

FEMTOCELLS

– A QUIET REVOLUTION IN MOBILE COMMUNICATIONS

Femtocells are set to transform the way mobile networks work. They have overcome initial challenges in development stage and now have widespread industry support for their distribution. Professor Simon Saunders, Chairman of the Femto Forum, explains more about how femtocells function and the impact they are likely to make.

A quiet revolution is taking place in mobile communications. Many of the largest and most influential operators around the world, including Vodafone, NTT DoCoMo and AT&T, have started deploying a new technology called the femtocell which is transforming the capabilities of mobile networks. Femtocells are small, smart mobile access points which are beginning to be found in homes, offices and shops. It is also likely that femtocell base stations will soon be seen hanging from bus stops and lamp posts around the world. Femtocells are set to bring mobile coverage to new areas, make mobile broadband radically faster and offer brand new services.

A femtocell connects into a standard broadband connection (asymmetric digital

subscriber line, cable or fibre) and provides high quality mobile phone coverage, fast mobile broadband and the potential for new services to existing mobile handsets. Installation is simple: the user can do it in a few minutes with no special skills. The user plugs in the femtocell, waits a few minutes and the green light will indicate that they are connected. In this short period the femtocell has contacted the operator's network, created a secure communications link, sensed the surrounding radio environment and configured its power and other radio parameters to optimise the service for the user while avoiding interference to others.

Femtocells come in four formats: a consumer device

The name 'femtocells' is inspired by the unit prefix for 10⁻¹⁵ (femto), emphasising its small size compared to traditional macrocell, microcell and picocell networks.

for homes and small offices; an enterprise model for office environments; a rural device that can be connected to satellite or terrestrial broadband to provide mobile coverage in remote regions; and a metro option that provides coverage and, more importantly, mobile broadband capacity in densely populated urban areas. The reason why femtocells are causing a major stir in the mobile industry is that they address two critical challenges: they pave the way for truly ubiquitous mobile coverage and they make mobile broadband networks significantly faster. Most importantly they do all of this affordably. Why though, are these two issues so critical to solve and why are femtocells the best solution?

INCREASING COVERAGE

As everyone who uses a mobile device knows, network coverage is limited. There are two main reasons for this: first, some areas have

such a small population that it is not economical for an operator to install and operate a conventional base station. This exacerbates the 'digital divide' and reduces competition for services, to the detriment of the consumer. Second, the high frequency mobile signals used in 3G systems are heavily attenuated as they pass through walls, typically by at least a factor of 10 in power terms, meaning that even if a user lives in an urban area, they still may not get coverage in all of the home.

Although they may have adequate voice coverage, 3G networks need much stronger signals with low interference to provide high data speeds, so a weak signal may be received or no signal at all which translates to slow mobile broadband and poor voice quality. In addition, the attenuation means that one indoor user consumes at least the same power – the main limitation on capacity - as 10 outdoor users, causing

congestion amongst users at busy times. Additionally, the proportion of mobile data consumed indoors is at least 70% and increasing to over 90% on some networks, which compounds the resources issue for overall service quality.

With traditional technology, operators would have to install many more base stations. This is simply not affordable without making mobile contracts more expensive. However, femtocells are significantly cheaper than conventional base stations so they can be installed in consumers' homes and even in the street to boost coverage.

BROADBAND ISSUES

The second big issue is mobile broadband where people use their mobile service to connect their laptops to the internet or using data services rather than making phone calls. It is difficult to overestimate the importance of this service to both consumers and operators alike. Smartphones together

with 'dongles' for laptops have driven an unprecedented rise in data usage.

With mobile broadband traffic doubling every year, the strain on mobile networks is enormous. Operators in the US and the UK have come under severe public scrutiny for the quality of their mobile broadband networks. While mobile voice usage is approximately constant, data use is rocketing and the growth shows no signs of slowing down. Unlike their fixed cousins, mobile operators cannot simply roll out fibre-optic networks to increase capacity; they rely on radio spectrum, which is an extremely limited resource.

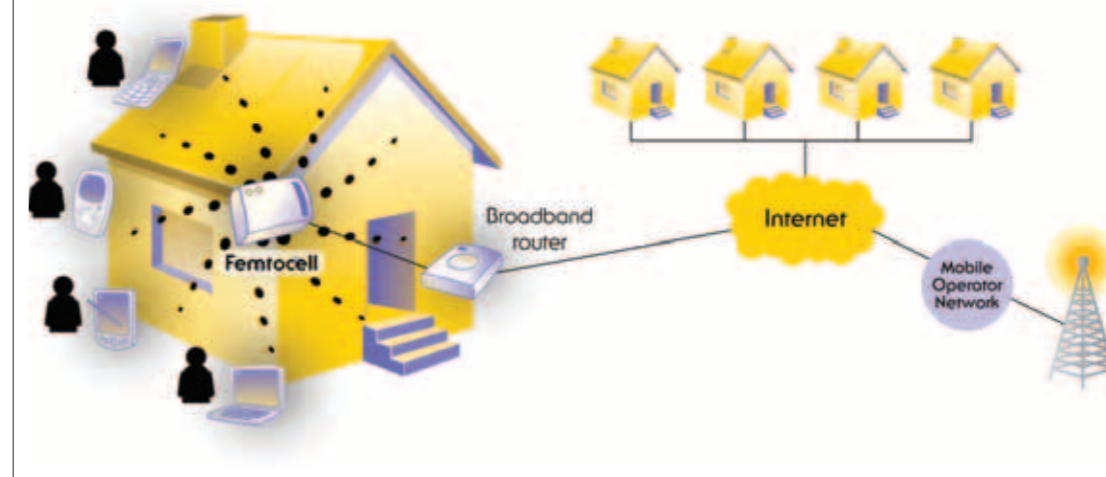


Femtocells can work efficiently across a much broader range of the radio spectrum than macrocell based systems. Airvana's HubBub UMTS femtocell is a hand-sized device that can deliver a throughput of data at 5 Mbps or quicker.

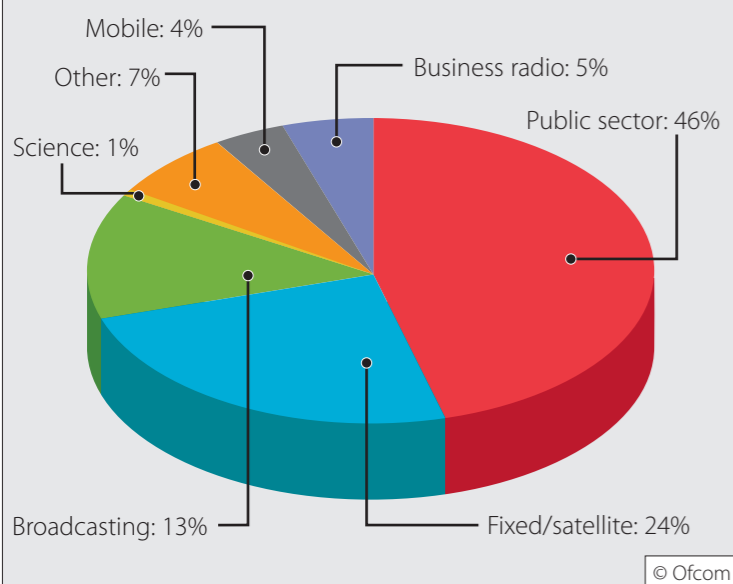
WHAT ARE FEMTOCELLS AND HOW DO THEY WORK?

A femtocell is a small wireless access point that transmits voice and data cellular signals within a home, office, outdoor urban or rural location. It connects to the mobile operator's network through broadband Internet connection (such as DSL or cable). Femtocells produce identical signals over the air to traditional base stations, although they radiate much lower power (typically a few milliwatts). Current designs typically support two to five mobile phones in a residential setting. They also incorporate many of the features of the Radio Network Controllers which usually control tens or hundreds of base stations, by making decisions on the radio resources (power, frequency and codes).

Femtocells incorporate an ability to monitor the surrounding network and adjust to maintain good network quality. Unlike traditional base stations they do not need a dedicated broadband 'backhaul' – the interface between the femtocell and the mobile network is able to operate efficiently over residential broadband, despite bandwidth and other restrictions. Typically a femtocell will be able to deliver four simultaneous voice calls and a good mobile data experience with an ADSL line delivering just 1 Mbps to the femtocell and 200 kbps to the network.



USE OF THE UK RADIO SPECTRUM



HURDLES OVERCOME

A major technical challenge that femtocell designers initially faced was the need to manage potential interference. It takes up to two years to install conventional base stations, during which time radio engineers meticulously plan a station's position and radio characteristics to avoid interference. However, such an approach is not viable in the case of femtocells, deployed potentially in their millions at random. Automating a process conducted by radio engineers was no mean feat and simply would not have been possible a few years ago.

Fortunately, the fact that the walls of buildings keep 3G signals out and keep the femtocell's signals in provides strong inherent interference mitigation for indoor femtocells. Extensive studies have shown that proper implementation of a few key techniques to reduce interference can take advantage of this attenuation in an intelligent manner. Such techniques include frequent monitoring of the cell's surrounding radio environment combined with adaptive power control. Indoor users gain faster data rates, as do outdoor users who now operate on less congested cells, while it costs less for operators to deliver higher overall network capacity. Large-scale, real-world deployments are demonstrating that these techniques work in practice and even allow new approaches, such as operating 3G networks in the same spectrum as 2G networks.

AT&T has deployed femtocells on the same frequencies as both the hopping channels for GSM macrocells and with UMTS macrocells. They have tested thousands of femtocells, and found that the mitigation techniques implemented successfully minimise and avoid interference. The more femtocells are deployed, the more uplink interference is reduced.

BETTER CONNECTED

Femtocells are set to be central to deployments of the next generation of mobile networks. Although today's 3G networks provide relatively fast mobile broadband speeds, the advent of next-generation mobile technologies, such as LTE (Long Term Evolution) and WiMAX (Worldwide Interoperability for Microwave Access – a telecommunications protocol that provides fixed and fully mobile internet access) are set to provide even higher data rates. However, they can only achieve this when the signal quality is very high. In practice the average data rates in the conventional macrocell environment may not be very much greater than those on today's 3G networks. Femtocells can have a dramatic impact because far fewer people share the service: they are also protected from interference by the very walls that make it difficult to deliver the service from outside.

In the future, LTE femtocells could provide the best possible environment for locally streaming high-definition media around the home while concurrently supporting traditional cellular services. Crucially this can be achieved with guaranteed quality of service unlike alternative local wireless technologies.

Additionally femtocells 'know' when a consumer is in the

home thereby enabling location, presence and context-based applications that automatically trigger when a consumer enters, or leaves, the home. A vast array of application opportunities is opened up once this capability is combined with the ability of femtocells to link to locally connected devices and the internet. For example, femtocell applications include music synchronisation with the PC when a customer returns home and virtual 'fridge notes' where a message is delivered when the recipient comes through the front door. Equally, families could receive a 'virtual home number' which when rung, automatically calls all mobiles in the home. We are now beginning to see the first of these services being unveiled and the range and innovation has already been impressive. Once the addressable market of installed devices and the developer community reaches critical mass, we are sure to see even more interesting and exciting applications.

STANDARDS AND INTEROPERABILITY

It is difficult to overstate the importance of commonly agreed cellular industry standards. Put simply, proprietary technologies or standards with little industry backing are never widely deployed. A fact well illustrated when one considers the success

FEMTO FORUM

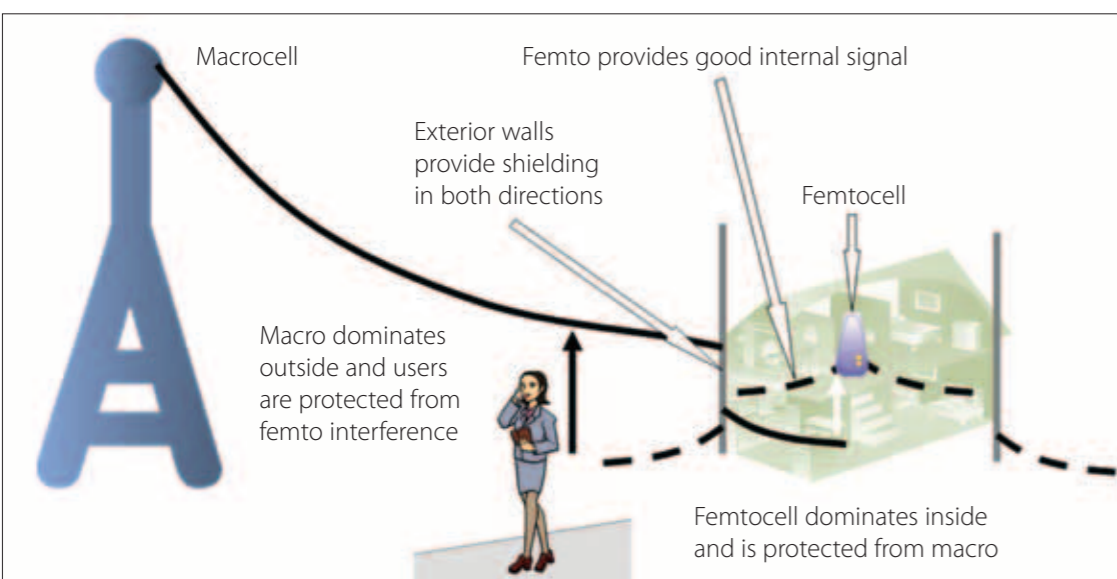
The Femto Forum was set up to promote the wide-scale adoption of femtocells. The forum supports and drives the adoption of industry wide standards and common architectures to enable the widespread adoption and deployment of femtocells by operators around the world. It will direct and implement a multi-faceted marketing campaign to raise profile, drive technology development and deployment and promote the potential of femto solutions among industry stakeholders, journalists, analysts, regulators, special interest groups, standards bodies and consumers – www.femtoforum.org

of the GSM mobile standard compared with the myriad niche alternatives available in pockets around the world. Until quite recently, there were numerous different formats of femtocell technology that were entirely incompatible with one another. However, a major effort allowed the first 3G femtocell standard to be completed in early 2009 from a standing start in 2008. This rapid achievement was the result of an unusually close collaboration between three industry bodies: the Third Generation Partnership Project (3GPP) standards body which published the standard; the Broadband Forum which lent its proven standards for scalable management of broadband devices in the home; and the Femto Forum, which helped to ensure that contributions to the standards were accepted by most vendors and met operators' requirements.

A standard on its own is not sufficient, however.

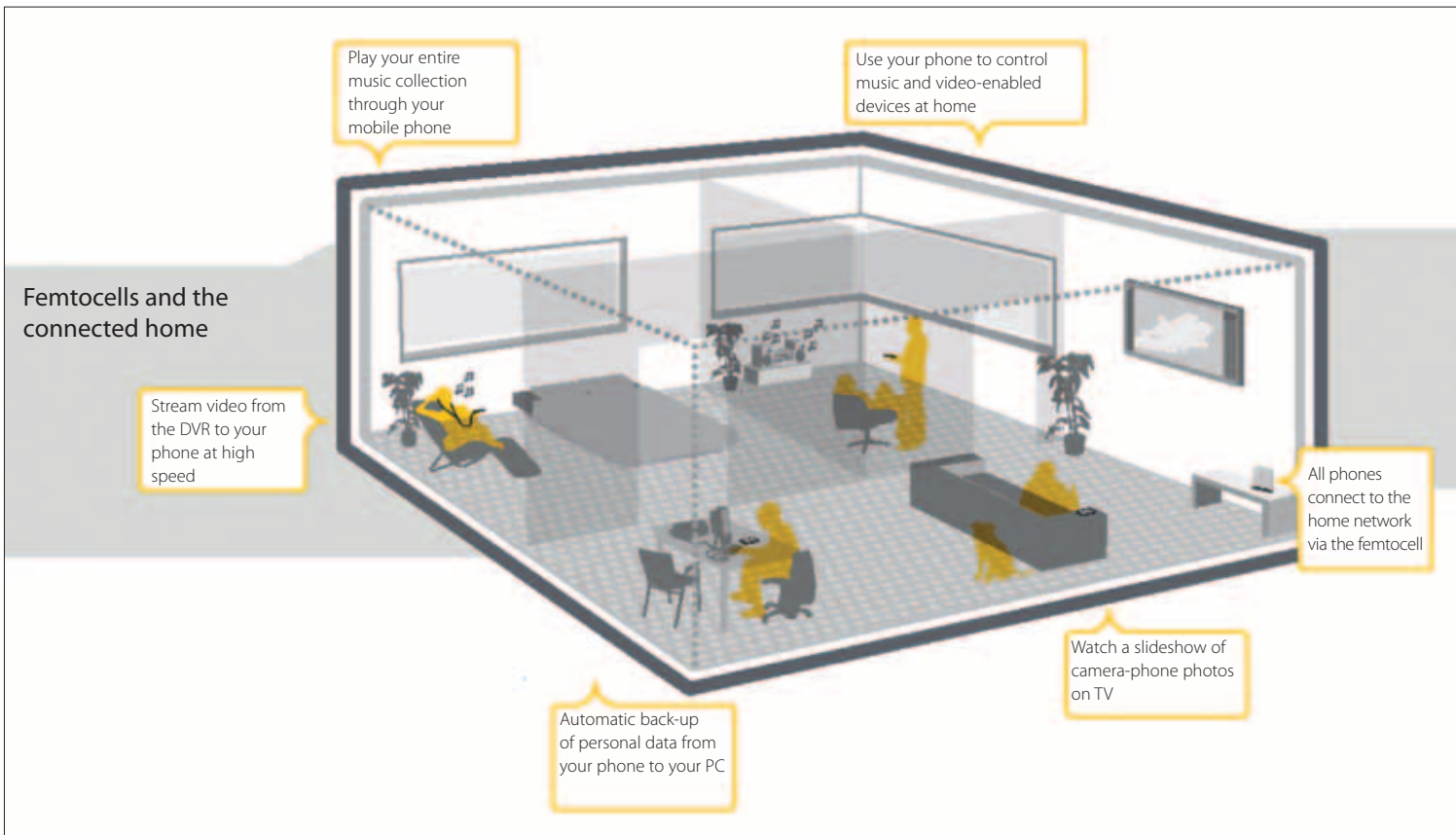
It also needs to be interpreted in a common manner and support from vendors in real commercial products. To promote this, in March 2010, the industry organised and ran the first 'plugfest' for 3G femtocells. Plugfests involve a number of vendors bringing their products together and testing their interoperability according to a defined agenda of tests relevant to the standard. Over 20 companies were involved in the event and more plugfests are planned for the future.

This effort will ultimately enable operators to obtain products from many vendors without having to adapt their networks. It will allow vendors to sell products with little or no modification to operators around the world. Most importantly, it will allow consumers to choose the femtocell they want with the features that best suits their needs.



Mobile networks are built on large cells (macrocells) each covering an area of a few square miles. Each cell serves hundreds of subscribers from a radio base station in a centrally located cell site. Macrocell architecture works well in covering large geographic areas but it falls short in providing consistent coverage, especially inside buildings where increasingly most usage occurs. House and office walls absorb most of the RF energy that operators transmit requiring up to 40 times the power of signal to reach internal subscribers.

Femtocells and the connected home



Femtocells promise in-home and in-office cellular coverage using dedicated high-speed 3G and 4G cell-phone data service © ip.access

STATE OF PLAY

At the time of writing there are 16 commercial deployments of femtocell systems around the world. Vodafone's 'Sure Signal' femtocell service in the UK has had considerable success, so much so that Vodafone has recently launched a service in Spain, this time targeted at business users. Elsewhere in Europe, femtocells are already available in France and Portugal. In Japan, traditionally regarded as the world's leading mobile market, the three largest operators – NTT DoCoMo, KDDI and Softbank - all offer the technology. They have also been the first to embrace advanced femtocell applications. Elsewhere in Asia, operators have deployed femtocells in China (China Unicom) and Singapore. In the US, the three largest mobile operators – Sprint, Verizon and AT&T – all offer the technology. According to

analysts ABI Research, there are currently around 60 consumer trials internationally, suggesting that there will be many more deployments will by the end of the year.

The concept of bringing the mobile network into homes and offices turns traditional cellular thinking on its head, yet the technology holds so many benefits for customers and operators alike that its appeal is undeniable. As with so many technologies, the jump from initial concept through to commercial reality has involved a number of challenges. However, the industry has worked to resolve these and, as the major commercial launches currently taking place testify, they have been highly successful.

The potential regulatory implications are not expected to impinge on the uptake. Femtocells operate in the same spectrum as existing networks

and have the same degree of control by the operator, so raise relatively few new regulatory concerns. The European Radio Spectrum Committee has stated that it is reasonable to assume that femtocells will comply with the existing technical licensing conditions and that the proliferation of femtocells will be supported in the context of more efficient use of spectrum.

Informa Telecoms & Media has predicted that the femtocell market will experience significant growth over the next few years,

reaching just under 49 million femtocell access points in the world market by 2014 and 114 million mobile users accessing mobile networks through femtocells during that year. Femtocells represent a major new opportunity for the mobile industry and provide a service for customers where a demand for better coverage and faster data already exists.

BIOGRAPHY

Professor Simon Saunders is founder of the consultancy Real Wireless and is founding chairman of the Femto Forum. He is an independent wireless communications specialist with more than 25 years of industry experience. He has worked for a range of companies including O2, Ofcom, NTL, BT, Motorola, BBC and many others. He is the author of over 150 books and articles and is a regular speaker at industry conferences. He is a member of Ofcom's Spectrum Advisory Board and a visiting professor at the University of Surrey.