Cognitive Downlink Interference LTE Femtocell

Nahla NurElmadina, Ibtehal Nafea(✉), and Nuha Bihary

Computer Science and Engineering College, Taibah University, Medina, Saudi Arabia
nahlla.awadnoor@gmail.com, nuhabeh@gmail.com, inafea@taibahu.edu.sa

Abstract. The next generation of cellular networks is based on the concept of autonomous infrastructure deployment. Deploying femtocells inside a macrocell in a cellular network can significantly increase the macrocell's capacity in terms of network optimization. However, the deployment of many femtocells within a macrocell's coverage area causes severe femto-femto interference, or macro-femto interference, which may have an impact on the overall performance of femtocells. Avoiding interference is very important for co-tier or cross-tier femtocells and macrocells. In this paper, we propose a femtocell resource allocation scheme to alleviate the problem of co-tier or cross-tier interference. In the proposed scheme, orthogonal avoid interference with other femtocells. This paper studies a framework for autonomous network optimization based on the method of cognitive interference management to decrease the system's capacity. Results showed improvement in femtocell QOS.

1 Introduction

Currently, more than 20 cellular operators worldwide, representing together more than 1.8 billion of the total 3.5 billion mobile subscribers in the world, have already stated a commitment to LTE, and more than 32 million LTE subscribers are expected by 2013 [4]. Figure 1 shows LTE traffic growth from 2013 and expected growth until 2017. Therefore, many researchers have concentrated their efforts on the study of LTE systems, proposing new solutions in order to analyze and improve their performance.

LTE has developed a new technology in order to enhance indoor coverage. This new technology is called femtocells (short distance) and is achieved with the use of access points installed by home users; however, interference problems between femtocells and the macrocells decrease the system's capacity. Femtocells are one sufficient solution to increase the capacity and coverage to meet the high demand of the next generation of services on broadband wireless access. This paper focuses on femtocell technology and studies a framework for autonomous network optimization based on the method of cognitive interference management to decrease the system's capacity. Femtocells are not only a good solution for users but also for vendors. E-UTRAN Node B (eNodeB) is the base station in the Long Term Evolution/System Architecture Evolution (LTE/SAE) network [3]. It has many functions, such as radio resource management, radio mobility, and routing user plane data towards SAE gateway,

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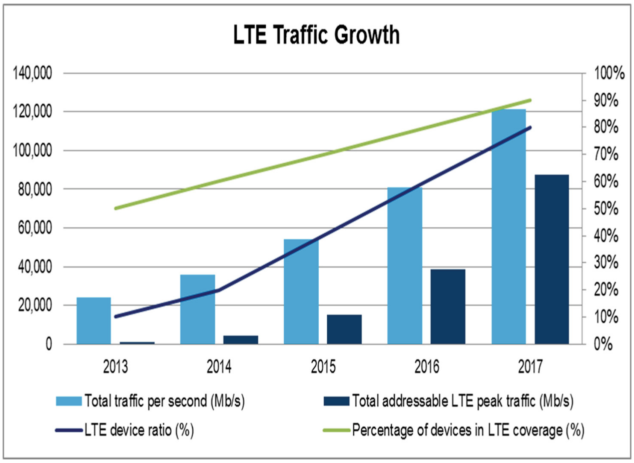

Fig. 1. LTE Traffic growth

internet protocol (IP) header compression and encrypting of data streams. eNodeBs are connected via X2, and to the SAE gateways (S-GWs) via the S1 interface. An access gateway in the radio network design connects eNodeBs together.

The paper is organized as follows. The first section presents related works. The next section defines the key issues regarding interference between femtocells and macro-cells, and one possible solution to the problem is shown. Next, the principle of cognitive channel allocation is explained. The last section presents simulation frame and performance results for capacity and coverage increase scenarios.

2 Related Works

The idea of project a vision for (LTE) 4G cellular networks based on the concept. [1] Femtocell is a low-power cellular base station designed primarily to provide the best coverage inside buildings in the commercial and small business office. It is affordable and it can be connected to an existing operator's network via broadband, such as DSL or cable, without the need for expensive towers. In addition, it is a limited user support to eight users. A call that begins from a handset equipped with a femtocell base station would start at a cellphone and then be sent to the femtocell, which would then go from the femtocell to the internet via a broadband connection and end up at the cellular network, as represented in Fig. 2 [5, 6].

As shown in Fig. 2, a femto network consists of a femtocell and various elements supporting a network which provides communication security, network provisioning, network management and integration. Home Node B (HNB) is the device that is installed to the user's premises serving as a femtocell. This operator has no exact control of the location.

In [8], they provided a survey of the different state-of-the-art approaches for interference and resource management in orthogonal frequency-division multiple

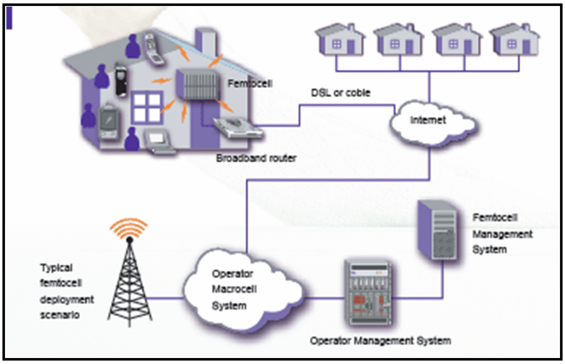

Fig. 2. Generic femto network architecture

accesses (OFDMA)-based femtocell networks. In addition they provided a qualitative comparison of the different approaches. They concluded that with efficient interference management schemes, the network capacity and coverage can be increased to benefit both the subscribers and the operators.

In [9] the author employed the colouring algorithm concept to mitigate the interference of the femtocell. The developed algorithm works by creating the interference graph by using the colouring algorithm, and once the graph is produced, the colouring algorithm is applied to that. The chromatic number of that graph is found, that chromatic number leads to a number of zones being created in the femtocell region, and once the zones are divided, the users are sent to a particular zone depending upon the SINR value. Meanwhile we allocate the number of channels to that particular user. They concluded that the proposed system algorithm reduces interference and increases the performance by more than 5 %, and in some scenarios it reaches up to 10 %.

3 Problems

The femtocell which operates at the same frequency band as the existing macrocell system would induce interference between femtocells or macrocell to femtocell, leading to these problems seriously affecting their performance [10]. Note that the term macrocell is used to describe the broadest range of cell sizes, and they are found in rural areas or along highways.

Co-channel interference is more critical in the femtocell network. There are two types that can thus be divided into tiers: themacrocell tier with femto interference and femto-femtocell tier interference [10] (see Fig. 3).

LTE cellular networks based on the concept of autonomous infrastructure deployment, cellular base station or femtocell access points are deployed by network users without being constrained by the conventional cell planning process from the network operator. Figure 4 explains the cognitive channel allocation procedure.

As seen in Fig. 4, cognitive channel allocation starts to process a femtocell access point by constantly sensing the radio environment (step one) and characterizes the

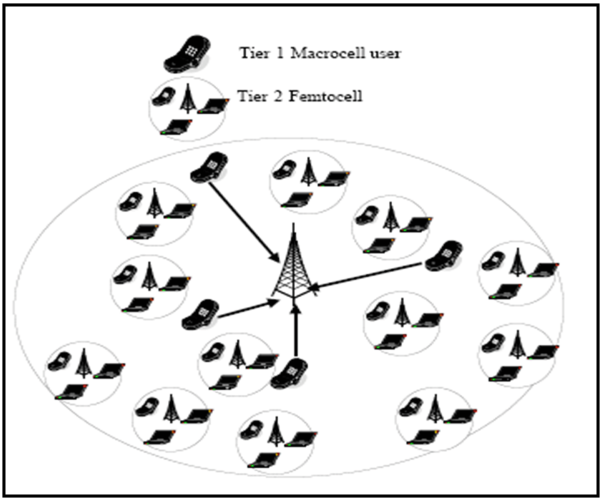

Fig. 3. A femtocell based two-tier OFDMA network [2, 7, 11]

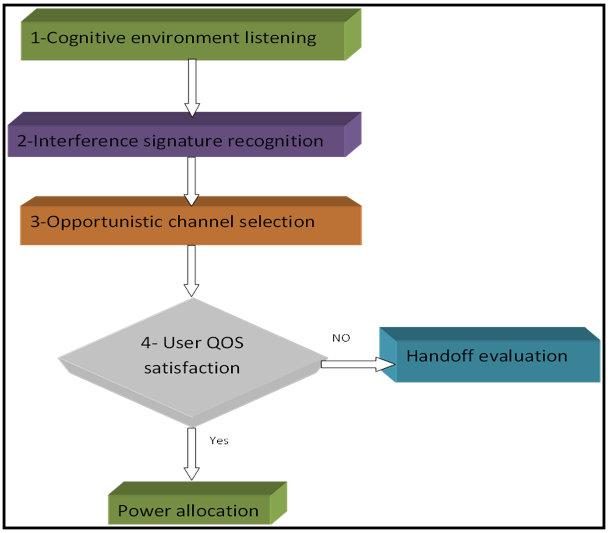

Fig. 4. Cognitive channel allocation procedure

interference signature from its neighbour (step two), then the condition channel information can be exchanged between femtocell and macrocell.

This process is supposed to run as a loop according to a particular control period (opportunistic channel scheduler is implemented) (step three). The scheduler works to always pick the best channel for reuse in which the inverse causes low interference to other cells. The user's Quality of Service (QOS) requirement will be evaluated based on the selected channel condition. If the channel can satisfy the target service requirement, a valid power will be allocated to serve the user according to the equation, otherwise a handoff processes an opportunistic channel reuse scheduler.

m = femto manages
j = total of number channel in a cellular network
i = number of user in femtocell

Cognitively characterized for user I as

$$\alpha_{m,i}^{j} = \frac{h_{m,i}^{j}{}^{2}}{I_{m,i}^{j}}$$

H and I = channel gain in user femtocell
Optimal channel

$$j^{*} = argmaxj(\alpha_{m,i}^{1}, \alpha_{m,i}^{2}, , , , , \alpha_{m,i}^{j})$$

$$\alpha_{m,i}^{j*} = \frac{h_{m,i}^{j*}{}^{2}}{I_{m,i}^{j*}}$$

Equation service quality

$$\frac{p_{m,i}(t)h_{m,i}^{2}}{I_{m,i} + N_{m,i}} \geq \gamma_{m,i}$$

$$\text{Min} \sum_{i=1}^{Nm} P_{m,i}$$

$$P_{m,i} * \alpha_{m,i}^{j*} \geq \gamma_{m,i}$$

$$P_{m,i} \geq 0$$

P(t) transmit power control of channel
H = channel amplitude from femtocell to user inside coverage
j* = best channel
$\gamma_{m,i}$ = user QOS of channel SINR
$N_{m,i}$ = noise level
$I_{m,i}$ interference from neighbor femto and macro cell

4 Simulation

Design macrocell scenario system is model one cell macro contains many femtocell we will main simulation assumption of study can be draw macrocell and user generation distribute in macrocell with femtocell.

Table 1. Simulation parameters.

Parameter	Value
Macrocell radius	500 m
Femtoocell radius	40 m
Carrier frequency	2 GHZ
Bandwidth (BW)	5 MHz
Tx power fmtocell	20 mw
Tx power macrocell	20 w
White noise (thermal noise)	−174 dB/Hz
Pathloss	38.4 + 20log(d),d = distance (meter)
Data rate	R = BW(1 + SINR)

The Matlab program is used for the simulation of macrocells. The system is modelled on one macrocell as four femtocells.

The main simulation assumptions of the study are shown in Table 1. The simulation is used to evaluate the performance of the cognitive channel allocation procedure.

Subscribers Generation. The system-level simulators are used to generate a random distribution of users as shown in Fig. 5. A total of 500 users are generated in a macrocell and contain four femtocells. (0–8) users in a femtocell serving base station of a given subscriber are taken as the one that is associated with the path loss.

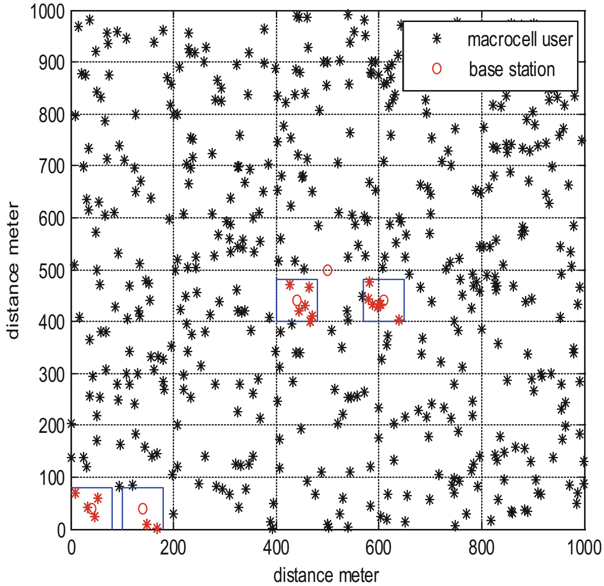

Fig. 5. Distribution of random subscribers

5 Results and Discussion

Figure 6 shows an estimation of the Signal to Interference plus Noise Ratio (SINR) (mobile terminate or user) level at any given position of the user's macrocell and user femtocell; it also shows the minimum improvement in SINR of the user's macrocell because of the high interference. This fact increases the experienced SINTR maximum level corresponding with the minimum distance requirement to preserve the SINR level.

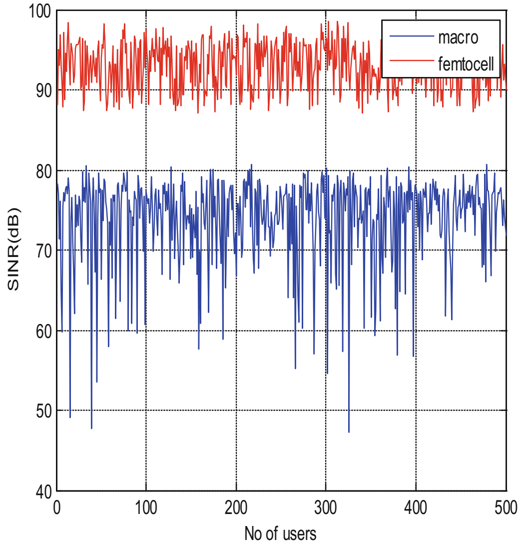

Fig. 6. SINR macrocell and femtocell

Figure 7 shows the maximum achieved data rate values. The femtocell users' data rate is higher than macrocell users' data rate. The users that are near to the centre of the femtocell receive higher power compared to those who are close to the centre of the base station.

Figure 8 shows the SINR for a femtocell. If the power is between p = 5mw, the performance of the SINR decreases. If the power transmits (femtocell) a maximum of 20 mw, the highest SINR, but decreases power, the femtocell's SINR decreases. This means high QOS (SINR) femtocell avoidance, so the interference between femtocells achieves the best signal for the femtocell.

Figure 9 shows an estimation of the Bit Error Rate (BER) of the user's macrocell and user's femtocell. It is also shows the minimum improvement in SINR of the user's macrocell because of the high BER. This fact increases the experienced SINTR maximum level corresponding with the minimum BER femtocell.

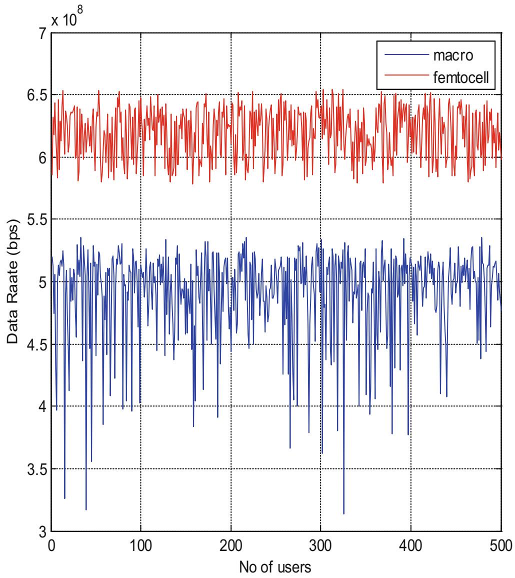

Fig. 7. Achieved data of macrocell and femtocell

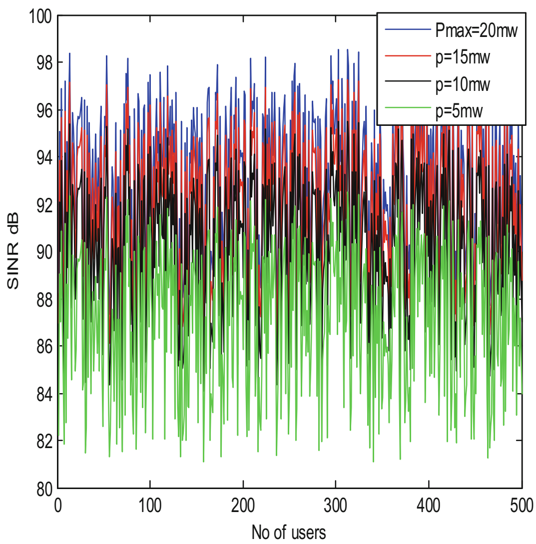

Fig. 8. Effect the power on SINR femtocell

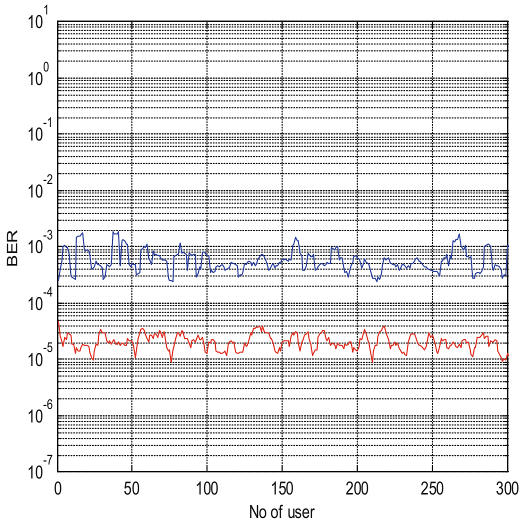

Fig. 9. Effect SINR on BER

6 Conclusion

In this paper a new framework has been proposed for autonomous network optimization based on cognitive interference management and simulation of macrocells and user generation distributed in macrocells with femtocells. Features covered by this simulator will allow both researchers and practitioners to test enhanced techniques for improving 4G cellular networks, such as decreasing the system's capacity and high performance, and so on.

The proposed system algorithm improves QOS of femtocells in next generation LTE and reduces interference. In addition, the proposed system increases the performance of femtocells by achieving more data.

Future works aims to study network capacity based on different strategies for user access i.e. open access, closed access or hybrid access. Other network factors will be considered in the model for power management, such as the traffic distribution in cells and mobile handoff between macrocells and femtocells.

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