M. S. Thesis

Resource Allocation in Heterogeneous Cellular Networks with Small Moving Cell

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Abstract

Due to the popularity of smart phones and wireless services, demand for high traffic has become a heavy burden in wireless cellular communication system. Deployment of small cells has been proposed as one of feasible solutions to support increasing traffic demand. However, it may need to resolve technical issues including the management of frequent handovers, cross-tier and inter-cell interference.

In this thesis, we consider the employment of small moving cells (SMCs) in a heterogeneous cellular network to improve transmission performance of the whole network. An SMC can provide services for a small number of users moving together with a mobility of up to a few hundred Km/hour. For ease of interference management and in consideration of SMC mobility, the macro cell shares the resource with SMCs in an orthogonal manner. To maximally utilize the resource, the macro cell adjusts the amount of resource for the SMCs in response to the change of SMC operational environments and utilizes the rest of the resource for itself. It can also allocate resource to each SMC in an orthogonal manner. Exploiting that the peak-to-average load ratio (PALR) is much larger than one, SMCs can maximally utilize the resource without inter-cell interference. Finally, the proposed resource allocation scheme is verified by computer simulation.

Keywords: Resource allocation, small moving cell, throughput

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1. Introduction

Wireless traffic load due to dramatic increase of smart phone users is expected to be 1000 times in the near future. To handle increasing traffic demand, advanced cellular networks consider the employment of small cells at hot spots [1]. Unlike the macro cell, simple installation and low expense make the deployment of small cells attractive. In fact, many researches have worked on the deployment of small cells to improve performance, such as throughput and spectral efficiency. However, small cells need to handle frequent handover, which may require for large processing complexity. Moreover, they make communications with the macro cell through a wired backhaul, which is not cheap for installation and maintenance.

Recently, deployment of SMCs has been proposed for advanced wireless communication systems [2]. SMC base stations (SBSs) can have a mobility of up to a few hundred Km/h and moves together with SMC users (SUEs). Thus, it may not require for handover processing of all SUEs even when an SMC is crossing over a cell boundary. However, the mobility may dynamically change operational environments including the generation of interference. Previous works for small fixed cells may not be applicable to SMCs. For example, resource can be allocated to SMCs in an orthogonal manner by means of frequency reuse [3]. However, the mobility of SMC may not maintain the orthogonal resource allocation and also cause cross-tier interference with the macro cell. The cross-tier interference problem may be alleviated by allocating a fixed amount of resource to SMCs, while making the macro cell utilizes the rest of the resource [4]. However, this technique may not be efficient because it does not consider the mobility and the variation of traffic load of SMCs. In general, the resource is prepared for a cell in consideration of peak traffic load. However, only a small part of resource is utilized in most of time since the PALR is larger than one [8].

In this thesis, we consider resource allocation in a heterogeneous cellular network with SMCs, where the macro cell allocates the resource to SMCs and also adjusts the size of resource for the operation of SMCs according to operation environments. Thus, we can maximize the resource for the macro cell, while maximizing the utilization of resource by SMCs, which may virtually reduce the PALR of SMCs.

The rest of the thesis is organized as follows. Section 2 describes the system model in consideration. Section 3 describes the proposed resource allocation scheme. Section 4 verifies the proposed scheme by computer simulation. Finally, Section 5 concludes the thesis.

2. System model

2.1 Heterogeneous cellular network with small moving cells

We consider a heterogeneous network where a number of SMCs are deployed in overlay with the macro cell, as illustrated in Fig. 1. Each SMC provides services to its users moving together, referred to SUEs, and makes communications with the macro base station (MBS) through a wireless backhaul.

If the macro cell and SMCs utilize the same resource, the mobility of SMC keeps operational environments changing dynamically. It is of great concern how efficiently to utilize the resource without suffering from interference. In this thesis, we assume that the macro cell and SMCs share the resource in an orthogonal manner [6], avoiding so-called cross-tier interference, as illustrated in Fig. 1. We assume that multi-user signal is transmitted using a resource block (RB) defined as the minimum resource unit in the 3GPP long term evolution (LTE) system [13]. The total amount of resource for SMCs, denoted by $\mathbf{B}_{SMC}$, comprises *n* frequency assignments (FAs) each of which comprises *m* sub-FAs, i.e., $\mathbf{B}_{SMC} = \{\mathbf{B}_{FA_1}, \mathbf{B}_{FA_2}, ..., \mathbf{B}_{FA_n}\}$, where $\mathbf{B}_{FA_k} = \{\mathbf{B}_{FA_k^1}, \mathbf{B}_{FA_k^2}, ..., \mathbf{B}_{FA_k^m}\}$ and $k = 1, 2, \cdots, n$.

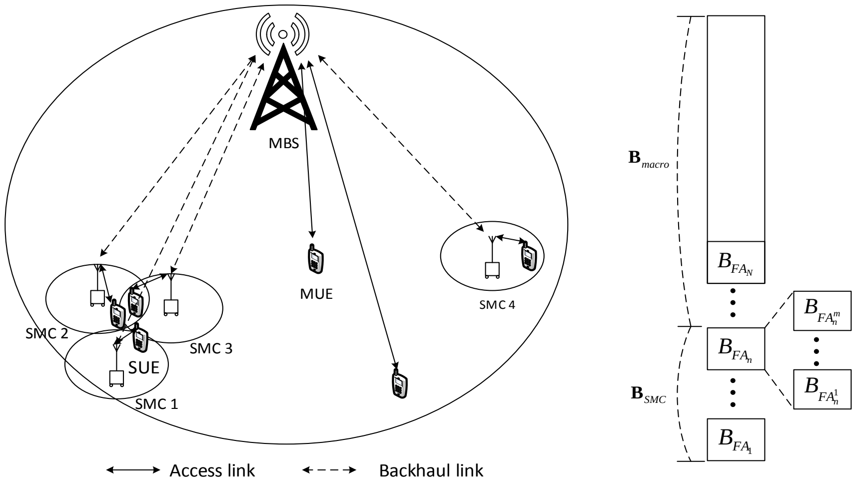


Fig. 1. A heterogeneous cellular network with SMCs

2.2 Signal-to-interference plus noise ratio (SINR)

We can assume that intra-cell interference can be ignored with the use of OFDMA transmission. Orthogonal resource allocation between the macro cell and SMCs makes signal transmission being free from cross-tier interference. Thus, the received signal of user i_k in SMC i through RB f can be represented as

$$\mathbf{y}_{i_k}^{(f)} = \sqrt{\alpha_{i_k}^{(f)}}\mathbf{h}_{i_k}^{(f)} s_{i_k} + \sum_{j=1\neq i}^{|\mathbf{S}|}\sum_{j_k=1}^{K_j}\sqrt{\alpha_{j_k}^{(f)}}\mathbf{h}_{j_k}^{(f)} s_{j_k} + \mathbf{z}_{i_k} \tag{1}$$

where $\alpha_{i_k}^{(f)}$ and $\alpha_{j_k}^{(f)}$ respectively denote the path loss from SMC i to user i_k and from adjacent SMC j to user j_k; $\mathbf{h}_{i_k}^{(f)}$ and $\mathbf{h}_{j_k}^{(f)}$ respectively denote channel from SMC i to user i_k and from SMC j to user j_k; s_{i_k} and s_{j_k} respectively denote the signal transmitted from SMC i to user i_k and from SMC j to user j_k; K_j and $|\mathbf{S}|$

respectively denote the total number of users in SMC j and the number of SMCs in a macro cell, and $\mathbf{z}_{i_k}$ denotes zero mean complex circular-symmetric additive white Gaussian noise (AWGN) of user i_k. Then the instantaneous SINR of user i_k can be represented as

$$\gamma_{i_k} = \frac{\alpha_{i_k}^{(f)} P \left|\mathbf{h}_{i_k}^{(f)}\right|^2}{\sum_{j=1\neq i}^{|\mathbf{S}|} \sum_{j_k=1}^{K_j} \alpha_{j_k}^{(f)} P \left|\mathbf{h}_{j_k}^{(f)}\right|^2 + \sigma_{i_k}^2} \tag{2}$$

where P is the transmit power of SMC. The throughput T_{i_k} of user i_k can be represented as

$$T_{i_k} = n_{i,RB} \cdot n_{RE} \cdot f_{MCS}\left(\gamma_{i_k}\right) \tag{3}$$

where $f_{MCS}(.)$ denotes a function that maps the SINR to the highest achievable transmission rate for a given modulation coding scheme set (MCS), $n_{i,RB}$ denotes the number of RBs used for user i_k and n_{RE} denotes the number of symbols in each RB.

2.3 FA Size

It may be desirable to use a proper FA size for efficient operation of SMC. Thus it may be desirable to determine the FA size taking into consideration of operation environments, including the number of SUEs, the type and amount of traffic load, and SNR. The required FA size can be represented as

$$B_{i,FA} = \sum_{j=1}^{K_i} \left(\eta_j \left\lceil \frac{b_j^{RT}}{n_{RE} \times f_{MCS}\left(\bar{\gamma}_i\right)} \right\rceil + (1-\eta_j) \left\lceil \frac{b_j^{NRT}}{n_{RE} \times f_{MCS}\left(\bar{\gamma}_i\right)} \right\rceil \right) \tag{4}$$

where b_j^{RT} and b_j^{NRT} represent the amount of real-time (RT) and non-real time (NRT) traffic load respectively, η_j is the ratio of RT and NRT traffic load, $\overline{\gamma}_i$ is the average SNR of SMC i, K_i is the number of SUEs in SMC i, and $\lceil x \rceil$ denotes the smallest integer larger than or equal to x. To accommodate the variation of FA size among SMCs, it may be desirable to determine the FA size in consideration of the average and the peak value of (4).

2.4 Traffic load

We assume that the traffic load is statistically generated in a form of a truncated Gaussian distribution, while yielding a given PALR. Here is used as the distribution of traffic load. It can be shown that the probability density function (PDF) of traffic load X can be represented as

$$f_X\left(x;\mu,\sigma,a,b\right)=\frac{\frac{1}{\sigma}\phi\left(\frac{x-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right)-\Phi\left(\frac{a-\mu}{\sigma}\right)} \quad ; \; a<x<b \tag{5}$$

where $\phi(x)=\frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}x^2\right)$ is the PDF of a normal random variable x and $\Phi(x)$ is the cumulative distribution function (CDF) of x. The average of traffic load can be represented as

$$E\left(X \mid a < X < b\right) = \mu + \frac{\phi\left(\frac{a-\mu}{\sigma}\right) - \phi\left(\frac{b-\mu}{\sigma}\right)}{\Phi\left(\frac{b-\mu}{\sigma}\right) - \Phi\left(\frac{a-\mu}{\sigma}\right)}\sigma . \tag{6}$$

Assuming a PALR range of 2 ~ 6, $a = 0$ and $b =$ peak traffic load, we can determine the value of the variance, σ . Fig. 2 depicts the PDF of traffic load when PALR is 2, 4 and 6 when b is 12. It can be seen that the traffic may have a high mean value when the PALR is low, and vice versa.

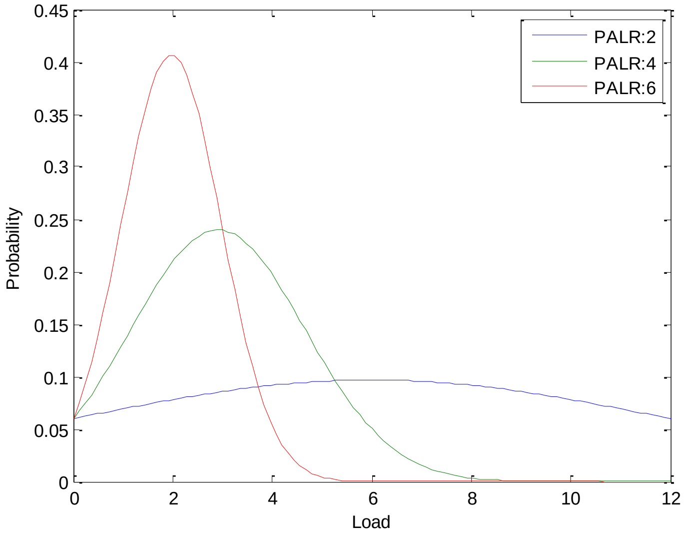
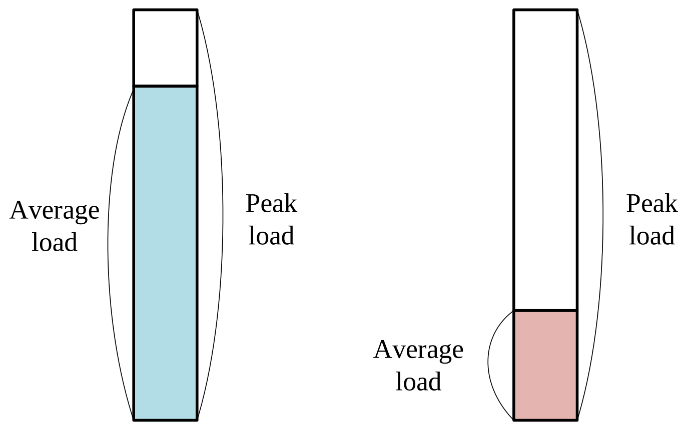


Fig. 2. PDF of traffic load for a PALR of 2, 4 and 6.

Fig. 3 illustrates an example of low and high PALR environments. When the PALR is low, the peak traffic load occurs in a form of uniform distribution. Since the PALR is normally much larger than one, it may be desirable to exploit opportunity for cooperation as the number of SMCs increases, which can be applied to the improvement of spectral efficiency and reduction of interference as well.



(a) Low PALR circumstance (b) High PALR circumstance

Fig. 3. An example of low and high PALR environments

3. Resource allocation for SMCs

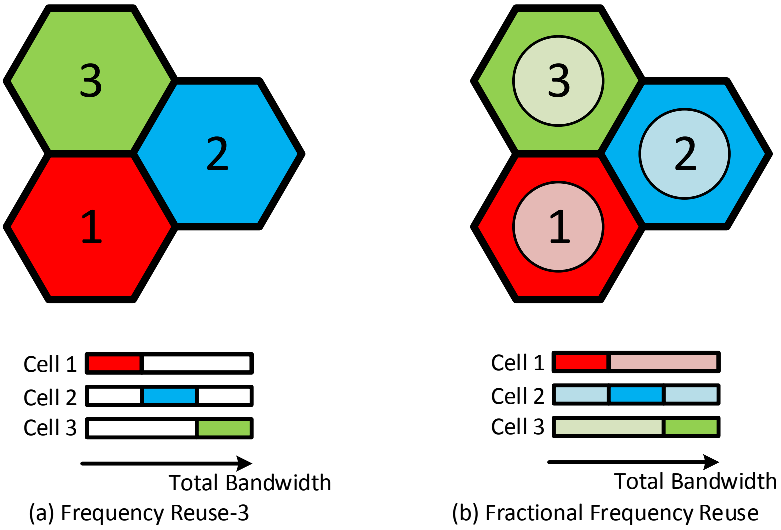
3.1 Previous works

Dense deployment of small cells in a small area may cause severe co-tier interference among small cells. To alleviate this interference problem, a number of works have been conducted especially in frequency domain.

Frequency reuse techniques are the most elementary and feasible technique to avoid co-tier interference [3]. By partitioning the whole resource into a number of parts, where the partitioning number is referred to frequency reuse factor (FRF), neighboring small cells can utilize the resource independently. A reuse-3 (i.e., FRF=3) scheme is illustrated in Fig. 4 (a), where each of neighboring cells can utilize one-third of whole resource. Since each cell experiences a PALR of much larger than one, it does not fully utilize the allocated FA in most of time, experiencing inefficient resource utilization. When applied to a HetNet with SMCs, where SMCs experience dynamical change of operation condition mainly due to the mobility, it may not provide desired performance as the case of fixed small cells.

The performance degradation with the use of FRF can be improved with the fractional frequency reuse (FFR). Two types of FFR techniques have been developed [4]. Fig. 4 (b) illustrates a FFR, where the area of cell is partitioned into two regions;

center region and edge region. Resource is orthogonally allocated to cells for operation in the edge region and resource unused in the edge region can be allocated for operation in the center region. Although the spectrum efficiency is higher than that of reuse-3, load of small cells is still not taken into account. Besides, when applied to a HetNet with SMCs, SMCs may keep changing the position due to the mobility. Therefore, the co-tier interference problem may still incur.



(a) Frequency Reuse-3 (b) Fractional Frequency Reuse

Fig. 4. Interference avoidance techniques in frequency domain

In a two-tier heterogeneous network, resource allocation between the macro cell and small cells can be categorized into three techniques; sharing resource allocation, orthogonal resource allocation and hybrid resource allocation, as illustrated in Fig. 5. The sharing resource allocation technique allows the macro cell and small cells to use the same resource, yielding severe cross-tier interference when macro-cell users

(MUEs) are near a small cell while using the same resource [5]. Conventional orthogonal resource allocation technique only allows the macro cell to allocate a fixed dedicated resource to small cells. An adaptive algorithm was proposed to adjust the resource allocated to small cells in consideration of only traffic load of the macro cell [7]. Hybrid resource allocation techniques, which combine the sharing and the orthogonal resource allocation technique, can improve spectral utilization while avoiding cross-tier interference [5] [10]. Small cells can only reuse a portion of the whole resource, while the macro cell can use the whole resource [10]. When MUEs are interfered by small cells, the MBS allocates MUEs dedicated resource to avoid interference. However, many MUEs may experience interference with small cells in hot spots when the dedicated resource is not sufficient. The ratio of resource sharing between the macro cell and small cells can be decided based on position of small cells [5]. Since small cells may experience different degrees of interference from the macro cell, small cells far from the MBS can reuse most part of the whole resource. However, hybrid resource allocation may not be applicable to a HetNet with SMCs. We consider orthogonal resource allocation which adjusts the size of resource for SMCs according to operation environments.

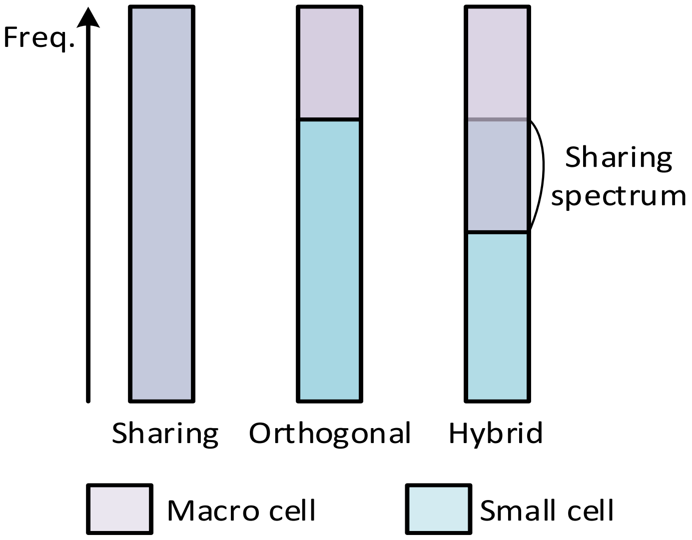


Fig. 5. Resource allocation between macro cell and small cell

3.2 Proposed resource allocation

We consider the resource allocation for SMCs by the macro cell. The macro cell allocates resource to SMCs in an orthogonal manner to avoid co-tier interference, in consideration of the traffic load and operational environments of SMCs. By exploiting that the PALR is larger than one, the MBS can minimally allocate resource to SMCs in addition to adjustment of FA size and number of FAs, achieving high resource utilization.

An SBS can initiate its operation after sending resource request information to the MBS through a wireless backhaul, where the resource request information includes the set of neighboring SMCs, traffic load, desired resource and average SNR. The information is summarized in Table 1.

We assume that SBS i can list a set of SMCs generating interference to SMC i. Let $\mathbf{S}_i$ be a set of SMCs nearby SMC i, defined by

$$\mathbf{S}_i = \left\{ S_j \mid P_{j,i} > P_0, \ \forall S_j \in \mathbf{S} \right\} \tag{7}$$

where $P_{j,i}$ denotes the received signal power from SBS j to SBS i and P_0 is a threshold to be determined. SMCs can figure out the cell identification (ID) of their neighboring SMCs. After the SBS allocates resource to its users, SUEs can also detect the neighboring SBS to improve the accuracy of detection. Desired resource can be selected by means of energy detection conducted by SBS and its SUEs.

Table 1. Transmitted information from SMCs to the macro cell

Component	**Information**
Set of adjacent SMCs	Cell ID of adjacent SMCs
Load information	Traffic load of SUEs to decide the quantity of allocated resource
Desired resource	Current unused resource by adjacent SMCs
Average SNR	Average SNR to decide FA size

3.2.1 Resource allocation based on the mean FA size

Consider the case when the MBS allocates resource to SMCs based on the mean FA size in a unit of FA. After receiving a load request and related information from SMC i, the MBS removes FAs allocated to neighboring SMCs of SMC i from the resource for SMCs and selects FAs in the remaining FAs, avoiding co-tier interference.

If the size of the remaining FA is larger than the desired size $N_{i,FA}$, the MBS can easily allocate desired resource to SMC i. If not, SMC i should consider the transmission of RT traffic. If the allocated FA size is larger than the FA size required for the transmission of RT traffic, SMC i transmits the RT traffic and a part of NRT traffic through the remaining FAs after the RT traffic transmission. If not, SMC i may request the MBS an additional resource for SMCs. If the MBS has resource available for SMCs, it additionally allocates SMC i resource to support the transmission of RT traffic temporarily. However, if not, the MBS informs SMC i that no additional resource is available, and SMC i stores its traffic in its buffer and waits for the next resource allocation. Fig. 6 summarizes the flow of the resource allocation algorithm.

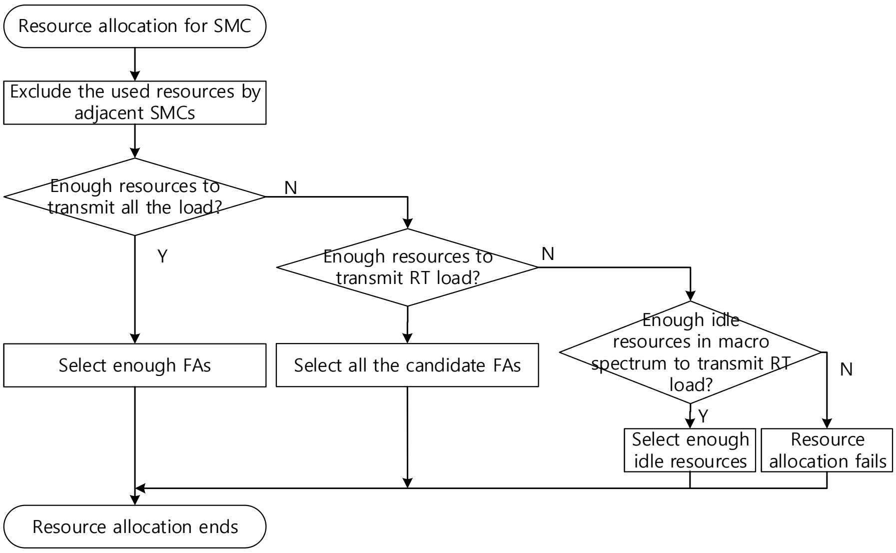


Fig. 6. Flow chart of resource allocation based the on mean FA size

3.2.2 Resource allocation based on the peak FA size

When MBS allocates resource to SMCs based on the peak FA size which can allow the transmission of peak traffic. Since the PALR of an SMC is generally larger than 1, SMCs does not use the whole FA unless its traffic reaches peak value. The proposed scheme allocates a part of an FA (i.e., sub-FAs) to an SMC and the rest of the FA to other SMCs.

Similar to the above resource allocation algorithm based on mean FA size, MBS firstly finds out the unused sub-FAs by adjacent SMCs of SMC i. From these unused resource, allocated FA is selected as the FA who has more than N_i sub-FAs and the lowest index in order to allocate resource compactly. To select N_i sub-FAs from the allocated FA, MBS intersects unused sub-FAs in the allocated FA and desired resource of SMC i. The intersection is selected. If the size of intersection is less than N_i, the insufficient sub-FAs are selected in the other unused sub-FAs in the allocated FA. But if there is none FA that has more than N_i sub-FAs, MBS selects one FA that can satisfy the transmission of RT load and has the most unused sub-FAs to maximize the transmission of NRT load. If RT load even cannot be satisfied, MBS selects some idle resource in macro spectrum to transmit RT load. However, resource allocation fails when there is not enough idle resource in macro spectrum. With the above resource allocation, one FA can be shared by several SMCs.

3.3 Resource adjustment for SMCs

To utilize spectrum efficiently, the macro cell needs to adjust the number of FAs allocated to SMCs. Since macro cell can only use the remaining spectrum, more FAs are allocated for SMC spectrum, less spectrum macro cell can use. In addition, due to mobility of SMCs, operational environments of SMCs constantly changes, which leads that leads the change of the necessary resource for SMCs. For example, when SMCs are far from each other, one FA is enough since resource can be reused without co-tier interference. On the contrary, when SMCs gather together, more FAs are needed since more orthogonal resource should be allocated to adjacent SMCs. Therefore, MBS can decide the number of FAs based on needed resource of SMCs. The total number of allocated FAs to SMCs can be represented as

$$N = \left| \bigcup_{i \in \mathbf{s}} \mathbf{r}_i^* \right| \tag{9}$$

where $\mathbf{r}_i^*$ denotes the determined allocated FAs to SMC i. After determining the SMC spectrum, MBS can exploit the remaining frequency resource to transmit load of MUEs.

By dynamically adapting SMC spectrum, only necessary resource is allocated as SMC spectrum in order to improve the spectrum efficiency than the conventional orthogonal resource allocation scheme with the constant dedicated spectrum for small cells. Flow of the whole resource allocation procedure, including operation of MBS and SBS, is illustrated in Fig. 7.

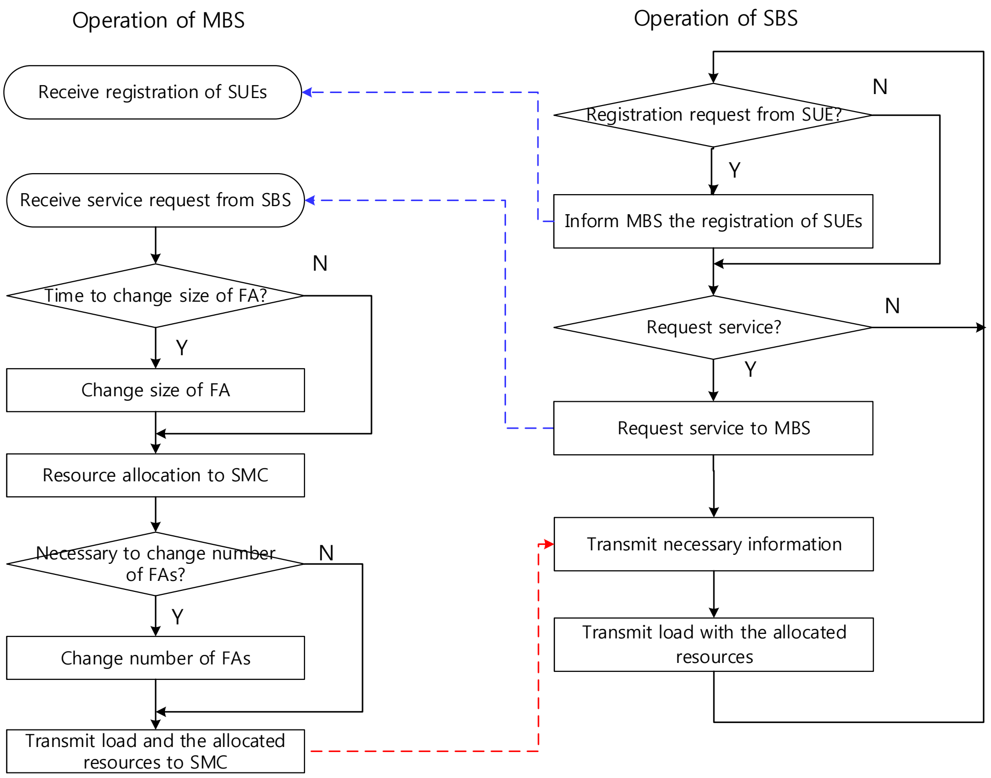


Fig. 7. Flow chart for operation of MBS and SBS

3.4 Overhead

Since the above resource allocation is conducted by the MBS, each SMC should exchange necessary information with the MBS, which may require for heavy signaling overhead. To compute the overhead, exchanged information between SMC and MBS and the size of each information are summarized in Table 5 and Table 6. Here we assume that the cell ID has the same size as that in LTE [15] and the average SNR level can also be expressed as the channel quality indicator (CQI) index in LTE [13], N_{FA}

and N_{sub-FA} denote the number of FAs and the number of sub-FAs in SMC spectrum, and N_{FA}^{sub-FA} denotes the number of sub-FA in one FA. In other works, N_{FA}^{sub-FA} equals one when resource is allocated based on the mean FA size and equals the number of RBs in one FA when resource is allocated based on the peak FA size. It can be seen from Table 5 that number of adjacent SMCs most influents the overhead.

Table 2. Signaling overhead from SBS to MBS

Component	Amount	Size (bits)
Set of adjacent SMCs	cell ID: 8bits, Num. of adjacent SMCs: *N*	$\log_2 N + 8N$
Load	Load < 2^5	5
Desired resource	Whether desired or not	$N_{sub-FA} = N_{FA} \times N_{FA}^{sub-FA}$
Average SNR level	Average SNR of operational environments	4

Table 3. Signaling overhead from MBS to SBS

Component	Amount	Size (bits)
Allocated resource	Whether allocated or not	$N_{sub-FA} = N_{FA} \times N_{FA}^{sub-FA}$
Number of FAs	Num. of FAs < 2^4	4
FA size	Size <= 16RB < 2^4	4

4. Performance evaluation

In this Section, the performance of proposed scheme is verified by computer simulation considering a heterogeneous cellular network with SMCs. We assume that the number of SUEs served by an SMC ranges from 0 to 4 and each MUE is positioned randomly and each MUE is allocated one RB. Traffic load model of SMC is simulated as truncated Gaussian distribution. Bandwidth of SMC spectrum has a limitation that less than 50 RBs, which is equivalent to almost 10MHz. The main simulation parameters are summarized in Table 4. In addition, FA size is decided based on the parameters of traffic load as numerated in Table 5. FA size is updated every 40 milliseconds according to the broadcasting of system information in LTE [14]. MCS is summarized in Table 6. To compare with proposed scheme, we introduce frequency reuse-3 technique (FFR-3). In FFR-3, number of FAs is fixed as 3 and FA size is selected as the peak value to guarantee load transmission. Resource is allocated in the unit of FA, which means that SMCs cannot share one FA.

Table 4. Main simulation parameters

Parameter	Value
Radius of macro cell/SMC	150m/30m
Radius of set of adjacent SMCs	Max 50 m
Channel	Rayleigh fading channel (0,1)
Average SNR of SMC	20dB
Number of SUEs	0 ~ 4
Total bandwidth	20MHz (100RB)
Max SMC spectrum	50 RBs
FA size	Max 20 RBs
PALR of SMC	2, 4, 6
Traffic load model	Truncated Gaussian distribution
Ratio of RT load	50%
Mobility	3km/h

Table 5. Components on deciding FA size

	RT traffic load	NRT traffic load
Peak load [bits/ms]	64 (Video streaming)	4000 (FTP 0.5Mbits/sec) [15]
Avg. load [bits/ms]	64	680 (FTP source rate 680 kbps) [16]

Table 6. Modulation and coding set table

Index	SINR(dB)	Modulation	Code rate	Bit rate
1	-5.57<SINR< -4.08	QPSK	1/12	1/6
2	-4.08<SINR< -0.96	QPSK	1/8	1/4
3	-0.96<SINR< 2.07	QPSK	1/4	1/2
4	2.07<SINR< 5.29	QPSK	1/2	1
5	5.29<SINR< 7.62	QPSK	3/4	3/2
6	7.62<SINR< 12.63	QPSK	1/2	2
7	12.63<SINR< 16.27	16QAM	1/2	3
8	16.27<SINR< 17.25	64QAM	2/3	4
9	17.25<SINR< 19.0	64QAM	3/4	9/2
10	SINR>19	64QAM	5/6	5

Fig. 8 depicts the total throughput and number of allocated FAs to SMCs. From Fig. 8(a), we can know that our proposed resource allocation scheme can obtain higher throughput than that of FFR-3. It results from the fact that our proposed resource allocation scheme utilizes less FAs than FFR3. Due to PALR of SMC, the whole FA cannot be utilized all the time in FFR-3. However, our proposed scheme allocates less FAs to SMCs because FA size is decided as mean size or one FA is divided into several sub-FAs which is allocated to SMCs. Therefore, more macro spectrum is available to achieve more throughput. Besides, when number of SMCs is larger than 3, FFR-3 cannot allocate orthogonal FAs to adjacent SMCs so inter-cell interference among SMCs occurs, which results the decline of throughput. Moreover, there are cross points with different FA size. It results from the fact that when number of adjacent SMCs is small, there are not many enough SMCs to share one FA with peak size. But with mean FA size, fewer resource is allocated to SMCs; on the contrary, when the number of SMCs increases, FA with peak size can be shared by more SMCs and resource is allocated in unit of sub-FA, i.e. RB, which allows the resource to be allocated more compactly. According to the above simulation result, MBS can adapt the FA size according to the number of SMCs.

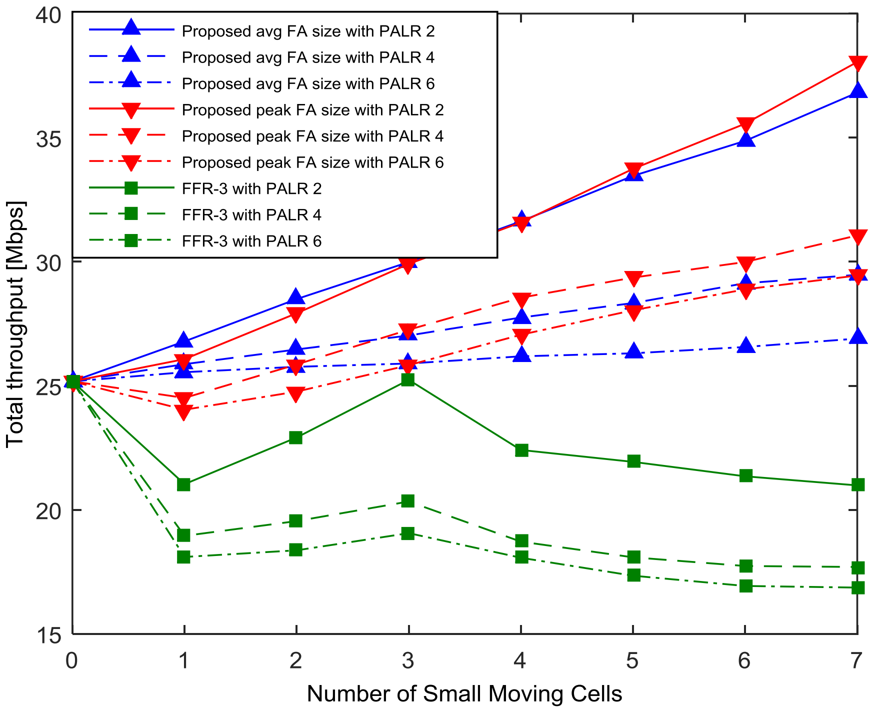


Fig. 8. Total throughput of the macro cell and SMCs

Fig. 9 and 10 depict the number of allocated FAs with the peak size and spectral efficiency of SMCs respectively. As mentioned above, because one FA can be shared by several SMCs and number of FA can be adapted to load and environments of SMCs, average number of allocated FA is less than 3, as showed in Fig. 9. So the spectral efficiency of our proposed resource allocation scheme is higher than that of FFR-3, which is illustrated in Fig. 10. Besides, we can find that there are cross points in Fig. 10 as well, whose reason is also that when there are several SMCs, fewer resource is allocated when mean FA size is applied. But with increase of SMCs, peak FA size can achieve higher spectral efficiency since one FA can be shared by many SMCs and spectrum is utilized more compactly.

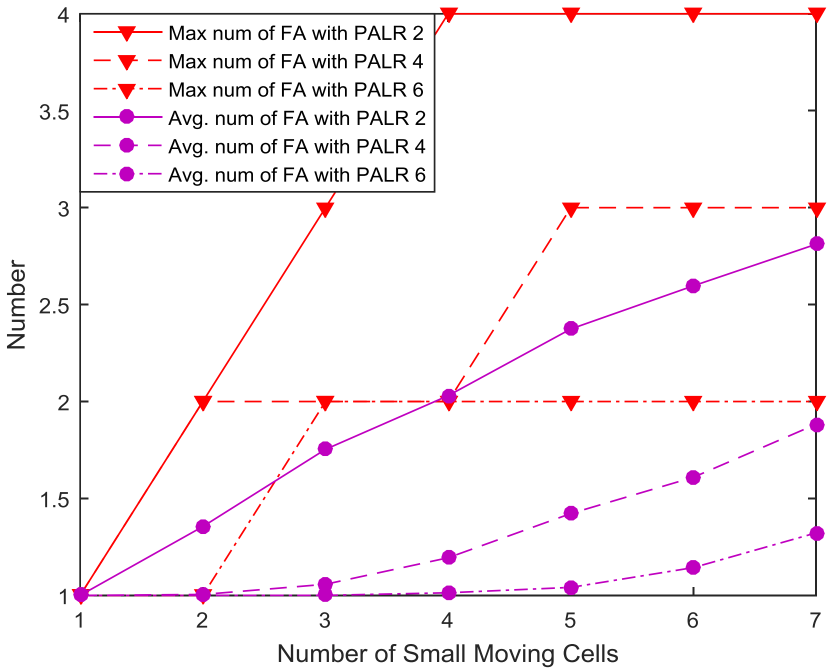


Fig. 9. Number of allocated FAs with the peak size

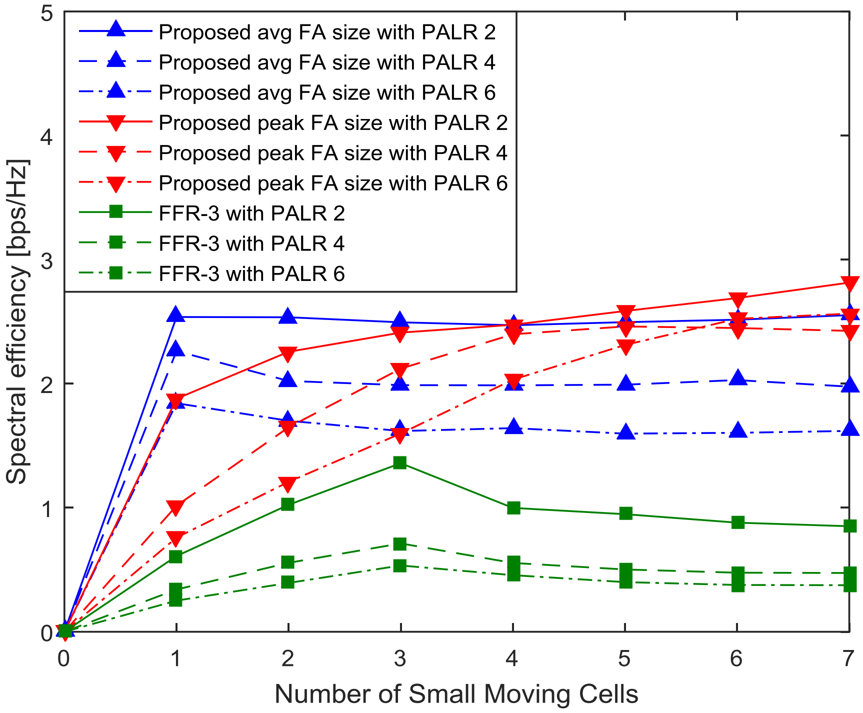


Fig. 10. Spectral efficiency of SMCs

Fig. 11 depicts the PALR of SMCs with different PALRs with peak FA size. It can be seen that PALR decreases with the number of SMCs by applying our proposed resource allocation algorithm. Since one FA can be shared by several SMCs, spectrum is utilized more compactly and efficiently. And with increase of number of SMCs, one FA can be shared by more SMCs so that PALR is virtually reduced significantly.

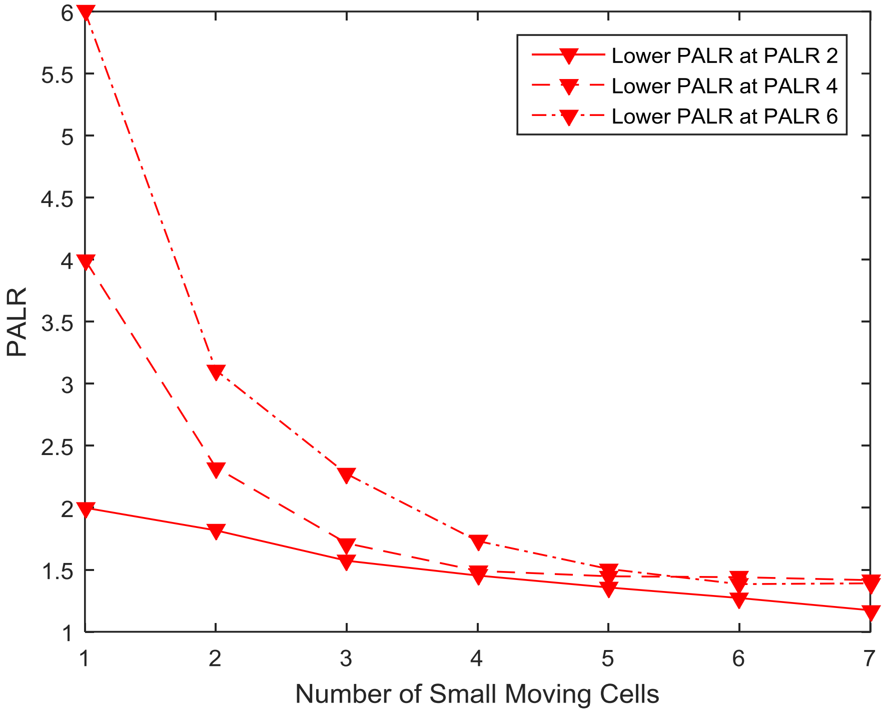


Fig. 11. PALR of SMCs with peak FA size

5. Conclusions

This paper presents a new orthogonal resource allocation scheme in a centralized manner in a heterogeneous networks with SMCs. To avoid co-tier interference among SMCs, orthogonal resource is allocated to adjacent SMCs. By exploiting PALR of SMC, only necessary resource is allocated according to load of SMC, which results that spectrum is utilized compactly. Resource allocation based on different types of traffic load are also taken into consideration to satisfy the quality of service of SUEs. In addition, resource adjustment for SMC spectrum, e.g. FA size and number of FA, is proposed to allocate necessary spectrum in consideration of operational environments and load of SMCs. Proposed resource allocation scheme can improve high total throughput and spectral efficiency, compared to FFR-3 technique. And PALR is virtually reduced. Simulation results verifies all the above advantages.

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1.초록

스마트 폰의 급증을 의해 무선 서비스 부하가 매크로 셀에게 이미 큰 부담이 됐다. 소형 셀을 이용해 매크로 셀의 부담을 졸릴 수 있지만 모바일 사용자의 잦은 핸드오버와 매크로 셀 경계 지역에서의 이기종간의 간섭에 의한 많은 문제를 아직 해결하지 못하고 있다.

본 논문에서는 상기 문제를 해결하기 위해, 이기종망 시스템에 새로운 소형 이동 셀 (SMC) 고려한다. 여기서, SMC 는 이동성을 가지고 적은 수의 사용자를 서비스 할 수 있는 소형 셀이다. SMC 가 매크로 셀과 우선 백홀을 통해 정보교환을 할 수 있다. SMC 의 이동성을 고려해 매크로 셀과 SMC 는 이기종 셀간의 간섭을 제어하기 위해 직교하게 자원을 사용한다. 또한, 최대한 자원을 이용하기 위해 매크로 셀이 SMC 의 주변 환경과 부하를 고려해 SMC 에게 직교 자원 할당한다. 그리고 소형셀의 평균 부하 대비 최대 부하 (PALR)이 1 부다 크기 때문에 할당 받은 전부 대역을 계속 사용할 수 없다. 그래서 본 논문에서는 SMC 의 부하를 고려해 부하만큼만 할당함으로써 희귀한 주파수 대역을 더 콤팩트하게 사용할 수 있게 할당한다.

主要語 : 자원 할당, SMC(small moving cell), 스룻풋

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