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Energy Saving by Handoff Classification in Femtocells Network

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Abstract—A femtocell is a radio equipment which aims to improve the quality of the telecommunications network in customers' homes and / or in places that do not support the coverage of macro network. We focused our work on the issue of saving the energy consumed by femto-cells. In this paper, we introduce an energy efficient solution, to the cited issue, based on the removal of unwanted mobility events by classifying them according to their probabilistic importance in the context of BWA (Broadband Wireless Access) networks. We derived the analytical model of the solution. The first simulation results seem to confirm the advantage of our solution in reducing energy consumption.

Keywords: Femtocells, mobility management.

1. INTRODUCTION

Before the mass commercial deployment of femtocells, operators need to ensure that new femtocell deployments should meet regulatory requirements [1] and enable smooth integration with the macro networks. However, there are still some problems in the process of carrying out this new technology. Because, femtocells are deployed randomly by users, these plug-and-play residential base station will be on or off self-willed and are possible to move anywhere at any moment. Such issue will lead to an unknowable change of the network topology. Therefore the handover scheme between femtocells and macrocells is very crucial [2-3]. In order to improve user's QoS and maintain a low outage rate, lower handover rate is absolutely necessary. This will enhance the throughputs of femtocells and macrocells [4-5].

2. POWER SAVING ALGORITHM

A WiMAX macro cell of 1.2 km radius is considered along with multiple femto cells deployed randomly at a distance of at least 'R' meter from the macro BS (figure 1). During operation, information on the number of mobility events and their time are collected and used for further refinement of the coverage by self-optimization of the pilot power of the femtocell. We here propose an optimization method that takes decision based on unwanted mobility events from transient users into account that briefly hand over to the femtocell and hand back immediately after passing.

We hereafter give a brief overview of the proposed algorithm and system model:

1. No femtocell is considered within 'R' meter of radius of the macro base station (BS) because the RSS of mobile within this area is assumed to be quite high. A number of mobile users are deployed randomly under the coverage of the macro BS with varied velocity and undergoing calls of varied service type.

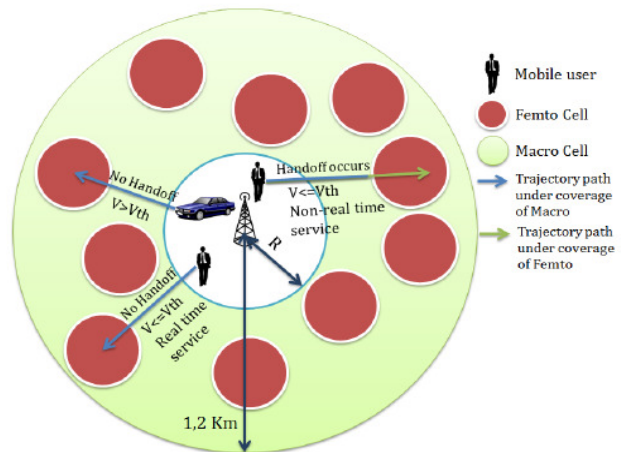


Fig. 1: Femtocell deployment

2. Initially, the femtocells are considered to be in the **idle** mode with all the pilot transmissions and associated radio processing at lower power sniffer (*Eidle*). The femtocell become active only when any end user is active under its coverage. This idle/active status aims to enhancing the energy consumption.

Case I: When the mobile user is moving at a very high velocity, no handoff from the macro to the femto is executed. The mobile remains attached to the Macrocell. As a user with very high velocity it undergoes huge number of macro/femto handoff within a very short period of time. The overhead of the macro BS thus increases unnecessarily. Hence, in this paper we have considered a velocity threshold 'Vth' of 30 Km/h (non motor vehicular speed).

Case II: If the mobile user is undergoing a real-time traffic, the number of handoff encountered degrades the call quality proportionately. Hence, in our scenario, no

handoff between the macrocell and the femto is triggered for them in order to maintain the call quality. The mobile remains attached to the Macrocell.

Case III: If $V < V_{th}$ and no real-time traffic, a power saving is performed:

The objective is to eliminate unwanted mobility events from transient users that briefly hand over to the femtocell and hand back immediately after passing the house. If the number of unwanted mobility events of passing users exceeds a pre-defined value of $n1$ events per time $t1$ the femto reduces its pilot power to $E1$. The femtocell then starts a new mobility event count for the updated configuration. If the number of unwanted events is smaller or equal to a pre-defined acceptable value of $n2$ events for a time $t2$, the femtocell increases its pilot power to $E2$, to provide improved indoor coverage.

3. PERFORMANCES EVALUATION

The energy consumed by l handoffs during the time period T can be expressed as:

$$E(T) = E_2 \times P_{leave}(l < n2) + E_1 \times P_{leave}(l > n1) + E_{ACTIVE} \times P_{leave}(n1 < l < n2) + E_{idle}P_{idle} \quad (1)$$

$$P_{idle} = 1 - (P_{leave}(l < n2) + P_{leave}(l > n1) + P_{leave}(n1 < l < n2)) \quad (2)$$

The probability of s new users in a time period of length T is modeled in this article by a Poisson process:

$$P(s, \lambda T) = P_s = \frac{(\lambda T)^s \cdot e^{-\lambda T}}{s!} \quad (3)$$

where λ denotes the intensity of such process.

Assuming that the users' holding time is exponentially distributed, the probability of exactly one user leaving a femtocell in a time period of length T is:

$$P_{leave} = 1 - e^{-\mu T} \quad (4)$$

where μ denotes the users' mean holding time.

Therefore, the probability of exactly l users leaving a specific femtocell, which has exactly Z connected users, in a time period of length T can be described as follows:

$$P_{leave}(l) = (P_{leave})^l \cdot (1 - P_{leave})^{Z-l} \cdot \binom{Z}{l} \quad (5)$$

Some initial simulations were conducted through Matlab. Main results are shown in the following figures (2-3). They show the adaptive behavior in femtocell power

consumption. Figure 3 demonstrates a considerable energy saving through our proposal compare to classical approach [2] that doesn't make power adaptation in active state.

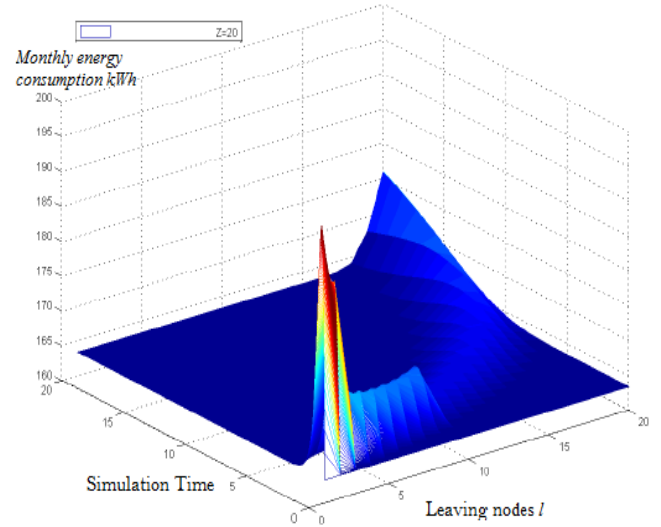


Fig. 2: Energy consumption in the proposed solution

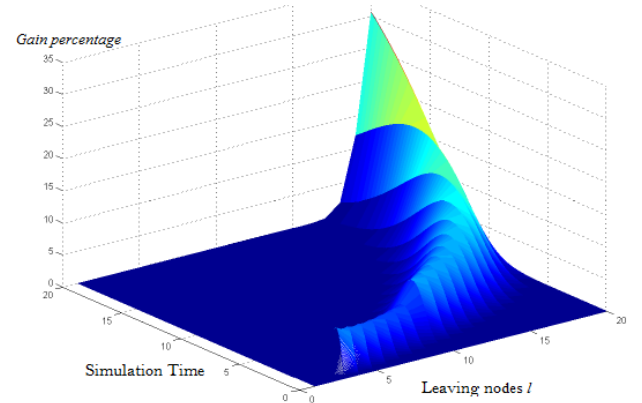


Fig. 3: Energy Gain

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