A Femtocellular-Cabled Solution for Broadband Wireless Access: A Qualitative and Comparative Analysis

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ABSTRACT

Broadband Wireless Access is a strategic opportunity for mobile operators which aim to provide connectivity in digital divide areas, in order to accelerate speed of deployment and save in installation costs. This paper presents an innovative approach to access the end user, relying on infrastructural integration of femtocellular technology with existing cabled network. Usually, the adoption of Femtocell Access Points, operating in the licensed cellular bands typically designed to be used in SOHO, improves the radio coverage and the building penetration of the existing mobile networks, based on macrocells. In the proposed solution, the peculiar functionality of femtocells is further improved using a MATV/SMATV cabled infrastructure which facilitates the signal connection inside the building. The potentiality of the solution is even more evident, taking into account the growing interest towards the possible deployment of new mobile technologies, like LTE in both the last portion of the UHF band V and the GSM frequency band, resulting from the re-farming process.

Keywords: Digital Dividend, Femtocells, Interference, LTE, Propagation Models, Refarming, Relay Stations, Wireless

INTRODUCTION

During the last decades people have experienced a relevant diffusion of wireless devices. However, although about 70% of calls occur indoors, cellular phones continue to face issues such as poor signal strength and service quality when calls are made into buildings.

In order to improve signal quality in critical areas, mobile operators are always looking for new architectural solutions and the deployment of femtocells is a possible answer to this key issue.

Technically, femtocells are low power wireless access point installed in Small Office-Home office (SOHO) environment to provide voice and broadband services increasing throughput for mobile data services.
They are similar in size to a router and offer excellent indoor signal coverage (2G/3G/4G), thereby reducing traffic load on the external macrocell. In particular, the femtocell approach leads to an increased data capacity of the overall system, determined by offloading traffic load from the mobile network towards the fixed one (xDSL connections, etc.), as well as a reduction of radiated power, infrastructure deployment and maintenance costs.

Strategic positioning of femtocell systems inside buildings, combined with their ability to deliver high-quality voice and data services, and to bridge mobile terminals with the rest of the home or office networks, permits to build compelling business cases for both landline system replacement and fixed/mobile services convergence. In fact, through the stipulation of a specific contract with the mobile operator it is possible to make the mobile terminal working as a domestic/office handset.

On one side, the key benefits of adopting femtocells are numerous for both operators and users. On the other side, operators must still face with several challenges in order to be able to deploy a large number of Femtocell Access Points (FAPs) operating jointly to the existing macrocells. In this context, for example, handovers (femto to femto), handouts (femto to macro), handins (macro to femto), electromagnetic interference mitigation and management, device miniaturization and general costs optimisation, still remain the major problems that strongly prevent a large deployment of multiple-tier cellular networks. In addition, mobile service providers do not have a plan to deploy these network devices, so they are doing the job of getting it in the customer’s hands. On the contrary, the customers bristle at the idea to pay an extra cost for a provider’s inability to guarantee service to them.

To pave the way to an extensive femtocells deployment, different solutions are under study. Among them, the one proposed in the present paper, based on the reuse of cabled infrastructures already existing in the customer premises, requires low financial impact and minimum time commitment. More in detail, the cabled-wireless solution makes use of an “enhanced femtocell”, as described in the following, integrated into a cabled distribution network (e.g. condominium SMATV/MATV infrastructure). This system might result advantageous in buildings located in extremely critical areas, where the customer, at his apartment, suffers a poor radio coverage from macrocell base station or the signal is definitely not present, while other customers in the same condominium, but at different floors, are still able to receive and transmit from/to the same base station.

The structure of the paper is as follows. At first, a brief introduction relating to the femtocellular technology is provided. After that a description of the mentioned solution based on a specific architectural configuration (Femto/Cable), with a detailed characterization concerning the propagation models adopted for different applicative scenarios is given. Successively, an extensive comparison, based on simulation results concerning signal power reception in different operative scenarios between the enhanced femtocell solution and the traditional macrocell one, is reported. In conclusion, some final comments aiming at analysing the system features and performance are reported.

LTE FEMTOCELL ARCHITECTURES: A BRIEF OVERVIEW

As previously mentioned, a femtocell is a small cellular base station, typically designed to be implemented in the customer premises (home or small business) to connect mobile users to the service provider’s network through a broadband fixed connection (such as DSL or cable). Current designs typically support from 2 to 4 active mobile phones in a residential setting, and from 8 to 16 active mobile phones in enterprise settings. Femtocells operate on licensed spectrum and provide excellent user experience through better coverage for voice and very high data throughputs.

The advantages of adopting a femtocellular technology are numerous for a mobile operator:
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