Interference Management Based on Clustering Method for Ultra-Dense Networks in Multicellular Network

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Abstract— One of solutions to address the increasing demands for data traffic by mobile users is to implement ultra dense network (UDN). UDN consists of many femtocells that are densely deployed on macrocellular communication networks. Since femtocells radius is very short and they are tightly packed, it faces interferences problem i.e., co-tier and cross-tier interferences. This paper proposes interference management technique based on clustering method for UDN multicellular communication networks at downlink transmission. It is purposed to reduce interference effects. To evaluate the proposed clustering method, two simulation scenarios have been designed; namely baseline system and system with the proposed clustering method. The scenarios applied is to randomly distribute femtocells following a uniform distribution in three macrocells areas. Through a clustering algorithm, adjacent femtocells are grouped into one cluster and assigned different frequency channels for each femtocell in that cluster. The same cluster pattern is repeated for all femtocells. Thus, interference effect is canceled within one cluster and reduced among clusters by widening the distance among femtocells that use the same frequency channels. Through simulation experiment, the proposed clustering method is evaluated and compared to the baseline system. The simulation results show that Signal to Interference plus Noise Ratio (SINR) of femtocells increases 0.44 dB, throughput increases 1.67%, Bit Error Rate (BER) reduces, and other parameters improve as well which include spectral efficiency, network energy, and average network energy. The proposed clustering method increases performances of the networks and provides better solution for transmission data speed in densely femtocell network.

Keywords— clustering method; co-tier interference; cross-tier interference; distance-based clustering; femtocell-macrocell; interference management; multicell scenario; UDN

I. Introduction

Wireless cellular communication technology rapidly develops over the decades. Especially in technology field, applications and mobile devices it continues to adapt to meet the increasing needs, particularly of many cellular users in using networks for data, voice and multimedia services in the requirements to send and to receive the information quickly and precisely. 5G as the latest generation cellular technology that continues to be developed in various countries and at this time many researches have begun to carry out on the fields of next generation of 6G. The need for easy access to information certainly causes demand for data traffic to increase. Ultra Dense Networks (UDN) is identified as a technique that can meet these needs [1]. Small size cells (femtocells) are deployed densely with the aim of increasing network performance and reducing the physical distance between transmitter and receiver to improve the system performances. Data transmission speed and overall network capacity can be increased through an UDN environment with densely distributed small cells with increased use of frequency reuse [2]. UDN have more or greater cell density, quantitatively 10^3cells/km^2 compared to the number of active users on the cellular network, UDN has been at the forefront of technology for years, even coming to achieve the different capabilities expected to be available by 5G and next-generation networks [3].

The UDN offers network throughput to increase. However, due to the density of base station deployed, it causes computational complexity and signaling overhead [4] and UDN also causes interference due to the reuse of frequencies in cells adjacent to neighboring cells. Interference increases when femtocells in close proximity uses the same frequencies or subcarriers. When small cells are tightly packed like an UDN, distances to neighboring cells become closer, coverage becomes overlapping, causing interference to both. For this reason, if the number of small cells (femtocells) is increased, the problem of interferences is increased, especially in multi-cell scenarios [2]. To overcome the interference problem that occurs due to inter-cell density, interference management techniques are required.

Based on literature survey, to manage interference we can apply relay-based clustering method [5]. It was showed that the result of Signal to Interference plus Noise Ratio (SINR) value outperformed the baseline system. The throughput and Bit Error Rate (BER) values improved as well. Other methods are available in the literatures such as power allocation [6], Dynamic Resource Allocation [7], power control [8], [9], interference alignment [10] and resource allocation [11]. However, these methods have high complexities.

Coordinated multi-point technology (CoMP) as popular technique can reduce interference between cells and improve cell edge performance and system throughput [12]. The results of simulation showed that user density and cluster size have an influence on load balancing performance compared to resource allocation and based on the use of control-data separation architecture (CSDA) [13]. The SINR and throughput values increase using the clustering method. CoMP also yields significant advantages of spectral and throughput efficiency

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and low running time compared to some existing clustering schemes, and it is effective to remove interference [14].

Energy efficiency needs to be considered to avoid wasting power due to dense base stations on the network by mitigating interference in Control-based UDN and user plane split (CUPS). A shared user and cluster-based energy efficient resource allocation scheme is proposed in [15] and another method with a cluster-based Energy Efficient Resource Management (CEERM) scheme is proposed to mitigate disruptions while ensuring quality of service (QoS), so that energy consumption can be minimized with small cells in clusters [16].

Another literature discusses concerning mitigation of interference by sharing resources of call-edge users in UDN. Clustering as proposed method helps to solve the problem by optimizing it. Performed user clustering by applying *K*-nearest Neighbor (KNN) as a fast-convergent iterative algorithm shows the result that the proposed method's throughput performance was better for both users on the average and cell-edge users and achieved good tradeoff between the gain and cost for per unit cooperation resource consumption in which get the highest rate gain per unit [17], [18].

User centric clustering method has been mentioned as one of methods to decreasing the interference by user-centric (UC) clustered. It achieved good performance when the access point (AP) becomes a place to offloading the tele-traffic because it related to the transmission delay [19], [20].

Various types of clustering methods have been discussed in previous literatures such as the use of dense cluster algorithm combining small cell networks (SCN), which adapts well by deploying dense SCN randomly, so increasing its achievement in delivering data flow [21]. Then in the multi-user scenario in UDN with Mobile Edge Computing (MEC), usage assignment is carried out in a cluster to minimize the overall delay for all users. Simulation results showed that the proposed scheme can improve the situation significantly [22].

Reducing the interference that occurs in dense cell structures in the UDN environment, the clustering method and inter-BS distance-based subcarrier allocation method were proposed to increase the sum-rate by reducing UE interference at the edge of the cell in the UDN environment [23]. Through the proposed method, the sum-rate was increased by reducing the interference from neighboring cells, and it is ensured that the performance can increase further as the number of UEs increases. It is also possible to achieve better sum-rate performance levels through exhaustive search algorithms. Resource management for clustering also needs to be considered because this affects the number of clusters that will be created. Based on the estimated results, it was depicted that the operating frequency band (channel characteristics) has the greatest influence on the optimal number of clusters [2], [23].

However, none of literatures mentioned above are considering multicell scenario. In this paper, the interference management approach that is proposed is the clustering method for UDN under multicell scenario. Our proposed clustering method is simple in calculation. Through a clustering algorithm, adjacent femtocells are grouped into one cluster and each femtocell is allocated a different set of frequencies in one cluster. The same cluster pattern will be repeated for all femtocells that make up the UDN. Thus, the interference effects are expected to be cancelled within one cluster and reduced between clusters due to the widened distance between co-channel femtocells. With the implementation of clustering method, it is expected to reduce the interference effect of UDN in multicell scenario and system performance will be improved. In [24] the clustering method has been designed for planning the indoor femtocells which is different to our proposed clustering method. In summary, our goal is to reduce the effect of co-tier interferences among femtocells for UDN in multicellular scenario through a distance-based clustering method.

This paper is expected to contribute in overcoming the problem of interference that occurs due to dense femtocells distributed in macrocells. Femtocells that are deployed densely and form UDN in macrocell provide high data rates by deploying small base station (SBSs) in macrocell. The deployment of femtocells causes unavoidable interferences between neighboring femtocells' users, even when the femtocell users increase, interference will become higher and performance will decrease. This paper proposes in managing interferences that occurs in dense femtocells to reduce interference among femtocells who are close each other.

This paper is structured as follow. Following the discussion in this section, the research method that has been adopted in this paper is discussion in section 2. It involves design of scenarios that describes the problem and implementation of proposed clustering method, analysis of performance parameters and the models, and describing the simulation parameters that have been determined. Section 3 presents the results of the simulations that have been carried out and discuss it. Section 4 concludes this paper.

II. METHOD

Modeling and simulation are employed in this paper as a main research method in carrying out the problem addressed and to achieve the goals. The aim of this paper is to reduce the co-tier interference effects in UDN formed by densely deployed femtocells underlaid macrocellular networks by using clustering method in multicell scenario. In addition, the clustering method is grouping the adjacent femtocells to use the different channel frequencies so reducing co-tier interferences among the femtocell users by widening the distance among femtocells that are allocated the same frequency channel. To achieve this goal, two heterogenous cellular networks consisting of femtocells and macrocells are designed as the simulation scenarios. The first scenario is called as the conventional system and it is also referred to as a baseline system. In this first scenario we investigate the interference problems in femtocells densely deployed in the three macrocells layout. Then, we describe second scenario where our solution i.e., clustering method is applied among femtocells to mitigate the interference problem. These two network scenarios are described in detail in the following sub-sections.

A. System Model and Description

We consider orthogonal frequency division multiple access (OFDMA) based cellular communication network on the downlink transmission. OFDMA has been chosen as a multiple access scheme since OFDMA has been spread adopted for 4th generation (4G) cellular network, 5G and beyond. Overall, the system is allowed to use a frequency bandwidth of B. For the first scenario, three macrocells network layout is set. In each macrocell it is deployed a number of macrocell user equipments (MUEs). We apply the frequency reuse factor (FRF) of 3 in this three macrocells in which each macrocell is allocated one third of total system bandwidth. A large number of femtocells, n, is deployed randomly in each macrocell forming UDN. Each femtocell is assigned a set of frequency channel randomly according to its appearance in a macrocell area and the femtocells are applied FRF of 3 for a cluster of three femtocells which does not consider the distance among femtocells. It is assumed that each femtocell is active that there is a transmission from femtocell base station (Home Evolved Node B/HeNB) to femtocell user equipment (FUE). We refer this first scenario to as baseline system.

Figure 1 illustrates the first scenario that is previously described. By the setting in Figure 1 we can see the occurrence of co-tier and cross-tier interferences at the femtocells that are being observed. As previously described, each macrocell and each femtocell are allocated a different sub-bandwidth which follows the use of FRF of 3 among the cells. As we divide the total system bandwidth into three equal-size sub-bandwidths, we indicate for three sub-bandwidths as channels 1, 2, and 3, accordingly. Figure 1 illustrates the allocation of sub-bandwidth channels for the considered first scenario where the macrocells 1, 2, and 3 are colored yellow, blue and green, accordingly as they are assigned channel 1, 2, and 3, respectively. The illustration of same colored channel assignment in Figure 1 is applied for femtocells. Therefore, both macrocells and femtocells are applied FRF of 3. Note in the first scenario that sub-bandwidth assignment to femtocells is random according to their appearance in the macrocells' area. By this setting there will be a possibility that the same sub-bandwidth is assigned to the femtocells that are close one to another. Hence, the level of co-tier interference occurrence will be higher especially when the femtocells are dense. Figure 1 shows the interference occurrence when we observe one femtocell in Macrocell 1 at downlink transmissions for both of macocells and femtocells. It is indicated as the blue dashed lines for co-tier interferences and red dashed line for cross-tier interference in Figure 1.

To reduce the effect of co-tier interferences that has been discussed, in this paper we propose a clustering method for the femtocells. Clustering method groups three neighboring femtocells into a cluster and assigns different channels for each femtocell in one cluster. And then, the same pattern of cluster is replicated to form another cluster. This procedure repeats until the last cluster formed in a certain macrocell area. This clustering method is applied in the similar setting in Figure 1 and it is depicted in Figure 2. By this clustering method it is guaranteed that there will be no neighboring femtocells assigned the same channels. Hence, the distance among femtocells that are assigned the same channel is widened,

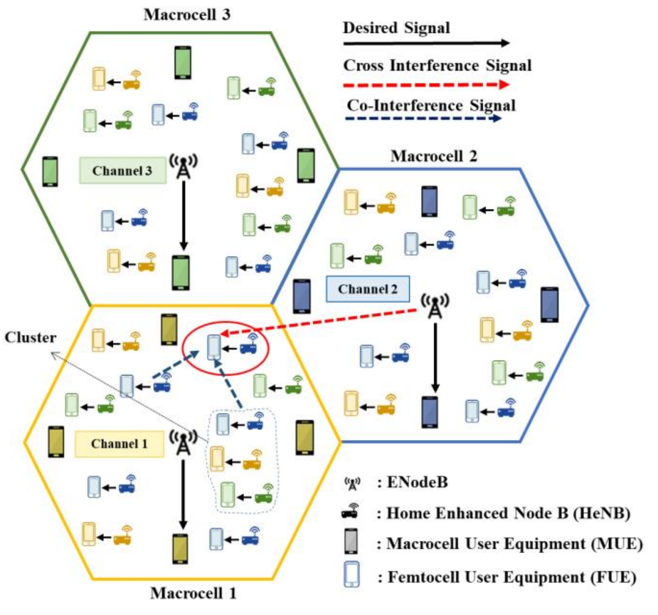

Figure 1. UDN Conventional System

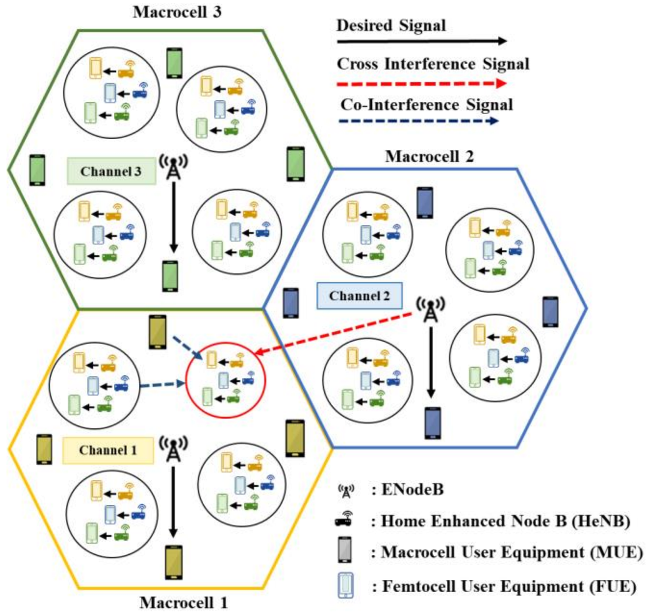

Figure 2. UDN with Proposed Clustering Method

therefore it is expected that the co-tier interference among femtocells is reduced.

Based on the scenario in Figure 2, several stages are carried out for the implementation of the proposed clustering method. First, a number of femtocells are densely and randomly distributed in three macrocells' areas. The closest femtocell to macrocell base station or (eNB) will be selected as a reference femtocell in forming a first cluster. This reference femtocell calculates its distance to other femtocells. The two closest femtocells from these calculation results are selected to become members of the first cluster. Then, these three femtocells have formed one cluster. In order to find the next reference femtocell, it is done by selecting the third femtocell which is closest to the first reference femtocell. Three femtocells that previously have formed a cluster are excluded from the list of femtocells that need to be grouped. The cluster formation algorithm continues to be repeated until the last femtocell is accomplished in a microcell area. The assignment of channels to clusters is determined according to the number of femtocells in a cluster, namely three channels assignment (FRF of 3) is carried out sequentially. So, by applying this algorithm to the clustering method, the distance among femtocells that use the same channel will be wider, and it is expected to have an impact on reducing co-tier interferences. Figure 3 demonstrates the flowchart of our proposed clustering method.

B. Performance Parameters Analysis

In this section we discuss the performance parameters that we use to evaluate the system performance, namely Signal to Interference Plus Noise Ratio (SINR), throughput, spectral efficiency, Bit Error Rate (BER), network energy, average network energy. In addition, also we discuss cumulative distribution function and complementary cumulative distribution function.

1) Signal to Interference Plus Noise Ratio (SINR)

Based on two considered scenarios for each macrocell and each femtocell there are randomly distributed a number of MUEs in each macrocell area and a number of FUEs in each femtocell area. In Figure 1 we can see that three macrocells are allocated different channels i.e., macrocells 1, 2, and 3 use channels 1, 2, and 3, respectively. It is assumed that there is

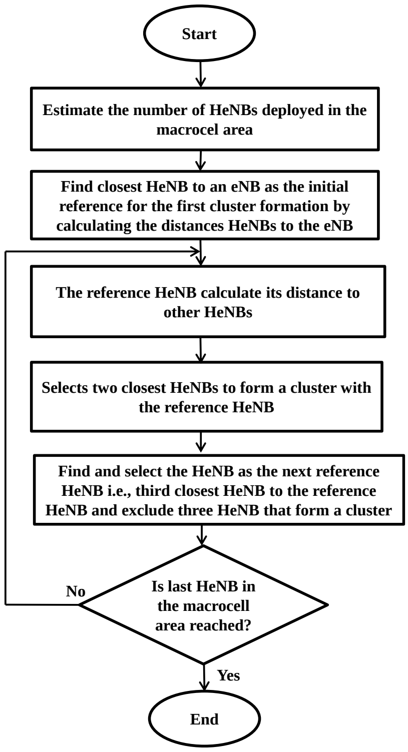

Figure 3. Flowchart of clustering method

only one FUE on each femtocell that actively uses the same channel as its co-tier and cross-tier channels. When we observe one femtocell at downlink transmission and all eNBs also transmit at downlink transmissions, there will be an expected signal i.e., this comes from the HeNB to the FUE in the area of observed femtocell. In addition, there will be unexpected signals from other HeNBs and eNB that uses the same channel to the observed FUE i.e., they are all as interferences. To analyze the signal quality observed at FUE in a femtocell, it can be determined by calculating SINR value. SINR is the ratio of the desired signal from the HeNB to the observed FUE and the total interferences plus the system noise power. The interferences come from other femtocells that use the same allocated channel (co-tier interferences) and the macrocell that use the same channel as the observed femtocell (cross-tier interference). Therefore, SINR can be calculated using (1).

$$SINR_{FUE} = \frac{P_{FUE}}{\sum_{i=1}^{n} I\_cross\_tier(i) + \sum_{j=1}^{m} I\_co\_tier(j) + N} \quad (1)$$

where P_{FUE} is the desired signal power at the observed FUE (in milliwatts), $I\_cross\_tier(i)$ is the i-th cross-tier interference signal power (in milliwatts), $I\_co\_tier(j)$ is j-th co-tier interference signal power (in milliwatts), n and m are the number of cross-tier and co-tier interferences, respectively, and N is the noise power in the system (in milliwatts).

The expected signal power P_{FUE} at the observed FUE can be calculated using (2).

$$P_{FUE} = \frac{P_{HeNB}}{L} \quad (2)$$

Equation (2) in decibel (dB) unit can be stated in (3).

$$P_{FUE}(dBm) = P_{HeNB}\ (dBm) - L\ (dB) \quad (3)$$

where P_{HeNB} is the transmit power of HeNB in milliwats or dBm and L denotes the propagation path loss (without unit or in dB) that is characterized by the terrain of network system. It is assumed that this system is located in an urban area. In urban area, the channel model is based on standard of 3GPP TR 36.814 version 10.2.0 for urban macrocell [25]. The standard channel model used for femtocells in urban area is based on 3GPP TR 36.922 version 10.0.0 release 10 standards [25]. It can be expressed in (4) [3] i.e., for macrocell systems

$$L_{macrocell}(dB) = 15.3 + 37.6\ log_{10}(r) + L_{oth} \quad (4)$$

and in (5) for femtocell systems:

$$L_{Femtocell}(dB) = 127 + 30\ log_{10}\left(\frac{r}{1000}\right) \quad (5)$$

where r is the distance between the transmitter (eNB or HeNB) to the receiver (FUE or MUE) and L_{oth} is penetration loss caused by the wall between the transmitter and receiver paths.

2) Throughput and Spectral Efficiency

Having analyzed SINR, the throughput (T) and spectral efficiency (η) performances can be calculated using (6) and (7), respectively [6], [17].

$$T = B * log_2(1 + SINR) \quad (6)$$

$$\eta = \frac{T}{B} \quad (7)$$

where B denote the system bandwidth and $SINR$ is a measured SINR, T is system troughput, and η is system spectral efficiency.

3) Bit Error Rate (BER)

BER performance depends on the modulation scheme applied on the system. In our system, we apply 16 Quadrature Amplitude Modulation (16-QAM). For 16-QAM, BER performance can be analyzed using (8) [6].

$$BER = \frac{3}{4} Q\left(\sqrt{\frac{4}{5} E_b/N_0}\right) \quad (8)$$

where $Q(.)$ denote Q function of the argument in the brackets and E_b/N_0 is a normalized measure for SINR per bit. SINR is related to the energy per symbol to noise power spectral density (E_s/N_0) is shown in (9) and the relationship between E_s/N_0 and E_b/N_0 is depicted in (10).

$$E_s/N_0 = \frac{SINR}{\eta} \quad (9)$$

$$\frac{E_s}{N_0} = \frac{E_b}{N_0} * log_2(L) \quad (10)$$

where L is the alternative level of modulation scheme i.e., 16 in our case.

4) Network Energy and Average Network Energy

Since we apply UDN i.e., femtocells in the three macrocells layout, we can analyze the network energy consumption (EC) in joules/bit (J/bit) for the femtocell network. The network energy consumption is defined by the consumed energy by femtocells per data rate (throughput) and it can be analyzed using (11) [26].

$$EC = \frac{\sum_{i=1}^{n} P\_HeNB_i}{T} \quad (11)$$

where P_HeNB_i denote i-th HeNB's consumed power, n is the total number of femtocells, T is the network throughput. Then, the average network energy (AVG_EC) can be calculated using (12).

$$AVG\_EC = \frac{EC}{n} \quad (12)$$

5) Cumulative Distribution Function (CDF) and Complementary Cumulative Distribution Function (CCDF)

CDF and CCDF can indicate the outage probability of network being analyzed. CDF and CCDF can be calculated using (13) and (14), accordingly [6].

$$CDF(z) = Prob(z \leq Z) \quad (13)$$

$$CCDF(z) = 1 - CDF(z) = Prob(z > Z) \quad (14)$$

where $Prob(z \leq Z)$ or $Prob(z > Z)$ is the probality of a random variable of Z less than or equal or greater than to a constant of z, respectively. In our case, the random variables being analyzed are the performance parameters that we use to evaluate the network.

C. Simulation Parameters

In this paper, the simulation experiment has been carried out. As mentioned early, this paper considers a multicellular system consisting of three macrocells, where each macrocell is assigned the different channel frequencies by FRF of 3. The radius of each macrocells is set to 1,000 meters and the radius of femtocell is set to 30 meters. In each macrocell, it is deployed a number of femtocells, n, randomly following a uniform distribution and densely that forms UDN network. Femtocells are also applied to use FRF of 3. Femtocells (HeNBs) are assumed to serve FUEs and there will be one FUE that is applied the same channels as one of eNBs and other HeNBs (co-channel usage). It can be carried out to perform analysis to the network performances. The number of femtocells, n, that are deployed is 210 femtocells. All femtocells are deployed at the same time and the FUEs in each HeNB is deployed randomly. The maximum powers for eNB and HeNB are set to 46 dBm and 23 dBm, respectively. The total system bandwidth, B, is set to 10 MHz. The modulation scheme that is implemented in the system is 16-QAM (Quadrature Amplitude Modulation).

The simulation experiment is run 10,000 times i.e., 10,000 iterations. In each iteration the performance parameters are collected and it is calculated the average value of each performance parameter. The performance parameters that are collected are SINR, throughput, spectral efficiency, BER, network energy consumption, and average network energy. Each performance parameter is measured according to the increase of the number of femtocells (HeNBs), from one femtocell to 210 HeNBs. To analyze the distribution of performance parameters, it is calculated the CDF of SINR and throughput and the CCDF of BER. Table I summarizes the simulation parameters that are applied in this paper.

III. Results and Discussion

This paper carries out the two scenarios described previously. The first scenario is the baseline system described in Figure 1. The second scenario is shown in Figure 2 that is the system with proposed clustering method. This section presents the simulation results that have been collected for the considered performance parameters that are mentioned in previous section. For all simulation results, we label the results for the baseline system and for the system with proposed clustering method as UDN conventional and UDN Clustering method, respectively.

Figure 4 shows the results for the SINR values versus the increase of the number of HeNBs. Based on the graph, generally the SINR value decreases as the number of HeNBs increases. The SINR value for a conventional UDN system at the number of HeNBs equal to 210 is 25.1 dB, meanwhile for the system with the proposed clustering method, the SINR value is 25.54 dB. Therefore, there is an increase in the SINR value of 0.44 dB. It is as expected in our intuition that the clustering method keeps the femtocells that are assigned the same frequency channels away each other and hence SINR performance for the proposed clustering method is better.

Figure 5 depicts the results of a comparison of CDF parameter for SINR between the baseline system and the system with clustering method. From the CDF results of SINR that was obtained, an outage probability analysis of SINR can be carried out. CDF of SINR in Figure 5 is based on SINR results when the number of femtocells equal to 210. It shows that the gap for the results comparing two systems is just a little

TABLE I. Simulation Parameters

No.	Parameter	Value
1.	Number of macrocells	3
2.	Frequency reuse factor of macrocells and femtocells	3
3.	Radius of macrocell [6]	1,000 meters
4	Radius of Femtocell [6]	30 meters
5.	Number of HeNBs (in each macrocell)	210
6.	Number of MUEs (in each macrocell)	210
7.	Transmit power of HeNB [9]	23 dBm
8.	Transmit power of macrocell eNB [9]	46 dBm
9.	Total System Bandwidth [9]	10 MHz
10.	Modulation scheme [9]	16-QAM
11.	Simulation time	10,000 iterations
12.	Noise Power Spectral Density [9]	-174 dBm/Hz

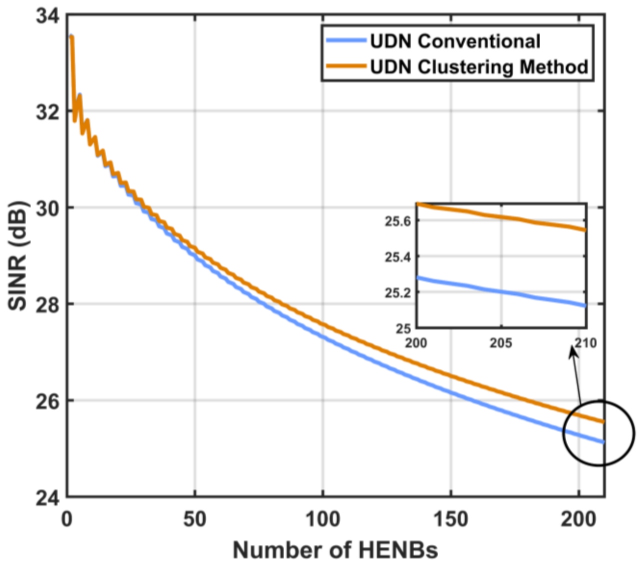

Figure 4. The simulation result of SINR versus the number of HeNBs

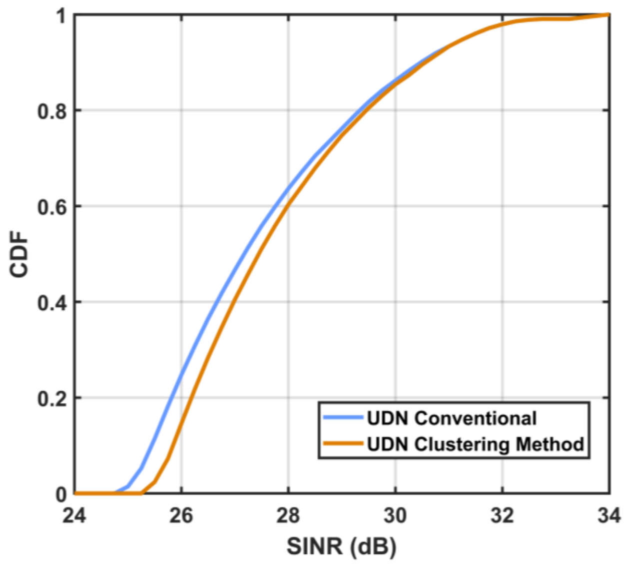

Figure 5. The CDF simulation result of SINR for HeNBs

visible in the graph. When we consider the value of SINR equals to 28.5 dB, the baseline system obtains the CDF value of 70.4%, meanwhile the system with clustering method reaches 67.9%.

Figure 6 illustrates the simulation results for the throughput versus the number of HeNBs. As we can notice, Figure 6 has the similar trend line as the results for the SINR. It entails that the throughput results confirm the SINR results. The system with clustering method outperforms the baseline system. The throughput for the baseline system when the number of HeNBs equal to 210 is 83.5 Mbps. Meanwhile, throughput for the system with proposed clustering method is 84.9 Mbps. The value of throughput increases 1.67%. Figure 7 shows the CDF of throughput relating to the throughput in Figure 6. The CDF of throughput shows that when the throughput value equal to 90 Mbps, the baseline system reaches 48.25% and the system with proposed clustering method obtains CDF value of 42.4%. There is an increase of 13.80%.

Figure 8 shows the spectral efficiency versus the number of HeNBs. When the number of HeNBs equals to 210, the spectral efficiency values for the baseline system and the system with proposed clustering method reaches 8.35 bit/s/Hz and 8.59 bit/s/Hz, accordingly. There is an increase for the spectral efficiency value of 2.87% by applying the proposed clustering method in system. It is consistent as the result for the throughput performance.

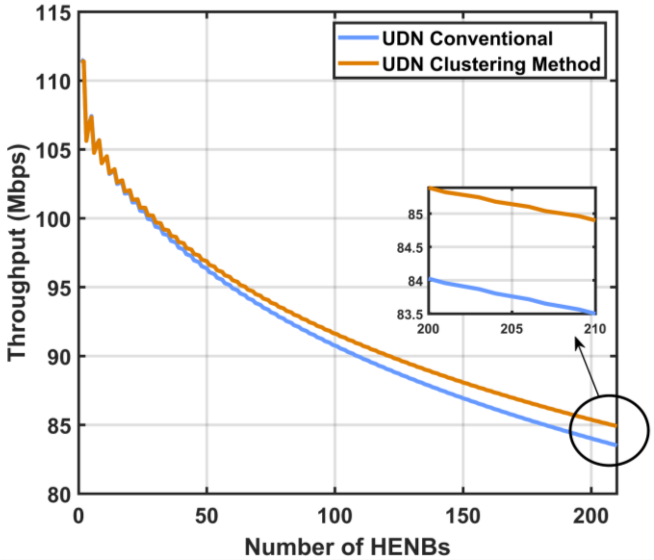

Figure 6. The simulation result of Throughput versus the number of HeNBs

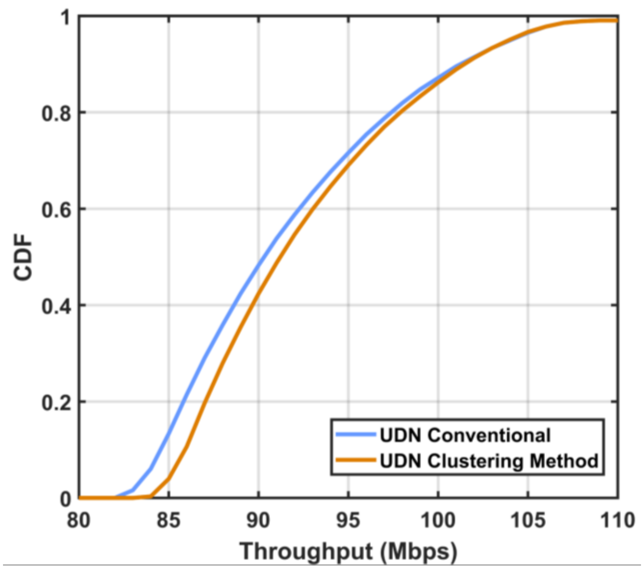

Figure 7. The CDF simulation result of Throughput for HeNBs

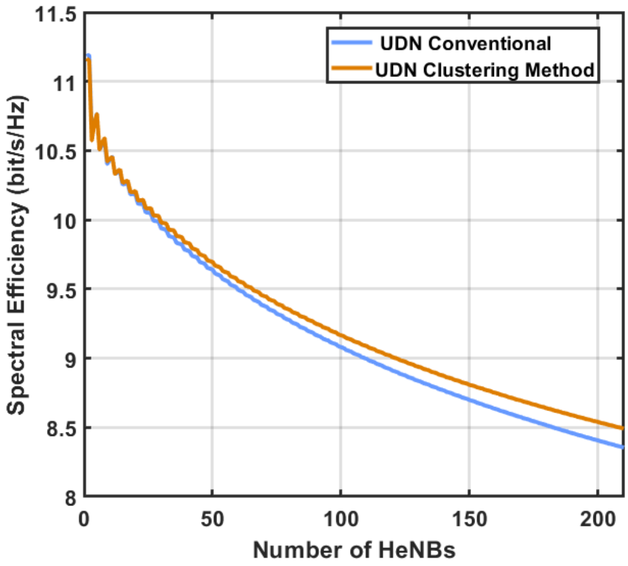

Figure 8. The simulation result of spectral efficiency

Figure 9 shows the BER performance versus the number of HeNBs. It can be seen in Figure 9 that when the number of femtocells equal to 200, the BER values for the baseline system and the system with proposed clustering method are $7.98\text{x}10^{-17}$ and $2.65\text{x}10^{-18}$, accordingly. The system with clustering method outperforms the baseline systems with the decrease of BER.

The results of the CCDF for BER are shown in Figure 10. It shows that when the BER value which are greater than 10^{-2}, the baseline system reaches 0.77 (77%) and the system with clustering method obtains an CCDF value of 0.25 (25%). It means the probability of errors in data transmission that the greater the BER value has been achieved for the system with proposed clustering method.

The comparison results of network energy and average network energy of the baseline system and the system with proposed clustering method are shown in Figures 11 and 12, respectively. When the number of HeNBs is equal to 210, the network energy for the baseline system reaches $1.68\text{x}10^{-13}$ J/bit, meanwhile the network energy value for the system with

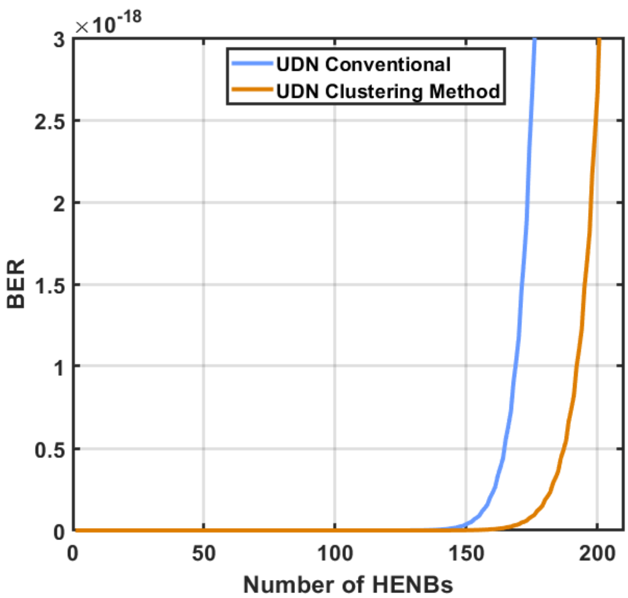

Figure 9. The simulation result of BER for HeNBs

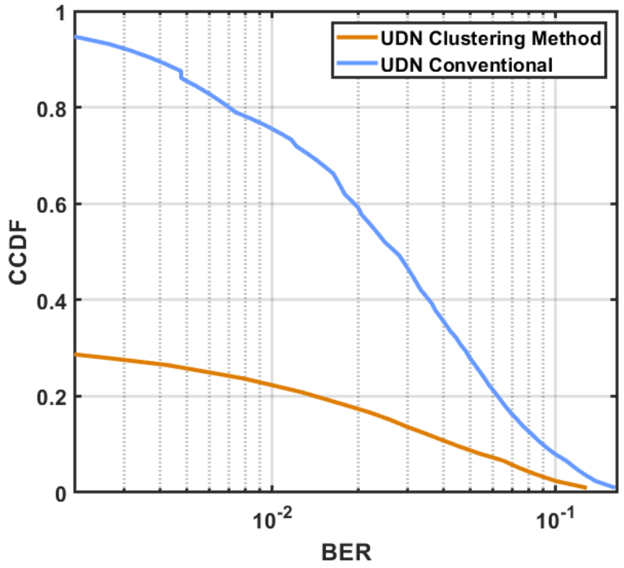

Figure 10. The CCDF simulation result of BER for HeNBs

proposed clustering method is $1.66x10^{-13}$ J/bit. In addition, based on Figure 12 the average network energy value for the baseline system when the number of HeNBs equal to 210 is $2.22x10^{-13}$ J/bit and for the system with proposed clustering method is $2.17x10^{-13}$ J/bit.

Based on all simulation results, the system with proposed clustering method outperforms the baseline system. The implementation of the proposed clustering method can reduce the effects of co-tier interference occurrences by widening the distance among the femtocells that are allocated the same channels. The proposed clustering method ensures that distance among co-channel femtocells.

To discuss our proposed clustering method to other methods mitigating the similar interference problems that are available in the literatures, we summarize it in Table II. Moreover, Table II presents the comparison of the research results from the other related works. Ref. [10] focuses on load balance performance and resource allocation with different user densities and number of clusters, by applying the control-data separation architecture (CDSA) model with the use of clustering methods where the resulting SINR improvement reaches 5 dB i.e., from -15 dB to -10 dB. In addition, the throughput value before using

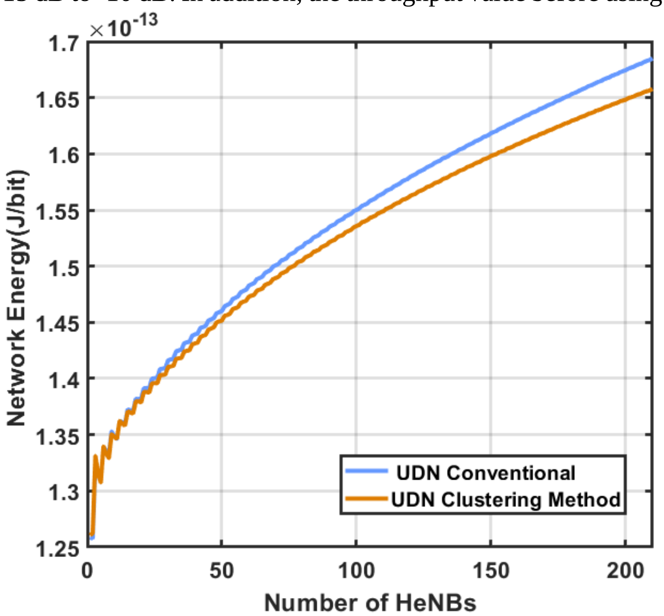

Figure 11. The simulation result of network energy

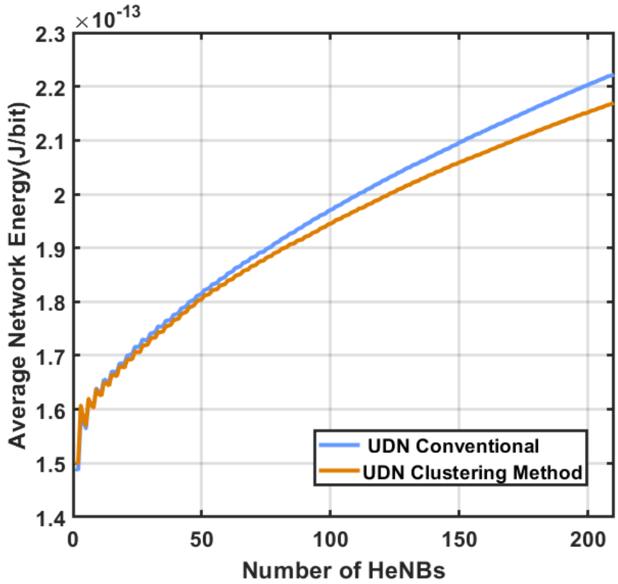

Figure 12. The simulation result of average network energy

the clustering is $2.2x10^{8}$ kbps and when using their clustering method reaches $6.9x10^{8}$ kbps. However, when the cluster size increases, the performance of load balancing becomes weaker than resource allocation.

Ref. [13] implemented a dynamic user clustering method based on spectral clustering. CoMP is presented to maximize system spectral efficiency (SE) and throughput on edge users only. By using their method, the SE and throughput results increase in which the quality of system for clustering method increase 16.91% and 5.37% for SE and throughput, respectively. It means that the obtained throughput has high value than the other algorithm, even with relatively lower

TABLE II. COMPARISON TO THE PREVIOUS RESEARCH RESULTS

Ref.	Method	Result
[2]	Clustering method by setting the clustering based on the distance between BSs	Clustering method is increasing the Central Processing Unit (CPU) calculation time with the value 0.028693 s and the proposed method reached sum rate 82 bps/Hz
[10]	Clustering method based on load balance and resource allocation uses CDSA model	The Cluster Method improved the SINR value by 5 dB and throughput increased by 4.67%
[13]	Practical dynamic clustering using spectral clustering in UDN	The Quality of system for clustering method increased 16.91% and 5.37% and the throughput obtained high value than the other algorithm, even with relatively lower complexity.
[18]	Distributed User-centric Clustering and choose base station mode	Network size increases linearly with the complexity by using clustering method and the performance loss value no more than 5.75%
[17]	Clustering Method based on KNN	Uses clustering method, it achieved good tradeoff between the gain and highest rate gain per unit cooperation resource consumption than the k-means algorithm

complexity. Meanwhile, in our current work, it focuses on mitigating interference that occurs due to femtocells that are densely deployed in macrocells. In order to overcome the co-tier interferences, a distance-based clustering method is proposed in our paper, where the distance among HeNBs who use the same frequency will be wider. From the simulation results of the obtained SINR value for the system with the proposed method, when the number of HeNBs reaches 210 users, the SINR value increases 0.44 dB i.e., from 25.1 dB to 25.54 dB and throughput also increases by 1.67% i.e., from 83.5 Mbps to 84.9 Mbps. Other considered performance parameters also confirm better values. Furthermore, our paper had analyzed the transmission to FUE with the scenario in multicellular network. The evaluation of clustering method as the interference management technique used in this paper based on the simulation. Our proposal is novel on the evaluation under multicell scenario.

IV. CONCLUSION

UDN is a technique that can meet the increasing demands for traffics on cellular networks. Small cells are spread and compacted with the use of increased frequency reuse with the aim of improving network performance and aiming to reduce the physical distance between transmitters and receivers to improve system performance. However, UDN also causes interference due to the reuse of frequencies in cells that are adjacent to neighboring cells. This paper proposes the use of a clustering method to reduce the effects of co-tier interference faced by the presence of UDN in the conventional macrocell area by widening the distance among femtocells that are allocated the same frequency channel. It is purposed to minimize the occurrences of co-tier interferences. The simulation results show a comparison between the baseline system and the system with proposed clustering method. The performance parameters have been collected during the simulation namely SINR, throughput, spectral efficiency, BER, network energy consumption, and average network energy. The simulation results show the improvements of 0.44 dB i.e., from 25.1 dB to 25.54 dB for SINR and 1.67% i.e., from 83.5 Mbps to 84.9 Mbps for throughput, both evaluated when the number of femtocells is equal to 210. The decrease of BER value has been achieved from $7.98 \text{x} 10^{-17}$ for the baseline system to $2.65 \text{x} 10^{-18}$ for the system with proposed clustering scheme. The simulation results for other considered performance parameters i.e., spectral efficiency, network energy consumption, and average network energy have depicted a good improvement as well. It is consistent among other performance parameters and it confirms our intuition that by keeping the distance of co-channel femtocells away will ensure the reduction of interference effects. All performance parameters were evaluated for the number of femtocells equal to 210. However, we argue more improvement can be achieved by reducing the cross-tier interference effects. It is subject to our future study.

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