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The applications of the femtocell in the mobile home networks

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Abstract

Femtocell (or femto in short) is the femtocell mobile base station launched in recent years based on the development trend of 3G technology and mobile broadbandization. It is also called home base station and is a base station product covered inside the user's house. The business modes and development of femto in StarHub, Vodefone and China Unicom are discussed in detail in this paper. In this article we overview the technical and business arguments for femtocells and compare it to other widely used network technologies.

Keywords femtocell, femto, femtocell base station, application case

1 Introduction

Femtocell is the femtocell mobile base station launched in recent years based on the development trend of 3G technology and mobile broadbandization [1–2]. It is also called home base station and is a base station product covered inside the user's house. The femto equipment is compact in size and can be placed on the roof in the house or hung on the wall. It can cover an area with a radius of 50 m which is close to that of WLAN AP. It can support 4 simultaneous phone calls and several people's high speed surfing on the net. Many manufacturers have built in the home multimedia center and WiFi function in it. The femto can connect computers, TVs and mobile phones together via a common platform and make them a center for home entertainment.

Fig. 1 Femto equipment of Starhub

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2 Other network schemes

1) IMS-base network architecture

The femtocell and the core network are connected via SIP protocol. The new core network provides service to femtocell users. The network terminal must support the SIP protocol. SIP/IMS is the ultimate objective for future network development. Before the core network is completely upgraded to all IP network of IMS, huge investment is needed and the maintenance cost is high.

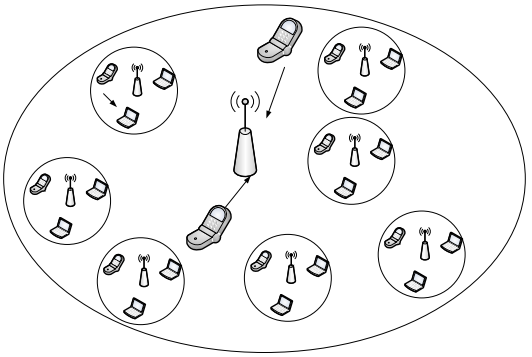

Fig. 2 Femto network architecture

2) Tunneled Iub interface- based network architecture

The network architecture of this scheme is similar to the architecture of today's wireless access network. The femtocell equipment has only the Node B function. It is the earliest femtocell access scheme. This scheme features less initial

investment. The femtocell can share RNC equipment with the Macrocell. The network structure is clear. The main disadvantages of this scheme include poor cost efficiency, waste of RNC equipment's port and capacity, and poor implementation.

3 Network architecture

The current mainstream equipment suppliers use a flat architecture which integrates the Node B function and RNC function into single access equipment. The femto equipment provides the standard lu interface. The femtocell CPE provides the standard air interface to mobile terminals. It can either be independent equipment or be integrated with ADSL Modem. The net side interface is provided by the femtocell equipment, such as lu_CS, lu_PS, Gn/Gi, etc. The femtocell equipment also provides the safety function to establish a safe tunnel from the femtocell CPE to the femto gateway equipment.

The standards bodies have published formal specifications for femtocells for the most popular technologies, namely WCDMA, CDMA2000, LTE and WiMAX. These all broadly conform to architecture with three major elements [1]:

1) The femtocell access points themselves, which embody greater network functionality than found in macrocell base stations, such as the radio resource control functions. This allows much greater autonomy within the femtocell, enabling self-configuration and self-optimisation. femtocells are connected using broadband IP, such as DSL or cable modems, to the network operators core switching centers.

2) The femtocell gateway, comprising a security gateway that terminates large numbers of encrypted IP data connections from hundreds of thousands of femtocells, and a signaling gateway which aggregates and validates the signaling traffic, authenticates each femtocell and interfaces with the mobile network core switches using standard protocols, such as Iu.

3) The management and operational system which allows software updates and diagnostic checks to be administered. These typically use the same TR.069 management protocol published by the Broadband Forum and also used for administration of residential modems.

The key interface in these architectures is that between the femtocell access points and the femtocell gateway. Standardization enables a wider choice of femtocell products to be used with any gateway, increasing competitive pressure and driving costs down. For the common WCMDA femtocells, this is defined as the Iuh interface. In the Iuh architecture, the femtocell gateway sits between the femtocell and the core network and performs the necessary translations to ensure the femtocells appear as a radio network controller to existing MSC's. Each femtocell talks to the femtocell gateway and femtocell gateways talk to the CNE (MSC for CS calls, SGSN for PS calls). This model was proposed by 3GPP and the femto Forum. In Refs. [3–4] New protocols HNBAP and RUA protocols have been derived; HNBAP is used for the control signaling between the HNB and HNB-GW [5–6] while RUA is a lightweight mechanism to replace the SCCP and M3UA protocols in the RNC; its primary function is transparent transfer of RANAP messages.

4 Application cases of femto

4.1 Business application of femto at Starhub, Singapore

4.1.1 Introduction to StarHub

StarHub is the second largest mobile operator in Singapore and the first operator who establishes the HSPA+ network. It has 350 thousands fixed broadband users and 1.70 million mobile users. Its business covers Mobile, Cable TV, Broadband and Fixed Network. In the end of 2008, StarHub became the world's first operator to launch the 3G-based femtocell business–HomeZone [7].

4.1.2 Business mode and charge

Charge and installation of femto CPE: femto CPE is lent to the end user by the operator free of charge (any damage shall be compensated by the user). It is usually installed by the user itself. Additional charge is needed for installation service.

Attraction: The fare of family member is packed together with the femto. Besides the applicator, 3 people may have the free family call and free SMS service. It supports 4 lines of simultaneous calls.

Charge: Monthly function charge shall be collected. The charge for MMS and data service shall be kept unchanged. The monthly function charge is 32.1 USD.

Comments: It is convenient for the operator to bind family users and to bind the cable broadband with wireless audio and broadband business. Relevant business may contribute to the gains of the operator. But the price is relatively high, so it is not easy to promote this service.

4.2 Business application of femto at Vodafone

4.2.1 Vodafone's femto brand- Sure Signal in UK.

Vodafone has business femto operations in UK, Greece, Spain and Qatar. Its femto brand in UK is Sure Signal. Vodafone launched this business in July 2009 with an aim to improve indoor coverage and attract 3G users and broadband users by terminal allowance and business combo mode.

4.2.2 Business mode and charge

AP equipment: Purchased by the user at one time or on installment. It is sent free of charge. The user can install it under guidance. The user can use any cable broadband above 1M as the backhaul.

Attraction: Since there are many blindness spots in some area of UK. Vodafone emphasize its superior signal. The advertisement of Vodafone is 'No other network in UK covers as large as Sure Signal, since the Sure Signal is Unique'.

Charge: Combo charge. If the user wants to buy a new mobile phone, he may select the combo containing a free mobile phone, or he may buy the equipment with 50 pounds (original price is 160 pounds) or pay 5 pounds monthly to rent the equipment.

Comment: It can improve the indoor signal coverage and the signal quality. It can promote the mobile internet service via combo business. It is convenient for the operator to launch value-added internet services. The business does not bind the family members effectively. Except the good signal, there is no other attraction.

4.3 Business application of femto at China Unicom

4.3.1 Business application of femto at China Unicom.

China Unicom started to research the femto in 2009. It is the first operator to launch femto business. Up to now, China Unicom has established the femtocell platform in 10 Northern provinces.

4.3.2 Business mode and charge

Equipment: The user may purchase or rent the equipment. If the equipment is rented, it will be bound with the broadband and a two-year broadband use agreement shall be signed.

Charge: Different charge for different equipment acquisition ways. If the equipment is bought by the user, the monthly function charge is 10 Yuan (RMB) and the equipment is 1 200 Yuan (RMB). For rented equipment, the monthly function charge is 40 to 60 Yuan (RMB).

Attraction: Better indoor coverage. High quality audio calls, high speed network services (7.2 M download rate) and high quality video calls can be obtained indoors. 16 people at most can share the high quality 3G signal. It is easy to install and it is unnecessary to change the mobile phone.

Table 1 The comparison for femotcell, distribute antennas and Microcell

	Capital expenditure	Operating expenditure	Benefits	Shortcomings
Femtocell	Subsidized femtocell hardware.	a) Providing a scalable architecture to transport data over IP; b) Upgrading femtocells to newer standards.	a) Lower cost, better coverage and prolonged handset battery life from shrinking cell-size; b) Capacity gain from higher SINR and dedicated BS to home subscribers ; c) Reduced subscriber churn	a) Interference from nearby macrocell and femtocell transmissions limits capacity; b) Increased strain on backhaul from data traffic may affect throughput.
Distributed antennas	AE and backhaul installation.	AE maintenance and backhaul connection.	a) Better coverage sinceuser talks to nearby AE; b) Capacity gain by exploiting both macro- and micro-diversity (using multiple AEs per macrocell user).	a) Does not solve the indoor coverage problem; b) RF interference in the same bandwidth from nearby AEs will diminish capacity; c) Backhaul deployment costs may be considerable.
Microcells	Installing new cell towers.	Electricity, site lease, and backhaul.	a) System capacity gain from smaller cell size; b) Complete operator control.	a) Installation and maintenance of cell towers is prohibitively expensive; b) Does not completely solve indoor coverage problem.

Comment: It is still on the trial operation stage. The charge is a little too high. Except the high quality signal, there is no other price or service attraction.

5 Comparison with other end-user deployed infrastructure

As shown in Table 1, we compare the benefits and the drawbacks of femtocell, distributed antennas and Microcell, and the main advantages of femtocell are list as follows [2]:

1) Better coverage and capacity. Due to their short transmit-receive distance, femtocells can greatly lower transmit power, prolong handset battery life, and achieve a higher signal-to- interference-plus-noise ratio (SINR). These translateinto improved reception-so-called five-bar coverage and higher capacity. Because of the reduced interference, more users can be packed into a given area in the same region of spectrum, thus increasing the area spectral efficiency.

2) Improved macrocell reliability**.** If the traffic originating indoors can be absorbed into the femtocell networks over the IP backbone, the macrocell BS can redirect its resources toward providing better reception for mobile users.

3) Cost benefits. Femtocell deployments will reduce the operating and capital expenditure costs for operators. A typical urban macrocellcosts upwards of $ 1 000/month in site lease, and additional costs for electricity and backhaul. The microcell network will be stressed by the operating expenses, especially when subscriber growth does not match the increased demand for data traffic. The deployment of femtocells will reduce the need for adding macro-BS towers.

6 Conclusions

Femtocell is the femtocell mobile base station launched in recent years based on the development trend of 3G technology and mobile broadbandization. A less expensive alternative is the recent concept of femtocells, also called home base stations, which are data access points installed by home users to get better indoor voice and data coverage. In this article we overview the technical and business arguments for femtocell and compare it to other widely used network technologies.

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