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Interference Management with Dynamic Resource Allocation Method on Ultra-Dense Networks in Femto-Macrocellular Network

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***Abstract*—Ultra-Dense Network (UDN) which is formed from femtocells densely deployed is known as one of key technologies for 5th generation (5G) cellular networks. UDN promises for increased capacity and quality of cellular networks. However, UDN faces more complex interference problems than rarely deployed femtocells, worse on femtocells that are located on cell edge area of macrocell. Therefore, mitigating or reducing effects of interferences is an important issue in UDN. This paper focuses on interference management using dynamic resource allocation for UDN. Types of interference considered in this study are cross-tier (macrocell-to-femtocell) and co-tier (femtocell-to-femtocell) interferences for uplink transmission. We consider several scenarios to examine the dynamic resource allocation method for UDN in case of femtocells deployed in the whole area of macrocell and in the cell edge area of macrocell. Simulation experiment using MATLAB program has been carried out. The performance parameters that are collected from the simulation are Signal to Interference and Noise Ratio (SINR), throughput, and Bit Error Rate (BER). The obtained simulation results show that system using dynamic resource allocation method outperforms conventional system and the results were consistent for the collected performance parameters. The dynamic resource allocation promises to reduce the effects of interference in UDN.**

Keywords: ***udn, interference management, uplink transmission, cell edge area, dynamic resource allocation***

***Abstrak—Ultra-Dense Network* (UDN) yang dibentuk dari *femtocell* tersebar secara rapat diketahui sebagai satu dari teknologi kunci untuk jaringan seluler generasi ke-5 (5G). UDN menjanjikan kapasitas dan kualitas yang meningkat pada jaringan seluler. Bagaimanapun, UDN mengemukakan permasalahan-permasalahan interferensi yang lebih kompleks dibandingkan dengan penyebaran femtocell secara jarang, lebih buruk lagi pada *femtocell* yang terletak di daerah sisi sel dari *macrocell*. Oleh sebab itu, penyelesaian dan pengurangan efek interferensi adalah satu isu penting untuk UDN. Artikel ini berfokus pada manajemen interferensi menggunakan alokasi sumber daya radio dinamis untuk UDN. Tipe-tipe interferensi yang dipertimbangkan adalah interferensi *cross-tier* (*macrocell*-ke-*femtocell*) dan interferensi *co-tier* (*femtocell*-ke-*femtocell*) untuk transmisi uplink. Penulis mempertimbangkan beberapa skenario untuk menguji metode alokasi sumber daya radio dinamis yang diusulkan untuk UDN pada kasus femtocell disebarkan pada keseluruhan area dari *macrocell* dan pada area sisi sel dari *macrocell*. Percobaan simulasi menggunakan program MATLAB telah dilakukan. Parameter kinerja yang diukur adalah *Signal to Interference and Noise Ratio* (SINR), throughput, dan *Bit Error Rate* (BER). Hasil-hasil simulasi yang didapatkan menunjukkan bahwa sistem menggunakan metode alokasi sumber daya radio lebih baik dari pada sistem konvensional dan hasil-hasilnya konsisten untuk semua parameter kinerja yang telah dikumpulkan. Alokasi sumber daya radio dinamis menjanjikan untuk mengurangi efek interferensi pada UDN.**

Kata kunci: ***udn, manajemen interferensi, transmisi uplink, area tepi sel, alokasi sumber daya dinamis***

I. Introduction

Wireless communication technology including wireless cellular communication technologies is very popular to the public at present; hence providers, academics, and communication industries are required to keep in delivering their best services to the users. One of simple ways to improve capacity and quality of cellular network service is to reduce cell size [1]. Reduced cell size will be able to serve many users efficiently with higher data rates. Therefore, femtocell emerged as a candidate that has very small cell coverage. Femtocells that are deployed densely in the macrocell area of cellular networks will form a very dense network called as Ultra-Dense Network (UDN) technology. UDN technology is well known as one of key technologies that forming the 5th generation (5G) cellular network in increasing the data capacity and speed [2]. However, in femtocells interference often

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occur because they share the same radio resources with macrocell. Type of interference that often occurs is usually among femtocells which is called as co-tier interference, and also interference that occurs between femtocell and macrocell which is called as cross-tier interference. The situation will get worse when they are located on cell edge area of macrocell [3].

There are several techniques to solve interference problems for UDN such as Interference Avoidance techniques [4-7], Interference Cancellation techniques [8-10], and Interference Coordination techniques [11-13]. The fundamental idea of Interference Avoidance technique is to divide the available resources into orthogonal proportions in several dimensions such as time, frequency, space, power, code, etc. [14]. Furthermore, there are several methods that are often used to reduce interference in the femtocell-macrocell network such as the radio resource allocation method [15-17]. The authors in [15] proposed an efficient resource allocation technique that can reduce the effect of uplink interference in a two-tier femtocell. To achieve the goal, those authors use an integer programming (IP) scheme. However, the results were efficient along with complexity of the scheme. The authors proposed to use heuristic scheme in which femtocell and macrocell were allocated the resources cooperatively.

In this paper, interference management will be carried out for the femtocell-macrocell network at uplink transmission based on Single Carrier Frequency Division Multiple Access (SC-FDMA), especially in the cell edge area of macrocell, which often experiences high interferences. The technique that is proposed for interference management in this paper is based on dynamic radio resource allocation method. In the proposed dynamic radio resource allocation method, femtocell uses neighboring macrocell radio resources by considering the smallest interference caused from users deployed in the neighboring macrocell area as the number of femtocells is increased. This paper considers a multicell cellular communication layout consisting of three macrocells. In macrocell 1 it is deployed increasingly a number of femtocells in step of 1. If the first femtocell selects radio resources from either macrocell 2 or 3 (neighboring macrocells) assuming the frequency reuse factor of 3, then adjacent femtocells cannot use same radio resources as the first femtocell that has been assigned. Then, femtocells are grouped based on the differently assigned radio resources to them which femtocell and macrocell will be allocated the radio resources cooperatively. Femtocells that belong to the same group are assigned the different radio resources.

A. Main Contributions

In this paper, we propose radio resource allocation algorithm as an interference management technique for a heterogeneous wireless cellular network consisting of macrocells and femtocells using the dynamic radio resource allocation method where femtocells are assigned the radio resources based on the lowest interference value from neighboring macrocells. In [18], it was presented an interference management technique using cooperative relay node (RN) based on channel estimation. The cooperative RN system manages cross-tier interference caused by cell-edge Macrocell User Equipment/MUEs (Cellular User Equipment/CUEs) to femtocell access points (FAPs). In our current paper, we propose a method of dynamic radio resource allocation that aims to mitigate the occurrence of co-tier interference occurring between one femtocell and another femtocell because the allocated radio resources are shared among the femtocells. The femtocells that are located close together cannot use the same radio resources, thus the co-tier interference that occurs among the femtocells can be minimized.

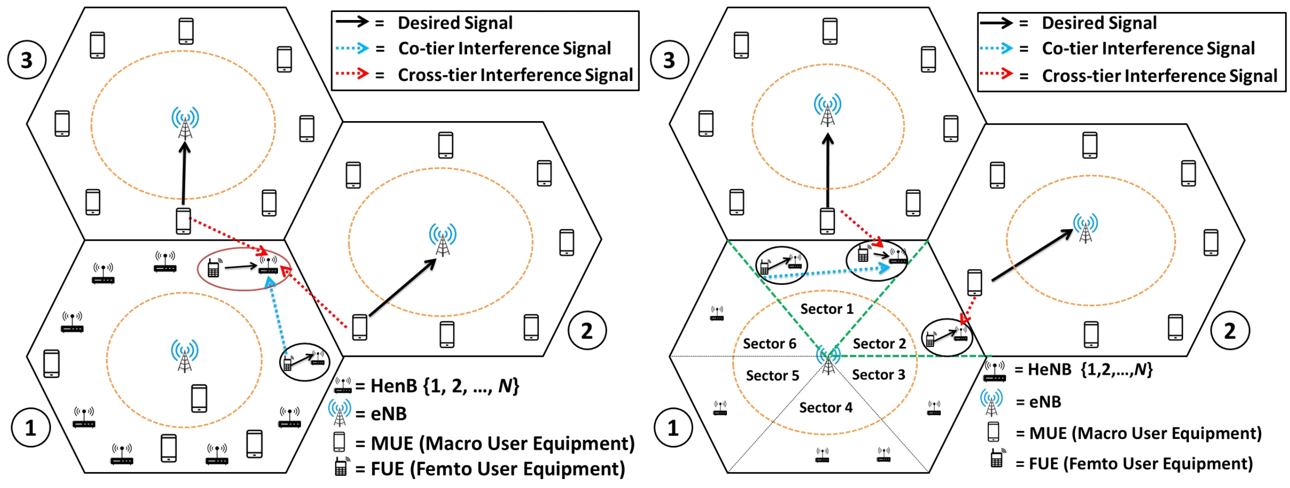
B. Paper Organisation

This paper is structured as follows. Succeeding this introduction, Section II describes the system model and the proposed dynamic resource allocation method. Section III describes the system model to be simulated including its simulation parameters. The simulation results are presented and discussed in Section IV. Section V concludes the paper.

II. System Model

In this paper, we consider four scenarios. For all scenarios we consider OFDMA-based cellular communication system in uplink transmission. Figure 1 (a) shows the first scenario for the system that is considered, where there are three macrocells, i.e., $M=\{1\ldots m\}$ with m equals to 3 for our case. Those three macrocells are assigned to use different radio frequency resources each (frequency reuse factor of 3). One of those three macrocells is deployed certain number of femtocells, but other two macrocells are not deployed femtocells. It is just deployed a number of MUEs for the sake of simplicity in analysis. The number of femtocell base stations or Home Evolved Node B (HeNBs), $F=\{1\ldots f\}$ that are deployed is 200 femtocells in the macrocell 1's coverage area, especially in the cell edge area of macrocell. It is assumed that the femtocells are applied frequency reuse factor of 2 where the femtocell uses and shares the same radio resources as used for other two neighboring macrocells. We refer this first scenario as conventional system and we use as a baseline system.

The second scenario is depicted in Figure 1 (b). Similar to the first scenario, in this second scenario it is considered three macrocells OFDMA-based networks in uplink transmission, where among macrocells it is assigned different radio resources. One of three macrocells is deployed a number of femtocells within its coverage area. Meanwhile, the other two macrocells are not deployed femtocells, but it is deployed a number of MUEs at their coverage area. Furthermore, in this second scenario, the macrocell 1 is divided into 6 sectors. Each sector is deployed 33 femtocells. In this paper, we focus the analysis just on sectors 1 and 2. Sector 1 is located adjacent to the



(a) (b)

Figure 1. Conventional system model (a) without sector division and (b) with sector division

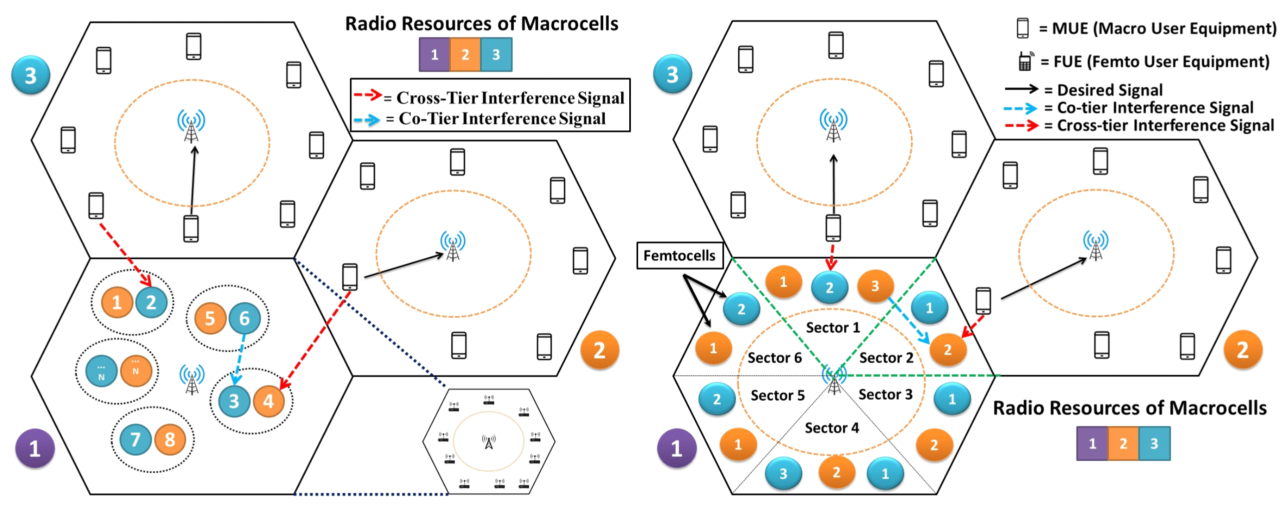
edge of macrocell 3, while sector 2 is located next to the edge of macrocell 2. Femtocells that are deployed within the macrocell 1 are assigned and share the same radio resources as other two neighboring macrocells that have been assigned.

As mentioned earlier, this paper considers uplink transmission in both macrocells and femtocells. Each macrocell (other than the one that is deployed the femtocells) contains a number of MUEs, $K=\{1\ldots k\}$. When femto user equipment (FUE), $S=\{1\ldots s\}$, is transmitting to HeNB i.e., in uplink transmission mode, and at the same time MUE is also transmitting to evolved Node B (eNB) in uplink transmission mode as well, therefore for the certain HeNB will suffer cross-tier interference caused from those MUEs. The illustration of interference problems that occurs in the femtocell-macrocell network can be seen in Figure 1 (a). The dashed blue arrow line indicates co-tier interference, while the dashed red arrow line indicates cross-tier interference, and the solid black arrow line denotes the desired signals.

To mitigate co-tier and cross-tier interferences in the femtocell-macrocell network, a dynamic radio resource allocation method is designed and proposed in this paper as illustrated in Figure 2 (a) and Figure 2 (b), in relation to Figure 1 (a) and Figure 1 (b), respectively. Using this proposed method, femtocell uses neighboring macrocell radio resources by considering the smallest interference from users which is deployed within neighboring macrocells as the number of femtocells is increased by a factor of 1. This method will be discussed further in sub-section 2.c.

A. Channel Model

Channel model that is used in this paper based on 3GPP TR 36.814 version 10.2.0 Release 10 [19] and 3GPP TR 36.922 version 10.0.0 Release 10 [20]. Channel model for femtocells in urban areas can be formulated in (1) as the following.



(a) (b)

Figure 2. System model with proposed dynamic radio resource allocation method: (a) without sector division and (b) with sector division

$$PL\left(dB\right)=15.3+37.6\ log_{10}\left(d\right) \quad (1)$$

The channel model for macrocells in urban areas can be calculated using (2) as follows.

$$PL\left(dB\right)=127+30log_{10}\left(\frac{d}{1000}\right)+L_{ow} \quad (2)$$

where d denotes the distance between the user to the HeNB or the eNB in meters and L_{ow} is the penetration loss of building wall, window, etc. which equals to 6 dB [21].

B. Signal to Interference and Noise Ratio (SINR)

The Signal to Interference and Noise Ratio (SINR) is calculated as a parameter to determine the link performance of a femtocell-macrocell network which can be written as in (3) as the following [22].

$$SINR=\frac{P_S^F}{\sum_{S=1}^{n} I_S+\sum_{K=1}^{m} I_K+N} \quad (3)$$

where
P_S^F : the transmit power at FUE to HeNB (in mWatt or Watt)
I_S : co-tier interference caused by another femtocell (in mWatt or Watt)
I_k : cross-tier interference from MUE to HeNB (in mWatt)
N : noise power (in mWatt or Watt).

The power transmitted from the FUE to the HeNB (the power for the desired signal) or the transmitted power from another FUE to the HeNB (co-tier interference) can be calculated using (4) as the following.

$$P_S^F\left(dBm\right)=P_{FUE}\left(dBm\right)-L_{femto}\left(dB\right) \quad (4)$$

P_{FUE} is the transmit power of the desired FUE or other interfering FUEs in dBm. The power transmitted from the MUE to the HeNB (cross-tier interference) can be written as in (5) as follows.

$$I_K\left(dBm\right)=P_{MUE}\left(dBm\right)-L_{macro}\left(dB\right) \quad (5)$$

where P_{MUE} is the transmitted power at MUE in dBm.

C. Throughput

Throughput can be calculated by the Shannon capacity using (6) shown below [23].

$$C\left(Mbps\right)=B\times log_2\left(1+SINR\right) \quad (6)$$

where
C : system throughput (in Mbps)
B : system bandwidth (in MHz)
$SINR$: Signal to Interference and Noise Ratio.

D. Bit Error Rate (BER)

Bit error rate (BER) for the considered system will depend on the type of modulation which is used. In this paper, the type of modulation that is considered is 16-Quadrature Amplitude Modulation (16-QAM). The calculation of BER can be written using (7) depicted below [24].

$$BER=\frac{3}{4}Q\left(\sqrt{\frac{4\left(\frac{Eb}{No}\right)}{5}}\right) \quad (7)$$

where Eb/No is ratio of energy per bit to noise and $Q(.)$ is Q function.

E. Proposed Dynamic Radio Resource Allocation Method

The proposed dynamic radio resource allocation method is shown in Figure 2 (a) as the third scenario and Figure 2 (b) as the fourth scenario. For the third scenario in Figure 2 (a) as mentioned early, we consider uplink transmission of OFDMA-based femtocell-macrocell networks. The designed system model has three macrocells which each is assigned a set of different radio resource. In macrocell 1 there are 200 femtocells that are deployed in the cell edge area of bottom left macrocell (macrocell 1) in Figure 2 (a), where the radio resources that are used in the femtocells are the same as macrocells 2 and 3 (radio resources sharing). In this scenario, the femtocell is determined to be assigned the radio resources based on the smallest interference from the neighboring macrocells. As the increased number of femtocells, i.e., the first femtocell has been allocated its radio resources, the next femtocell will not be allocated the same radio resources as the previous femtocell. Then, set of femtocells which has been allocated different radio resources are grouped in one cluster as shown in Figure 2 (a). Femtocells that use the same radio resource as Macrocell 2 are indicated by an orange circle, while femtocells that use the same radio resource as Macrocell 3 are indicated by a blue circle. This algorithm will be repeated along the way as the number of femtocells increases, starting from the first femtocell with considering co-tier interference as well. Thus, the radio resources are allocated dynamically, since the presence of femtocells are randomly generated. By this algorithm it is expected that the interferences in the femtocells are minimized and hence it can be expected that the performance of the femtocell system will be improved.

Similar to the third scenario, in the fourth scenario (Figure 2 (b)) it also uses the dynamic radio resource allocation method to reduce the effects of interferences in the femtocell-macrocell network. However, in this scenario, dynamic resource allocation method is used to mitigate interference when the observed macrocell area is divided into 6 sectors in addition to dividing the macrocell area into inner and outer areas. It is purposed to focus our analysis on the femtocells located at the cell edge area of macrocell as well as the MUEs from the neighboring macrocells that are interfering coming from the cell edge area of neighboring macrocells. The dynamic resource allocation method is used to improve performance of the conventional system which has been divided into 6 sectors for the system as shown in Figure 1 (b). Each of 6 sectors is deployed 33 femtocells, but the focus of the analysis in this paper is just on sectors 1 and 2. Sector 1 is located adjacent to the edge of macrocell 3 and sector 2 is located next to the edge of macrocell 2. Selection of radio resources allocated to the femtocells based on the lowest interference caused from MUEs on the macrocells 2 or 3 to the observed femtocells. As the number of femtocells is increased and if the first femtocell has been determined its radio resources to be assigned, then the next femtocell adjacent to the first femtocell is not allowed to be allocated the same radio resource as the first femtocell. This algorithm works continuously until the last femtocell are generated and repeating from the first femtocell as the presence of next femtocell that randomly generated. With the intention of femtocells that close one to another they will use different radio resources as shown in Figure 2 (b). Therefore, co-tier interferences that are caused by other femtocells can be minimized.

III. Simulation Settings and Parameters

A. Simulation Settings

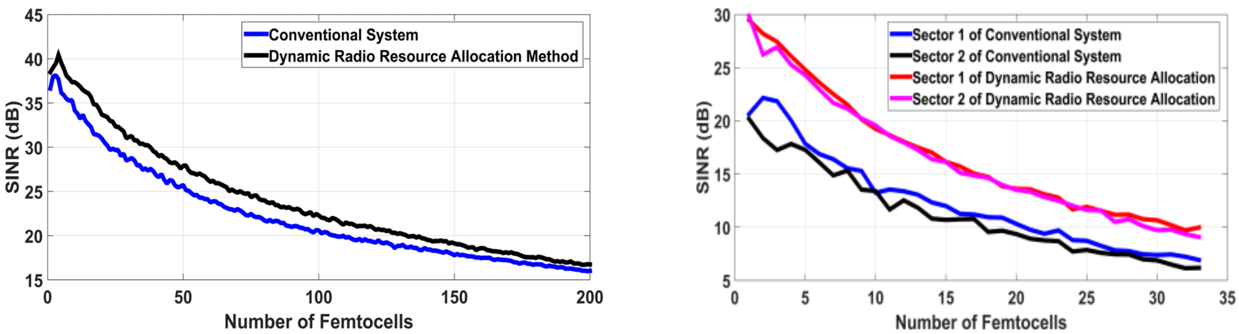
A simulation experiment has been carried out in this paper using MATLAB software through writing the simulation programming codes. The simulation settings in this paper are based on four scenarios that have been considered. The first scenario is shown in Figure 1 (a), where there are three macrocells based on OFDMA. One of those three macrocells is deployed femtocells especially in the cell edge of macrocells, but the other two macrocells are not deployed femtocells. The first scenario is referred to as a conventional system, as mentioned previously. The second scenario used in the simulation is shown as in Figure 1 (b). In this scenario, macrocell 1 is divided into 6 sectors. Each sector is deployed 33 femtocells within its coverage area. The designed system model has three macrocells in which have been assigned a different radio resource accordingly. The femtocells are assigned the same radio resources as two neighboring macrocells which is referred to as the frequency reuse factor of 2. The third scenario uses the model system as shown in Figure 2 (a). In this scenario the femtocell is assigned the radio resources based on the smallest interference referred as dynamic resource allocation as discussed previously. The third scenario is purposed to explore the effect of proposed dynamic resource allocation method in improving the performance of femtocells in conventional system in the first scenario. The fourth scenario is shown in Figure 2 (b). Similar to the third scenario, this scenario also uses the dynamic radio resource allocation method. However, the dynamic radio resource allocation method in this scenario is used to improve the conventional system in the second scenario, where we consider the conventional system based on the division of 6 sectors. The scenarios that have been designed are then simulated using MATLAB software. The simulation results will be displayed with a graph, where the results in the compare between the first scenario and the third scenario, and the second scenario is compared with the fourth scenario.

B. Simulation Parameters

The simulation parameters that are used for all scenarios can be seen in Table 1. There are three OFDMA-based macrocells which have been allocated different radio resources. One of the three macrocells is deployed femtocells especially in the cell edge area of macrocell. In the first and third scenarios it is set up that the number of femtocells is increased up to 200 femtocells by the factor of 1, while in the second and third scenarios it is associated that the number of femtocells is increased up to 33 femtocells for each sector. The femtocell is allocated the same radio resources as used in the two neighboring macrocells (frequency reuse factor of 2). The radius of each femtocell is set to 30 meters. In this paper, femtocells are assumed to be able to serve 1-16 users. The system bandwidth used is given to 10 MHz [26]. We use 16 QAM modulation type on the system. Each femtocell is observed and the performance parameters that are collected are averaged for all femtocells and the simulation is run for 20 times.

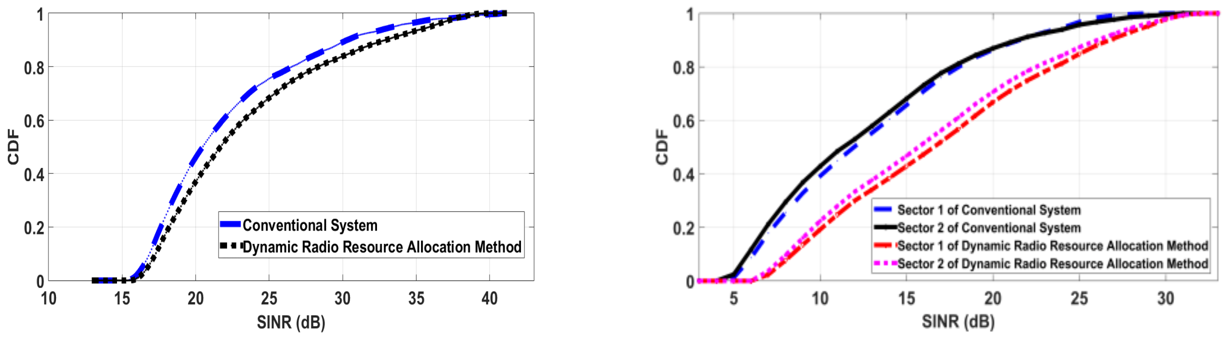
IV. Results and Discussion

Based on the simulation results that have been collected from the MATLAB simulation program, the results are



(a) (b)

Figure 3. Simulation results for SINR performance of: (a) comparison of conventional system and system with dynamic resource allocation method, (b) comparison of conventional system and system with dynamic resource allocation method based on sector division



(a) (b)

Figure 4. The simulation results for CDF of SINR of: (a) comparison of conventional system and system with dynamic resource allocation method, (b) comparison of conventional system and system with dynamic resource allocation method based on sector division

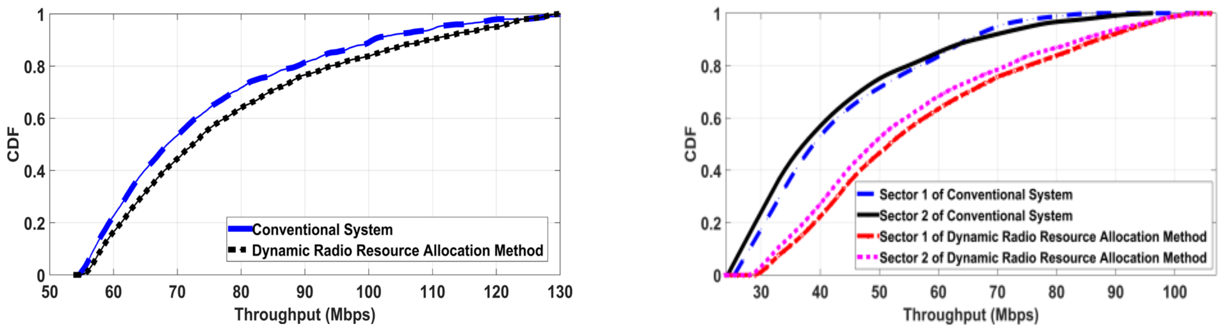
obtained in graphical forms. The graph of performance parameters used in this paper is based on the parameters of SINR, throughput, and BER. Figure 3 shows the simulation results for SINR versus the number of femtocells. Typically, as the number of femtocells increases, the SINR value decreases both for the conventional system and the system with dynamic resource allocation method.

Femtocell performance is getting worse due to cross-tier interference caused by MUEs and co-tier interference caused by others FUEs. From Figure 3 (a) and (b), the SINR for the system with dynamic resource allocation method is better than the conventional system. However, the SINR value in Figure 3 (a) is better than Figure 3 (b) for both conventional system and system with dynamic radio resource allocation method. This is because femtocells deployed in macrocells that have been sectored are more susceptible to interference from neighboring MUEs, since they are located very close to the femtocells on the cell edge area. The SINR results in Figure 3 fluctuate slightly since the simulation is run for 20 times due to the limitations of our experiment resources. More simulation running times will make the results smoother. In addition, the randomly generated femtocell locations cause SINR values to fluctuate as well.

Figure 4 (a) and (b) show the Cumulative Distribution Function (CDF) of SINR. Figure 4 (a) is a comparison of the CDF of SINR for the conventional system and system with a dynamic radio resource allocation method where femtocells were deployed randomly at the cell edge area of macrocell. Meanwhile, Figure 4 (b) is a comparison of the CDF of SINR for the conventional system and the system with dynamic resource allocation method based on sector division.

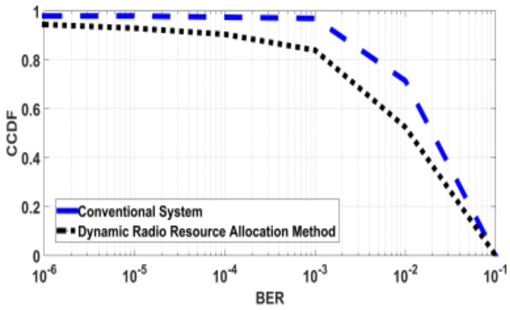
When we are targeting a SINR value of 20 dB which is excellent criteria for the quality of service, it can be seen in Figure 4 (a) that the probability of SINR not reaching the target, it means the SINR value is below 20 dB, for the conventional system and system with dynamic radio resource allocation method are 46% and 38%, respectively. Meanwhile in Figure 4 (b) that the probability of SINR not reaching the target for conventional system in sector 1 and 2 are both 86%. The probabilities of SINR for the values of 19-24 dB in Figure 4 (b), the conventional system, at both sectors 1 and 2 are the same because the interference values received by HeNB in both sectors demonstrate the similar values and when the average values are calculated, the results show similar or same values.

However, system with dynamic radio resource allocation method not reaching the target in sector 1 and 2 are 68% and 70%, respectively. From these results it can be said that the dynamic radio resource allocation method can improve the performance of femtocells located in the cell edge area of macrocells. The resource allocation method is able to mitigate cross-tier interference because the selection of femtocell resource allocation is based on the lowest interference from macrocell 2 or macrocell 3. In addition, the resource allocation method is also able to mitigate co-tier interference caused by other femtocells

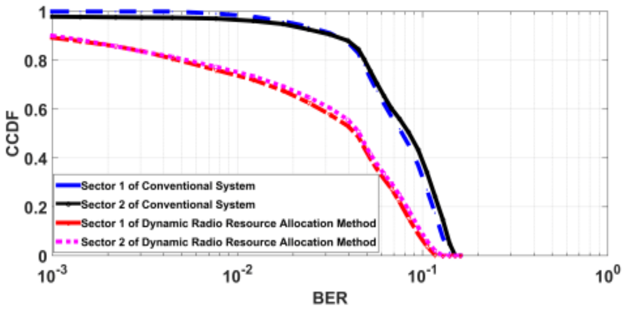


(a) (b)

Figure 5. The Simulation results for CDF of throughput of: (a) comparation of conventional system and system with dynamic resource allocation method, (b) comparation of conventional system and system with dynamic resource allocation method based on sector division system



(a)



(b)

Figure 6. The comparison of CCDF of BER of: (a) comparation of conventional system and system with dynamic resource allocation method, (b) comparation of conventional system and system with dynamic resource allocation method based on sector division system

because femtocells that have different radio resources are grouped into the same cluster.

Figures 5 (a) and (b) show the CDF of throughput. Figure 5 (a) is a comparison of CDF of throughput for the conventional system and the system with the dynamic radio resource allocation method where femtocells are deployed randomly in the cell edge area of macrocell. Meanwhile Figure 5 (b) is a comparison of CDF of throughput for the conventional system and the system with the dynamic radio resource allocation method based on sector division. In Figure 5 (a), the throughput probability of a conventional system and the system with dynamic resource allocation method which is less than 60 Mbps are 23% and 18%, accordingly, while in Figure 5 (b), the probability of femtocell throughput which is less than 60 Mbps in the conventional system in sector 1 and 2 are both 85%. However, the probability of femtocell throughput that is less than 60 Mbps in the system with dynamic resource allocation in sectors 1 and 2 are 63% and 69%, respectively. As the number of femtocells increases, the throughput for both systems decreases in both systems. The reason is because both interferences co-tier and cross-tier interferences increase as well.

From these results, it can be said that the system that applies the dynamic radio resource allocation method where femtocells are deployed randomly in the whole area of macrocell outperforms a system that applies a dynamic radio resource allocation method where femtocells are deployed in the cell edge area of macrocell with sectorization i.e., that has been observed on sectors 1 and 2. This is because the femtocells deployed in sectors 1 and 2 within the macrocell 1's coverage area are located very close to the MUE on the edge of the neighboring macrocell, with the intention of the femtocells in sectors 1 and 2 are exposed to greater interferences than the femtocells that are randomly deployed inside the whole area of macrocell.

Figures 6 (a) and (b) show the comparison of Complementary Cumulative Distribution Function (CCDF) of Bit Error Rate (BER). Figure 6 (a) is the comparison for the CCDF of BER between the conventional system and the system with dynamic resource allocation method where femtocells are deployed in the whole cell edge area of macrocell. In addition, Figure 6 (b) shows the comparison for CCDF of BER between the conventional system and the system with dynamic resource allocation method based on sector division. In Figure 6 (a), the probability of BER in the conventional system above 0.01 is 71 %, while the system with the dynamic resource allocation method that has a BER above 0.01 is 52%. In Figure 6 (b), the probability of BER above 0.01 in the conventional system in sectors 1 and 2 reaches 95% and 94%, respectively. Meanwhile, the probability of BER above 0.01 for the system with dynamic resource allocation in sectors 1 and 2 reaches 74% and 75%, respectively. When the number of femtocells increases, the BER values also increase. It is understandable that the error that occurs in the femtocell is caused by the increasing amount of interference, both co-tier and cross-tier interferences. These results indicate that the errors that occur in femtocells deployed in macrocells that have been divided into sectors, especially in sectors 1 and 2 are greater than femtocells deployed randomly in the whole edge area of macrocell due to the closer interferences from the neighboring cells, as we focus the analysis on the cell-edge area of macrocells, both femtocells located on the cell-edge area as well as MUEs located on the cell edge area of macrocells as the interferences.

V. Conclusion

This paper proposes an interference management method in femtocell-macrocell network using dynamic resource allocation method for the UDN. In this paper, we have considered four scenarios. The first scenario is the system that does not apply the dynamic radio resource allocation method called as a conventional system, where femtocells are deployed randomly in the cell edge area of the macrocell. The second scenario is a conventional system where femtocells are deployed in the macrocell area which has been divided into 6 sectors. However, in this study, we focused on analysis in sectors 1 and 2 which are located close to the neighboring macrocells applying three cells of multicell cellular network layout. To improve femtocell performance on the conventional systems in both the first and second scenarios, we designed interference management using dynamic resource allocation method. Then, the third scenario is a dynamic resource allocation method that is applied to femtocells in which are deployed randomly in the cell edge area of the macrocell. Therefore, the simulation results are to compare the first scenario with the third scenario (comparison of the conventional system and the system with dynamic resource allocation method). The fourth scenario is to apply the dynamic radio resource allocation method to femtocells deployed in macrocells which have been divided into 6 sectors. However, we only focus on the analysis on sectors 1 and 2 as pre-defined. This scenario was compared with the second scenario, i.e., comparing the conventional system and the system that applies the dynamic radio resource allocation method based on the sectoral division of the observed macrocell.

The simulation results obtained from the MATLAB program show that the systems using the dynamic resource allocation method are better than the conventional systems. It has been shown on the simulation results of the probability of SINR, throughput, and BER. When we target a SINR value of 20 dB, the probabilities of SINR for the conventional system and the system that applies a dynamic radio resource allocation method for femtocells that are deployed randomly in the cell edge area of a macrocell do not reach the target are 46% and 38%, respectively. Meanwhile, the SINR probabilities for the conventional system in which a femtocell is deployed within the macrocell that have been divided into six sectors and observing the sectors 1 and 2 do not reach the target are both 86%. After the dynamic resource allocation method applied, the probabilities of the SINR in sectors 1 and 2 do not reach the target is reduced to 68% and 70%, accordingly. The throughput probabilities of the conventional system and the system that applies the dynamic radio resource allocation method for femtocells that are deployed randomly in the cell edge area of macrocell below 60 Mbps are 23% and 18%, respectively. However, the probability of throughput for the conventional system in which femtocells are deployed within macrocell that has been divided into 6 sectors, observing sectors 1 and 2 which are below 60 Mbps are 85%, when the dynamic radio resource allocation method is applied, the throughput probabilities below 60 Mbps in both sectors 1 and 2 is reduced becoming 63% and 69%, respectively. All simulation results show the consistency among the performance parameters that we have considered.

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