenders of potential mobile content revenues and platforms for IP cannibalization of voice and SMS revenues. Also terminal suppliers like Nokia and Apple are moving into Internet based service markets and connect more closely to the end-users. This raises the inevitable question: what is left for the operators?

Figure 5 - The telecom and Internet business perspectives (WHITE, 2008)



■ Options for operator strategies

Reduction of network costs

Network sharing

Network sharing includes all forms of operator cooperation where sites or parts of the networks, as well as spectrum are shared. In Sweden all 3G operators are involved in different types of joint ventures; and for the deployment of "4G" a new constellation was announced during the spring 2009. The potential for cost saving is obvious as the deployment of macro base station are very costly, see Figure 4.

Spectrum re-farming

Another way to exploit and re-use current networks is to replace or mix radio access technologies in specific frequency bands. In the 900 MHz band WCDMA, HSPA or LTE can replace GSM/EDGE resulting in increased capacity per site and MHz of spectrum. The use of WCDMA and/or LTE in the 900 MHz band implies that 3G and 4G coverage can be achieved with fewer sites compared to the 2.1 or 2.6 GHz bands. Hence, these benefits would be most valuable for wide area coverage. When calculating the benefits the costs for the whole WCDMA, HSPA or LTE implementation has to be included.

Offloading heavy data traffic to local networks

Rather than deploying a large number of outdoor base stations for mobile broadband the heavy data traffic can be offloaded to local networks or by using indoor systems (www.vodafone.com). Compared to capacity expansion using macro or micro base stations the use of WLAN systems or cellular femtocells indicate potential for substantial cost savings (MARKENDAHL *et al*., 2008). However, the potential will be altered if higher bandwidths are used and with the introduction of LTE with higher spectrum efficiency. Also, the conditions can vary between operators depending upon availability of existing WLAN networks and fixed broadband networks.The performance and cost for equipment, deployment and operation are similar for femtocell and WLAN systems. The opportunities with indoor deployment can be exploited if the local networks can be easily and cost efficiently deployed and operated. This usually requires cooperation with facility managers, enterprises or other actors that "control" the local environment.

Pricing strategies and service differentiation

Currently the flat rate subscriptions are associated with some type of restrictions, e.g. maximum amount of data per month (1GB, 5GB) and/or maximum data rate. Operator "3" in the UK offers subscriptions with different caps of data per month, e.g. 1 GB for £10 and 15 GB for £30. Heavy data users have to pay which is a way to reduce the revenue gap. One motivation for higher prices is if the connectivity offer is linked to some guarantees for the service availability or quality. In the sensitivity analysis presented below we explore the impact of increased MBB prices on the overall ARPU

New types of services and revenues

In order to evaluate the potential of new types of services in more detail we will focus on what we call Exploitation of proprietary assets. Operators have more or less monopoly access to some assets that may constitute foundations for new services. Such assets are e.g. the customer and billing relations, control of the phone number, information about the geographical position of the terminal, ownership of the SIM card and spare capacity during off-peak hours (WERDING *et al*., 2006).These proprietary assets can be exploited for cooperation with other market actors. One example is SMS based ticketing services, e.g. for parking and bus transportation, where the operator makes use of its customer and billing relationship and the service platforms that enable payment support. Hence, the operator is an actor that contributes to the value chain for a non-telecom type of service. This kind of business approach can be extended in order for operators to offer new types of value added services. By using NFC technology (Near Field Communication) the mobile terminal can be used as a "mobile wallet" and exploit the opportunity with micro transactions (MADLMEYR *et al*., 2007). This enables operators to be involved in services supporting "daily life activities", e.g. mobile payments, ticketing, access control to offices, public transportation etc. The operator would be part of an ecosystem for delivery of business-to-business-to-consumer (B2B2C) services (www.gsmworld.com). We believe that these B2B2C services have a potential to increase the ARPU. Operators can re-use assets and exploit the control of the SIM-cards, the customer relations and the payment and billing support functionality. In this case we believe that operators have an advantage compared to companies like Microsoft, Apple, Nokia and Google.

■ Models and assumptions

The operator market and the spectrum usage

The cost & capacity analysis is made for a country case, could be a "Sweden size XL". The analysed market consists of four operators, one Greenfield and three established operators with an assumed market share of 25 % for mobile broadband. All operators are assumed to have 10 MHz of spectrum in the 900 MHz band and 40 MHz in the 2.1- 2.6 GHz bands. Operator 1 and 2 build their own networks while operator 3 and 4 build a common network where sites and spectrum are shared. We assume that operator 1 is a Greenfield operator i.e. is starting the business, and that operator 2, 3 and 4 have deployed GSM/EDGE and UMTS networks, i.e. with a number of existing sites that can be re-used. In each type of area the deployment starts with the 900 MHz band assuming that this band is re-farmed allowing the use of HSPA and LTE. At least half of the available 900 MHz spectrum needs to be allocated to GSM voice services. When the 900 MHz band is fully utilized higher frequency bands are applied re-using existing sites. New sites will be added when the available spectrum in all bands no longer is sufficient.

Estimation of user demand

The modeling and analysis of network capacity and cost is made for rural, suburban, urban and "super-urban" areas. Two levels of demand are considered. The low level is represented by a total penetration of 10% of the population and a monthly usage of 5.4 GB per user. For the high level we assume 40% penetration and a monthly usage of 10.8 GB per user. The network dimensioning the demand is expressed as Mb per second per km2, see Table 2. Here we assume a busy hour load of 12.5% of the total traffic. This is similar to the assumption that all traffic during a day is generated during 8 hours. 5.4 GB and 10.8 GB per user and month correspond to 50 kbps and 100 kbps per user during the busy hours.

Table 2 - Area decription and demand (the same for all operators)

Area type	*Covered area (km^2)*	*Inhabitants per km^2*	*Low demand (Mbps per km^2*	*High demand (Mbps per km^2*
Rural	200 000	20	0.025	0 2
Suburban	20 000	200	0.25	2
Urban	2 000	2 000	2.50	20
Super-urban	50	20 000	25	200

Radio access network characteristics

The existing GSM sites will be used as a starting point for the deployment. In general the radio range depends on the data rate considered, the higher the data rate the shorter the range. The values in Table 3 are based on our assumption of average user data rates during busy hours (in the range 50-100 kbps) and on the radio coverage analysis in (HOLMA & TOSKALA, 2007). The radio ranges are estimated for different frequency bands for a 1 Mbps data service using a LTE system and 10 MHz of bandwidth. With the assumptions on antenna heights, wall propagation losses and on antenna diversity the ranges for indoor coverage are 1.5 km at 900 MHz and 0.7 at 2.5 GHz for urban deployment and 3.6 km at 900 MHz and 2.5 km at 2.5 GHz for suburban deployment. Hence, our assumptions as decribed in Table 3 would be quite relatistic.

Table 3 - Range, coverage and number of sites different types of areas

	Radio range	*Coverage area*	*Number of sites*
Rural	5.65km	~100 km^2	2 000
Suburban	2.53km	~20 km^2	1 000
Urban	0.57km	~1 km^2	2 000

The network is modeled as a number of sites with capabilities to meet the user demand in terms of capacity and coverage. The capacity is expressed as throughput per area unit (Mbps per km^2), see Table 4. We assume that three-sector sites are used and that spectrum is allocated in steps of 5 MHz. The operators can use different amounts of spectrum and choose between two types of access technologies with different spectrum efficiency (SE). The radio access technologies with SE ~ 0,7 bps/Hz and ~ 1,7 bps/Hz are representative for the current releases of HSPA and future releases of LTE. A spectrum efficiency of 0.7 bps/Hz implies a site capacity in terms of average throughout of 0.7 * 5 * 3 = 10.5 Mbps ~ 10 Mbps for each chunk of 5 MHz bandwidth. For a radio access technology with spectrum efficiency of 1.7 bps/Hz the corresponding site capacity will be 1.7 * 5 * 3 = 25.5 Mbps ~25 Mbps.

These numbers can be used to estimate the average throughput per area unit considering that the user data rate strongly depends on the distance to the base station. BERGMAN *et al*. (2009) illustrates the differences between peak data rate and typical data rates for the case of HSPA evolution systems. For a peak data rate of 28.8 Mbps the following user data rates can be achieved. For low cell load (~ 5 %) the average data rate is 7-9 Mbps and the cell border data rate is ~1.5 Mbps. For high cell load (~ 70 %) the average data rate is 5-7 Mbps and the cell border data rate is around 1 Mbps. It is interesting to note that the "high traffic volume", ~ 70 % of full load corresponds to roughly 2 GB per hour which is equal to ~ 4.4 Mbps during "all seconds of the hour". This number corresponds well to the 3.5 Mbps cell throughput used as our assumed HSPA performance.

Table 4 - Capacity expressed as throughput per area unit (Mbps per km^2) assuming a three-sector site with different amounts of spectrum

Used band width	*Special efficiency = 0.7 bps/Hz*			*Special efficiency = 1.7 bps/Hz*		
	5 MHz	*10 MHz*	*20 MHz*	*5 MHz*	*10 MHz*	*20 MHz*
Cell area: 1 km^2	~10	~20	~40	~25	~50	~100
Cell area: 10 km^2	~1	~2	~4	~2.5	~5	~10
Cell area: 100 km^2	~0.1	~0.2	~0.4	~0.25	~0.5	~1

Cost calculations

Our method which enables us to calculate production cost per GB is based on the following assumptions. Firstly, the estimated capex is a function of the required number of base stations and carriers for the various cases. The assumed cost for deploying a macro base station in rural areas is €100K, while sites in urban and suburban areas are estimated to cost € 50K per installation. The cost for the first three sector radio configuration is estimated to be €40K, which is in line with industry experts (BLENNERUD, 2009) and additional radio carriers cost €20K per added 5 MHz of bandwidth. The investments in existing sites are considered to be sunk costs. However, investments in new sites are included for the greenfield operator and for existing operators that are forced to deploy new sites in order to increase capacity. The capex for sites and radio equipment are depreciated over 20 and 5 years respectively, with an applied cost of capital of 12.5%. This adds up to an annualized capex included as a cost item in the result.

The revenues are derived from ARPU (average revenue per user), which we assume to be €20 per user and month, multiplied by the average number of users during the period. We apply an opex level of 45%, including networks operations, marketing sales and admin, cost of goods sold and customer care. This translates into an EBITDA (earnings before interest, taxes, depreciations and amortizations) margin of 55%. This gives the basis to charge for the annualized capex, which adds up to an operating profit, EBIT. The ratios of GB per annualized capex and production cost are based on the assumption that the actual utilized traffic volumes are inserted into the calculation. Subsequently, the annualized capex per GB is calculated by dividing the total annualized capex with actual demanded traffic volume. The production cost per GB is not only including annualized capex but also opex, in order to reflect the entire cost base on the mobile broadband business case.

■ Analysis of network costs

Demand impact on deployment

For all operator cases and for all area types the low level demand can be satisfied using the existing sites equipped with HSPA type of radio using 5 MHz of bandwidth at 900 MHz. For the high demand level the LTE type of technology will satisfy the demand in both rural and urban areas by using 5 MHz at 900 MHz for the single operator cases. The cooperating operators 3 and 4 can do the same by using 5 + 5 MHz at 900 MHz. This result is quite surprising - the demand can be met by using existing sites and only the 900 MHz band. In suburban areas the available amount of bandwidth in 900 MHz band is not sufficient even when the LTE type of technology is used. Capacity needs to be deployed in both 900 MHZ and 2100 - 2600 MHz bands. Using the LTE type Operators 1 and 2 can deploy 5 + 5 MHz and operators 3 and 4 need 10 + 5 MHz. If the HSPA type of technology is used the required amount of spectrum is doubled. With our assumptions this would be more expensive since the "radio cost" depends on the amount of used spectrum. In the super-urban environment we assume that 50 of the "urban sites" can be re-used. In order to meet the demand these sites are built out with the LTE where the entire available spectrum at 2100-2600 MHz is used. Using HSPA all operators need to deploy new sites. The impact of different demand levels are shown in Tables 5 and 6. The business case for high demand is depending on i) more revenues due to higher penetration and ii) better utilization of the deployed network capacity. For the high demand level there is no major difference in profitability between different types of areas. For the low demand level there are substantial differences between area types, which can be explained by the amount of over-provisioning of capacity in relation to the demand and hence the revenues.

Sharing of base station sites and spectrum

The cooperating operators 3 and 4 show much better profitability than the operators that are deploying and operating own network, this is especially true for the low demand level. The main reason is all costs can be shared and that the spectrum can be used more efficiently due to the combination of the spectrum resources, compare data in Tables 5 and 6 (LTE type of technology).

Table 5 - Cost analysis for the single operator re-using sites and using LTE

	Low capacity					*High capacity*				
	Rural	Sub-urban	Urban	Super-urban	Total	Rural	Sub-urban	Urban	Super-urban	Total
Capex (MEUR)	80	40	78	3	201	80	80	78	10	248
Annualized capex (MEUR)	22.4	11.2	22.0	0.8	56.4	22.4	22.4	22.0	2.8	70
Annualized capex per GB(MEUR)	3.5	1.7	3.4	0.5	2.7	0.43	0.43	0.42	0.21	0.41
Production cost per GB (EUR)	5.1	3.4	5.1	2.2	4.3	1.27	1.26	1.26	1.05	1.25
EBIT margin	-38%	8%	-37%	41%	-17%	32%	32%	32%	44%	33%

Table 6 - Cost analysis for cooperating operators re-using sites and using LTE

	Low capacity					*High capacity*				
	Rural	Sub-urban	Urban	Super-urban	Total	Rural	Sub-urban	Urban	Super-urban	Total
Capex (MEUR)	40	20	39	2	101	60	50	59	10	178
Annualized capex (MEUR)	11.2	5.6	11.0	0.7	28.5	16.8	14.0	16.5	2.8	50
Annualized capex per GB(MEUR)	1.7	0.9	1.7	0.4	1.4	0.32	0.27	0.32	0.21	0.30
Production cost per GB (EUR)	3.4	2.5	3.4	2.1	3.0	1.16	1.10	1.15	1.05	1.13
EBIT margin	32%	9%	44%	18%	18%	37%	40%	38%	44%	39%

Table 7 - Summary of cost analysis for the Greenfield operator building new sites

	Low capacity					*High capacity*				
	Rural	Sub-urban	Urban	Super-urban	Total	Rural	Sub-urban	Urban	Super-urban	Total
Capex (MEUR)	279	90	176	3	548	279	159	176	12	627
Annualized capex (MEUR)	50.0	18.0	35.6	0.8	104.4	50.0	30.5	35.6	3.1	119
Annualized capex per GB(MEUR)	7.7	2.8	5.5	0.5	5.0	0.96	0.59	0.69	0.24	0.71
Production cost per GB (EUR)	9.4	4.5	7.2	2.2	6.6	1.80	1.42	1.52	1.07	1.54
EBIT margin	153%	-20%	-93%	41%	-79%	3%	23%	18%	42%	17%

Cost analysis when deployment of new sites is needed

In order to estimate the impact of deployment of new sites we compare the cost figures for operator 2 (Table 5) with a Greenfield operator with similar spectrum allocation (Table 7). The capex for the Greenfield operator is more than 2.5 times higher than for an operator that can re-use sites, translating into that annualized capex per produced GB is 70 - 90 % higher. However, operators may consider deploying more base stations for two other reasons: i) to compensate for wall penetration losses and ii) to ensure that higher data rates can be provided in larger areas. Even quite low values of wall attenuation require a substantial number of new sites, e.g. 5 dB and 15 dB wall attenuation would call for 100% and 400% more sites respectively. To compensate for large wall attenuation capex has to be increased to levels where the operator is likely to receive a very low level of return on the investment.

Cost comparison with local networks

For urban and super-urban areas with high demand levels the macro site solutions considered can be compared with deploying a) a denser macro network or b) an indoor femtocell network. The macro networks are using LTE technology and 40 MHz of spectrum in the 2100-2600 MHz band. For the femtocell network we apply a different deployment approach compared to the macro networks. We assign a group of eight users to a single femtocell since we do not know "where" the users are located within the area. The assumed capcity for a femtocell is 4 Mbps. With 2000 users per km2 it requires 250 femtocells per km2, in total 12 500 femtocells. The capex for one femtocell, including installation and transmission, is assumed to be 1000 € (MARKENDAHL *et al.*, 2008). If the existing macro network can provide the required capacity at indoor locations it is equally cost efficient as the femtocell network. However, as soon as there is a need to increase capacity in the macro network, e.g. in order to compensate for wall attenuation losses, the femtocell solutions provide a more cost efficient solution, see Table 8.

Table 8 - Comparison between macro and femtocell deployment in high demand areas

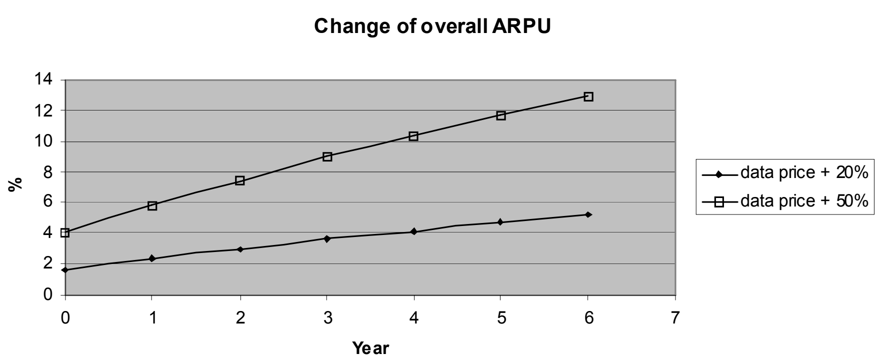
	Existing Macro network	*Denser Macro network*	*Femtocell network*
Number of base stations	50	250	12 500
Deployed capacity (Mbps)	10 600	53 000	50 000
Capex - Sites (MEUR)	0	10.0	0
Capex - radio (MEUR)	9.8	51.0	12.5
Total annualized Capex (MEUR)	2.7	15.7	3.5

■ Analysis of options to increase revenues

Impact of higher prices for the mobile broadband access

In order to analyze the impact of higher MBB prices we conduct a sensitivity analysis where we increase MBB ARPU by 20% and 50% respectively. We have assumed an operator with both a voice and MBB business. The MBB penetration is assumed to expand by 5% per annum and data volumes per user to increase by 20% per year. This will result in a nine fold growth of data traffic from year 0 to year 6. The ARPU distribution year 0 is voice 80% and MBB 8%, corresponding to Sweden 2008. Assuming that voice and MBB prices are constant the MBB traffic growth will change to ARPU distribution to voice 65% and MBB 26% in year 6. The impact on the overall ARPU for increased data price is shown in Figure 6 where the reference corresponds to unchanged MBB prices. A 20% increase of MBB ARPU would raise estimated total revenues by less than 2 % in year 0 and around 5% in year 6. An increased MBB ARPU of 50% would push up the total revenues by 4% for year 0 and 13% for year 6. The overall revenues will increase; year 6 it will be +24%, + 30% and +40% with MBB price changes of 0%, 20% and 50% respectively. Since the traffic is increasing almost nine times the pricing changes will not reduce the gap between mobile broadband traffic generation and revenue contribution. This analysis shows that mobile broadband has the potential to be disruptive for the mobile operator business. The data traffic is increasing nine times, which will force operators to upgrade the capacity and increase capex.

Figure 6 - Impact of increased MBB ARPU on the overall revenues



Analysis of the impact of new types of services and revenues

One option to increase revenues is to introduce new Value Added Services (VAS), e.g. mobile payment and ticketing. In order to explore the impact of these new types of services we differentiate between three user categories, frequent VAS user to low user VAS with three levels of "clicks" per month. With a price per click of €0.05 this adds up to an additional ARPU per month from €1.25 to €12.50. Taking as a starting point a voice ARPU of €22 per month we calculate the total revenues by adding the three categories of VAS users. The result is that the revenues in the base case would increase by around 15%, see Table 9.

Table 9 - Usage and ARPU for modeled value added services

Type of user	*No of users*	*No clicks/ month*	*ARPU/ month*
High frequency	10%	250	12.50 €
Medium frequency	20%	150	7.50 €
Low frequency	30%	25	1.25 €
No usage	40%	0	0

Some implications

In order to answer the question if higher prices or new services can bridge the revenue gap we need to combine different sources of ARPU taking into account the trend with declining voice ARPU and the need to increase investments. We expect voice ARPU to fall by 6% from 2009 to 2011 and MBB ARPU to increase by 4% driven by higher usage and stabilized prices. The substantial increased traffic volumes require capacity upgrades. Besides upgrades are maintenance capex, inevitable in order to guarantee network operation establishing the base capex level. On top of this comes upgrade capex in order to cope with substantially increased traffic volumes. The operator is therefore forced to increase capex which raises the ratio of capex to sales, alternatively to boost revenues with new kinds of services which we have elaborated on above. Although a 50% higher ARPU would raise revenues up to 13% it indicates the difficulty to maintain the ratio of capex-to-sales unchanged, rather giving it a push upwards. Since higher MBB prices will only result in a limited contribution to the overall ARPU it seems likely operators will need to find other sources of revenues.

■ Cooperative business strategies

Network sharing between mobile operators

Sharing of networks, sites and spectrum reduces capex and opex compared to deploying and operating an own radio access network. In low demand and revenue areas network sharing can be a way for operators to be profitable. In high demand areas benefits can be achieved due to more efficient utilization of licensed spectrum and of existing sites. Network sharing is a long term cooperation between operators that reduces costs but maintains the competition for end-customers. In Sweden all 3G operators are involved in network sharing agreements, which have been followed by a new agreement for "4G network" cooperation between two operators.

Cooperation between mobile operators and hot spot operators

A way to reduce capex in high demand areas is to off-load data traffic to a local network. These networks can be based on WLAN or femtocell technology and can be deployed by mobile operators or 3rd parties. In both cases the solutions need to be open to all users wich implies the possibility of national roaming. The important issue is to avoid large investments in macro layer networks. The benefits can be identified in hot spot areas although the cellular technology with high spectrum efficiency shows good cost-capacity performance. In 2009 the Swedish mobile operators Telia and Tele2 have announced agreements with hot spot operators Clue and The Cloud respectively. In these cases the local network operators offer access in existing hot spots to the customers of the mobile operators. In the UK the Cloud and the operator O2 have announced a joint "off-load project" where hot spots are deployed in areas where O2 has capacity constraints.

Cooperation between mobile operators and non-telecom companies

Mobile operators have a possibility to exploit their market position, the customer base, billing systems and SIM cards in order to offer services using the mobile phone. For these B2B2C services another actor; e.g. a shop, a transportation company or a hotel, has the main customer relation. Other actors that can be involved in similar ecosystems are banks, credit card companies and a "trusted service provider" (TSM). The TSM is an essential actor since this type of services, e.g. mobile payment and ticketing, need to be independent of specific actors like banks or mobile operators. We believe that these types of services have the potential to generate value growth. In contrast to cooperation focused on cost savings B2B2C services support new forms of added value and revenue generation.

Conclusions and implications

We have analyzed the traffic and revenue aspects of the increased usage of mobile broadband services. In many markets broadband data traffic is dominating, with up to 80% of total traffic, but the contribution to the revenues is so far very limited, representing 5-10 % of total revenues. With the expected increased data traffic operators will need to invest in additional network capacity, but the limited revenue stream from mobile broadband has so far failed to finance increased investments. A number of strategies are available for operators in order to bridge this "revenue gap"; i) reduction of network costs, ii) increased revenues from existing services and iii) new sources of revenues. Our sensitivity analysis shows that increased prices for mobile broadband have a minor impact on overall revenues since voice is the dominating revenue source. Hence cost reductions and new revenue sources are more promising. The new radio access technologies, HSPA evolution and LTE, with enhanced spectrum efficiency compared to GSM/EDGE and WCDMA, have the potential to faciliate cost-efficient large scale deployment. However, the potential cost efficiency for one single access technology depends on the specific levels of demand, deployment strategy and business context. For wide area networks network costs can be reduced using network and spectrum sharing and re-use of existing sites. The replacement of GSM in the 900 MHz with other radio access technologies is a key component for cost-efficient deployment. Operators that deploy new sites will have a more challenging business case than those that can re-use sites. For high demand areas there is a large potential to reduce the need for investments in macro networks by using indoor systems. This may lead to increased use of network sharing of local networks.

In order to bridge the revenue gap operators need to combine "improvements" of current systems and services with various types of solutions. In addition, the different "technical" options to reduce the revenue gap can be linked to business strategies that include cooperation with both other operators as well as with non-telecom actors. One example is to extend the operator value chain into mobile payment and ticketing using NFC enabled handset and B2B2C relations. Operators need to challenge

Internet companies and handset manufacturers in areas where operators have an advantage. Initiatives by e.g. Apple and Nokia in order to connect customers more closely will most likely not result in any increased revenues for the operators, just more traffic in the networks. Hence, innovations in the business domain enable technical solutions to be better or fully exploited. In addition, cooperation outside the "vertically integrated value chain" will enable operators to be better prepared for existing and future challenges due to changes in the mobile ecosystem.

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