The Case for Femtocells

Operator business case & consumer propositions

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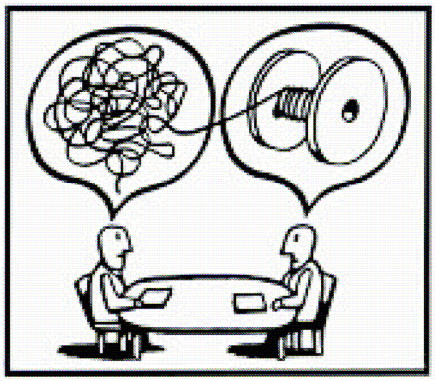

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ip.access is a technology innovator and a pioneer in cellular over IP, with more than 20 operators worldwide using our picocells. Our Oyster 3G™ femtocell was launched in February 2007 at the 3GSM World Congress, where it won the GSM Association award for Best Radio Access Product.

In this paper, we examine the business case for femtocells as a potential solution to 3G coverage and capacity issues in the home, and explore the consumer marketing propositions that will help operators to realise these business benefits.

1 INTRODUCTION

Femtocells are tiny, low power 3G radio systems that plug into a residential broadband connection to provide a mobile signal directly in the home.

Apart from being able to extend network coverage where none previously existed, femtocells have the potential to play a significant disruptive role in Fixed Mobile Substitution (FMS).

Delivering high-quality mobile services inside buildings is a tough challenge for the macro network because walls attenuate the radio signal. This is a particular problem for 3G because it uses higher spectrum bands where radiofrequency signals attenuate more rapidly, and because fast data rates are only possible when the quality of the signal is strong.

A home femtocell not only delivers a good signal and fast data rates, but it does this at very low cost because the traffic is backhauled to the mobile operator's core network over the household's existing broadband link.

These cost savings can be passed on to customers in the form of targeted "femtozone" tariffs, making the mobile phone competitive not only with the fixed line telephone, but also with the TV and PC for entertainment and information services in the home.

2 FEMTOCELLS & FIXED MOBILE SUBSTITUTION

Many operators have introduced homezone tariffs to encourage FMS. These tariffs are based on the macro network cell ID, and provide mobile calls at fixed-line rates in the home. However, homezone tariffs suffer from three problems:

- Firstly, they rely on a good signal from the macro network in the home. Consumers won't use their phones at home unless the user experience is good.
- Secondly, homezone tariffs cut the price of services without cutting the cost of delivering them, thereby eating into the operator's profit margins.
- Thirdly, a homezone tariff based on macro network cell ID extends beyond the home. The consumer gets fixed line rates even in places where the fixed phone is not available, and the operator loses the valuable premium for mobility outside the home.

Femtocells, combined with "femtozone" tariffs, can solve all these problems, giving a good user experience in the home at an affordable cost to the operator, with price discounts that don't leak outside the home.

Furthermore, 3G femtocells can expand the scope of FMS well beyond simply substituting voice minutes from the fixed line phone. With operators now promoting mobile internet services, and adopting new business models based on revenue share with web and media partners instead of per-megabyte data pricing, they need to encourage use of entertainment and information services

on the mobile handset. As a result, FMS will increasingly become more concerned with stealing a share of content and advertising revenues from the traditional sources of entertainment and information in the home – the PC and TV. This is explored further in the next section.

3 THE SIGNIFICANCE OF MOBILE DATA

3.1 Strategic importance to operators

Consumer adoption of 3G data services did not live up to the initial hype. However, with HSDPA data speeds, ever-improving multi-media handsets, flat rate data plans, and new mobile service offerings from web and media brands, this looks set to change.

European mobile data service revenues are suddenly growing ahead of analysts' expectations. Credit Suisse & Dresdner Kleinwort both recently reported improvements in the growth of user-generated content, mobile TV, data-cards, and mobile email, pointing to the introduction of flat rate pricing as the main catalyst for growth[1]. Deutsche Bank believes that HSDPA finally creates a good enough user experience: "Consumers using HSDPA can get data rates that 'feel' like a good cable modem connection, rather than a poor DSL connection that WCDMA offered. Carriers we spoke with…saw big increases in data plan attach rates with HSDPA phones."[2] And Ericsson is predicting a 10-fold increase in data traffic by 2012[3].

Encouraging use of mobile data services, especially for web applications such as social networking and internet search, is strategically important for mobile operators as they begin to embrace internet business models, sharing content and advertising revenues with web and media partners. In this regard, mobile operators are much better placed than their fixed line counterparts. Web and media brands need operator cooperation to install their applications in mobile phones, promote their services to subscribers, and to provide billing services for content downloads. The more users purchase and download content directly to their phones, and the more they use the phone for internet search and social networking, the greater the advertising and content revenues a mobile operator can generate.

3.2 Strain on the 3G network

Many of the more attractive new mobile data services consume a lot of bandwidth. Music, video and podcast file downloads are typically several megabytes each, and video streaming can require 128 kbps or more for a reasonable user experience.

Most 3G networks are running well below capacity today, but even a moderate level of adoption of mobile broadband services can quickly strain the network to breaking point. For example, Telenor reported recently that its 3G network can only support two users per cell for live video streaming of Norwegian Premier League football matches[4]. Broadcast technologies such as DVB-H will only solve part of the problem, because they only increase efficiency if lots of people want to watch the same thing at the same time. We have learned from the internet's "Long Tail" effect, and the phenomenal success of video-sharing sites like YouTube, that most video content will need to be

[1] http://www.unstrung.com/document.asp?doc_id=119491

[2] Deutsche Bank report on 3GSM Congress 2007.

[3] Ericsson CEO Carl-Henric Svanberg, May 2007 (http://www.mobilemonday.net/news/ericsson-traffic-to-grow-ten-fold-in-5-years)

[4] Presented at the Telco 2.0 Brainstorm in London, March 2007

streamed on demand. If mobile TV and other bandwidth-hungry data services are to be commercially successful, operators need a way to deliver this data much more cost-effectively via the 3G network.

3.3 Consumer demand for mobile data at home

It is widely reported that about 30% of mobile voice calls take place at home, but do consumers really want to use mobile data services in the home environment? After all, the PC and TV are readily available, free, and in many ways more natural choices for video entertainment, internet browsing, social networking, instant messaging and other applications. Interestingly, it seems that the mobile phone does indeed retain its appeal, even when pitted against the PC and TV. For instance, a recent McKinsey report highlighted that 35% of mobile TV is watched in the home[5].

By way of possible explanation, the mobile phone offers privacy (which may be important for IM sessions and internet browsing), as well as the convenience of being immediately to hand for quick tasks like internet search. Furthermore, the PC is sometimes an unnecessary intermediary between the phone and the web. Much of the user-generated content shared on the internet is captured on mobile phones, and RSS feeds and podcasts are often consumed on portable devices, so it makes sense to upload videos and photos directly from the mobile phone to websites like YouTube and Flickr, and also to download podcasts and music directly to the phone from the web. This is much more convenient than transferring files via the PC.

3.4 Femtocells & mobile data

Femtocells can encourage the adoption of mobile data services by providing a good user experience in the home, where new services are often tried first. Providing a high quality 3G signal directly in the home is a real problem for the macro network. For example, if the macro cell gives a 98% probability of coverage for a 3G voice call outdoors, then the probability of making the same call indoors drops to around 70% in a suburban area, and the probability of a successful indoor data session at 384 kbps is little more than 20%[6]. Femtocells solve this problem by providing the 3G signal directly in the home, ensuring a good user experience even for high speed data services.

Equally importantly, femtocells allow the operator to deliver data services at a very low cost, enabling attractive pricing for end users without sacrificing profitability for the operator. This is explored further in section 4 below.

As subscribers become familiar with using data services inside the home, so they will use the same services more outside the home as well. In fact, femtocells have an additional, hidden benefit for outdoor users. Firstly, removing indoor data sessions from the macro network reduces the number of users each macro cell needs to support. Secondly, because of the way WCDMA works, power is shared amongst all users in a 3G cell. If some users are indoors, the radio signal must penetrate through walls to reach them, and their phones therefore consume a large share of the available power. The net result is that the capacity of the macro cell is reduced, and quality of service suffers for all users in the cell[7]. If the indoor users are served via femtocells instead of from the macro cell, the capacity of the macro network increases out of all proportion to the number of users who have been removed from the cell.

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[5] McKinsey; "The Revolution of the Third Screen", October 2006.

[6] Signals Research Group, LLC; Signals Ahead, 9 May 2007: "Femtocells – who says size doesn't matter?"

[7] For further details, see the ip.access white paper "3G femtocell architectures - the evolution to IMS".

4 OPERATOR BUSINESS CASE FOR FEMTOCELLS

Femtocells offer clear benefits to mobile operators, but they are more complex to implement and support than alternatives such as homezone tariffs. Also, installing a femtocell at home demands more effort from the consumer, who may therefore need an additional incentive to adopt a femtocell as compared to simply signing up for a homezone tariff.

This section explores the business case for femtocells from the point of view of the mobile network operator. It is important to appreciate that this is quite separate from the business case for the end user (see section 5), but the two are related. If the business case for the operator is strong, there will be plenty of scope for attractive discounts and other incentives that encourage end users to welcome femtocells into their homes.

4.1 Business case for voice services

The most obvious business case for femtocells is providing coverage for mobile voice services in areas where the macro network is not available. With 30% of mobile calls are made at home, operators with coverage holes in residential areas have the potential to significantly increase revenues by deploying femtocells.

For example, a subscriber with no mobile coverage at home whose monthly bill is €45, 80% of which is from voice services, could be expected to spend around €11 more each month. This would more than cover the fully subsidised cost of the femtocell (see Appendix below). Femtocells might initially be provided to subscribers with no home coverage who are highly motivated to make and receive mobile calls at home (e.g. corporate executives), and who would be willing to pay a monthly subscription for the femtocell in order to have this convenience.

A case can also be made for using femtocells with a femtozone tariff as an alternative to homezone tariffs for encouraging substitution of voice minutes from the fixed line phone. The femtocell approach is more profitable because it prevents leakage of the discounted tariff outside the home. For example, assuming an average discount of €0.04 per minute in the homezone / femtozone, a subscriber making 50 minutes of calls per month from outside the home but still within the same macro cell would generate €2 per month more profit with a femtocell. The femtocell also increases profit margins on each call inside the home by using the subscriber's broadband connection for backhaul.

4.2 Business case for data services

Because femtocells gives a faster data speed and better quality of service, they will encourage greater use of data services inside (and outside) the home. This is probably the most important strategic reason for a mobile operator to deploy femtocells in its network, rather than relying on the macro network alone. However, it is instructive to consider the business case for a worst-case scenario, where the femtocell does not drive any additional usage at all.

In order to simplify the analysis, we will consider a hypothetical network that is used for a single application - video streaming (e.g. watching YouTube on the mobile phone). In practice, the real network will be used for a range of services, but the simple model provides a reference point for a world in which mobile data services are becoming adopted more widely.

The business case is established by comparing the cost of serving a city of 500,000 inhabitants from the macro network alone with the cost of serving the city from a macro network supplemented with a femtocell layer for serving indoor users.

The following assumptions are made:

- 30% of video streaming sessions take place indoors.
- Peak cell throughput is 2 Mbps, but this is reduced when some users are indoors[8].
- The busy-hour share of daily traffic is 20%.
- Acceptable blocking probability is 1% (i.e. 1% of video streaming sessions are blocked, or reduced to below acceptable quality, because the cell capacity has been exceeded).
- Mobile phone penetration in the city is 90%, and the operator's market share is 20%.

Basis of calculations

The effect of the following variables is explored in the model:

- Average number of video streaming sessions per user per month.
- Video streaming bit-rate.
- Average length of a video streaming session.
- User penetration of femtocells (i.e. the percentage of users that can access a femtocell for indoor sessions).
- Average number of users served by each femtocell.
- Femtocell price (to the mobile network operator).

The maximum number of simultaneous video streaming sessions that can be supported by one macro cell is calculated by dividing the peak cell throughput by the video streaming bit-rate. Subject to the desired blocking probability, this allows the maximum traffic intensity within the cell to be determined from an Erlang B calculation[9].

The maximum number of users that a single cell can support is then calculated from the traffic intensity, the length of a video session, and the average number of video streaming sessions per user per day.

If 30% of video streaming sessions take place indoors, and 20% of users have access to a femtocell for indoor use, then 6% (i.e. 20% x 30%) of the total video streaming sessions will be removed from the macro network. This allows each macro cell to support more users, which in turn means that fewer macro cells are needed to cover the city. In fact, the effect is magnified because removing indoor users also increases the effective throughput of the macro cell for outdoor users. In other words, because indoor users require more cell resources than outdoor users, removing one indoor user creates capacity on the macro cell to serve more than one outdoor user.

The overall business case is calculated by taking the saving from deploying fewer macro cell sites and subtracting the cost of deploying the femtocell layer.

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[8] The model uses data from Ericsson in "The Impact of Indoor Traffic on the Performance of WCDMA HSDPA Within Macro Cells", Oct 2006. E.g. 30% indoor usage (i.e. zero femtocell deployment) decreases cell throughput by about 35%.

[9] See, for example, http://en.wikipedia.org/wiki/Erlang_unit

Example calculation

Lets assume the following values for the variables in the calculation:

- Average number of video streaming sessions per user per day = 1.
- Video streaming bit-rate = 128 kbps.
- Average length of a video streaming session = 3 minutes.
- User penetration of femtocells = 20%.
- Average number of users served by each femtocell = 2.
- Femtocell price (to the mobile network operator) = €200.

With no femtocells deployed in the network, the throughput of the macro cell is effectively reduced to 1.3 Mbps (because 30% of usage is indoors). Each macro cell can therefore support 10 concurrent video streaming sessions (1.3 Mbps / 128 kbps). At 1% blocking, the maximum traffic intensity works out at 4.46 Erlangs. Based on our usage assumptions, this means that each macro cell can support 446 users. With 90,000 subscribers in the city, 202 macro cell sites are required. Assuming a population density of 10,000 per square km, the macro cell sites would need to be spaced about 535 m apart.

If femtocells are deployed in the network in such a way that 20% of users have access when indoors, we would expect 20% of indoor video streaming sessions to be removed from the macro network. Since 30% of sessions are indoors, this corresponds to 6% of total sessions being removed. This has the effect of increasing the effective throughput of the macro cell from 1.3 Mbps to 1.4 Mbps, which means that each macro cell can now support 11 concurrent video streaming sessions. At 1% blocking, the maximum traffic intensity works out at 5.16 Erlangs. Based on our usage assumptions, this means that each macro cell can now support 549 users (that's 103 more users than without femtocells), and only 164 macro cell sites are required to cover the city.

Deploying femtocells therefore saves 38 macro cell sites, for which the fully subsidised monthly cost is around €186k (see Appendix). Assuming on average that 2 users share each femtocell, the number of femtocells required to cover 20% of the user base is 9,000, at a monthly cost of around €96k. The net monthly saving for the operator is therefore around €90k per month, which is well over €1 million each year (almost €12 per customer) in just this one city.

Analysis of femtocell cost savings

Figure 1 shows that femtocells can bring very significant cost savings to the operator, even at moderate usage levels. For example, if subscribers average just one 3-minute video streaming session per day at 384 kbps, a 20% user penetration of fully subsidised €200 femtocells (each serving a household of 2 users) will save the operator around €65 per customer per year (i.e. €65 for each subscriber in the city, not only those who have femtocells).

With 128 kbps video streaming, femtocells become profitable at a usage level below 20 sessions per user per month (which corresponds to about 56 MB of data transferred per user).

Two factors give rise to these cost savings:

- Firstly, removing some of the indoor video streaming sessions from the macro network reduces the number of users each macro cell needs to support, thereby reducing the number of cell sites required to serve the city.
- Secondly, removing indoor users increases the throughput of the macro cell, which in turn increases the number of simultaneous sessions that each macro cell can support.

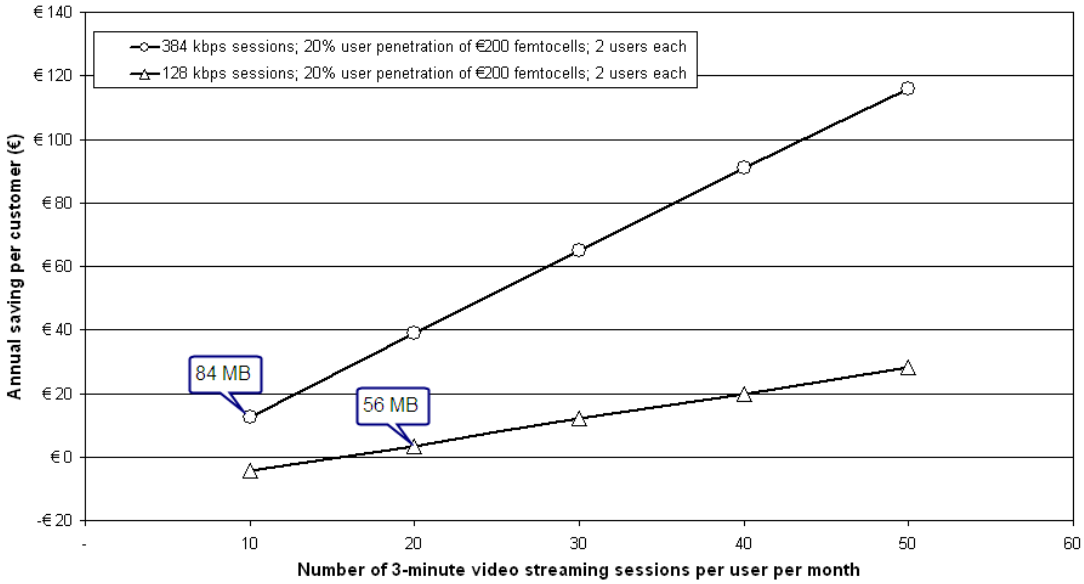

Figure 1: Annual femtocell saving per customer – effect of data rate

Figure 2 indicates that there is a dramatic payback from increasing femtocell penetration within the user population, and Figure 3 shows that the business case is not especially sensitive to the cost of femtocells.

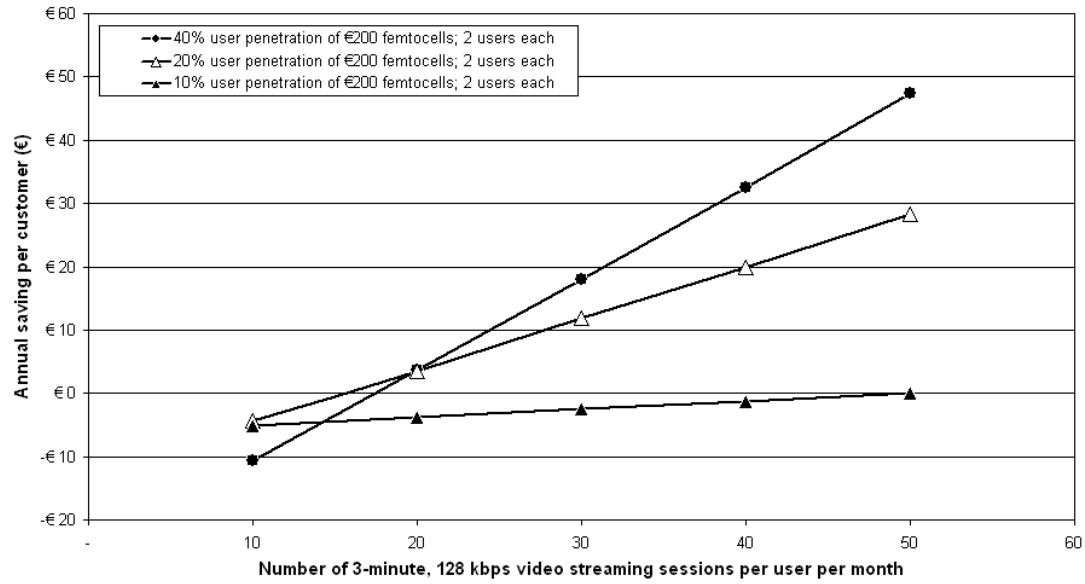

Figure 2: Femtocell saving for 128 kbps video streaming - effect of femtocell penetration

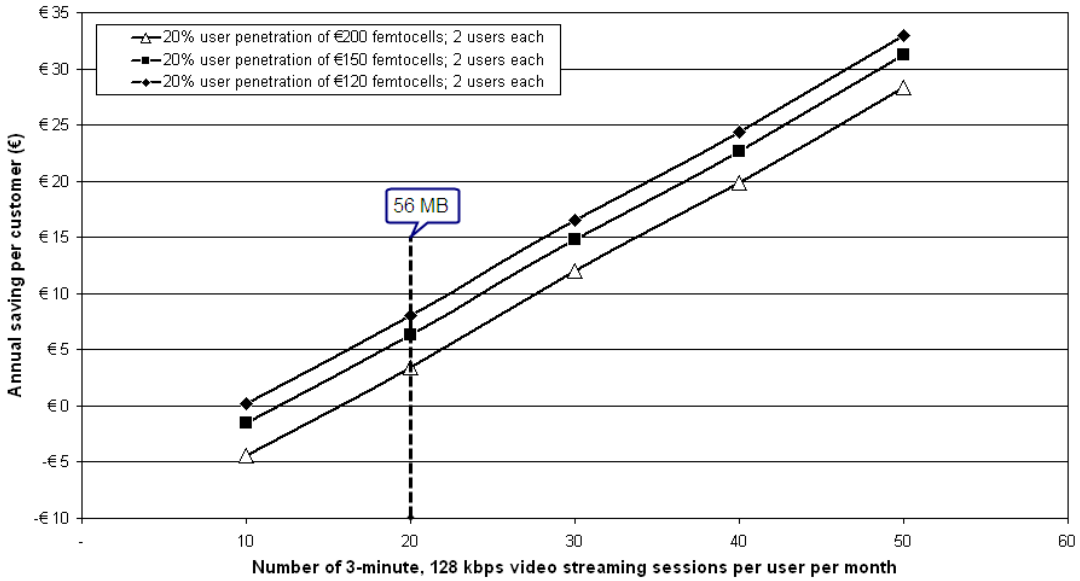

Figure 3: Femtocell saving for 128 kbps video streaming – effect of femtocell price

Note that the simple model above may significantly underestimate the business case. The model assumes that macro cells and femtocells are optimally redeployed to cover the city's population as usage levels rise. This is a reasonably sensible approximation for femtocells, if we assume that customers are equally likely to install a femtocell irrespective of where they live. However, when more macro cells are required to support increased usage, in the real world it is not feasible to move existing macro cells about freely in order to cover the city optimally. In practice this will make it much more expensive to support increased usage by upgrading the macro network than the simple model assumes.

4.3 Operator business case summary

The strategic case for femtocells is primarily based on Fixed Mobile Substitution. The femtocell delivers a great user experience for 3G voice and data services, thereby enabling the mobile phone to compete not only with the fixed line phone but also with the PC and TV for entertainment and information services in the home. In this respect, the macro network will not provide a viable alternative once data service usage begins to ramp up.

Even if femtocells did not create any additional usage of mobile services in the home, there would still be a good business case for operators to deploy them (perhaps even fully subsidised) based on cheaper service delivery costs and better control of homezone tariff boundaries.

5 CONSUMER PROPOSITIONS

Network cost-savings and improved coverage and performance are all well and good for the mobile operator, but what are the benefits for the mobile subscriber to have a femtocell in their home? Operators will need to create compelling consumer propositions that persuade people to take a femtocell home and plug it in. These propositions must offer a better user experience and / or better value for services that consumers want to use at home. Table 1 lays out some possibilities.

	Voice	Data
Better user experience	• Make & receive mobile calls at home (even when there is no network coverage)	• High-speed mobile data services at home • New femtozone services (automatic podcast reload, YouTube upload, home intercom, mobile IPTV…)
Better value	• Cheaper calls at home	• Cheaper mobile data subscription • Femtocell bundled with DSL broadband subscription • Mobile downloads at PC prices

Table 1: Consumer marketing propositions for femtocells

Better voice experience

Perhaps the most straightforward proposition is simply providing voice coverage where none existed previously (top left box in Table 1). This is still a big issue for many consumers, especially in countries where mobile network coverage is relatively sparse (e.g. the United States). In places with greater overall coverage, some operators view voice in-fill as more of a niche proposition, and are sceptical about their chances of winning back customers from competing networks who already provide good coverage. Also, shouting too loudly about improved voice coverage risks creating the perception of generally poor network coverage. Even so, there are potentially attractive opportunities with enterprise customers who want to ensure that their senior staff can be contacted at home.

Better value for voice

Offering cheaper voice calls at home (bottom left box in Table 1) also provides an incentive for consumers to adopt femtocells. Again, this may vary from one country to another. Operators in Germany, for example, might find it difficult to retract their existing homezone tariffs that already offer discounts over a wider area than the femtozone, and in the UK and US, many mobile subscriptions include a large bundle of minutes, which means that femtozone discounts would not kick in until the bundle is used up. However, these scenarios by no means apply universally, and voice discounts in the femtozone will be attractive to many subscribers.

Better data experience

In the long run, femtocells should prove compelling to consumers because they offer a better user experience for data services at home (top right box in Table 1). For example, Telenor could guarantee access to the football game via a femtocell (see section 3.2 above) – something that might never be possible on the macro network. However, demand for mobile data services – especially in the home where the PC and TV provide good alternatives – is probably insufficient today for operators to lead their femtocell marketing campaigns with the "better data experience" proposition. This is something that will emerge over time, as subscribers begin to demand more from their mobile data services.

But before discarding the top right hand box, it's worth considering how femtocells could offer extra services that are not available on the macro network. For example:

- A femtozone-aware application on the mobile phone could automatically upload user-generated content to websites like YouTube and Flickr, as well as automatically downloading podcasts and other content from the internet, whenever the phone is connected to the femtocell. This would be expensive for the operator to offer as a service

on the macro network, but could be provided cheaply – even free of charge to the end user – at home using a femtocell.

- Femtocells could enable presence updates when family members enter or leave the home. For example, parents could receive an SMS when family members' phones connect to the femtocell, or see who's at home via a web page launched from a mobile browser.
- Femtocells also offer the potential to support advanced applications that integrate with the home LAN. For example, a personal video recorder (PVR) could record TV programmes from the internet during the day, and stream them to the phone later at high bandwidth via the femtocell. Similarly, a femtocell-enabled presence server could route calls locally when family members are at home, enabling a free-to-use intercom or push-to-talk system for the household.

Better value for data

Finally, where homezone tariffs almost exclusively offer discounts on voice calls, femtozone tariffs are likely to offer similar discounts for data services as well (bottom right hand box in Table 1). This could mean a cheaper data subscription, or flat-rate data plan, but discounts could also be applied to content. If operators want the mobile phone to become a viable alternative to the PC and TV in the home for entertainment and information services, they will need to offer competitive pricing. For example, downloading a music track to a mobile phone generally costs more than downloading it to a home PC, but with a femtozone tariff the same download to a mobile phone at home could be priced competitively with the PC download.

Many mobile operators also offer a fixed broadband service. These operators have the option to integrate a femtocell within a DSL home gateway box, and to bundle femtocell services and discounts with the broadband subscription. This is a cost-effective solution that creates synergy between the fixed and mobile services, and differentiates the operator's broadband service from fixed-only competitors.

Summary

Ultimately the success of femtocells depends on operators finding the right combination of discounts and new services to attract end users, and to overcome potential objections to more clutter in the home, or fears about mobile phone emissions[10]. This will involve careful customer segmentation and creative marketing. But the potential benefits for operators are significant, and should more than justify the cost of these initiatives, including femtocell subsidies and service discounts.

6 CONCLUSION

Femtocells are an attractive proposition for consumers and operators alike. Consumers will get attractively priced voice and high-speed mobile data services in the home, and seamless handover to the macro network when outdoors. Mobile operators benefit from lower costs and increased fixed mobile substitution, leading to higher revenues and more profitable relationships with their newfound internet and web partners.

[10] In practice, femtocells will reduce exposure to radiofrequency emissions because mobile phones will be able to work at much lower power within the home. However, it may be difficult to make this a selling point without raising concerns about using mobile phones at home without a femtocell.

APPENDIX: COST MODELS

Monthly cost of femtocells

We'll assume that the operator subsidises 100% of the cost of femtocells, and gives the consumer an additional incentive of €25 to install the femtocell at home (e.g. in terms of discounted service usage). The core network and integration costs amount to about 15% of the cost of the femtocell. Adding in ongoing support and operational management overheads, and writing off the femtocell over 2 years, the monthly cost (to the operator) of a €200 femtocell then amounts to €10.74. The monthly cost of a €150 femtocell amounts to €8.34.

Monthly cost of a macro cell

The monthly cost of operating a macro cell site is conservatively assumed to be €4,905 (see Table 2). Data is taken from *HSDPA / HSUPA for UMTS*, edited by H. Holma & A. Toskala, 2006, p144-153. The assumed cell site specification is a 2+2+2 HSDPA configuration with a spectral efficiency of 2 Mbps/cell, for which the maximum site throughput is around 650 GB per month, requiring 3 E1 lines for backhaul.

Cell site spec	
2+2+2 HSDPA configuration	
Spectral efficiency of 2 Mbps/cell	
Busy hour utilisation is 80%	
Busy hour share of daily traffic is 20%	
Radio capex costs (includes TRX, RNC and core network)	
Cost per sector per carrier	€ 16,000
Number of sectors	6
Capex cost	€ 96,000
Cost per month (with amortisation over 6 years)	€ 1,333
Cell site costs	
Macro site acquisition	€ 37,000
Macro site construction	€ 88,000
Cost per month (with amortisation over 15 years)	€ 694
Opex	
Power (3 kW at €0.10 per kwh)	€ 216
Cooling	€ 69
Site rental	€ 750
Site maintenance (1 visit per annum)	€ 42
Opex per month	€ 1,077
Backhaul costs	
Cost of E1 backhaul line per month	€ 600
E1 bandwidth (Mbit/s)	1.9
E1 full capacity (MB/month)	615,600
E1 actual max capacity (MB/month)	225,720
Number of E1 lines required (at full capacity)	3
Total backhaul cost per month	€ 1,800
Total monthly radio cost per cell site	€ 3,105
Total monthly backhaul cost per cell site	€ 1,800
Monthly cost of a cell site at full capacity (capex + opex inc backhaul)	**€ 4,905**

Table 2: Monthly cost of operating a macro cell site