Master's Thesis
석사 학위논문

Scheduling for carrier aggregation with LTE-A

Yeung uk Song(송 영 욱 宋 永 旭)

Department of Information and communication engineering

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by

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Department of information and communication engineering

DGIST

A thesis submitted to the faculty of DGIST in partial fulfillment of the requirements for the degree of Master of Science in the Department of information and communication engineering. The study was conducted in accordance with Code of Research Ethics[1]

1. 8. 2016

Approved by

Professor Jihwan Choi (Signature)
(Advisor)

Professor Jonghyun Kim (Signature)
(Co-Advisor)

[1] Declaration of Ethical Conduct in Research: I, as a graduate student of DGIST, hereby declare that I have not committed any acts that may damage the credibility of my research. These include, but are not limited to: falsification, thesis written by someone else, distortion of research findings or plagiarism. I affirm that my thesis contains honest conclusions based on my own careful research under the guidance of my thesis advisor.

Scheduling for carrier aggregation with LTE-A

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Accepted in partial fulfillment of the requirements for the degree of Master of Science.

1. 8. 2016

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ABSTRACT

The 4th generation mobile communication systems, LTE-A, have explosive subscriber increase and the demand of supporting backward capability for LTE users. Therefore, LTE-A systems need more careful allocation of communication resources to provide enough data rate from BS for subscriber devices. This thesis deals with scheduling for efficient resource distribution according to whether the subscriber can use carrier aggregation.

We propose the scheduling with a max-min optimization tool to improve the performance of subscribers as distinct cell coverage areas are served with different frequency bands. The simulation results show performance improvement of the subscribers both for LTE and LTE-A.

Keywords: Carrier aggregation, resource allocation scheme, Long term evolution-advanced, optimization

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I . INTRODUCTION

The recently mobile communication environment was confronted with some issue like communication medium starvation. Mobile communication environment was changed multimedia service from mainly used voice and text service by appearance of smartphone and tablet PC. According to CISCO's report [1], global mobile traffic grew 69 percent in 2014 that was recorded 2.5 exabytes per month, this predict it is increasing 2.5-time by 2016. This is demanded wide bandwidth for supporting of faster data transition speed, but licensed band of astronomical rental fee limit infinite extension of the bandwidth. For solving the problem, 3GPP propose the Carrier Aggregation (CA) technology in process of evolution for LTE-A. LTE-A with CA systems solve support of wide bandwidth to enable aggregate different frequency band, but this remains the medium resource allocation problems by coexistence of LTE and LTE-A. We are focus on resource allocation scheme in terms of LTE-A with CA communication systems.

LTE-A mobile communication systems have some characteristic compare to previous mobile communication, 2nd Generation (2G) or 3rd Generation (3G) mobile communication systems, one characteristic is this system enable to support LTE clients, so called 'backward capability' [2]. The other characteristic is unbalanced medium resource caused by differential coverage. The LTE-A communication environment makes more complexity when Base-Station (BS) allocates communication resource with considered frequency coverage and user types for two characteristic. For example, BS serves some client, the BS allocates client to transmit data, some client consists clients are whether or not exist transmit data or whether LTE and LTE-A client. If both LTE client and LTE-A client need resource,

BS is concerned from throughput and fair of clients. How many resource, who allocate problem is essentially required many condition. Previous generation of 4th Generation (4G) mobile communication resource allocation scheme or scheduling was adopted Proportional Fair algorithm (PF). This algorithm decides allocation list in term of client throughput and total client throughput in one channel, but it is not efficiently as the LTE-A mobile communication systems characteristic for CA capability that demands considering the dependency in multiple carrier. Recently studies proposed supplemented algorithm. Some proposal improved resource utility of the PF algorithm with dependency consideration of each other carriers [3][4], the others make scheme adopted optimization tool for fairness increase [5][6].
This proposed scheduler objective focused on lead throughput or fairness of improve LTE-A user's in viewpoint of BSs.
However, User Equipment (UEs) have relatively loads more than BSs since the UEs have limited battery capacity, antenna transmission power and chip manufacturer cost. For example, communication chip supports the various bandwidth and wide frequency band for utilized the CA. this take increase manufacturer cost as it is difficult implement for supported the wide bandwidth. In this paper, we are proposed the scheduling to consider the viewpoint of manufacturers company such as production expense of antenna chip. When this scheduling adopted, the mobile communication systems is scheduled to regard the weak UEs for non-available total function.

The rest of the paper is organized as follows. Section II provide the basic concept of 4G mobile communication and related works with scheduling. The proposed scheduling formulation is proposed in section II. Section IV provide the performance evaluation of the proposed scheduling via simulation by using matlab, finally, section V concludes this paper.

II. Related work

In this section, we look into background of LTE-A system such as communication frame structure, CA specification and related works of resource scheduling.

2.1. LTE-A

LTE communication is represented number of release. First LTE include version that called release 8 and release 9 by 3rd Generation Project Partnership (3GPP). This adopted OFDM technology that become rate up to 300 Mbps under downlink [7]. LTE-A correspond over the release 10. That version achieve peak data rate is 1 Gbps in downlink with adopt CA and extended MIMO technology. As the release 10, LTE-A is match the IMT-Advance target, it is designated standard of 4G. More detail the release, release 8 is start version of LTE with adopted OFDMA in downlink and release 9 improvement service along with new developments to the network architecture and new service, which is LTE femtocells. Release 10, started LTE-A support CA combination of up to five carriers to enable up to 100MHz and MIMO antenna configurations up to 8*8 downlink. Recently, 3GPP start the release 13 which is called LTE-A pro improve entire performance for establish of 5G standard.

2.2. Data frame structure

LTE-A mobile communication modulation method is used Orthogonal Frequency Dynamic Modulation (OFDM) is consisted time domain and frequency domain so that have resource unit for complex one time unit and one frequency band unit.

In the time domain, this one frame structure have long 10ms as the LTE-A component specification. This frame is divided 10 sub-frame occupy each long 1ms like figure 1. 1 sub-frame is consisted 2slot that is determined Frequency Division Duplex (FDD) or Time Division Duplex (TDD) whether the slot differentiate DL and UL. 1 slot have 7 OFDM symbol that have 2 parts is cyclic prefix (CP) part and data part. Cyclic prefix parts support defended inter symbol interference. If CP is generally CP, CP time have 4.7us but first CP 5.1us and 66.7us data time. Meanwhile extended CP, All CP time become 16.7us and data time same for generally CP case. In the frequency domain, one channel has 180 kHz. This channel is consisted 12 sub-carriers that bandwidth is 15 kHz like figure 2 [8]. Minimum resource unit, Resource Block (RB), makes one carrier and one slot size. This is become minimum resource unit and allocated minimum unit of one user. For example, if users access the BS for association, BS should allocate resource at least one RB or more. One RB does not allocate over one user. In the embodiment, Data rate, 75Mbps, is maximum rate of LTE standard with 10 MHz bandwidth. If only one user had transmission data, the user allocates all RB, 50, and it became the maximum rate.

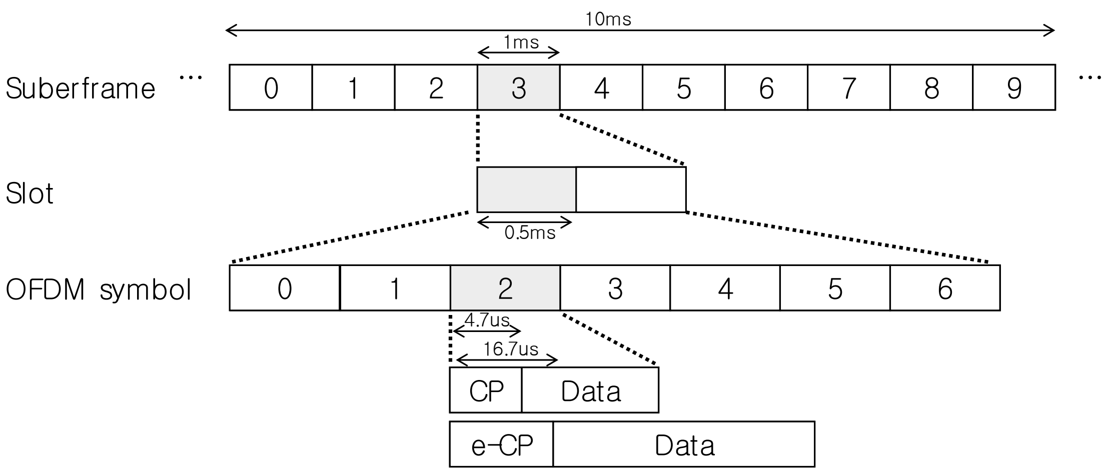

Figure 1. LTE-A frame structure

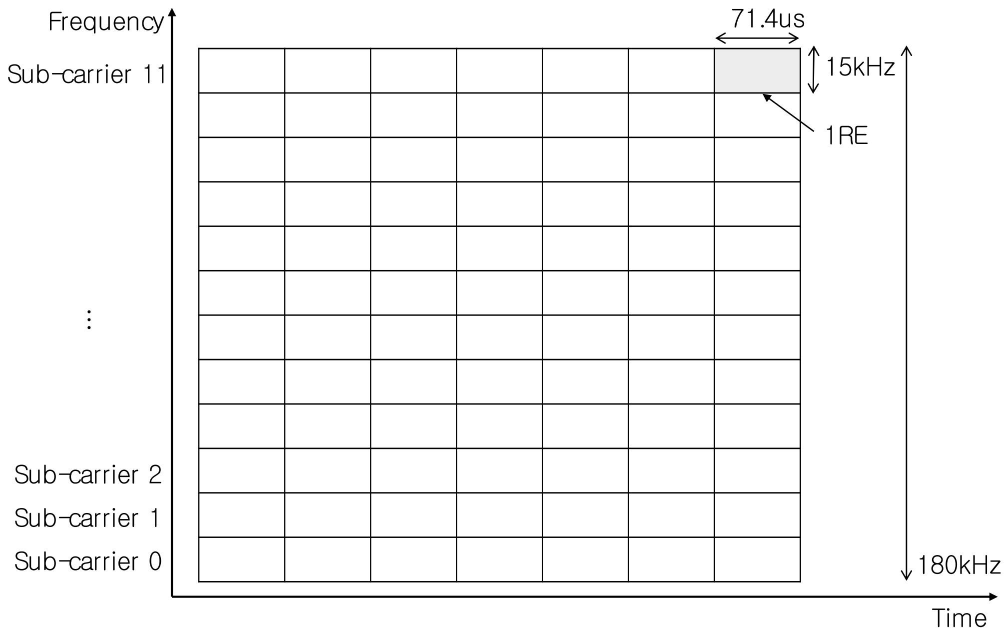

Figure 2. Resource block structure

Data rate of standard is based on what is value of spectral efficiency. Spectral efficiency, spectrum efficiency or bandwidth efficiency represent information rate that is a measure of how efficiently a limited frequency spectrum. This refer to bit number with consisted 1sec and 1 Hz. The unit is bit/s/Hz or bps/Hz as bit/s is replaced rate unit, bps. LTE spectral efficiency is 15 bps/Hz and LTE-A spectral efficiency is 30 bps/Hz at peak value. In detail, this data has some different condition but we assume the same condition as this consideration makes complex.

Since this value is ideal value of standards, we need calculate the value with adopting the channel state. Data rate of some user is consisted with multiple channel state and spectral efficiency constant. Channel state value is determined path loss with distance from BS and shadowing or fading. Spectral efficiency reflects how many resources are used for data transmission like overhead that is pilots or cyclic prefix. This of LTE-A important factor are 600 data subcarriers, a useful time equal to 66.7us/71.4us of the total symbol length (by excluding the cyclic prefix equal to 5.1us/71.4us at non-extend cyclic prefix), and an over sampling factor of 43/28. Then, the constant factor is given 129 Hz sec = 0.5ms* 9/50 MHz* 66.7/71.4* 43/28.

2.3. Carrier Aggregation (CA)

LTE-A systems adopted some new technology for achieving high speed rate. This is known for Multiple-Input Multiple-Output (MIMO) and CA. MIMO improve the throughput with increase the spatial multiplexing gain, CA achieve same that with extend bandwidth. We concentrate CA which is specification and characteristic [9].

Basic concept of CA is aggregation of two or more component carriers in order to support wider transmission is first proposed in 3rd generation communication systems, High Speed Packet Access (HSPA) with it called multi-carrier [4]. First objective of multi-carrier concept becomes users feeling faster throughput. Meanwhile, it does not violation of HSPA communication standards as huge cost with changing background network. At the reason, multi-carrier support aggregation up to 2 carriers and one carrier bandwidth is fixed with 1.4 MHz. CA is extended the multi-carrier concept and more flexible control with LTE-A characteristic like figure 3. This figure's boxes are bandwidth. Square box is narrow bandwidth case and rectangle box is wide bandwidth case.

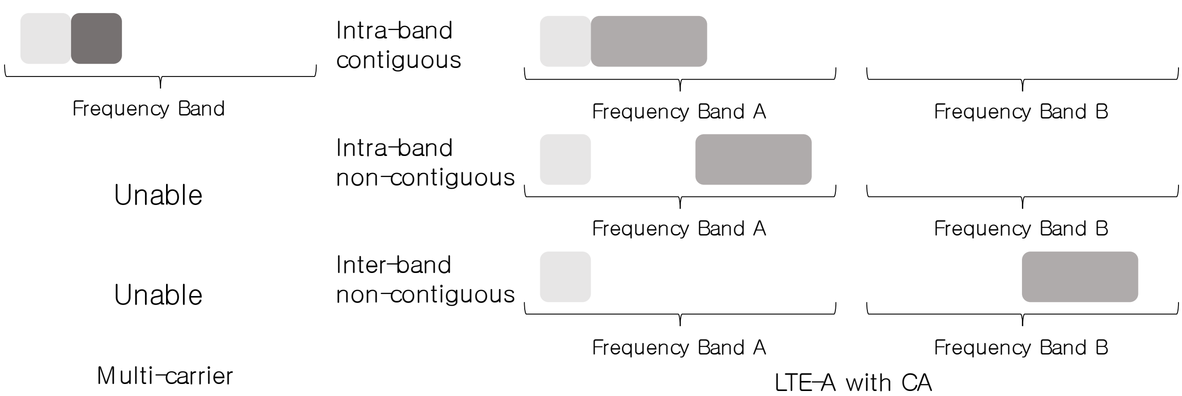

Figure 3. Different multi-carrier and CA

CA concept combine over 2 bandwidths for accepted combination set by ITU-R. This support wideband transmission for aggregating multiple adjacent or non-adjacent component carriers. Moreover, combination LTE communication characteristic allows using various bandwidth up to 20 MHz (1.4, 3, 5, 10, 15, 20 MHz) [10] make effectively frequency resource utilization and high-speed rate achievement. For example, if user devices need to high speed service or multimedia service, base station allocates wide bandwidth like 10, 15, 20 MHz. Otherwise, if user devices demand low power or energy and didn't demand high speed, communication medium allocates narrow bandwidth like 1.4, 3, 5 MHz. LTE-A with CA is able to combine bandwidth both same bandwidth and different bandwidth. This advantage becomes easy to support wideband service and utilize edge band by communication company under the various and discrete band.

Also, when adopted CA was changed network topology as using band more than 2 number like figure 4. To compare single carrier systems, this is able to utilize various deploy methods with channel state. Figure 2 show the deployment scenarios this case has 2 frequency band f1 and f2. The bands have same frequency or not, if each other bands have different band, f1 have frequency lower than f2 become coverage is more than f2. In the follow [11], this cases divide 4. Scenario 1 like figure 4-a is when the frequency band, f1 and f2, have same band. This band coverage area collocated and overlaid with the bands. The scenario supports all users high rate in the coverage areas. Second Scenario deploy band coverage area collocated but no overlaid with different frequency band f1 and f2 like figure 4-b. figure 4-c is co-locate with f1 and f2 are different band. At last scenario is f1 band provide macro coverage of f2 cell. We assume figure 2-b scenario with simulation of proposed scheduling.

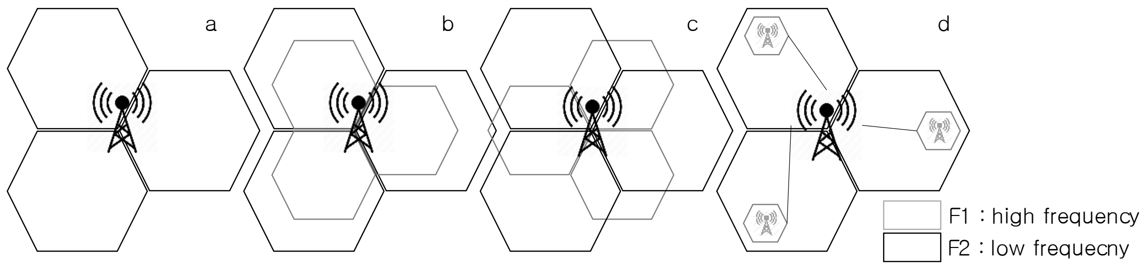

Figure 4. LTE-A with CA scenario

2.4. CA scheduling

In this part, we introduce propose scheduling methods. Although we show graph compared round robin, makes this part help to understand. Previous mobile communications have simple cases as this networks only support the same specification devices and transmission of voice or messaging services. So this networks resource allocation method used simple like proportional fair (PF) scheduling. This allocate fairness resource at associated one channel. Resource scheduling method of PF scheduling divide resource which is considered users occupied resource rate in the previous like below

$$k = \arg\max_{i} R_i/\overline{R_\iota} \tag{1}$$

where selected user k, user i, instance time data rate of user is R_i and Average of user i is $\overline{R_\iota}$. Denominator is average of resource allocated users, and numerator is resource with some user. PF form have constant. This value small than other case, it become orders of priority is increase. Implementation of this is very simple but this form is restricted resource number that only one. For example, 3G or LTE mobile communication such as using single carrier independently allocate resource as PF form is adopt for independent each carriers. This case become efficient scheduling. But PF form doesn't efficient scheduling any more in LTE-A like adopted CA. because this scheduling do not consider state of other carrier resource allocation. So many researchers proposed advanced scheduling or more efficient scheduling. We check some scheduling.

i. Generalization of cross-CC PF

Disadvantage of PF scheduling do not aware state other carriers of allocation resource to users. Generalization of cross-CC PF improve the problem for consideration of all carriers and weight factor.

This form has tradeoff between average cell throughput and cell edge user throughput as the weight factor. As a result, this scheduling more consider about distinct of LTE-A and LTE users and adjust priority for users with various channel qualities. This form is extended to cross-CC scheduling by replacing the denominator with the user throughput aggregated over the CCs. The form is equal to below

$$\mathcal{M} = \frac{\alpha(k)r(k,n,m,t)}{R(k,t)^{\beta}} \tag{2}$$

Where α is value of depends on the user category, and β is exponential weighting factor. It improves resource scheduling performance but it need to improve with loss in network utility. [4]

ii. User Grouping PF

User Grouping PF divide the two group with user to defined whether is higher than a threshold. One group have good channel qualities; other group have bad channel quality such as cell edge users. This scheduling select allocate selected user with way to maximize. That form is like below

$$i^* = \arg\max_{i \in M} \left\{ \frac{r_i(n,s)}{\overline{R_i(s)}} \cdot \beta \right\} \tag{3}$$

$$s.t\ M = M_k \cup M_{k+1} \cdots \cup M_L = \bigcup_{j=k}^{L} M_j \tag{4}$$

where β is weight factor which can adjust the average channel access probability of different user groups in proportion to ther number of carriers that they can be scheduled on. This form only considers center user and edge user of LTE-A which is not considered LTE user although they have low performance. [5]

III. Proposed scheduling

In this section, we refer some assumption before making system model and introduce the proposed scheduling. Proposed scheduling assume the cell coverage area scenario is composed various cells are overlapped like to center in BS like figure 5.

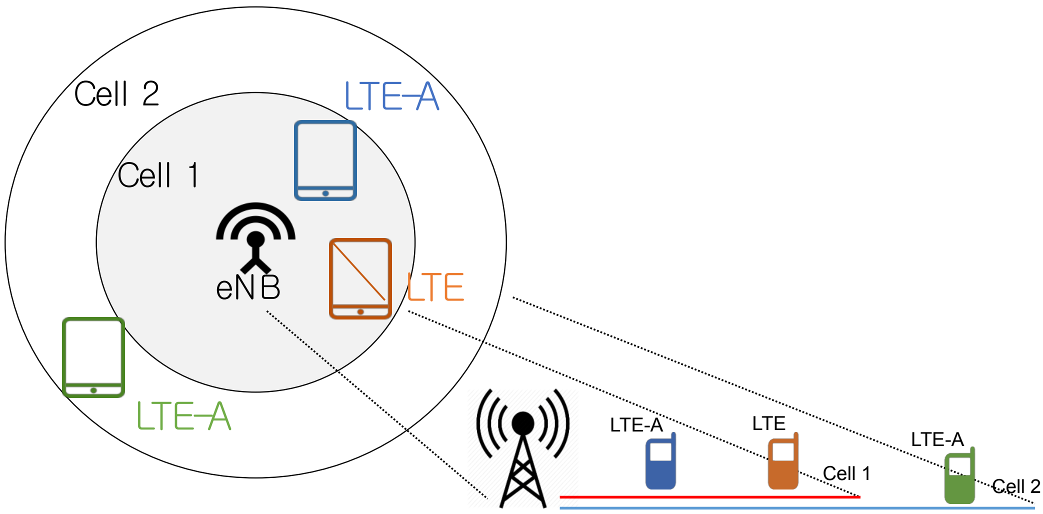

Figure 5. Network coverage for propose scheduling

Generally, each cells have same or different frequency band and used the non-adjacent frequency band or adjacent frequency band. The scheduling assume non-adjacent frequency band with low frequency is 2.1 GHz and high frequency is 2.6 GHz. Previous mention, the number of frequency band are matching the number of cell and if frequency is higher than others, it has lower number of cell. Each cell includes one frame is consisted of RB which is combination for subcarriers and symbols. RB is minimum unit of allocated UEs. RB is allocated from various CC under the LTE-A UEs, but LTE UEs are able to use RB from only one

CC in one frame section. This make some types with combination of user location and communication type. UEs are distinguished three types like below

Symbol	Type	Location	CA capability
A	LTE-A	A < cell1, A < cell2	CA available
B	LTE	B > cell1, B < cell2	CA non-available
C	LTE, LTE-A	B > cell1, B < cell2	CA non-available

Table 1. Each types condition

Type A is consisted of the LTE-A (over the Release10) with CA UEs that is located in both cell1 and cell2. As A UEs are able to select CA mode for activation or deactivation, simultaneously use carrier of cell1 and cell2 and use single carrier among the cells. Type B is LTE (Release8/9) UEs that is same location of type A. but this need to decide the frequency band, cell1 or cell2, as the type B UEs use the only one. At last type, type C is LTE-A (over the Releas10) UEs who is edge UEs are located in out of cell1. As the type is included in only cell2 that is more narrow coverage. Type A is represented UEs to have good channel quality and need low transmission power. Also, type B have similar condition but this performance lower than type A with same allocation RB as communication type is LTE. Type C have disadvantage that locate out of cell1 and it became disable CA. Under this condition, type B or type C have unfair compared type A although this is allocated same RB.

However, mobile communication cooperation should support to accept users demand as they make contract subscriber. So installed BSs need to schedule for supporting all users sufficient rate with consideration type B and type C.

To efficiently utilize the LTE-A resource like channel information and RB is properly allocated for distinct of user status. As the proposed algorithm allocate resource distribute the type of user, affluent UEs, type A, reduce allocated RBs and other type UEs allocate more RB. For presenting the form, we use the max-min optimization technique. The technique is maximized total throughput through the minimum of user data rate per weighted that is defined as

$$Maximize \min_{i \in A \cup B \cup C} \frac{r_i}{w_i} \tag{5}$$

where the i is i-th user to belong between the types. w_i is as weight for the i-th user and r_i is as data rate for the i-th user. We formulate the CC and RB allocation problem in terms of the subject to below

$$\text{Subject to } r_a = n_{1a} \cdot R_{1a} + n_{2a} \cdot R_{2a} \tag{6}$$

$$r_b = n_{1b} \cdot R_{1b} + n_{2b} \cdot (1 - x_{1b}) \cdot R_{2b} \tag{7}$$

$$r_c = n_{2c} \cdot R_{2c} \tag{8}$$

$$\textstyle\sum_{a \in A} n_{1a} + \sum_{b \in B} n_{1b} \leq N_1 \tag{9}$$

$$\textstyle\sum_{a \in A} n_{2a} + \sum_{b \in B} n_{2b} \cdot (1 - x_{1b}) + \sum_{c \in C} n_{2c} \leq N_2 \tag{10}$$

$$\begin{gathered} n_{1a} \geq 0, n_{1b} \geq 0, n_{2a} \geq 0, n_{2b} \geq 0, n_{2c} \geq 0 \\ integer\ for\ evry\ a \in A, b \in B, c \in C\ x_{1b} = 0\ or\ 1, for\ every\ b \in B \end{gathered} \tag{11}$$

where the r_a, r_b, r_c represents data rate per each type A, B, or C of each user. r_a is summation type A user's data rate of cell1 and cell2 that include number of RB times channel state. r_b is similar to r_a, but this has variable x_{1b} is different. This variable determines user of type B where carrier component selected the cell1 or cell2. As using the only one carrier component, r_c contain cell2 carrier and RB. We refer total RB of one symbol by N_1 and N_2. Although, this technique is method of optimization, but this form is achieved hard to find the point as the having non-linear program that is the form (7) is consisted variable n_{1b} and x_{1b}. So we solve more easily that form, replaced linear program and auxiliary variable R. form (5) ~ (11) are replaced below

$$Maximize\ R \tag{12}$$

$$Subejct\ to\ n_{1a} \cdot R_{1a} + n_{2a} \cdot R_{2a} \geq\ w_a \cdot R \tag{13}$$

$$n_{1b} \cdot x_{1b} \cdot R_{1b} + n_{2b} \cdot (1 - x_{1b}) \cdot R_{2b} \geq\ w_b \cdot R \tag{14}$$

$$n_{2c} \cdot R_{2c} \geq\ w_c \cdot R \tag{15}$$

$$\sum_{a \in A} n_{1a} + \sum_{b \in B} n_{1b} \cdot x_{1b} \leq N_1 \tag{16}$$

$$\sum_{a \in A} n_{2a} + \sum_{b \in B} n_{2b} \cdot (1 - x_{1b}) + \sum_{c \in C} n_{2c} \leq N_2 \tag{17}$$

$$\begin{gathered} n_{1a} \geq 0,\ n_{1b} \geq 0, n_{2a} \geq 0, n_{2b} \geq 0, n_{2c} \geq 0 \\ integer\ for\ evry\ a \in A, b \in B, c \in C\ x_{1b} = 0\ or\ 1, for\ every\ b \in B \end{gathered} \tag{18}$$

w_a, w_b is weight variable of each type user. For solving the form, we divide three steps. First, variable n_{1b} change to randomly constant under the x_{1b} is that suggested B user exists both cell1 and cell2 like form (19)

$$n_{1b} \cdot x_{1b} \cdot R_{1b} + n_{2b} \cdot R_{2b} \geq \; w_b \cdot R \tag{19}$$

This point, form (19) becomes linear program and solve the problem about x_{1b}. Using the determined x_{1b} is values zero of one solve the problem.

IV. Simulation

In this section, we verify the performance of the proposed algorithms with simulation experiments of LTE-A with CA are conducted via MATLAB. The whole composition component follows the below section.

4.1. Channel composition

4.2. Comparison scheduling

4.3. Simulation environment

4.4. Estimation result

4.1. Channel composition

The simulation channel model is implemented with COST-231 hata path loss model and the log-normal shadowing. As the base simulation, we use 2 CCs for minimum aggregation number that frequency assumes 2.6 GHz and 2.1 GHz.

COST-231 hata model, Channel model, is extends the urban hata model. This is covered elaborated range of frequencies with distance. This model form is divided 3 cases with area location that is urban, suburban and rural which form follows below

$$L = 46.3 + 33.9logf - 13.82logh_B - a(h_R) + [44.9 - 6.55logh_B]logd + C \tag{20}$$

$$a(h_R) = (1.1logf - 0.7)h_R - (1.56logf - 0.8) \tag{21}$$

$$C = \begin{cases} 0\ dB\ for\ medium\ cities\ and\ suburban\ areas \\ 3\ dB\ for\ rural\ area \end{cases} \tag{22}$$

where, L is median path loss, f is frequency transmission which unit have MHz, h_B is base station antenna effective height, h_R is mobile station antenna effective height, d is link distance which unit become kilometer and $a(h_R)$ is mobile station antenna height correction factor as described in the hata model for urban areas. For adopting the form, we assume rural area, h_R height is 4m and h_B height is 2m.

4.2. Comparison scheduling

Estimation of proposed scheduling, we compare other scheduling. Basic concept for round robin scheme, Compare case, round robin, is basically concept as generally and elementary method with resource allocate cyclic direction. Since this way uniformly allocated RBs does not support similar data throughput. more detail, it is neglected consideration factors like channel condition, device specification, transmission power and so on. Although uniform allocation method, it is considered possessed advanced devices or good channel state users rate of each band in LTE-A systems topology.

We divide 3 round robin case for aspect of good state users. First case is all type B users are located in high frequency band. Second case is type B and type C users are fixed in low frequency band. It speaks to type A have all high frequency band resource. Last case is each types use all available bands. High frequency band allocate type A and type B and low frequency band allocate all types with divided uniform resource blocks like figure 6

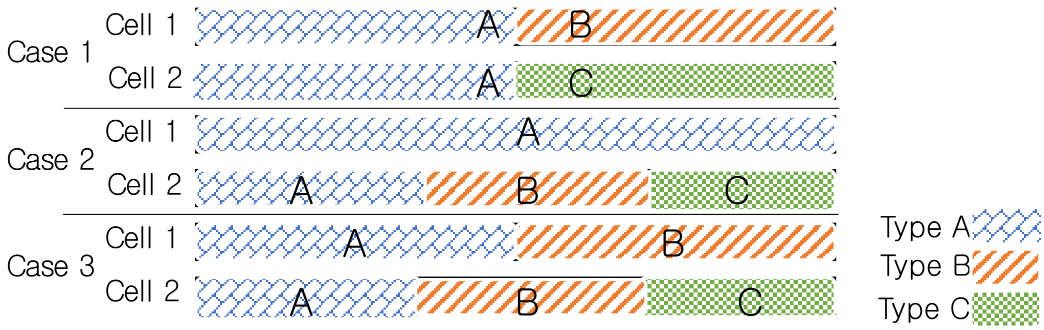

Figure 6. Uniform allocation case

As divided case, we have advantage performance respect. When used many band in LTE-A systems, we were checked difference of independent and dependent allocation method.

4.3. Simulation environment

Each of which contains 50 RBs under the 10 MHz bandwidth with the bandwidth of each subcarrier has 15 kHz. Each type UEs are located the uniform distribution.

The basic experiment compares the throughput for the result of proposed algorithm and round robin resource allocation algorithm. Round robin (RR) algorithm allocate uniformly RB irrespectively of channel state. Detail simulation environment follows the below table.

Parameter	Value
Cell coverage	1.22, 1.56 km
Center frequency	2.6GHz, 2.1 GHz
Path loss model	COST-231 hata
Fading	Lognormal shadowing
Bandwidth	10 MHz
Number of RB	50

Table 2. Simulation environment

Cell coverage distance follow the article [12][13]. BS is based on this, BS output power decrease end of cell coverage have closed zero power.

UEs is distributed like figure 7. As one BS's user capacity is up to 20 users, our simulation increase user number 3 up to 20 with each type distribute uniform. Type A and B locate mixed distribution and Type C is distributed edge area.

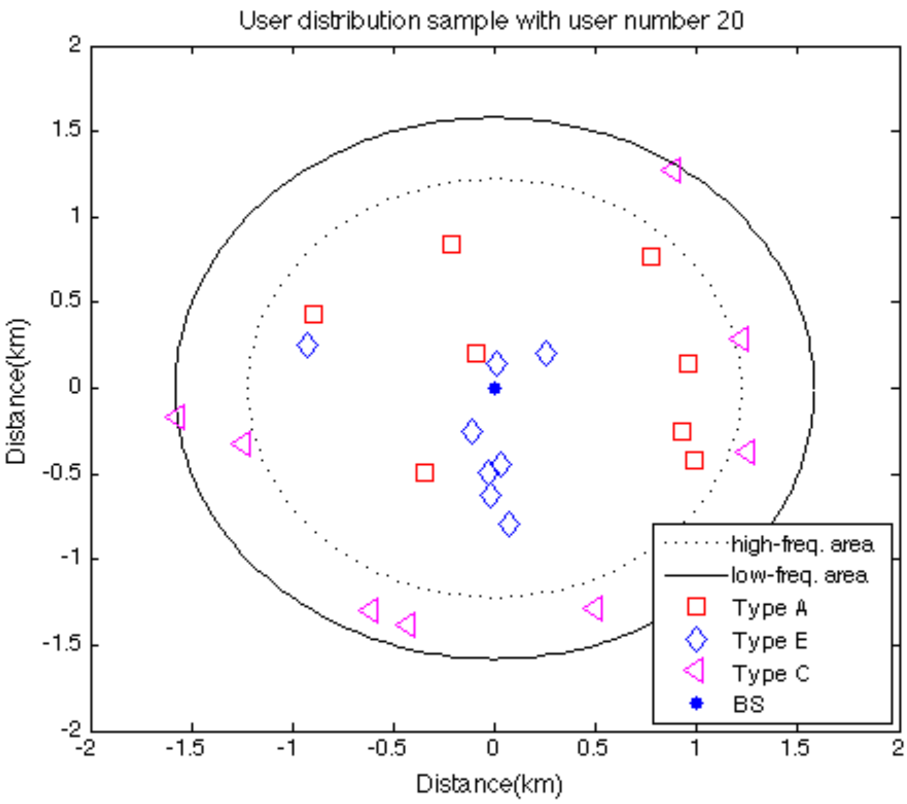

Figure 7. User distribution map

4.4. Estimation result

Estimation of proposed scheduling investigate how many show the performance improvement and resource utilization efficient. So first step checks the total average throughput through the comparison of round robin scheduling like figure 8.

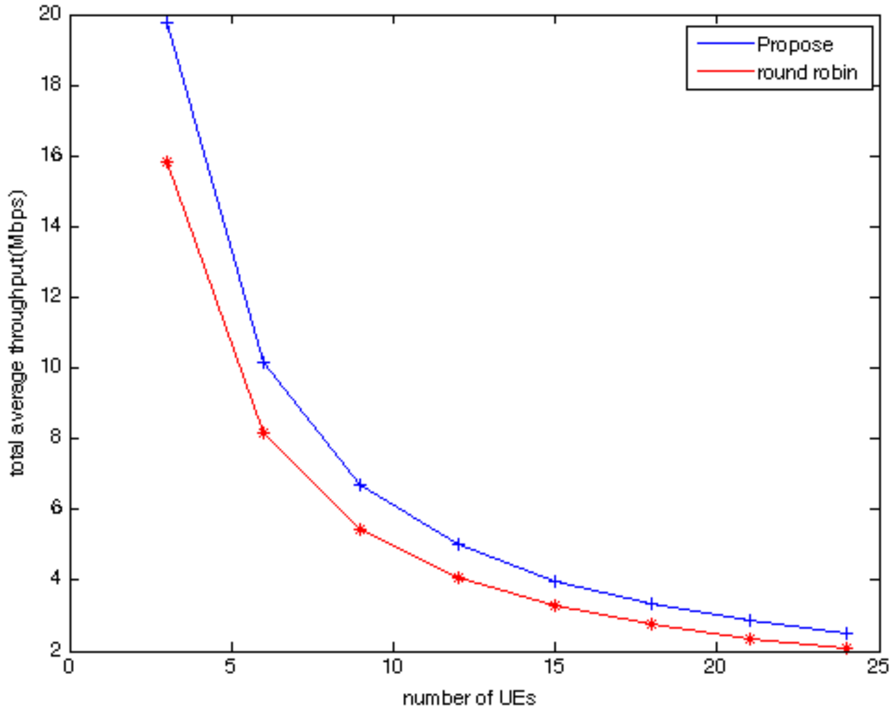

Figure 8. Total average throughput

Total average throughput shows increase of performance with the proposed scheduling is located more upper side compare with round robin cases. But it does not predicate proposed scheduling have good performance since that is average. For reinforcement, we check the performance of each type with minimize user performance and average performance like figure 9, 10. As proposed scheduling affect to decrease type A user, this average throughput lower than round robin cases. This exactly show figure 11 which is represented rate of types.

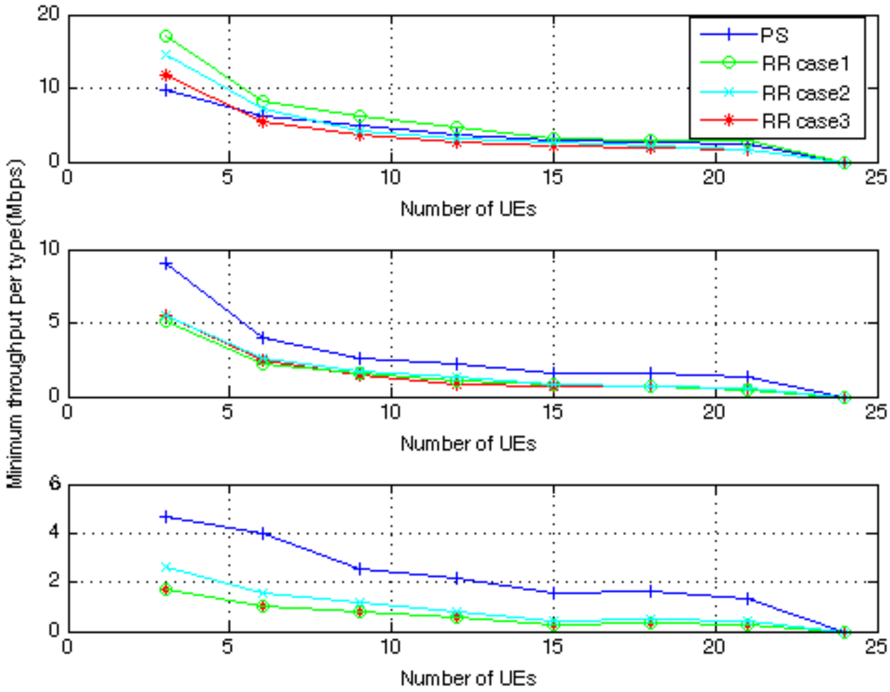

Figure 9. Minimum throughput per type

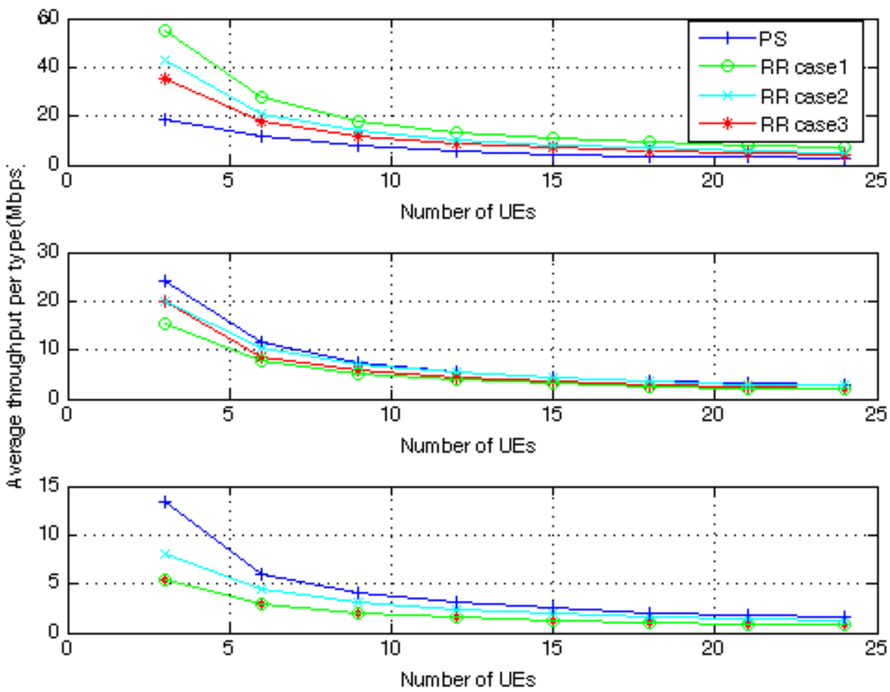

Figure 10. Average throughput per type

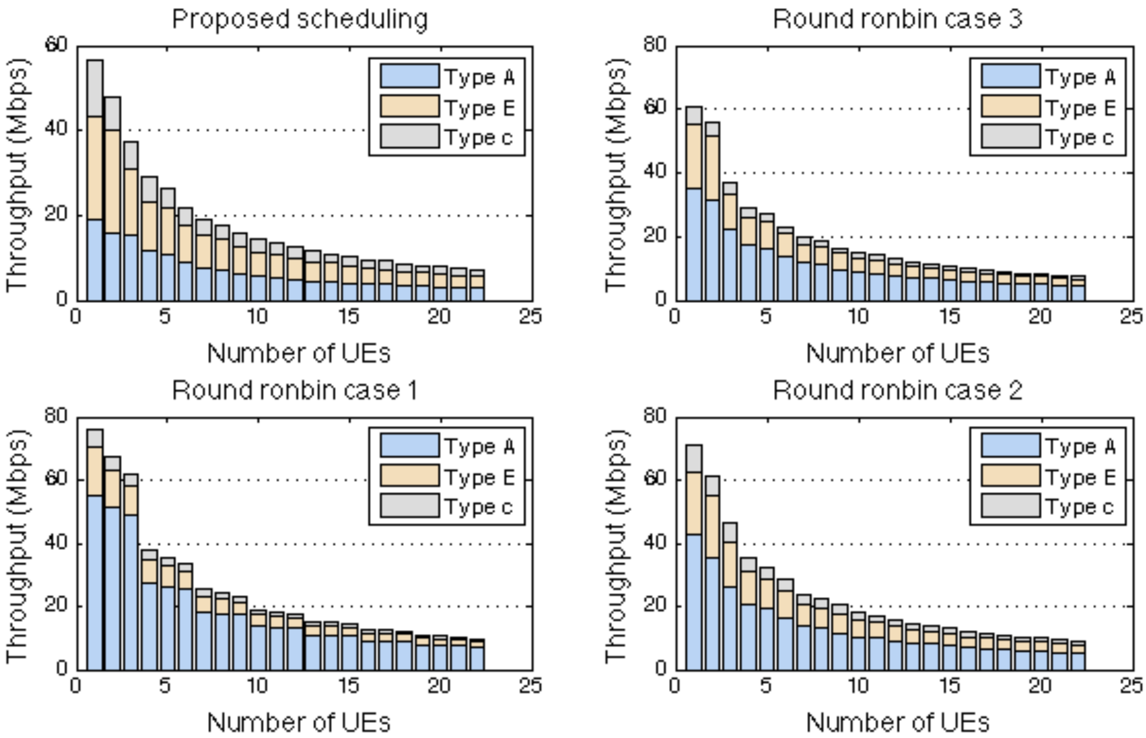

Figure 11. Each types throughput rate comparison

For supporting various information, we adopt jain's index rank [14]. This shows like figure 12 which is represented how much equality allocate resource with focused user data rate by jain's index rank. This is represented spectrum efficiency and form is equal to below.

$$f(x) = [\sum_{i=1}^{n} R_i]^2 / n \cdot \sum_{i-1}^{n} R_i^2 \tag{23}$$

R_i is each user data rate for multiplication allocated RBs and rate per RB. Index range have 0 to 1, which is fair to close 1. If the value is 1, it represents the all user data throughput equal. This graph limit users number for we remove interruption of other condition with check this index under equal user's type rate like 1:1:1. As the result, index value represent our proposed scheduling more closed to 1.

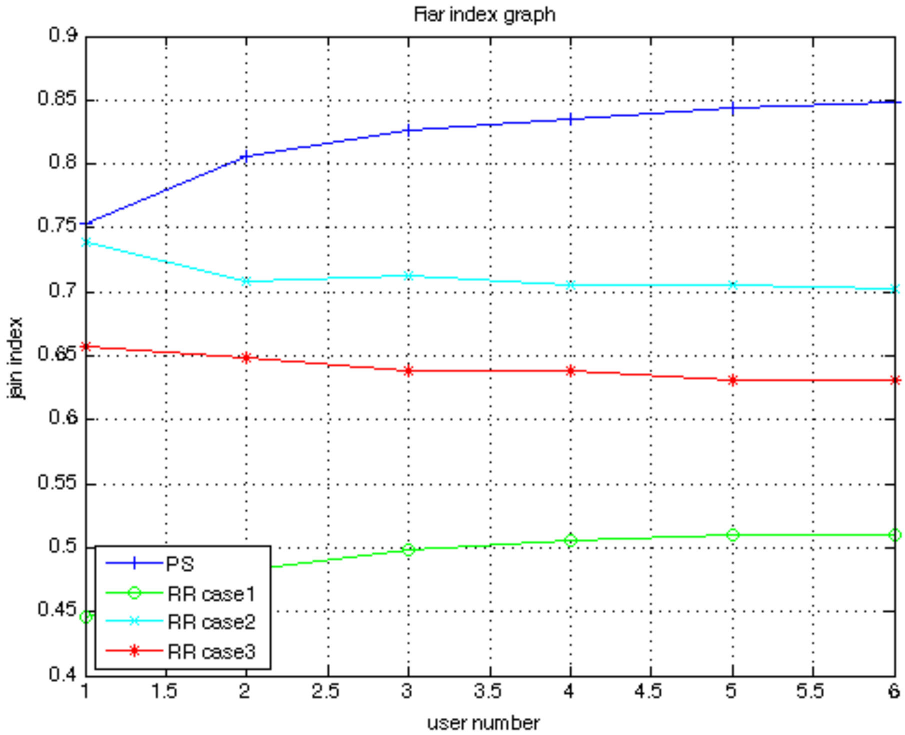

Figure 12. Jain’s fairness index.

V. Conclusion

In this thesis, we proposed a scheduling for using max-min optimization tool to resource allocation of LTE-A systems to supporting the handicapped user in network like users having LTE devices or located starvation area among the cells. Different previous mobile communication systems, various types' device users co-exist in LTE-A networks systems. So, resource allocation issue is being magnified as efficiently resources utilization and provide stability service. Various scheduling researches propose BS point of view, but UEs have more load for transmission power and antenna chip cost to handle complex wireless channel environment. We were started this point; our proposed scheduling suggests scheduling to adopt UE's factors constant for w.

Given our result, we envision some simulation result show remarkable performance distinct like all user throughput increase. But really simulation result shows good environment case, this type is A, decrease the allocated resource and throughput same also. Type B and C which have handicap increase resource and improve the throughput with comparison of previous scheduling. Especially, located low rank users in throughput increase reflects our purpose which serve sufficient performance with acceptable by user.

In the supplement part, this simulation is processed basically performance estimation with using mathematically technique. For more practically performance estimation, we need to use more realization tool or demonstration.

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요 약 문

주파수 집성기술이 적용된 LTE-A에서 Max-min 최적화기법을 사용한 스케쥴링 기법

본 논문은 LTE-A에서 통신자원을 할당하는 방식에 있어서의 이슈에 대해 알아보고 기존의 관점과는 다른 방향에서의 자원할당방법에 대하여 연구하였다. LTE-A 네트워크에서는 주파수 집성기술이 적용되어 더 빠른 통신속도를 보유한 기기들과 기존의 LTE 기술이 적용된 기기들이 혼재되어 운영된다. 일반적으로 LTE-A 기술을 가진 기기들은 동일한 양의 자원을 받더라도 상대적으로 빠른 통신속도를 제공할 수 있기 때문에 자원을 어떻게 분배하느냐에 따라 상대적으로 성능이 낮은 LTE 기기나 제한적 상황에 놓인 기기들이 충분한 성능을 낼 수 없게 되는 현상이 발생 하게 된다.

따라서 본 논문에서는 앞에서 언급한 LTE 기기나 LTE-A 기기임에도 집성기술을 이용할 수 없는 상황에 놓인 기기들의 통신속도를 높이는 방향으로 스케줄링 방법에 대하여 제안하였다. 제한적인 자원을 가지고 있는 상황에서 Max-min 최적화 기법을 이용하여 상대적으로 성능 및 채널상황이 좋은 그룹에 할당되는 자원을 줄이되 다른 기기들에게 더 많은 자원을 제공하는 방법을 제안하였다.

제안된 스케줄링 방식은 시뮬레이션을 통하여 일반적인 방식의 자원할당 방법보다는 상대적으로 높은 성능을 보여주고 있음을 확인 하였다.

핵심어: Carrier aggregation, medium resource scheme, Long term evolution-advanced, Optimization