Mobile Broadband Evolution and the Possibilities

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The paper presents a comprehensive rollout analysis of HSPA in a medium large European country with an operator who already has a GSM network. The rollout coverage will be higher in the densest areas. It is also assumed that the traffic per user is higher in the densest areas. Forecasts for mobile broadband accesses and the traffic per user in the peak hour is an important part of the analysis. The traffic forecasts are used to make a strategy for upgrading the capacity of the base stations based on throughput calculations for upgrading with additional sectors, additional carriers and HSPA 3.6, 7.2 and 14.4 Mbps respectively. Techno-economic calculations are performed for the rollout cases based on ARPU predictions, cost evolution of the network elements, evolution of OPEX and assumption of future market share and competition. The long-term access and traffic forecasts are uncertain. To examine the impact, techno-economic calculations are performed for increasing forecasts.

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1 Introduction

Apart from leased lines, broadband telecommunications have been deployed and offered since the late nineties. However, the main part of countries in the world did not get broadband until this century. The dominating technologies were the wireline technologies DSL and HFC (cable modem). Later technologies for the nomadic market, Wi-Fi, were developed and offered. In 2006/2007 mobile broadband was offered in the market. The main mobile broadband technologies are HSPA based on Wideband Code Divison Multiple Access (WCDMA) and CDMA2000.

The objective of this paper is to examine and evaluate rollout alternatives for mobile broadband. Specific forecasting models for demand of mobile broadband accesses have been developed. Further, forecasting models for traffic volume in gigabytes per user per month have been established and also models for the expected traffic in peak hour.

The traffic forecasts are separated in demographic and geographic segments. The forecasts are crucial and used as input to techno-economic models calculating the economic value of different rollout alternatives. OPEX and CAPEX cost assumptions and predictions of future ARPU evolution are linked to the forecasts.

The techno-economic model is used to evaluate different rollout strategies for mobile broadband based on HSPA. The rollout strategies depend on capacity possibilities for the base stations based on number of carriers used, number of sectors used, capacity offered (3.6 Mbps, 7.2 Mbps, ...), etc. The capacity and the base station density must be allocated according to the increased traffic forecasts without over-investment.

2 Market Description and Segmentation Mobile Broadband

Country Specification

A fictive Western European country with 10 million inhabitants and 4 million households is the base for the analysis. The number of employees is 4.5 million and the age of the employees is in the interval 15 – 74 years.

The country has a significant volume of cottages, often clustered in special cottage areas, mainly situated in very rural/remote areas. However, in this paper the analysis will concentrate on mobile broadband rollout in more densely populated areas.

The population is divided into the following geographic areas or 'geotypes': Dense Urban, Urban, Suburban, Rural Towns and Very Rural/remote. All but the Very Rural/remote area are considered for base station coverage.

Dense areas are defined as areas with one or more cluster of buildings, where cluster of buildings is defined as an area where there is a minimum of 200 buildings and the distance between two neighbour buildings in the cluster does not exceed 200 metres.

The influence of movement of national and international tourists creating different busy hour at specific sites during the year is not taken into account in this analysis.

Table 1 shows population and business figures in 2008 as well as growth factors. A negative growth in an area means depopulation as a result of people moving from remote areas to urban environments.

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Area	Total population in 2008: 10,000,000			Total number of employees in 2008: 4,500,000		
	Population		Growth	Business (employees)		Growth
Dense Urban	30 %	3,000,000	0.3 %	50 %	2,250,000	0.5 %
Urban	30 %	3,000,000	0.3 %	30 %	1,350,000	0.5 %
Suburban	20 %	2,000,000	0.2 %	15 %	670 000	0.2 %
Rural towns	10 %	1,000,000	-0.1 %	25 %	112,500	0.2 %
Very rural/remote	10 %	1,000,000	-0.2 %	2.5 %	112,500	0.1 %

Table 1 Population and number of employees 2008 and growth projections

Area	Area definition by density	Avg. density km^{-2}	Area km^2
Dense urban	> 5,000 km^{-2}	7,500	400
Urban	[1,000, 5,000] km^{-2}	3,500	857
Suburban	[200, 1,000] km^{-2}	1,000	2,000
Rural	[50, 200] km^{-2}	70	14,286
Very rural/remote	< 50 km^{-2}	20	50,000

Table 2 Population densities

Area	Distance between base station sites [m] Planned for coverage in GSM grid	Cell range [m]
Dense Urban	700	467
Urban	1,000	667
Suburban	2,000	1,333
Rural Towns	5,000	3,333

Table 3 Cell ranges, and distance between base station sites

Table 2 shows the average population density (2008) and area in km^2 for the different geotypes.

Base Station Segmentation

In Dense Urban areas, the distance between buildings is shorter and the attenuation of radio signals through buildings is typically larger than 20 dB. In addition, the traffic is much more concentrated in these areas compared to less dense areas. Therefore the distance between base stations has to be much shorter than in suburban and especially rural areas.

Radio propagation has different characteristics at 2100 MHz – which is used in most 3G deployments – compared to the 900 MHz band used for GSM. A higher frequency means a shorter range and therefore shorter distance between base stations. Most GSM operators have both 900 MHz and 1800 MHz spectrum; the latter being used as an overlay spectrum for capacity. The radio propagation at 1800 MHz is quite similar to that at 2100 MHz. Mobile operators with an existing GSM network reuse most of their radio sites for 3G base stations, which are also called NodeB. In the densest areas, the distance between NodeBs can be less than 400 – 500 m.

Table 3 summarizes the average distance between NodeBs and cell range.

Broadband Mobile Access Users

The demand for broadband mobile accesses is generated by the business and the consumer segment.

The access demand is assumed to be lower in less dense areas simply because the competition in these areas is not as intensive as in the most urban areas. The adoption rate during the first years is relatively higher in low age segment. However, the mobile access demand for the various age segments is only slightly different in different geographic segments.

The mobile accesses are divided in different price/volume products according to the usage. During the next years we will see large differentiations on price, traffic volume cap, service level agreement (SLA) and access speed. For a specific operator, products and detailed price plans have to be specified. However, in the analysis we only differentiate between consumer and business accesses and consider averages. The diffusion of subscribers from one product to another and the flattening or slight decrease in Average Revenue Per User (ARPU) caused by competition are reflected in the forecast of the ARPU evolution.

Traffic Volume Demand

Traffic volume is defined as the accumulated number of gigabytes generated during one month. The customers have different usage behavior during the month. However, the traffic behaviour between consumer and business customers is less in the mobile broadband compared with the traffic in the broadband world where the business traffic is more linked to the business sites. So far it is noted that companies have given mobile broadband accesses also to employees without specific needs. The broadband business traffic also reflects usage by several employees on the same access. Mobile broadband traffic measurements have shown lower traffic generated from employees than for consumers.

The mobile broadband applications can be divided between real time applications (voice over IP, streaming, …) and other applications (email, downloads, …).

Mobile Broadband Tariffs and Further Evolution

The tariffs on broadband have for many years since the introduction in 1999/2000 decreased continuously. The first years the tariffs were very high and the speed offered very low. The demand was limited the first years and the technology immature. Mass production of network components reduced the cost after some years.

The situation for mobile broadband is very different. Many operators already have 2G/3G networks with base stations, which means that an important part of the investments have been carried out. Systems for billing and customer care have been established. The technology for mobile broadband is not completely new, but more an enhancement of the old one. In addition the demand for mobile broadband has nearly exploded from the start. Therefore, the tariffs start already on a low volume level.

There are different data tariff regimes ranging from completely free usage (flat rate) to stepwise payment for traffic volume. The first GB may be free; the second may be charged by a certain tariff, the third by a new tariff etc.

In this analysis 21 Euro is used as the monthly ARPU as a mean for the consumer market and the business market. The ARPU is given in real terms, ie. it is not adjusted for inflation, with VAT extracted and does not include the voice traffic. A reduction to around 14 Euro in 2015 is assumed due to increasing competition. It is assumed from the start that there will mainly be a flat rate regime as for broadband. However, there are reasons to believe that traffic will increase very significantly in the next years. One question will be how to limit the traffic in peak hours not to use too much investment for capacity expansions. One way to control the traffic is to introduce differentiated SLAs and payment for better service quality than best effort traffic. Another possibility is to introduce volume limitations for the monthly traffic volume. This is already introduced for service classes which have free traffic usage during periods of the week, while the users have to pay for the traffic outside these periods.

There are also reasons to believe that the subscription tariffs will be more complicated in the future. The Scandinavian mobile operator Nordisk Mobiletelefon[1)] AB has introduced a one week subscription and TDC a 24 hour subscription; both with limits for download volume. The ARPU will in the future be a function of different subscription contracts and traffic used relative to different volume limits.

In a way there are two main factors which influence the future evolution of the tariffs. One is the traditional one based on higher demand, mass production and lower production costs and in addition more intense competition. The other factor is the increased investment levels because of much more traffic in the network. In this analysis a modest reduction of 5 % of the ARPU each year is used in the calculations both for the consumer and the business market. However, the analysis shows bad economic results if the mobile broadband traffic increases beyond certain limits.

Traffic in Peak Hour

Dimensioning of the base station capacity and the network is dependent on the traffic in peak hour (busy hour). A conversion factor based on the share of traffic in peak hour compared with the day and night gives a link between the traffic volume during one month and the traffic in an average peak hour. The traffic in a maximum busy hour will typically be 50 % higher than the average. Maximum busy hour is used in the dimensioning of the network.

3 Mobile Broadband Forecasts

Mobile broadband was introduced only two years ago (2006). Operators in many European countries have

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1) *Nordisk Mobiltelefon's service offer is called "ice", see: www.ice.no (Norway), www.ice.net/se (Sweden) and www.ice-net.dk*

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already started to offer the service. The countries with the highest penetration in Europe are Austria, Hungary, Ireland, Italy, Lithuania, Slovenia and Sweden. Austria is leading the evolution having already more than 25 % of broadband accesses as mobile broadband accesses [1].

Description of Forecasting Models

The forecasting models used are based on the four parameter Logistic model. The model is simply based on the assumption that growth in for instance subscribers, is proportional to the number of persons in the population who have adopted the service and also proportional to the number of persons in the population who have not adopted the service. To get more flexibility the additional parameters are included. The forecasting model is given by:

$$Y(t) = \frac{M}{(1+\exp(\alpha+\beta t))^{\gamma}} \quad (1)$$

Where $Y(t)$ is the accumulated demand at time t, M the saturation level, α a level parameter, β and γ growth parameters. The parameters except M are estimated by a recursive regression procedure.

The model is suitable for new services with limited observations. The model was applied for broadband demand at the start of the broadband evolution with good results. See [2], [3], [4].

Mobile Broadband Access Forecasts

The mobile broadband access market consists of two markets; one is the consumer market, the other the business market.

For the consumer market the 'long-term' saturation level, M, for mobile broadband accesses will be a share of the total population as opposed to the fixed broadband market where the saturation level is part of the households. Now, the question is who will demand mobile broadband accesses in the long term. What about the mobile device/terminal evolution? For the moment mobile broadband can be accessed directly via for instance HSPA and CDMA terminals which also can be connected to PCs. It is possible to use this connection occasionally or to order a subscription. Another possibility is to buy a dongle with radio access, establish a subscription and use it on the PC.

The increase in mobile broadband accesses has been tremendous in some Western European countries during the last year. One factor is the continuous replacement of new mobile terminals. Now, the replacement time or lifetime of a terminal is about 1.5 year. However, the mobile broadband statistics are based on number of subscriptions. It does not say anything about the actual usage of the service, eg. in terms of data volume transferred, how often it is in use, etc.

In the first phase especially young users (from 16 years and upwards) have a higher broadband adoption rate than the same groups on traditional broadband relatively to the other age groups. Very relevant user groups for mobile broadband are students, persons with newly established homes and persons with flexible homes and flexible working places.

Mobile broadband also competes with fixed broadband. For some user groups the mobile broadband will be a substitute for fixed mobile; for others it will be a complement. In Figure 2 are shown forecasts developed for the period 2008 – 2015 in the consumer and business market respectively. These are based on a broadband access evolution similar to several European countries in the period 2006 – mid 2008.

The long-term broadband saturation level in the consumer market is estimated to be 32 %, based on the following assumptions:

- The consumer saturation will be 80 % mobile telephone consumer accesses.
- 40 % of the accesses will in the long run be mobile broadband accesses.

The accesses forecast volume is found by multiplying the penetration by the population size 10 million.

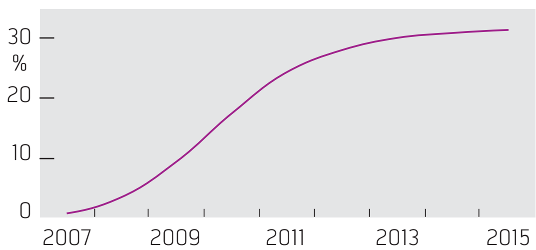

Figure 2 Mobile broadband penetration forecasts, consumer market, 2008 – 2015

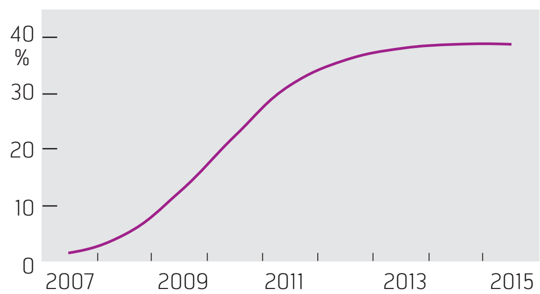

Figure 3 Mobile broadband penetration forecasts, business market, 2008 – 2015

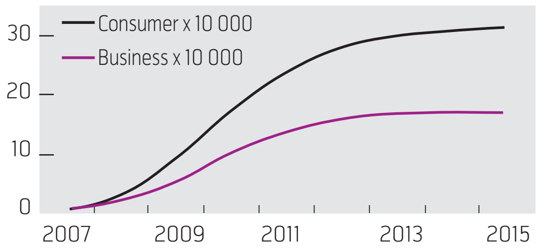

Figure 4 Mobile broadband forecasts consumer and business market, number of accesses, 2008 – 2015

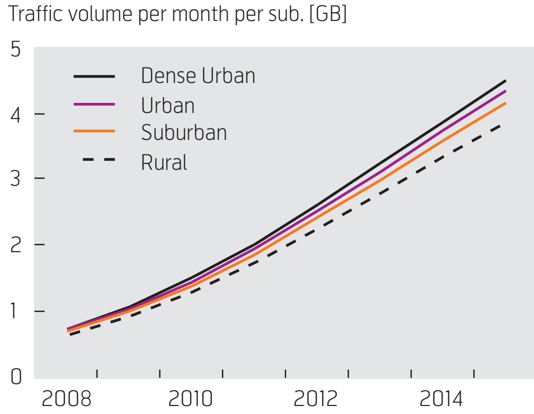

Figure 5 Monthly mobile broadband traffic volume per subscriber: Consumer segment, 2008 – 2015

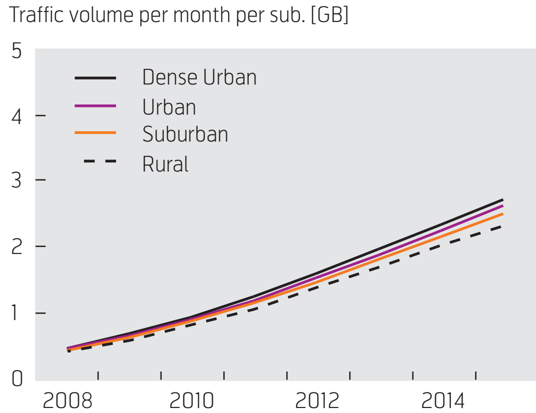

Figure 6 Monthly mobile broadband traffic volume per subscriber: Business segment, 2008 – 2015

The forecasts for number of mobile broadband accesses in the business market are based on number of employees in the country and also the number of employees who already have a business mobile access paid by the company.

The long-term saturation level in the business market is estimated to be 39 % based on the following assumptions:

- The business mobile telephone access saturation will be 65 %.
- 60 % of the accesses in the long run will be mobile broadband accesses.

Penetration 2006 – 2007 and estimated penetration at end of year 2008 for the consumer market and the business market show an extraordinary growth compared with other telecommunication services the first years after introduction. Hence, the forecasts also indicate that the penetration of mobile broadband accesses during the next years will increase very significantly flattening out from 2012 – 2013. Forecasts for number of accesses are shown in Figure 4.

The mobile broadband forecasts for the consumer and business market are used as input to the techno-economic calculations.

Traffic Forecasts

A logistic model has been used for modelling the traffic per subscriber in gigabytes (GB) per month. For simplicity, the same shape has been used for the different areas, but different saturation values have been used. In addition, we have assumed that the traffic per business user is 60 % of the traffic per consumer using mobile broadband. The consumer traffic forecast in Urban areas is based on a Logistic model assuming 0.7 GB per month in 2008, 2.5 GB in 2012.

It is assumed that the traffic volume differs in the different area types, mainly because of different income levels. The evolution of the monthly traffic per subscriber is shown in Figure 5 and Figure 6 for the consumer and business segment respectively as the basic case. The figures show the assumptions of how the traffic is differentiated between dense urban, urban, suburban and rural areas and also between the consumer and the business market.

To examine how the traffic is influencing the economics in the rollout, the effect of different evolutions of the basic case is analysed. The traffic evolution alternatives are shown in Table 6 and Figure 13.

Busy Hour Forecasts and Dimensioning

The total network busy hour is defined as the average traffic in the busiest hour of the whole network measured in Gbps at the packet core. The total generated traffic volume V in GB is a weighted sum of the number of subscribers multiplied by traffic volume. The conversion of traffic volume into busy hour traffic $T_{\text{Total Network}}$ is done in the same way as in [5]:

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$$T_{\text{Total Network}} = \frac{V \times 8 \text{ bits/byte} \times \text{Percentage of daily traffic volume in network busy hour}}{30 \text{ days/month} \times 3600 \text{ seconds/hour}}$$

The dimensioning traffic at the radio interface is modelled by using an effective utilization factor which incorporates traffic concentration, the fact that base stations have peak traffic which does not coincide with the network busy hour, cell breathing characteristic to W-CDMA and non-homogeneous traffic load in different sectors. 0.5 – 0.6 seems to fit well with traffic measurements and planning guidelines for HSPA. The utilization factor is thus set to 0.6 in the calculations.

$$T_{\text{Radio Network}} = \frac{T_{\text{Total Network}}}{0.6}$$

The traffic demand per base station is compared to the throughput that can be offered for various upgrade levels, eg. number of codes used and number of 5 MHz carriers.

There are definitive uncertainties in the long-term traffic forecasts. The main reasons are the new and immature mobile broadband service and also the evolution of the devices and the screens. Questions arise concerning eg. how often data communication will be generated by the mobile device and how often by PCs connected to mobile broadband. In the analysis different traffic loads are used for screen traffic and for usual device traffic. Furthermore, it is uncertain in what way data communication usage varies during a day both for the business and the consumer market and how this affects the peak hour traffic. Another uncertainty is the future evolution of new applications and new content and how this will affect the traffic generated. The forecasts made give a sort of expected mean value of the traffic evolution.

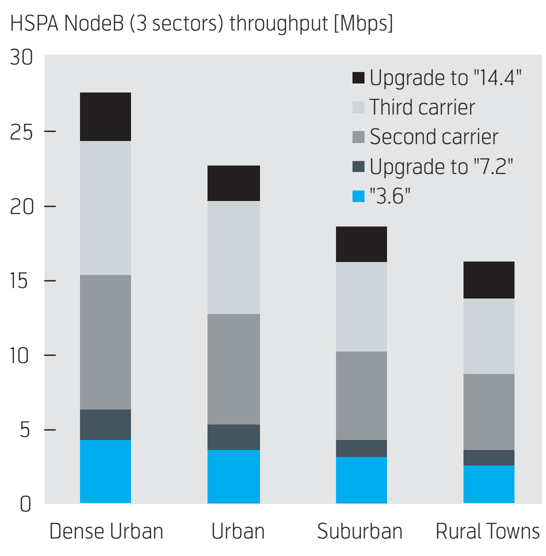

Figure 7 Throughput assumptions for 3-sector NodeBs with HSPA

Additional research and also monitoring of the carried traffic during the coming years will differentiate the assumed picture of the traffic growth so far. Also specific actions for traffic control will be an important part of the picture. The service quality will probably be differentiated by a set of Service level agreements. In addition, as we see today, the increasing price tariffs of transferred data volume per month may also to a certain extent reduce the traffic. Another aspect is Mobile TV and on-demand TV applications which could easily make the network reach the capacity limit.

To be able to make better traffic forecasts in peak hour, it is necessary to follow the mobile broadband evolution and continuously extract new information.

4 Coverage and Capacity

The real HSPA radio network planning process includes at least three main phases:

- Dimensioning,
- Capacity and coverage planning, and
- Network optimization.

In the dimensioning phase propagation conditions from the actual regions, spectrum availability and traffic density information is needed. Also information about the existing base station structure is necessary to optimize the site investments. Output will typically be a rough number of base stations and sites.

The output of the capacity and coverage planning are the base station locations, base station configurations, cell specific parameters and quality of service analysis.

For the network optimization it is crucial to have measured the network performance to do the necessary adjustments. Most 3G operators with a WCDMA network operating in the 2100 MHz band have 2 x 15 MHz of FDD (frequency division multiplex) spectrum, meaning 15 MHz in both the downstream and upstream direction. The spectrum unit granularity is 5 MHz for WCDMA. In the following, the term 'carrier' is used for this 5 MHz unit of spectrum.

For a base station with three sectors, the following upgrade steps have been considered and included in the analysis:

- Upgrade from basic NodeB to '3.6'
- Upgrade from '3.6' to '7.2'
- Using the second carrier
- Using the third carrier

The data throughput has been assumed to be 30 % lower for the first carrier compared to that of the second and third carrier. This is due to circuit switched voice traffic sharing the first carrier with HSPA data traffic. The second and third carriers are assumed to be used for HSPA data traffic only.

The throughput per NodeB with HSPA (3 sectors) for different areas is shown in Figure 7.

The reason for the higher throughput in the urban areas compared to the rural areas is mainly due to demand for higher traffic in the busy hour.

Figure 8 shows the CAPEX breakdown of a Dense Urban NodeB with HSPA. This includes basic NodeB costs, installation costs, site acquisition and preparation, backhaul radio link, software upgrades and additional carriers. It is assumed that an existing site GSM is used. The HSPA upgrade costs include the specific software and hardware upgrades due to basic HSPA radio upgrades (‘3.6’, ‘7.2’, ‘14.4’ Mb/s), backhaul upgrades if existing capacity is exceeded as well as antenna upgrades when the third carrier is taken into use.

Figure 9 shows the CAPEX breakdown for a Suburban new site.

The main differentiators in the CAPEX for different areas are backhaul costs and the site installation/ preparation cost. It has been assumed that the backhaul overhead is 30 % meaning that for a maximum throughput of 20 Mbps (application layer) at the NodeB, at least 20 x 1.3 = 26 Mbps is needed for the link.

All estimations assume that the mobile operator is using microwave only and no leased lines as their backhaul transport solution.

Figure 10 shows a tree topology of backhaul links being used in the calculation model. Here, four NodeBs are sharing the second hop and 13 NodeBs are sharing the third hop.

For a mobile operator with existing GSM and 3G networks, sites are backhauled with TDM-based microwave solutions, up to 16 x 2 Mbps for the first hop from the base station site. When the capacity threshold is exceeded, Ethernet microwave links are assumed to be used for data traffic while freezing TDM-based investment at sites co-located with GSM. For new sites, ie. outside the existing site grid, the backhaul is assumed to be purely Ethernet-based.

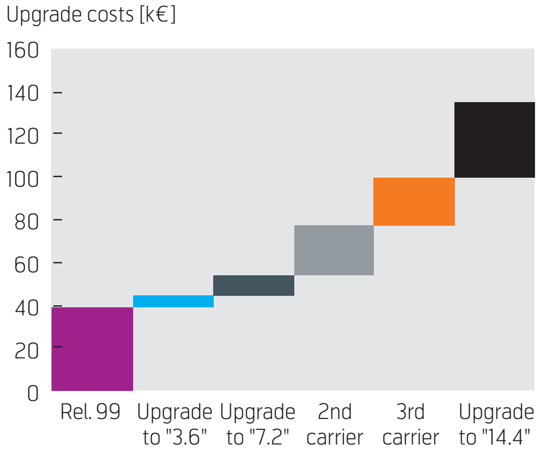

Figure 8 CAPEX breakdown of a Dense Urban 3-sector NodeB with HSPA

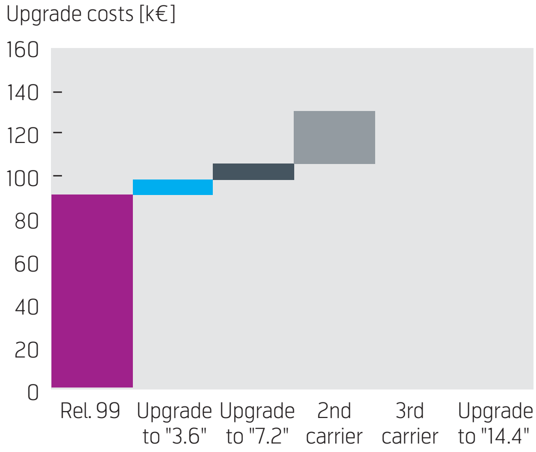

Figure 9 CAPEX breakdown of a Suburban 3-sector NodeB with HSPA

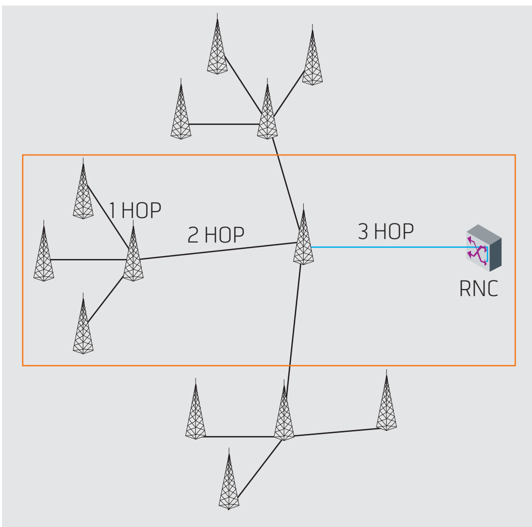

Figure 10 Backhaul topology of microwave links

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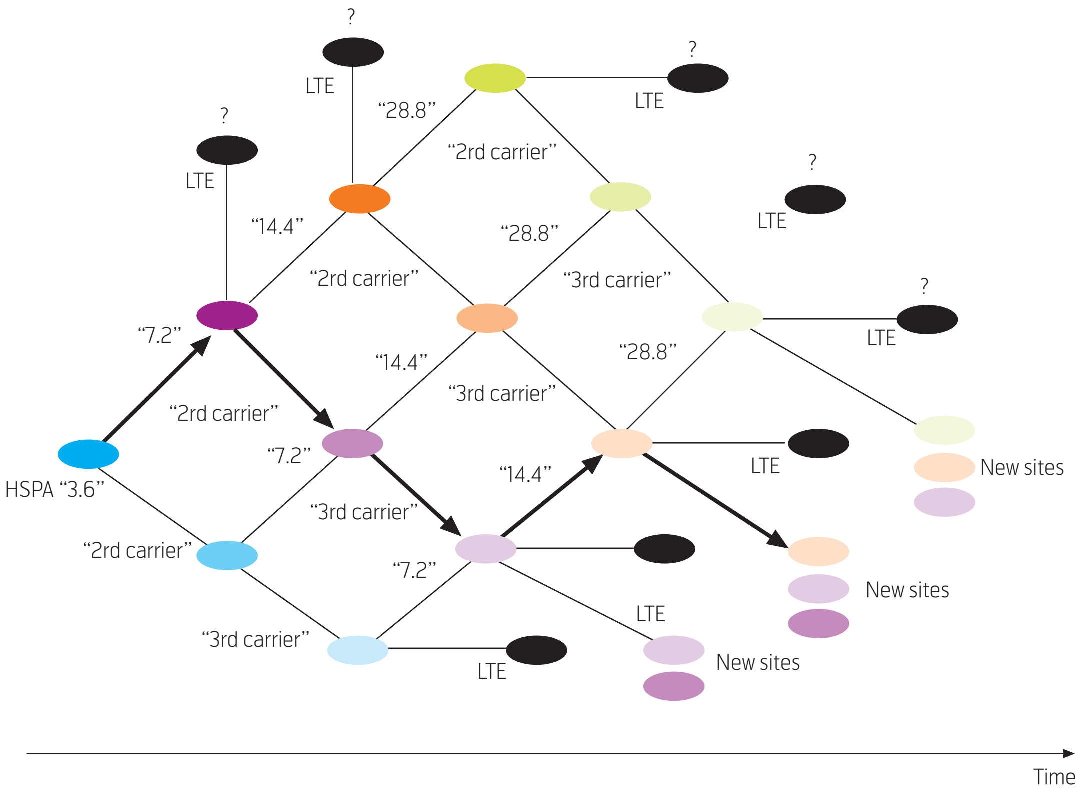

Figure 11 Different upgrade alternatives and background for base station rollout

5 Mobile Broadband Rollout Scenarios

A mobile operator with an existing GSM and 3G network has been considered. This means that the operator already has a grid of existing sites and some 3G base stations. The operator can decide to roll out an HSPA network in 2008.

Figure 11 shows the upgrade studied in this analysis selected from a more exhaustive number of migration paths for mobile broadband based on Third Generation Partnership (3GPP) technologies: HSPA, HSPA evolution ('28.8') and LTE.

The figure illustrates the different evolutionary paths for upgrading the capacity on the base station. The upgrading is a function of the traffic increase. Figure 7 shows how the throughput is increased by upgrading alternatives. In addition Figure 11 gives guidance for rollout of new sites/base stations when the traffic forecasts exceed given limits. The dark alternatives in the figure indicate LTE. There are so far some uncertainties about the future throughput for LTE. Therefore, the LTE alternatives are indicated in the figure.

HSPA is offered from existing 3G base station sites, from existing GSM sites together with new 3G NodeB equipment and from new sites outside the GSM grid.

Only upgrades up to and including '14.4' have been considered in this analysis – HSPA evolution (HSPA + or '28.8') and Long Term Evolution (LTE) have not been included. These options are based on MIMO (multiple input and multiple output) antenna technol-

	Number of NodeB 2007		2008	2009	2010	2011	2012	2013	2014	2015
75 %	Dense urban	541	75 %	85 %	100 %	100 %	100 %	100 %	100 %	100 %
60 %	Urban	264	60 %	80 %	80 %	80 %	80 %	80 %	80 %	80 %
40 %	Suburban	103	40 %	70 %	80 %	85 %	85 %	85 %	85 %	85 %
5 %	Rural towns	23	5 %	10 %	20 %	20 %	20 %	20 %	20 %	20 %
		932	49,0 %	64,6 %	72,1 %	73,2 %	73,2 %	73,3 %	73,3 %	73,4 %

Table 4 HSPA rollout of selected mobile operator

ogy. LTE requires entire new base station equipment – known as eNodeB (enhanced NodeB).

Table 4 shows the rollout strategy used in this analysis. The operator makes a fast rollout in dense urban areas by 100 % coverage during a few years, while the coverage is 80 – 85 % in urban and suburban areas and low in rural towns (eg. some selected holiday resorts). The reason for the limitations in the rollout is the high investment level in rural areas required for coverage in the 2100 MHz frequency band.

6 Analysis and Results

The rollout strategy based on the coverage plan shown in Table 4 is the basis of the techno-economic analysis. Figure 12 shows the economic evolution of the HSPA rollout case based on the subscription (SIM card) and traffic forecasts, evolution of market share, ARPU, CAPEX and OPEX costs. The ARPU for 2008 is set to 20 Euro for the consumers and 10 % more for the business users. It is assumed a yearly decrease in ARPU of 5 – 7 % in the period 2008 – 2015.

A discount rate of 12 % before tax has been used. A risk free rate of 5 % has been used for discounting yearly CAPEX. Net present value (NPV) and internal rate of return (IRR) have been calculated with and without terminal value for a period of eight years. The terminal value is based on the book value of the network assets. Infrastructure and equipment investments late in the period will serve subscribers and secure revenues beyond 2015.

The operator is assumed to have a market share starting at 40 % and decreasing to 30 % due to competition caused by new market entrants. The cash flows, NPV and IRR for the base case are summarized in Figure 12.

The business case results are in general very sensitive to assumption on traffic evolution. In the following, the sensitivity to the evolution of the traffic volume per subscriber per month is investigated. For the base case traffic assumptions shown in Figure 5 and Figure 6, the aggregated average data volume over all areas and market segments is 0.6 GB in 2008, 2.1 GB in 2012 and 3.5 GB in 2015.

	2008	2009	2010	2011	2012	2013	2014	2015
Revenue	17.8	68.8	139.1	202.3	237.2	247.8	245.2	237.0
COGS								
- SAC	28.5	65.8	91.2	84.4	67.1	54.7	48.2	45.4
- SIM card costs	1.4	3.3	4.6	4.2	3.4	2.7	2.4	2.3
	29.9	69.0	95.8	88.7	70.5	57.4	50.6	47.6
Revenue margin	(12.1)	(0.2)	43.3	113.7	166.7	190.4	194.6	189.4
Network OPEX								
- OAM costs	1.6	2.1	2.4	2.4	2.4	2.4	2.5	2.9
- Site rental costs, power etc	11.0	14.5	16.3	16.5	16.5	16.5	17.0	19.7
- Man power costs	5.5	5.8	6.1	6.4	6.7	7.0	7.4	7.7
- SGSN+GGSN support costs	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
- RNC support costs	0.2	0.2	0.3	0.5	0.7	0.9	1.1	1.2
- NodeB support costs	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
	18.8	23.1	25.6	26.3	26.8	27.4	28.5	32.1
Non-Network OPEX								
- Customer care and billing	0.7	3.0	6.4	9.9	12.2	13.4	14.0	14.2
- Sales and Marketing	2.4	6.5	12.1	17.2	20.0	20.8	20.6	20.0
Total OPEX	21.9	32.6	44.2	53.4	59.0	61.6	63.1	66.3
EBITDA	(34.0)	(32.8)	(0.9)	60.3	107.7	128.8	131.5	123.1
CAPEX	37.6	24.4	52.4	20.8	31.8	8.7	33.2	36.9
Free cash flow	(71.5)	(57.2)	(53.2)	39.5	75.9	120.1	98.3	86.2
Cash balance	(71.5)	(128.8)	(182.0)	(142.4)	(66.5)	53.6	151.9	238.1
Discount factor – WACC	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523
Discount factor – Risk free rate	1.000	0.9479	0.8985	0.8516	0.8072	0.7651	0.7252	0.6874

	wo terminal value	w terminal value
NPV [mill Euro]	35.6	80.3
IRR	14.8 %	19.2 %

Figure 12 Results of HSPA rollout business case

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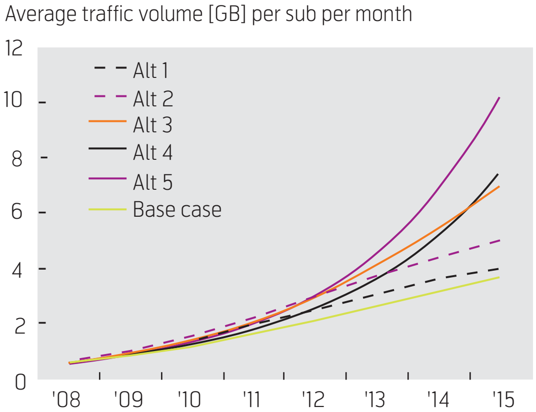

Figure 13 Traffic evolution alternatives, comparison with base case

To examine the traffic impact on the business case, a set of alternative traffic evolution scenarios described in Figure 13 are evaluated. The traffic volume in 2008 is kept fixed in all cases at the base case level of 0.6.

The figure shows the base case traffic evolution which has been analysed and five additional traffic volume forecasts with higher growth. The alternatives have a reasonably close evolution until 2011, but larger deviations in the last part of the period. Alternative 4 and 5 are based on exponential distributions, while alternative 1 – 3 have an S-shaped form.

Table 5 shows the net present value (NPV) and internal rate of return (IRR) with and without terminal value for the rollout business case given that network capacity is expended to handle the traffic based on the five described alternatives. The table illustrates that there are limits for having a positive rollout case based on the assumptions used in the analysis.

7 Conclusions

It is seen that the rollout of HSPA with the given assumptions becomes unprofitable for high traffic volumes (higher than around 5 GB per subscriber per month in 2015) if the strategy is solely based on HSPA up to '14.4'. In order to offer such data volumes for mobile broadband, alternative or complementary technologies such as for example HSPA+, LTE, and use of alternative frequency bands would have to be used in the most traffic-loaded areas in order to avoid excessive macro network investments, new sites and backhaul. If it takes some years before it starts to hurt using HSPA alone, the operator will inherently have flexibility to choose the timing of new and/or complementary technologies and to seek synergies between mobile and fixed network technologies on backhaul and IP transport network investments. The possible path for the operator depends heavily on the commercial maturity of new network technologies as well as the regulatory regime and access to various spectrum bands.

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Traffic evolution alternatives	Traffic growth	Volume [GB] 2012	Volume [GB] 2015	Without terminal value		With terminal value	
				NPV [mEuro]	IRR	NPV [mEuro]	IRR
Alternative 1	S-scurve	2.5	4.0	8.6	12.7 %	60.0	17.1 %
Alternative 2	S-curve	3.0	5.0	-95.5	8.0 %	17.0	13.3 %
Alternative 3	S-curve	3.0	7.0	-171.1	2.0 %	-23.9	10.2 %
Alternative 4	Exponential	2.5	7.4	-175.3	1.9 %	-3.7	11.7 %
Alternative 5	Exponential	3.0	10.1	-345.9	-5 %	-83.1	6.0 %

Table 5 Traffic evolution alternatives

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For a presentation of Nils Kristian Elnegaard and Kjell Stordahl please turn to page 2.

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For a presentation of Thor Gunnar Eskedal please turn to page 62.

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