



## **FEMTOCELLS – A PETAOPPORTUNITY OR AN ATTODIVERSION?**

### ***Executive Summary***

A femtocell can be thought of as a mobile basestation for the home. It provides enough capacity for about four phones and has a range of about 200 metres. However, instead of being a direct part of a mobile network operator (MNO) network, it plugs first into the home broadband connection. Voice and data traffic to and from a handset connected to a femtocell therefore involves the assets of an MNO (the femtocell has to use licensed spectrum), an Internet Service Provider (ISP) and a local line fixed telecoms operator at the very least.

Femtocells must overcome a number of technical barriers if they are to be considered “fit-for-purpose” as an alternative to current network architectures or competing developments like WiMax.

One way to identify whether a real opportunity exists is to consider what problem a player would be trying to solve with this product, what product they are using today to solve that problem and therefore to ask what kind of a difference will the new product make.

Using this approach it would appear that:

- femtocells could make a significant difference to MNOs’ problems of margin loss and cost improvement
- femtocells can make some difference to fixed telco/cableco/ISPs, but this is unlikely to be significant, compared with other initiatives they could undertake

*Crucially, femtocells do not appear to represent a major breakthrough for any problem a user faces, so it is not clear what market gap they would be able to fill.*

As a result, femtocell developers and vendors are generally in the “sounds great in theory but revenue is behind in practice” state of evolution. The reality is that technical challenges have not yet been overcome and that mobile operators are reluctant to move to large-scale trials or deployments until costs are further down and the technical and business case more proven. Even when this is achieved, it is not clear that mass market users will be interested in a femtocell solution.

## **1. Introduction**

A femtocell can be thought of as a mobile basestation for the home. It provides enough capacity for about four phones and has a range of about 200 metres. However, instead of being a direct part of a mobile network operator (MNO) network, it plugs first into the home broadband connection. Voice and data traffic to and from a handset connected to a femtocell therefore involves the assets of an MNO (the femtocell has to use licensed spectrum), an Internet Service Provider (ISP) and a local line fixed telecoms operator at the very least.

Femtocells, in theory, can help solve problems of revenue growth and cost reduction for MNOs and mobile service providers (MVNOs), fixed telcos and ISPs. In theory, they can also bring benefits to end-users of a better and more complete mobile experience. This paper looks at the extent to which the benefits to such players are likely to be real or very different from what they can do today.

Although primarily positioned as an opportunity for today's 3G (UMTS/W-CDMA) operators, femtocells are being developed for a range of radio access technologies, including 3G-HSPA, the 802.nn family (including WiMax) and UMTS-LTE (Long-Term Evolution).

The paper provides an introduction to femtocells' possible role in the market dynamics of telecoms, media and technology (TMT). First of all, though, Section 2 provides a bullet-point summary of technical issues that remain to be solved, and Section 3 looks at some alternatives to femtocells.

## 2. Technical challenges

Femtocells must overcome a number of technical barriers if they are to be considered “fit-for-purpose” as an alternative to current network architectures or competing developments like WiMax. A simple breakdown has three categories of barrier:

### Unit cost of femtocell

- needs to be low, say <\$100, to allow for competitive pricing in mass distribution or subsidisation by service provider (eg as part of a service package)
- information from GSMA showed that baseband (digital signal processor, etc) cost now ~\$25; total femtocell cost \$150-\$300, depending on who you ask
- development of consumer electronics devices that could have integrated femtocell capability, eg set-top box, home router, cable modem, games console, media centre

### Integration to radio layer of MNO

- theory of femtocell is that it should be “high-street purchase” and “plug and go”, maybe even simpler than a WiFi home router
- but, today’s MNO radio networks are very carefully planned, quite the opposite of “customer-generated capacity”
- has to work on licensed spectrum (typically W-CDMA), so can interfere with existing larger cells in the same area and with neighbour’s femtocells.
- to overcome the issue, femtocell has to be “smart” in order to “self-provision” and “self-control” to become live on a chosen MNO network. MNOs currently testing, but no large-scale (eg citywide) trials yet done
- one element is “oscillation” of signal, ie synchronisers in femtocell control software are not yet precise enough to stick to tightly defined spectrum frequency use
- access control, ie can a person walking by my house use my femtocell?
- Licensed area, ie what’s to stop someone buying a femtocell and plugging it into another network outside the licensed area of the vending MNO?
- All these are live issues.

### Integration to network layer of MNO

- Emergency call obligations – all cells in an MNO network have to be able to provide emergency service access, as well as, in many countries, location information
- Protocols and messaging for control and backhaul – still being tested
- Development of “collapsed stack” with Radio Network Controller (RNC) in femtocell, so as to allow SIP/IMS IP end-to-end connectivity (this is also a unit cost issue)

<http://www.picochip.com/solutions/femtocells> has good source material and technical explanations of product components. Products like Trillium protocol software from Continuous Computing are aimed at standardizing some of the build and test issues.

### 3. *Technical substitutes*

“Traditional mobile” (ie GSM/UMTS/CDMA) is potentially threatened by a number of alternative wireless access technologies, of which WiMax (802.16x for a family of x's) is the most talked about and the most funded. Intel, in particular, have thrown millions of dollars into acquisitions and marketing support, mainly as a way for Intel to try and re-introduce itself to the mobile market, where its thick-client strategy has lost out to the simpler mobile phone. Cisco is another company that is trying to transform itself from “internet infrastructure” to direct presence in the home, mainly through a series of acquisitions. Most recently, it has bought WiMax base station developer Navini and rebranded it “Cisco Broadband Wireless”, giving Cisco a claim to provide “a complete end-to-end IP wireless broadband solution” from home to IP next generation network.

**WiMax** is promoted as the natural next step beyond WiFi (802.11x family), both for the home and for town centres, hotels and other campuses. WiMax lobby groups are also requesting telecoms regulators to reserve certain spectrum auctions for WiMax technologies. In markets that are saturated with mobile and already have high broadband penetration, it is difficult to see what major market gap can be filled by WiMax. Countries without, in particular, a fixed broadband infrastructure, or perhaps without 3G licences, may be more fruitful. At the same time, spectrum auctions that would permit WiMax deployment could be a vehicle for providers without wireless assets to enter the market.

**Repeaters** are an alternative to femtocells, as a way of providing extra coverage – though not extra capacity. These repeater stations are parented on existing base stations, instead of on base station controllers. The link from repeater station to parent base station is itself wireless, and it is the MNO that is deciding and managing targeted coverage. Products are stable and do not require lots of new testing or integration. Companies such as C&S Microwave (Korea), and Juni (Australia) are pushing aggressively into this product market, with repeaters for home, indoors (eg apartment block) and outdoors (eg in the shadow of a hill). Many of the technical challenges in Section 2 are thus avoided, and the MNO would treat a repeater as “business as usual”. However, note that a home repeater would require a visit from an MNO technician. It also raises the interesting question of whether/how much the MNO pays the homeowner to rent the space in the home.

**Picocells** are laptop/suitcase size cells that can be deployed by MNOs to infill coverage or capacity. They are directly part of the MNO's radio network and are targeted mainly at voice and 2.5G/EDGE services. Some European operators are testing them at the moment. Issues of interference and power management are still to be resolved.

**WiFi** is already prevalent in the home. It works on unlicensed spectrum and has standards that are stable. Most high-end devices/notebooks/laptops now come WiFi-enabled, and wireless routers are a standard ISP offering in a home network service. Even though some mobile phones are WiFi-enabled, setting up the phone to make or receive voice calls over WiFi is still very much an early adopter market.

**Do nothing different** is a very acceptable technical substitute to femtocells, ie the household has a fixed broadband connection, and all household members own a (usually subsidised) mobile phone. Most wireline customers now receive free calls, at least for weekends and evenings. It is virtually impossible to avoid paying a fixed line rental, even if one just uses broadband over the wired network. In addition, mobile operators provide huge bundles of minutes on contract phones, plus large bundles of text messages on postpay and prepay. Home broadband speeds and contentions, while varying a great deal by geography, at least allow for an always-connected experience for the end-user. Users simply decide, as they do now, which device and which access method to use for each use.

**The next sections** consider the market opportunity (or lack of it) from the perspective of:

- MNO
- fixed telco (or cable operator) with local lines (either owned or leased via unbundling)/ISP
- enduser
- femtocell developer / vendor

One way to identify whether a real opportunity exists is to consider what problem a player would be trying to solve with this product, what product they are using today to solve that problem and therefore to ask what kind of a difference will the new product make (see eg the management book "Seeing What's Next", by Prof Clayton Christensen)

In a summary paper like this, we will not go into detail about strategies of different players. Suffice it to say that all providers are competing for (a) a greater slice of their customers' communication and content consumption, (b) lower operating costs, (c) lower capex.

We will also summarise femtocells as being relevant to the "home" market, recognising that "home" also could include small businesses.

Lastly, we will restrict discussion to mature (saturated) mobile markets, as these require more sophisticated and precise targeting of coverage. In other developing markets, generic issues of coverage, capacity and quality, combined with distribution and price, are to the forefront. We would expect any implementation of femtocells to follow behind. We will also assume that the technical challenges can be fixed – including the cost question.

#### 4. *The MNO perspective*

To date, MNOs have seen only embryonic (though growing) mobile data activity. They are seeking to encourage incremental voice and data usage (ie use mobile devices to do stuff that today doesn't involve telecoms) and to substitute other usage from wireline services. By extending coverage, capacity and mobile quality in the home, MNOs should be able to provide a more compelling experience to their customers. In particular, an indoor 3G service via an outdoor macrocell is a limited experience, as 3G has very poor propagation through walls.

On the cost side, base station site acquisition is a massive cost and slow process for MNOs, due to a combination of NIMBYism (Not In My Back Yard), aesthetics, local planning rules and continued perceptions of health links to base stations. In other MNO operations, managing the radio layer is more expensive than managing the core network, eg radioplanning is a very complex activity, as is maintaining QoS across thousands of base stations. Thirdly, an MNO's costs are fairly fixed, once a base station is installed. Marginal profit – be it retail or wholesale – from extra minutes and megabytes is therefore high.

*One can therefore summarise the MNO's problem as: "how do I make it easier for my customers to use their mobile devices at home without it costing me a load of money?"*

Today, the MNOs solve that problem by installing more planned base stations, especially to extend geographic coverage of 3G. MNOs outsource many of their site acquisition and management activities and contract multi-site agreements with hotel chains, restaurants, airport operators and the like. 2G/2.5G (with some GSM-EDGE deployments) is reasonably ubiquitous at 900MHz and/or 1800MHz (1900MHz in North America). These propagate better than 3G, so give users some form of access to voice and data services.

MNOs also fund, through marketing campaigns, channel commissions, development support and – often – handset subsidy, new devices that are supposed to provide a better user experience. The most notable of these is the Apple iPhone, which has resulted in dramatically (10x) higher usage of mobile data than any other mobile device. The least notable is probably BT's Fusion phone (mobile+wifi), which has gained little traction in the marketplace (beyond BT employees).

Lastly, MNOs increasingly seek to spread their costs by striking wholesale arrangements with mobile service providers and virtual network operators (MVNOs), with the aim of such MVNOs delivering services that will provide incremental traffic on to the MNO's network.

Looking at the way that the MNOs solve their problem, we can see that femtocells could make a significant difference to the MNO:

- base station rollout is increased, and in a way that actually shifts operational cost from the MNO to the end-user, ie the user has to install, power and run the femtocell and pay for the backhaul out of their monthly ISP subscription. The MNO has no site acquisition cost, no rent and very little marginal radioplanning – but some more core network management
- Coverage and capacity is delivered in a self-selecting way towards those users who will use mobile services more while at home – if they didn't want to, they wouldn't buy a femtocell. In addition, the MNO would now be more directly "part of the home".
- The MNO could fund a bundle of femtocell, device and service plan, which may allow more targeted marketing for specific types of device, esp those for mobile data
- The MNO can use their hold over the licensed spectrum to make sure they are part of the value chain if/when MVNOs offer femtocells directly to the market.

## 5. *The fixed telco/cableco/ISP perspective*

This is the perspective of fixed operators who have fixed local loop assets (owned or leased) but no MNO assets. Examples would be BT in Europe, Comcast in USA, Carphone Warehouse and BSkyB in the UK, Neuf/Cegetel in France. Most ISPs now at least lease local loop assets.

The core business of such fixed players is the provision of voice and data connectivity (lines, calls and broadband) over local loop assets. Cable players are also able to provide TV services (and telcos are trying to get in via IPTV-based services). These connectivity revenue streams are commoditising rapidly. Voice lines and calls are also seeing large-scale substitution to mobile calls and, in some markets, to VoIP services. Note that the home is the most common location for customers to make/receive mobile calls today. Some fixed operators are providing WiFi-based services in the home (eg BT Homehub), as a way of trying to make their own services the “hub” of home communications and entertainment.

Further commoditisation is taking place at the wholesale level, as regulation forces unbundling of the local loop, pushing incumbents down a value stack from managed, or at least bitstream-level, products to simple lease of the local dedicated copper pair from the local central office to the home.

*One can therefore summarise the fixed operator's problem as: “how do I keep both traffic on my local loop and my place in the value chain for communications?”*

Femtocells can make some difference to the fixed telco, but this is unlikely to be significant:

- fixed operator could distribute femtocells directly and provide either a mobile-only service or a bundled fixed/mobile service (eg link femtocell+mobile phones+broadband into a “household bundle”), but would have to have some form of MVNO-type arrangement with the MNO in order to gain access to the licensed spectrum
- could also be a defensive move – if mobile broadband does start to gain market momentum, eg if other iPhone-like devices appear and give good user experience, then fixed operators could use femtocells to ensure at least some role in the value chain, as the femtocell puts mobile traffic on to the local loop.
- One can think that fixed operators would want to spend their marketing and capex dollars on solutions closer to their core business or even on spectrum for themselves, eg WiMax, or further WiFi hubs, or entertainment services, such as BT Vision or Deutsche Telekom's “Entertain Comfort” package.

## 6. *The end-user perspective*

Life is getting more connected and more digital. End users can use a range of tools to help them connect to other people, to information and to entertainment. To date, most users have considered their broadband connectivity as a household purchase (ie internet via the family PC or a PC and laptop(s) hooked up through a home network – perhaps via a wireless [WiFi] router). Users have similarly viewed the wireline as a family item – one line, one bill, perhaps several phones. On the other hand, mobile phones are individual purchases and can be satisfied individually. MNOs and MVNOs try very hard to sell family packages and discounts, but these are usually lost in the noise of a large bundle of free minutes and/or text messages to the personal customer.

End-users are also very concerned about privacy in all its forms. It would be a challenge to overcome a perceptual barrier that users were installing public base station that were at the same time related to their own mobile use and therefore to their own privacy. Similarly, users would be concerned about non-invited people “free-riding” on a base station sited in the home. Note that such concerns would quickly extend to a feeling that the MNO was “free riding” on the user’s broadband connection payments.

In saturated mobile markets, users are also very savvy. In particular, they share information with friends and neighbours and are very knowledgeable about which networks work well, or don’t, in and around their home. A relatively simple solution to a user feeling that coverage on Network A is poor in their home is simply to switch to Network B, which they would know to be better.

Trends of rapid digital convergence are strong, though. For example, of the UK’s 25m households, 22m now have digital TV. Broadband is in over 13m homes. Apple’s iPhone data usage is perhaps 20MB per user per month, and feedback from relevant MNOs indicates that behaviours (ie sites visited) are very similar between the iPhone and the PC. The user is gaining a sense of control over information and entertainment, be it rarely watching a TV programme at its scheduled hour, to high-volume surfing on YouTube, to generating content via a blog or social network or fileshare. These increases in data usage are the areas that MNOs are trying to tap. From a user’s perspective, though, the questions are far more those of easy and value-for-money access to the right information or people, using whichever service is most familiar.

*One can therefore summarise the end-user’s problem as: “how do I keep me and our home connected with as much value for money, as much privacy and as little hassle as I can?”*

The paragraphs above show that end-users solve this problem today by separating fixed and mobile use, primarily because the former is a household purchase and the latter an individual purchase. Users are also generally very well informed, particularly if there are young people in the home, about alternative mobile networks and mobile tariffs.

For these reasons, femtocells do not appear to represent a major breakthrough for any problem a user faces. If this is indeed true, then MNOs and other providers will only gain traction with customers through large price reductions, be they through giving the femtocell away (or even paying users to run them), bundling and deep discounts, or simple price cuts. None of these sound compelling enough to give confidence of early mass market adoption.

**7. Implications for femtocell developers and vendors**

Overall, MNOs are under severe capex and opex pressure, as profit margins are under severe pressure (as explained in Section 4). This makes any discretionary projects, such as femtocell development, a lower priority than, say, billing systems, customer care investment or customer retention spending.

Femtocell developers and vendors are generally in the “sounds great in theory but revenue is behind in practice” state of evolution. The reality is that the technical challenges have not yet been overcome and that mobile operators are reluctant to move to large-scale trials or deployments until costs are further down and the technical and business case more proven.

The technical challenges appear to be solvable, and companies such as Picochip, Radioframe Networks and ipAccess are at the forefront of developments and are partnering with major vendors, such as Samsung, Huawei, NEC and Netgear. Despite this, no operator has moved past limited technical trials.

If the analysis in Section 6 is correct, and femtocells are not going to fill a large gap in users' lives, then femtocell vendors, especially the retail brands, may have to come up with creative business models to help MNOs provide the subsidies and discounts that may be needed to create a large market for femtocells.

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