CHAPTER 1
INTRODUCTION

1.1. Background

Today most of world's population use mobile communication in their daily life for many types of service (i.e. voice, data and video). Internet applications especially mobile applications are become more and and more bandwidth consuming, hence operators urge to seek next technology that able to deliver more bandwidth to fulfill their customers demand. More bandwidth means more frequency spectrum that needs to be used. So that, mobile systems is required to be able to operate in a flexible with possibility of varying channel bandwidth includes different frequency bands, different size spectrum allocation or even in fragmented spectrum. It is an established fact that an optimized network performs better and subscribers notice the difference, hence operators have been investing in and upgrading their networks to meet demand, since they realize that their success will be based on a differentiated service quality, attractive services, and a good value proposition [1].

LTE stands for Long Term Evolution and it was started by 3GPP (Third Generation Partnership Project) in 2004. It is also widely known in the market as 4G, intends for high speed data access for mobile communication system. LTE is evolved from Global System for Mobile Communications (GSM) and Universal Mobile Telecommunication System (UMTS) . First version of LTE was documented in Release 8 of the 3GPP specifications. LTE claims to be able to deliver up to 20 times higher than its predessor (3G). Regards to flexibility of varying channel bandwidth issue, LTE use OFDMA (Orthogonal Frequency Division Multiple Access) as its downlink transmission scheme and SC-FDMA (Single Carrier-Frequency Division Multiple Access) as for its uplink.

Network optimization has draw attention of many researchers and continously investigated. The process tries to make an optimum network performance with several constraints that consist in the environment. In previous research [2-6], designers sought to optimize Base Station from the geographical and configuration side of the network planning process, so as to meet the amount of available traffic, resources owned and QoS (Quality of Service).

It is common to find trade-off between several key factor combinations of network elements and parameters that need to be considered in developing optimum network (e.g. antenna tilt, azimuth, base station location, power). All of those contribute in solution space size that would determine the degree of complexity of solution finding process. In LTE the number of options is greatly varied, so optimal network configuration more found suitably by using hereustical method. The network designers are required to consider all the technical limitations that affect the whole design process to yield a network that able to give optimum coverage and capacity.

Most of studies of LTE base station planning deployment base station were based on heuristic approaches such as tabu search, simulated annealing and genetics algorithm. In the past, research on BS placement also existed that collaborated on discrete randomized optimization algorithms and tabu search algorithms by considering the quality from mobile station to Base Station and user traffic [5-8]. Researchers have been implemented genetics algorithm in base station location determination to optimize mobile networks [9-12] and simulated annealing [13]. Optimization performed by setting the Base Station output power at a given location based on user generated traffic using stochastic algorithms is mentioned in [14]. The distributed heuristic variant of the gradient ascent method to antenna tilt is implemented in optimizing the LTE network [15].

Grey wolf optimizer (GWO), as novel heuristic algorithm inspired from wolves hunting process, has the advantages of simple solution search flow. It is due to less parameter used for instance number of particles, coefficients vector, and three dominants decision maker. It also has low computational cost, and fast in finding solutions (convergence) [16]. Because of those abilities, GWO impelemented in solving many cases includes engineering. Nevertheless that facts, only few impelementations of GWO in wireless network LTE optimization have been studied such as in [17]. This research compare the performance of GWO and PSO (Particle Swarm Optimation). The result shows that PSO performance is better than GWO. Meanwhile, GWO has been widely used in engineering cases and shows satisfactory results. GWO performance has also been enhanced through modifications proposed by many studies. This opens opportunities for improving GWO performance in the case of base station location determination on LTE network.

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1.2. Gap of The Real Condition and The Future

Radio cell planning and optimization can be divided into three steps : dimensioning, detailed planning and post planning & optimization. Dimensioning consists of rough estimation of network layout, network elements, and link budget. In detailed planning phase, real values is given and replaced assumption value that previously made in dimensioning phase. The final phase in radio planning network is post planning and optimization. Test concentration is conducted in this phase due to measurement of the radio plan.

In cellular network, the most important elements is the base stations since its role in building physical connection between base station and mobile user. The basic planning task is a result of optimization problems to determine the number and the locations of the base stations in order to meet capacity and coverage requirements.

Several last works in LTE network planning can be divided into two types. The first type is solving capacity and coverage by applying heuristic algorithm. Hence the network is able to do self organizing at small time granularity. The second type is by taking into account total; energy and cost impact in network planning.

GWO as a novel heuristics algorithm has excellence in simplicity and at least the parameters used. Best solution is decided in guidance of three dominants α, β, and γ. This algorithm has been used for solving optimization problem in many research areas for instance Economic Emission Load Dispatch [18], reactive power dispatch [19] and surface wave parameters[20]. GWO also has been studied in optimation of LTE network through implementation in BTS location determination. The study shows the performance of GWO had not reach its optimum. This thesis proposes a modified GWO to increase the performance of GWO in locating BTS of LTE.

1.3. Problem Definition

With the increasing demand for data communications, the number of users and the expansion of service coverage, telecom operators must be able to deploy networks with optimally, both technically and financially. The main problem of planning LTE network is to locate the base stations that can give higher capacity and broader coverage regards to many key factors constraint. Knowledge about coverage area, propagation environment is very important since those factors are varied. Traffic load and required services which are not constant and vary from time to time makes radio network planning is NP (Non- Polinomial) hard and considered to be a non-stop process. Genetics algorithm and swarm intelligent algorithm such as PSO and GWO has been studied to address in finding optimum solution in such a wide space solution.

Evolutionary algorithms such as genetics algorithm involve many operators in the search process including mutations, cross-overs, elitism, and selection parameters. The PSO, which is one of the best-known algorithms of the Swarm Intelligent group, lacks the vulnerability of being trapped in local optima in high-dimensional spaces and has low convergence rate [21]. As new comer, GWO has advantages over a smaller number of operators, the ability to pass information from previous generations and local optima avoidance. Nevertheless, recent studies [22-24] showed the need to improve GWO performance, in particular to achieve global optima, for instance by extending the exploration phase.

The designated base station locations must meet the predefined capacity and threshold requirements. This thesis only considers the capacity and coverage parameters refer to [17], so the problem is to provide base station location that meet certain conditions as follows:

- capacity threshold fulfillness

$$\sum_{j=1}^{N_{BS}} \sum_{s=1}^{N_S} \frac{N_{UBS}}{N_S} \cdot \rho_{s,i,j}\left(x_j, y_j\right) \geq \eta . D_i . A_{(i)} \qquad \forall i = 1,2,\ldots,N_{Area} \qquad (1.1)$$

Where :

η = tolerance parameter

N_{UBS} = number of users in base station

Ns = number of sectors

D_i = user density of area-i

A_i = observed area

$\rho_{s,i,j}\left(x_j, y_j\right)$ = portion of intersection between surface covered by sector s of base station j and sub area i to the observed/intended surface

- coverage threshold fulfillness

$$\sum_{n=1}^{N_{ref}} \gamma_n\left(x, y\right) \geq \tau . N_{ref} \qquad (1.2)$$

Where :

τ = tolerance parameter

N_{ref} = number of reference node

$\gamma_n(x,y)$= node reference function, valued 1 if the reference node is covered by at least one base station and return zero in contrast.

More detail on this function is discussed on chapter 3.

1.4. Problem Limitations

LTE network planning process involves many factors, in addition to the air interface factor, factors that come from customers such as the number of users, user behavior, user movement, user traffic types also affect the design of the built system. Generic traffic types and characteristics (i.e. delay sensitive, real time, etc) make the planning process requires knowledge such as packet scheduler function. In addition, there are factors derived from the network itself such as power settings, packet scheduler, attenuation, and channel bandwidth. Beyond technical matters, network planning is also influenced by factors such as location licensing, environmental conditions, and regulation.

According to problem definition, this thesis has limitations as follow :

1. Communication system used is LTE MIMO 2x2
2. Band frequency user 1800 MHz with 10 MHz channel bandwidth
3. Maximum number of users does not exceed maximum number of LTE users
4. Location type is green field,no base station existed before
5. Position of initial base stations is randomly generated without predefinition
6. Outdoor planning LTE networks with single environment (urban/sub-urban/metropolitan)
7. Observed area is square in shape
8. Propagation model used is COST-231 Hata
9. During the simulation air interface parameters remain unhanged
10. Simulation run on MATLAB

1.5. Research Objectives

The objective of this research is to provide better for LTE network capacity in terms of user number and also coverage by modifying Grey Wolf Optimizer. The analyzed parameters in this thesis are percentage of capacity provided to threshold required and percentage of area covered.

There are three types of variables in the research:

1. Dependent variables

   The dependent variable as the variable observed in this study are the number of users successfully served termed capacity, the area of observation successfully enclosed by the optimized base station arrangement termed the coverage, and the fitness value generated on each algorithm iteration.

2. Independent variables

   Independent variables used to obtain capacity data, coverage and fitness values used are number of users, deployment area, traffic load, number of iteration, number of search agent, capacity threshold, and coverage threshold, number of reference nodes. By changing the values and combinations of these variables, it is hoped that data can be obtained which gives an overview of the behavior of the algorithm to the case of this research.

3. Control variables

   Control variables are used to simplify the simulation so that the observation of the dependent variable can be done with more focus. Control variables used include network configuration, propagation type, frequency band, bandwidth, and spectral efficiency. This variable is a variable related to the characteristics of LTE networks. Meanwhile, other variables derived from users who are also controlled during this study is the type of user distribution and data rate threshold.

1.6. Hypotheses

This thesis proposed to prolong exploration phase in GWO in order to achieve better fitness value that indicated by higher capacity and coverage. It is achieved by modifying the equation of coefficient vector |A|. This modified GWO algorithm, named double step GWO will provide an optimum solution to the selection of locations and the number of base stations in the LTE network whilst maintain its network performance.

The process of finding food on grey wolves is done on guidance from alpha, beta, and delta positions. These wolves need to spread throughout the area to open up opportunities to meet very suitable prey. In GWO, this divergence is emphasized by the presence of the coefficient vector | A |. The exploration phase is controlled by a decrease in the value of **a** designed linearly decreased from 2 to 0. Under this condition, the exploration phase is limited to 50% of the iteration time. So that it also limit the possibility to reach globab optimum. The frame of thinking of this hypotheses is depict in Figure 1.1. below.

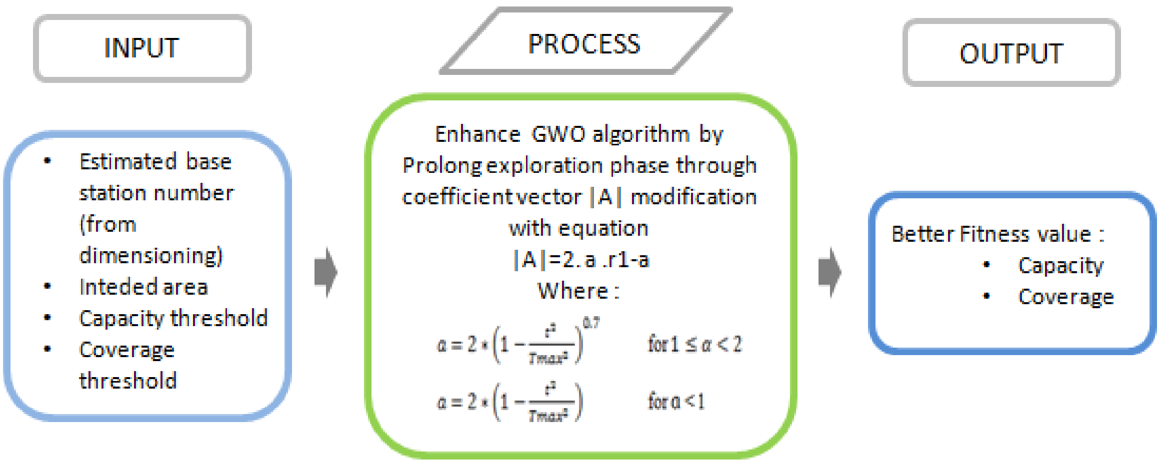

Fig.1.1. Hypotheses frame of thinking

With number estimated from dimensioning, intended area, user number, threshold that need to fulfill from capacity and coverage side as input, selection of base station location need to be optimized take an advantage of using GWO. Instead of using well known GWO, this thesis use longer exploration phase that have been proven able to reach better global optimum. It modified coefficient vector |A| equation with double step equation that prolong exploration to 80% of iteration. This will eventually lead to better fitness value that represent capacity and coverage. Modified GWO by prolong the exploration phase open more possibility to spread over wider search space. Based on Mittal e*t al*.[23], changing decrement factor **a** that consist in coefficient vector |A| from $\frac{t}{T_{max}}$ into $\left(\frac{t}{T_{max}}^{2}\right)$ has succeeded in prolong exploration phase to 70% from initial 50% and give better result than well known GWO.

1.7. Scope of Work

This research tries to find optimum performance of LTE network based on location of base station deployment. The new modified wolf optimizer implemented in base station location planning considering networks constraints and compare it with well known GWO The work contains of activities as follows;

1. Determine variable (independent, dependent, and control variables)
2. Conducting a research to locate base station by applying Grey wolf optimizer. The research will use simulation software to simulates the performance evaluation of modified GWO,named double step GWO. Number of users percentage as representation of capacity and also coverage percentage calculation will be conducted based on :
    a. Varied number of mobile users
    b. Varied observation areas
    c. Varied number of iteration
    d. Varied number of search agent
    e. Type of environment (urban-sub-urban)
    f. Compare the optimum solution and the performance of modified Grey Wolf Optimizer to GWO