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DEVELOPMENT OF COVERAGE BASED CELL SELECTION ALGORITHM FOR WIMAX

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ABSTRACT

Fourth generation (4G) mobile systems focus on effortlessly incorporating the existing wireless technologies like GSM, wireless LAN, and Bluetooth. This contrasts with third generation (3G), which simply focuses on developing new standards and hardware. WiMAX have been rapidly emerging in the last few years. The mobile subscriber and traffic volume have been largely increased in WiMAX. During the stage of network planning, a cell capacity and size are typically fixed depends on the calculation of peak traffic load. Cell planning is one of the most basic problems in network design. In this paper, a development of Coverage Based Cell Selection (CBCS) algorithm for 4G is introduced. The proposed model utilizes the cell selection algorithm. The best coverage base station can be selected based on three criteria: i.e. demand, profit and capacities. The performance of the proposed CBCS algorithm is compared with the four existing approaches like greedy algorithm, Bounded Greedy Weighted Algorithm (BGWA), Call Admission Control (CAC) and Joint Scheduling & Resource Allocation (JSRA). The proposed CBCS algorithm results better network throughput and also provides better bandwidth consumption ratio than the existing approaches.

Keywords:- *Base Station, Capacities, Cell Selection, Demand, Fourth Generation (4G), Network Planning, Profit and WiMAX*

1. INTRODUCTION

WiMAX is a wireless digital communications system that provides fixed and fully mobile internet access. The current WiMAX revision provides up to 40 Mb/s, with the IEEE 802.16m update and expected to offer up to 1 Gb/s. Cell Planning is an important and basic requirement for WiMAX networks. Such a design issue embraces scheduling a coverage of the base station for service area with respect to the current and future requirements, desired QoS and available capabilities. Based upon these constraints, the goal is to minimize the network operator's total system cost. The geographical distribution of the traffic demand can be broadcasted using demographic data like telephone density, motor vehicle density, distribution of income etc. A general outcome of the cell planning process includes a set of base station, set of antenna, coverage of the antenna in each site and allocation of frequencies to various cells. The LTE-A is a mobile communication standard and usually submitted as a candidate 4G system. Like all mobile communication systems, in LTE a terminal should perform some steps before it can transmit or receive data. These steps can be classified as cell search and cell selection, derivation of system information and random access. The entire procedure can also be known as LTE initial access, shown in fig.1. After that access steps, the terminal can able to transmit or receive the data.

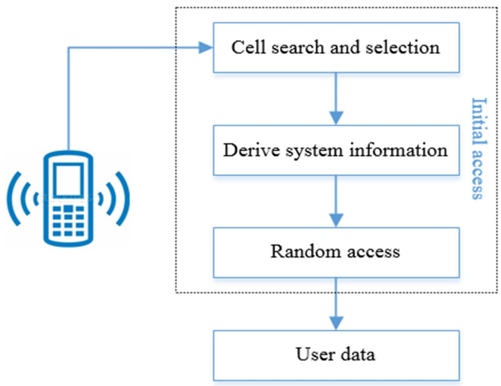

Fig.1. LTE Initial Access: cell search and cell selection

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The upcoming 4G networks are intended to provide a variety of services, high quality of audio and video calling, and high data rates through wireless channels. Even though, still the framework for 4G systems are not yet designed. The 4G system supports up to 2-10 GHz wideband frequencies. These kind of high frequencies results rapid signal degradation and diffusion from small obstacles and hence services the reduction of cell size. As a significance, 4G systems have various size cells: picocells, microcells and macrocells. In micro and picocells, the base station antenna are at the range below roof level. Hence, it is less affected and disturbed by the interference from the nearby base station. It means, the same frequency can be reused more frequently in a micro or picocells than macrocells.

In this paper, a novel approach is proposed for cell selection and planning in WiMAX. The coverage based cell selection algorithm is introduced based on the three major criteria. The criteria are demand, profit and capacity. It is used to the best coverage base station to handover the mobile device from one base station to another.

The remainder of this paper is organized as follows. Section 2 summarizes the related works in the cell selection techniques. Section 3 describes about the proposed system. Section 4 describes the performance analysis. And finally, the paper is ended with the conclusion and future work at section 5.

2. RELATED WORK

Cell Selection gained much attention in recent years. In this section the recent works related to the cell selection. *Garcia et al* designed a framework to address the interference management problem. A Generalized Autonomous Component Carrier Selection was utilized to overcome the problem. It concentrates on the downlink and it results properties of the network performance [1]. *Guo et al* investigated an automated small cell deployment for heterogeneous cellular networks. The radio planning methods were incorporated, which based on stochastic geometry and Monte Carlo simulations. Also, an automatic deployment prediction scheme for low power nodes. This scheme enhances the network performance and reduces the complexity of radio planning, energy consumption and capital expenditure of the cellular network [2]. *Huang et al* suggested an interference management scheme for heterogeneous network with the cell range extension [3]. *Kim et al* proposed a scheme for joint interference and user association in cellular wireless networks. This scheme considers a utility maximization problem for joint optimization of bandwidth and power allocations. The design can integrate a huge class of network topologies, network constraints, interference models and SNR to rate mappings. The computation of upper bounds was implemented via augmented Lagrangian techniques [4].

Lee et al introduced a spectrum aware mobility management in cognitive radio cellular networks. The goal of this scheme is to mitigate the heterogeneous spectrum availability. A mobility management scheme was established to support the varied mobility events. It incorporates the intercell resource allocation, user mobility management and spectrum mobility management. The spectrum mobility management calculated a target cell and cognitive radio user's spectrum band. It was dependent on time varying spectrum opportunities to yield better cell capacity. To minimize a switching latency a proper handoff mechanism was selected at the cell boundary [5]. *Louvro et al* designed a LTE cell coverage planning algorithm to optimize the uplink user cell throughput. This model uses an appropriate analytical mathematical approaches. It was based on queuing theory to predict the overall interference. The analytical mathematical model cell planner device can automatically adjust the predictions. It calculates the uplink cell edge to guaranteed the throughput rate [6].

Mai et al developed a multi objective evolutionary algorithm for 4G base station planning. Here a mathematical model was utilized in 4G base station planning. The cell edge rate, co-channel interference, orthogonal frequency division multiplexing (OFDM) and reference signal received power (RSRP) were considered. The goal of this scheme is to reduce the construction cost and improve the coverage and capacity [7]. *Olmos et al* proposed a cell selection algorithm for mobile networks with backhaul capacity constraints. This model analyzes the opportunity to exploit load balancing between base stations to enhance backhaul capacity utilization. The cell selection algorithm considers the radio interface and backhaul conditions. The analytical model was used to determine the performance of backhaul aware cell selection algorithm [8]. *Jung-Min et al* formulated an efficient cell selection algorithm in hierarchical cellular networks. The uplink transmit power was utilized and cells were selected based on the synchronization of multiple users [9].

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Madan et al designed an approach for cell association and interference coordination in heterogeneous LTE-A cellular networks. The cell splitting, range expansion, fast dynamic interference management for QoS through air signaling, semi static resource negotiation over third party backhaul connections and range expansion were considered to minimize the overhead [10]. *Niu et al* proposed a concept of cell zooming to adjust the cell size affording to user requirements, channel conditions and traffic load. A usage case was investigated for energy saving. Hence, centralized and distributed cell zooming algorithm were designed [11]. *Buddhikot et al* proposed a cognitive radio technology in cellular networks. The Dynamic Spectrum Access (DSA) was utilized for capacity augmentation in macro cell. Self-X mechanism was introduced to configure, monitor, diagnose, repair and optimize the LTE networks [12]. *Boiardi et al* designed an energy efficient model for cellular network planning under insufficient cell zooming. The evaluation strategy was introduced to determine the energy efficiency [13].

Singh et al proposed an efficient algorithm for optimizing the base station site selection to cover a convex square region in cell planning [14]. *Fallah-Mehrjardi et al* suggested a centralized algorithm to attain the user level fairness and spectrum efficiency. A priority based greedy coloring algorithm was used to enhance the reuse metric and spectrum efficiency. To share the remaining resources, a novel fairness index was applied among users of FAPs [15]. *Sharma et al* introduced an artificial bee colony optimization aided adaptive resource allocation in OFDMA systems with proportional rate constraints. A probabilistic selection scheme was incorporated, which assigns the probability values to the possible results based on their fitness values. The infeasible individuals were used to allocate the resources to the corresponding users based on their violations in the downlink OFDMA system [16]. *Lopez-Perez et al* focused the concept of heterogeneous networks and discuss about the challenges and issues regarding such network structures. Also, the standardization activities were focused within the 3GPP associated with improved inter-cell interference organization [17].

Jung et al formulated an efficient cell selection algorithm in hierarchical cellular networks with multi user coordination. The uplink transmit power was utilized and the cells were selected based on the coordination of multiple users instead of a single user [18]. *Juejia et al* introduced an energy source aware target cell selection and coverage optimization scheme for power saving in cellular networks. This scheme focused on guiding more power consumption interested in green source energy. Hence, hand over and power control parameters were used for target cell selection and coverage optimization [19]. *Jong et al* handled an intelligent cell selection which satisfies the user requirements for inter system handover in heterogeneous networks. The system considers the following parameters: communication cost, mobile speed, system interference, packet loss, transmission delay and cell loads in the decision process. The calculation procedure needs the aggregation functions based on fuzzy set theory. Depends on the current state of heterogeneous networks, the relative value of cell selection parameters were analyzed [20].

Table I Various Generations Of Network Systems

1G Analog system	2G Digital system	3G Multimedia applications	4G Ubiquitous service
➢ Circuit switched ➢ Basic voice service	➢ Circuit switched ➢ Voice and data applications	➢ Digital packet and circuit switched ➢ Multimedia services	➢ Digital packet switched ➢ High quality multimedia
AMPS	GSM,IS-95, IS-136	CDMA2000, WCDMA, HSPA	LTE/LTE-A, WiMAX
FDMA	TDMA, CDMA	CDMA	OFDMA
8 Kbps	144 Kbps	2 Mbps	100 Mbps to 1 Gbps

TABLE I illustrates the different types of generations of network systems and TABLE II depicts the comparison between the LTE and LTE-A.

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Table II Requirements Of LTE And LTE-A [21]

	LTE		LTE-A	
	Downlink	Uplink	Downlink	Uplink
Peak spectrum usage efficiency (b/s/Hz)	>5	>2.5	30	15
Average spectrum usage efficiency (b/s/cell)	1.6-2.1	0.66-1.0	2.4-3.7	1.2-2.0
Cell-edge spectrum usage efficiency (b/s/user)	0.04-0.06	0.02-0.03	0.07-0.12	0.04-0.07
Operating bandwidth (MHz)	1.4 – 2.0		Up to 100	
User plane delay (unidirectional) (ms)	<5		<5	
Connection setup delay (ms)	<100		<50	

3. DEVELOPMENT OF COVERAGE BASED CELL SELECTION ALGORITHM FOR WIMAX

The development of a new generation of wireless is intended to complement and replace the 3G systems. The 4G networks provides seamless connection to huge services and retrieving many informations, images, and video and so on. Being highly dynamic and application adaptability are the key features of 4G services.

Every network needs cell planning in order to improve the coverage and avoid interference. The cell planning process includes various tasks to attain a well working network. Cell planning is a critical section for effective design, deployment and development of broadband wireless networks. Appropriate cell planning and succeeding network optimization are necessary to attain the maximum availability and performance for all system users. An efficient planning is accompanied by a severe process of investigation, definition of system wide technology parameters, analysis and allocation of radio frequency resources. The primary goal of cell planning projects is to maximize traffic capacity and performance by optimizing system coverage and spectrum efficiency. The flow of the proposed structure is depicted in Fig.2.

3.1 LTE-A Cell Selection

LTE depends on a hierarchical cell search procedure where the radio cell is identified by a cell identity. The establishment of LTE-A focused on resulting higher bandwidths and enhanced performance for the mobile user. LTE-A includes the carrier aggregation up to 100MHz. LTE-A can provide high speed, high capacity mobile broadband networks. The maximum channel bandwidth is up to 100MHz and maximum data rate speed is up to 3Gbps. LTE-A service areas can be extended gradually to existing LTE service areas due to backward compatibility of LTE-A with LTE.

The node location is updated to select the best coverage base station. The following metrics are considered to select the base station.

- Demand (i)
- Profit (j)
- Capacities (k)

The metric demand measures that how many users are waiting for each base station. Profit estimates that how much free space is available at the base station. Based upon the demand and profit, the capacity is computed as the ratio between the above two criteria.

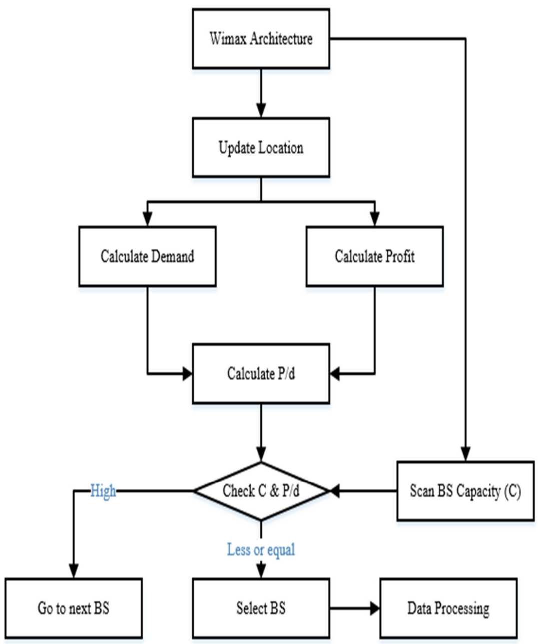

Fig.2. Complete Structure Of The Development Of Cell Planning And Selection For Wimax

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Fig.2. depicts the complete structure of the proposed model. WiMAX is a wireless communications standard which is especially designed to allow 30 to 40 Mb/s data rates and nowadays it provides up to 1 Gb/s for fixed mobile stations. The base station capacity is calculated based on the coverage based cell selection algorithm.

CBCS: Coverage based cell selection Algorithm

S = A, B, C
Demand i
Profit j
Capacities k
m ← Maxflow (S_x)
If *t is a Mincut in* S_x *then*
    Return m
End if
If *there exist* $b \in B$ *such that* $p(b) = 0$ *then*
    $m \leftarrow CBM(S' = (A, B\backslash\{b\}, C\backslash C(b)), i, j, k)$
    Return m
Else
    For every $b \in B$, *set* $\epsilon_b = \frac{j(b)}{i(b)}$
    Set $\epsilon = min_b\ \epsilon_b$
    For every $b \in B$, *set* $j_1(b) = \epsilon \, . \, i(b)$
    Set $j_2 = j = j_1$
    $m \leftarrow CBM(S, j, j_2, k)$
    for every b such that $j_2(b) = 0$ *do*
        $Q \leftarrow \{b' \in B \mid m(b') = i(b')\}$
        Set $E_{\bar{Q}\{b\}} = E(B\backslash(Q \cup \{b\}))$
        Set $N_{Q\cup\{b\}} = A\backslash E_{\bar{Q}\{b\}}$
        $n \leftarrow Maxflow \quad (S_l(N_{Q\cup\{b\}}, Q \cup \{b\}))$
        $o \leftarrow Maxflow \quad (S_l(A, Q \cup \{b\}))$
starting from
        the initial feasible flow n
        if *t is a Mincut in* $(S_l(A, Q \cup \{b\}))$
            $m \leftarrow o$
        end if
    end for
    return m
end if

The subroutine Mudflow (S_l (A, B)) denotes the calculation of the maximum s-t flow in the graph (S_l (A, B)) using the algorithm that estimates a maximum flow from s to t.

Example scenario for real network:

A coverage area is splitted into cells and each cell is served by a base station. Each base station is assigned to a group of channels. When a mobile device is in a call and transfers from the current cell to a neighbor cell, then the network needs to switch over the device to the neighboring base station. This process is named hand off.

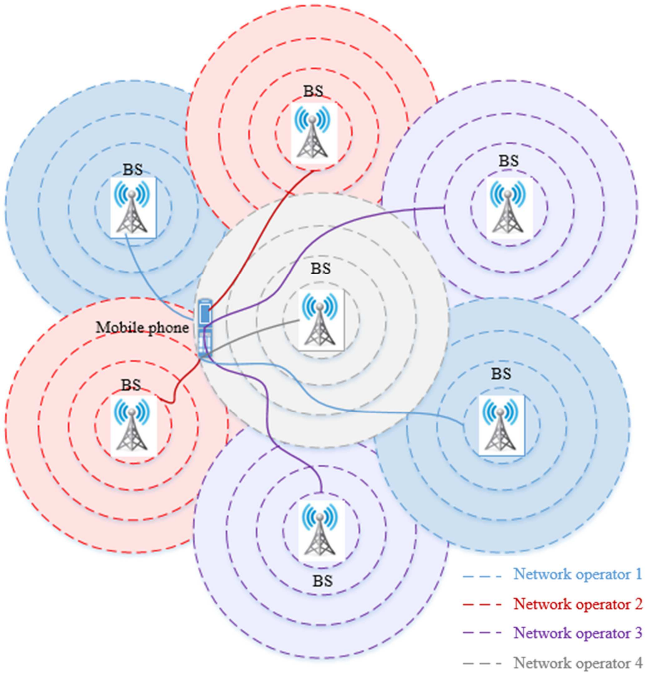

Fig.3. Example For Scenario In A Real Network

The mobile node receives all the base stations but at different power levels. The mobile user selects the strong cell for each carrier. Fig.3. illustrates the example scenario for real network base station selection.

3.2 Major Technologies used in LTE-A

Each technology can be adopted independently and can be used with any existing LTE band. Some of the technologies are:

i. Carrier Aggregation- Aggregation of multiple LTE carriers can achieve high data rate transmission using up to 100MHz bandwidth.
ii. Heterogeneous Network (HetNet) - Various types of base stations are deployed in the same geographical area. Enhanced inter cell interference coordination among base station to improve cell edge throughput etc.
iii. Enhanced MIMO – Increased number of MIMO streams. Enhancement of multiuser MIMO.
iv. Coordinated Multipoint Transmission and Reception (CoMP) – Coordinated transmission and reception among multiple base stations to improve cell edge throughput etc.
v. Layer 3 relay (wireless backhaul) – Relay transmissions between a base station and a mobile station to extend coverage to various locations.

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4. PERFORMANCE ANALYSIS

In this section, the performance of the proposed model is validated and compared with the existing models. The simulation results are weighed with the following existing approaches: Greedy approach, Bounded Greedy Weighted Algorithm (BGWA), Call Admission Control (CAC) and Joint Scheduling & Resource Allocation (JSRA). The network throughput and bandwidth consumption ratio are considered and evaluated for all the existing approaches and the proposed Coverage Based Cell Selection (CBCS) algorithm.

4.1 Network Throughput Analysis

Network throughput is defined as the rate of successful message delivery through a communication channel. This data can be transferred through a logical or physical link.

Scenario 1: For varying the amount of bandwidth, the network throughput is determined and compared between the proposed CBCS algorithm and the existing approaches. Fig.4 shows that the proposed model can result better network throughput than the existing approaches in terms of varying amount of bandwidth.

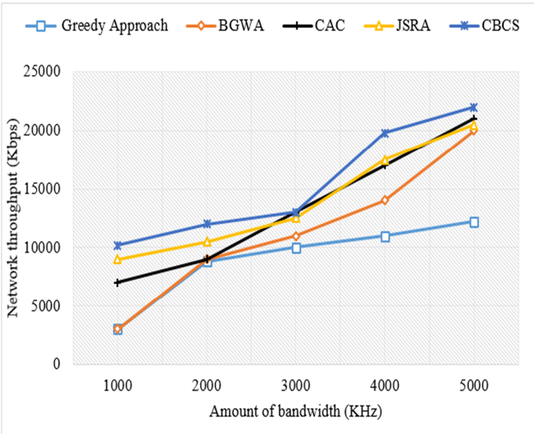

Fig.4. Amount of bandwidth vs Network throughput

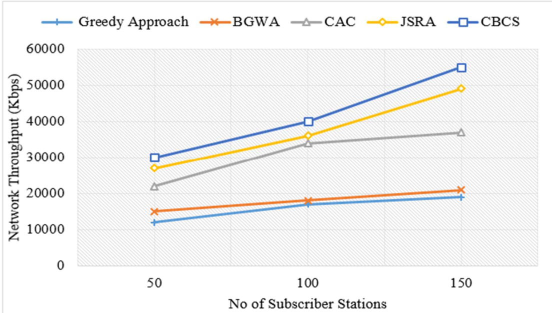

Fig.5. No Of Subscriber Stations Vs Network Throughput

Scenario 2: The number of subscriber stations is varied as 50, 100 and 150. Fig.5. shows that the proposed model can result better network throughput than the existing approaches while changing the number of subscriber stations.

4.2 Bandwidth Consumption Ratio

Network bandwidth is an amount of the bit rate of available or consumed data communication resources stated in terms of Kb/s, Mb/s etc.

Scenario 3: It is evaluated in terms of amount of bandwidth and compared with the existing approaches. Fig.6. depicts that the proposed CBCS algorithm results better bandwidth consumption ratio than the existing approaches like greedy approach, BGWA, CAC and JSRA.

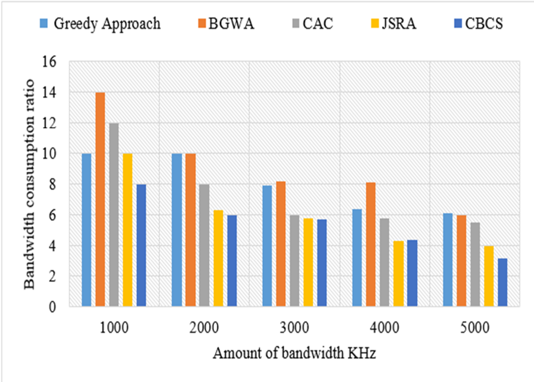

Fig.6. Amount of bandwidth vs Bandwidth consumption ratio

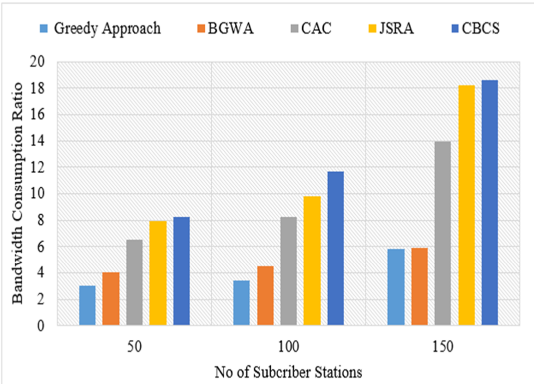

Fig.7. No of subscriber stations vs Bandwidth consumption ratio

Scenario 4: The number of subscriber station is varied and the bandwidth consumption ratio is evaluated. Fig.7 noted that the proposed CBS can result better bandwidth consumption ratio than the existing approaches.

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5. CONCLUSION AND FUTURE WORK

In this paper, a coverage based cell selection algorithm for WiMAX is introduced. The proposed algorithm is well suitable to choose the best coverage base station. The major criteria for cell selection such as demand, profit and capacity is also presented to select the base station. The performance of the proposed CBCS algorithm is compared with the existing approaches. It obviously proves that the proposed model can yield better network throughput and also provides bandwidth consumption ratio than the existing approaches.

In future, the proposed system is incorporated with the relay station to balance the load and traffic control.

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