A Study on the Effect of Moving small cell in Heterogeneous Networks with Interference Cancellation

Inseok Kang, Sarang Han, Cheolwoo You
Department of Information and Communications Engineering
Myongji University, 116, Myongji-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, South Korea
kang060215@gmail.com, saranghan90@gmail.com, cwyou@mju.ac.kr

***Abstract*—** Wireless data traffic is growing exponentially with the spread of smartphones and tablet PCs. To meet the demand for such wireless data traffic, researches on next generation mobile communication networks are actively proceeding. In this paper, we have studied the effects that occur when small cells have mobility in heterogeneous networks (Het-Nets)with interference cancellation. Simulation was per-formed using conventional continuous interference cancel-lation techniques. It has been found that when a small cell with mobility (i.e. moving a small cell) is used in HetNets, the performance of user equipments at a location where there is severe intercell interference, such as cell edge, can be improved.

Keywords—5G, heterogeneous networks, MIMO, Successive interference cancellation(SIC)

I. Introduction

These days, as the use of smart devices such as smart phones and tablet PCs has increased, wireless data traffic is increasing exponentially. This trend is expected to accelerate with the realization of next generation 5G mobile communication technology. In particular, heterogeneous networks (HetNets) and massive MIMO using small cells are considered as technologies to satisfy massive machine type communication, which is one of the key to keep performance indicators of 5th generation mobile communication.

Among them, heterogeneous mobile communication techno-logy using small cells is an important technology and many studies are under way. HetNets technology can dramatically increase network capacity by using small cells in macro cells, but there is a problem that inter-cell interference occurs between small cells and macro cells [1,2]. In order to solve this phenomenon, it is need to cancel interference between several base stations and user equipment (UE) by using an interference cancellation scheme. Interference cancellation techniques include parallel interference cancellation (PIC) and successive interference cancellation (SIC).

In this paper, we have studied the effects that occur when small cells have mobility in heterogeneous networks (HetNets) with interference cancellation. Experimental results are also presented using existing interference cancellation techniques.

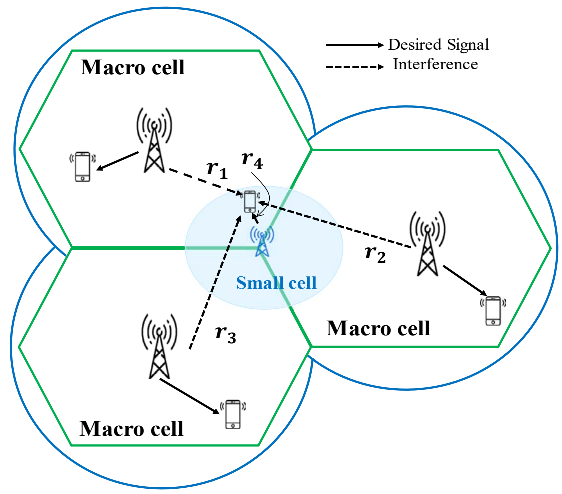

Fig. 1 Example of heterogeneous networks.

II. System Model

In this paper, SIC and moving small cell have been applied to improve cell edge performance in HetNet. Fig. 1 shows an example of HetNet considered in this paper, where the HetNet consists of three macro cells and one small cell. The UE can receive the desired signal from one of the three-macro cells having high transmission power and the small cell having low transmission power. In this case, the signals received from the remaining base stations will act as interference. Performance is evaluated based on one UE in a small cell.

It is assumed that base stations and the UE have one transmitting antenna and one receiving antenna, respectively. Also, the flat Rayleigh fading channel and an additive white Gaussian noise (AWGN) are assumed. In this case, the receive signal of the UE can be expressed as

$$\mathrm{y} = \boldsymbol{Hx} + \mathrm{n}, \tag{1}$$

where $\boldsymbol{x} = [x_1, \dots, x_N]^T$, x_i is the signal transmitted by the i-th base station and n is AWGN. In Eq. (1), $\boldsymbol{H} = [h_1, \dots, h_N]$ is a channel vector and h_i represents the channel between the i-th base station and the UE. In the simulation, the perfect channel state information is assumed. In addition, SIC method using QR decomposition algorithm [3] is used. In Fig.1, it is assumed that the base stations are all connected by the X2

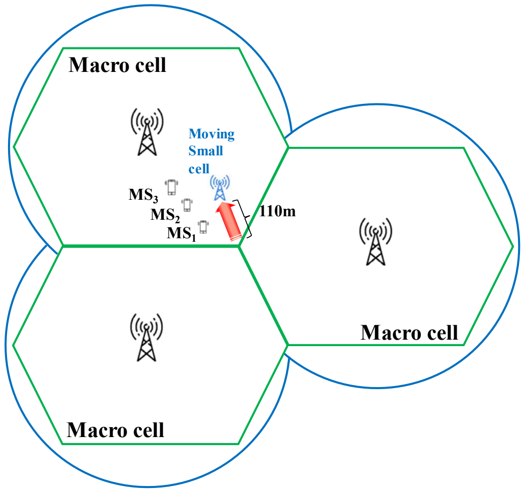

Fig. 2 Scenario for considering moving small cell.

interface [4]. In this paper, we assumed that the UE is located in a small cell radius and then the place of the UE moves to MS_1, MS_2, and MS_3. In Fig. 1, the distance between the base station and the UE is defined as r_1, r_2, r_3 and r_4. In addition, the received power of the UE is defined as $P_t / r_n{}^4$, where P_t is the transmit power each base station, and r_n is the distance between the UE from each base station.

In Fig. 2, the blue antenna represents a small moving cell and the red arrows indicate the moving path of the moving small. Since the MS_3 is located at the cell edge far from the small cell base station, the performance is not good even if the SIC technique is used. To solve this problem, it is possible to improve performance by moving the existing small cell. MS_1, MS_2 and MS_3 represent UEs located at 50m, 150m and 250m from the initial position of the small cell, respectively.

III. Simulation Result

In this paper, we evaluate the BER performance of two cases when the UE and the macro cell are connected and when the UE and the small cell are connected. The above-mentioned SIC technique and the BPSK modulation are used. The QR decomposition algorithm with relatively low complexity for zero-forcing(ZF)-SIC is used. The data frame each base station transmits consists of 1024 bits.

Fig.3 shows the BER performance of UE according to each position when using ZF-SIC method. The performance of MS_2 in Fig.3 shows that the performance of a UE connected to a small cell is similar to that of a macro cell. This fact allows us to know that the location of MS_2 is the edge of a small cell. In case of MS_3 which is out of the coverage of small cell, the performance when UE is connected to small cell is worse than that when it is connected to macro cell.

Fig. 4 shows the performance of each terminal when the small cell moves to the location given in Fig. 2, that is, when the small cell moves 110m from its initial position toward the cell boundary. In this figure, we can find that performance deterioration due to serious interference at the cell edge can be improved by movement of a small cell.

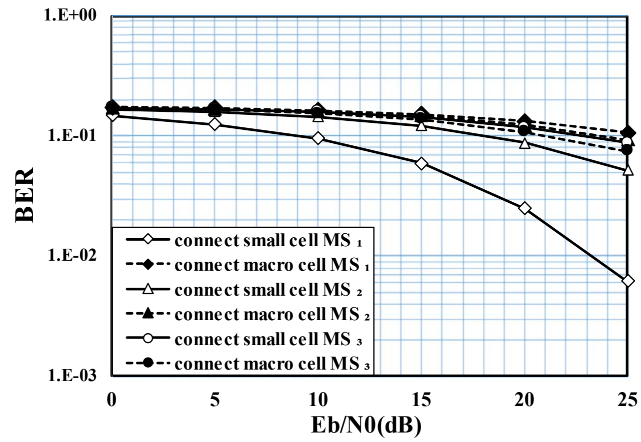

Fig. 3. UE performance using ZF-SIC according to each terminal location when the cell is in the first position.

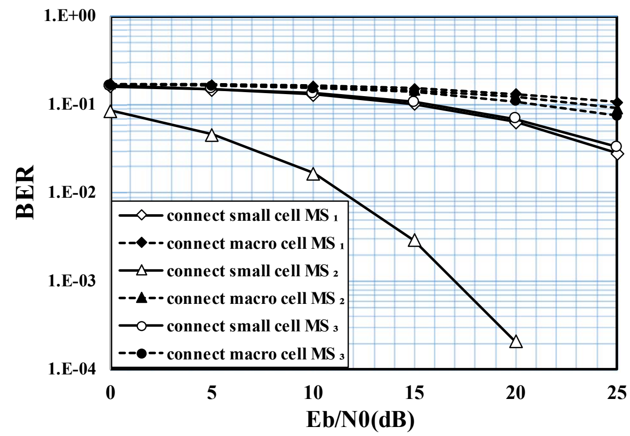

Fig. 4 UE performance using ZF-SIC according to each terminal location when the cell is moved.

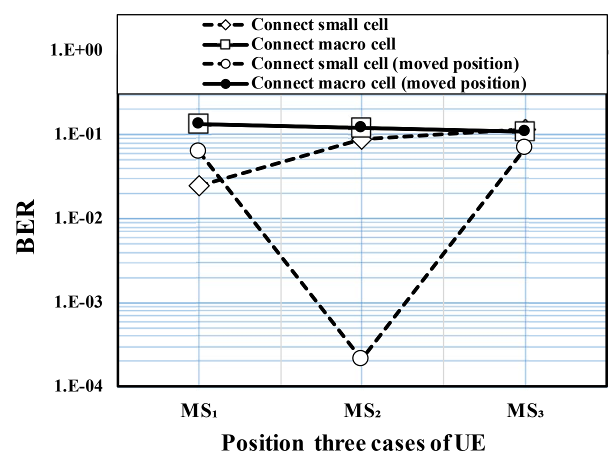

Fig. 5 Performance according to each UE position at $Eb/N0$ = 20dB before and after small cell movement when using ZF-SIC.

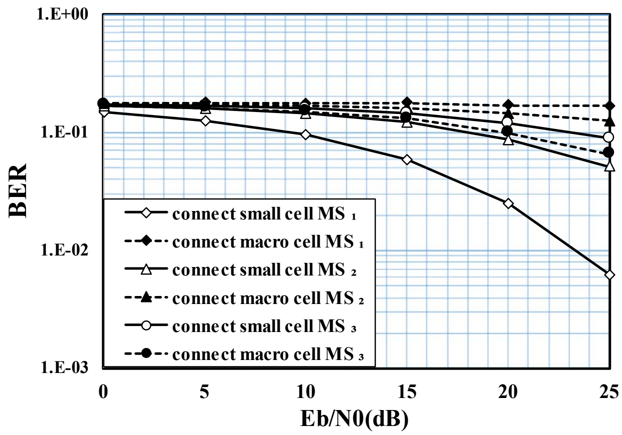

Fig. 6 UE performance using MMSE-SIC according to each terminal location when the cell is in the first position.

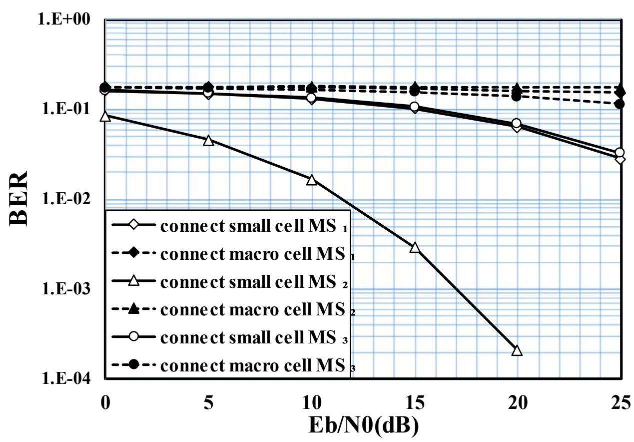

Fig.7 UE performance using MMSE-SIC according to each terminal location when the cell is moved.

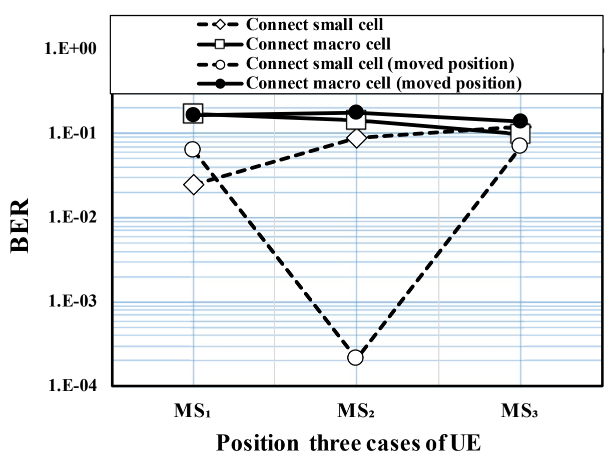

Fig. 8 Performance according to each UE position at $Eb/N0$ = 20dB before and after small cell movement when using MMSE-SIC.

Fig.5 shows the performance according to each UE position at $Eb/N0$ = 20dB. As you can see from this figure, the performance of the UE connected to the small cell in the MS_2 is remarkably improved even though the small cell moved 110 meters. From this fact, we can see that when a small cell has mobility, there is a possibility of improving the performance of the terminals in a position where serious interference exists.

In addition, we tested the performance of MMSE-SIC method. Fig. 6 and Fig. 7 show the BER performance using MMSE-SIC at each terminal location when the cell is in the first position and when the cell is moved, respectively. Finally, Fig. 8 shows the performance when using the MMSE SIC method at each UE location with $Eb/N0$ = 20dB as in Fig. 5.

As can be seen in Fig 5 and Fig. 8, when connected to initial small cell, as the distance increases, the performance deteriorates even though the SIC technique is used. In contrast, it can be seen that performance degradation at the cell edge can be improved by using a moving small cell.

IV. DISCUUSSION AND COMCLUSION

In this paper, we evaluate the performance of heterogeneous networks using SIC technique and also compared the performance when connected to the initial small cell and the performance connected to the moving small cell. As can be seen from the simulation results of this paper, performance deterioration can be effectively improved at the cell edge even if the small cell is moved only 110m. This distance can be moved in only a few seconds, and there is a strength that can be applied to a moving object.

In this study, the simulation is performed on the assumption that the small cell has already moved, but the future study will test the performance of small cells while they are actually moving. Also, consider moving small cells with different speeds to work together. Moving small cell technology is expected to become a key technology to solve the cell edge problem in the urban area upcoming next generation communication system.

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