CHAPTER 1
INTRODUCTION

1.1 Background

In the process of data transmission, LTE systems using OFDM techniques. The OFDM technique divides one frequency band into several groups of subcarrier (chunk). Then this chunk will be allocated to user to do the communication. Then Carrier Aggregation (CA) was introduced in LTE-A. CA is a method that aggregated two or more component carriers in a system. This method can increase the number of chunks that could be allocated to the user. With CA, every user can be scheduled on multiple carriers, so one user may get resources from several frequencies. In inter-band carrier aggregation scheme, which each component carrier has a large difference in frequency, there are some problems that emerge:

1. The different fading characteristics from each frequency carrier that makes the difference in channel quality on user.
2. Very bad channel quality happens when the cell-edge user received a chunk from highest carrier (highest fading characteristic)

Work [3] [4] propose scheduling scheme for LTE systems with one carrier (without CA) so there are no differences in fading characteristic from each carrier. Research on [5] [6] proved that conventional proportional fair algorithm is not optimal on CA system caused by the differences in character fading from each carrier. Then, the grouping method is proposed to overcome this problem. While in [2] [7] , grouping method is modified and applied on mean greedy-based algorithm.

In terms of energy saving, [8] proposed chunk allocation process with power control to meet the energy saving issue on heterogeneous cell. The energy efficiency on LTE-advanced has become a new performance standard on allocation algorithm. This day, with less power, the more capacity must be obtained. So, the energy efficiency is an important thing to observe. In other hands, the time complexity of the algorithm must be maintained. The time complexity represents how much process in a algorithm and how long the process will be done.

This study has designed a process to optimize energy efficiency in resource allocation. The new algorithm uses UCG process and IWF algorithm. With UCG process, user will

be divided into several groups according to the quality of the component carrier received by each user. After that, the allocation algorithm will be conducted in each respective group with addition of IWF power allocation to improve the energy efficiency.

1.2 Problems Definition

Problems raised in this study are:

1. Difference energy level from each component carrier caused by the different frequency that being used in CA interband scheme.
2. Within a certain range, user better use a chunk from low frequency which have low fading characteristic to maximize energy efficiency.
3. Higher power is needed when user on the cell edge get resource from high frequency carrier.
4. The time complexity of the proposed algorithm must be maintained

1.3 Reference Tracing

In [3] [4] resources allocation in LTE systems with single carrier (without CA) is proposed. It is assumed all users can be scheduled on the same carrier. In [4] the allocation algorithm applied on downlink using proportional fair-based algorithm. In [3] the allocation algorithm applied on downlink using greedy-based algorithm. While [9] applied on uplink with mean-greedy based algorithm.

Works [5] and [6] proved that CA system makes the conventional proportional fair scheduling algorithm is not optimal. This happens because the differences in fading characters on each carrier. Then the user grouping process is proposed. The grouping process executed before the proportional chunk allocation. In [5] the grouping process only applied on the user side, while in [6], the grouping process applied both on user side and chunk side of each carrier. This process increase the fairness among users, but decrease average user throughput. In [7], the grouping process in [6] applied in mean greedy-based algorithm. Simulation process show that the result is same between mean-greedy algorithm with grouping and without grouping. Then the modified grouping process is proposed in [2] to improve the performance of mean-greedy algorithm process on LTE-A with inter band non-contiguous CA scheme.

Meanwhile, in terms of energy saving, in [8] chunk allocation process with power control process is proposed to meet the energy saving issue. This method used in heterogeneous LTE-Advanced networks. Waterfilling algorithm is applied to cut energy consumption. The result shows the increment on energy efficiency in data transmission process [10].

1.4 Research Purposes

The purposes of this research are :

1. Design a modification of allocation algorithm to be applied on LTE-A system with the CA that can minimize energy usage.
2. Apply user grouping method and the power control algorithm to achieve better energy efficiency.
3. Evaluate and analyze the performance of the algorithm. The performances parameter that will be observed is :
   (a) Spectral efficiency
   (b) Energy efficiency
   (c) Fairness index
   (d) Time complexity

1.5 Scope of Work

This study aims to save energy in the process of resource allocation in the LTE-A system with CA scheme. Several steps that will be pursued are:

1. Design new algorithms for LTE-A system with the CA that can maximize energy efficiency.
2. Simulate the algorithm in the LTE-A system with CA system corresponding with the following specifications:
   - Single cell system, fixed user, and no handover
   - eNB antenna using omnidirectional antenna
   - Applied in downlink
   - Using inter band non-contiguous CA with frequency of component carriers are 700 MHz, 900 MHz, and 1800 MHz.
   - All component carriers have same power transmit
3. Observe the advantages and disadvantages of the new algorithm and evaluate it.

1.6 Research Hypotheses

In the new algorithm which designed to improve energy efficiency, two process are added in. The user grouping process will group each user according by fading characters received from each component carrier. This process makes the cell edges user always receive resources from lowest carrier which have the lowest fading character [5] [7]. This is expected to reduce energy consumption to transmit data. The inverse SNR waterfilling power control method is performed to avoid the use of excessive transmit

power when sending data to the user [11].

By adding the user grouping and power control the fairness of the system will be decreased. The grouping process will restrict the outer user to get more resources from eNB. Meanwhile the inverse SNR waterfilling power control method will give users with good channel gain more power and give users with bad channel gain less power. This condition will disrupt the fairness in the system

Both of these methods is expected to improve spectral and energy efficiency on LTE-A system. But, by adding these 2 method in the algorithm, and decrease the system fairness, while the time complexity of the proposed algorithm will remain the same.

1.7 Steps of Research

The research on this works are divided into several steps, they are :

1. Problem Identification

   The problems identification in this research are performed with study of literature. The literatures are derived from the results of recent studies, either paper or journal from international conference and related textbook.

2. Model System Design

   In this process, the cell environment was designed for simulation and evaluation process of the algorithm. The observed cell is a single cell system without interference from the other cell. In the cell there are 3 component carriers non-adjacent inter-band scheme with equal power allocation (40 Watt) and same bandwidth (5 MHz). Each channel will be affected by lognormal fading with $/mu = 0$ and $\sigma = 3$. The users will be distributed randomly within the cell and the user number will be varied.

3. Algorithm Design

   In this step, grouping process, allocation algorithm, and waterfilling power control scheme will be designed. UCG process will devides each user into several groups according to the quality of carriers. Meanwhile, the IWF method will allocates power to each user proportionally with the channel gain. The designed scheme must match the condition of LTE-A system with CA, so the algorithm can achieve better system performance.

4. System Integration

   After all process was designed, each process will be integrated with the other process, so further modification is needed. The output of each process must fulfill the input requirement of the following process. The integrated algorithm must achieve the main purpose of research.

5. Simulation Process

   Simulation will be conducted on the cell system with computer software. Simulation will performed through several scenario to see how the algorithm works.

6. Simulation Results Analysis

   The results of the simulation will be reviewed and analyzed. In this step, all simulation scheme will be analyzed rather the scheme achieved the research purposes or not.

7. Drawing Conclusion

   The conclusion will be pulled according to simulation and results analysis. The final conclusion must meet the research main purposes.

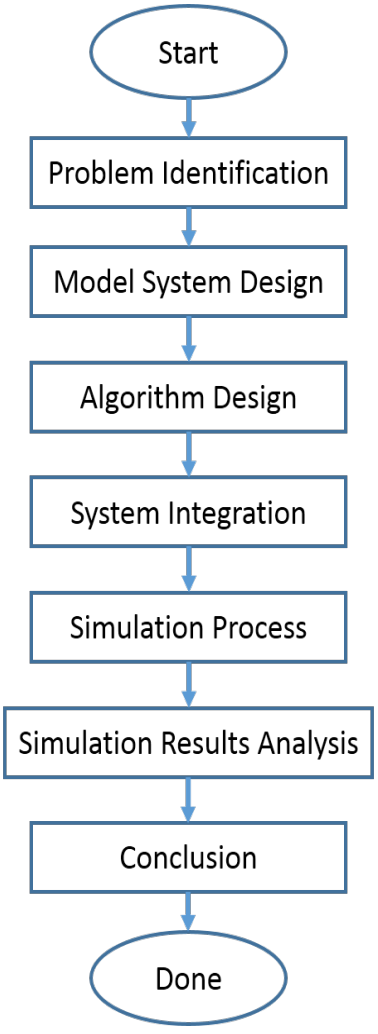

FIGURE 1.1: Steps of Research