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JSRA: Robust Joint Scheduling and Resource Allocation in IEEE 802.16 WiMAX Wireless Networks

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Abstract-*The WiMax (IEEE 802.16) standard provides a mechanism for creating multi-hop mesh, which can be deployed as a high speed wide-area wireless network. The scheduling and resource allocation has become a significant issue in WiMax wireless networks. In the proposed work, the Joint Scheduling and Resource Allocation (JSRA) Algorithm is introduced to maximize the network throughput and provides the robust resource allocation in WiMax. The proposed methodology supports unicast mechanism which can be applied to any kind of wireless networks. At first, the route request (RREQ) is composed from the receiver. Consequently, the route is discovered and further the data rate is evaluated. The time slot is allotted for discovering the route. The proposed method provides the time slot for each and every authenticated user using JSRA algorithm. Therefore, the waiting time is reduced for the user and thus the user satisfaction is enhanced. The experimental analysis achieves higher network throughput to bandwidth consumption ratio than the existing greedy approaches.*

Keywords-WiMax, IEEE 802.16, Resource allocation, Unicast, Joint Scheduling and Resource Allocation (JSRA) algorithm, Time slot

I. INTRODUCTION

WiMax is an acronym meaning of Worldwide Interoperability for Microwave Access. It is an IP based wireless broadband technology, which supports point to multi-point (PMP) broadband wireless access. It provides performance similar to 802.11/Wi-Fi networks with the coverage and QoS (Quality of Service) of mobile networks. This technology is specified by the IEEE 802.16 standard. WiMAX supports numerous networking usage models: (1) transferring of data across an internet service provider (ISP) network, namely backhaul, (2) formation of fixed wireless broadband internet access instead satellite internet service, (3) formation of mobile internet access. The benefits of WiMax are:

- Mobility
- Security
- QoS
- Scalability
- Portability
- Higher throughput
- Last mile connectivity

Also provide mesh technology than the wired networks.

Figure 1 describes the architecture of WiMax which contains one Base Station (BS), established by the service provider to redistribute the technology in a covered area and one or more Mobile Stations (MSs) or Subscriber Stations (SSs), established with clients [1]. The major goal is to deliver high-speed internet access without wires. WiMax is a more complex technology than Wi-Fi and has to handle issues of importance such as QoS guarantees, carrier-class reliability, Non-Line-of-Sight (NLOS). The data are transmitted from SSs via mesh and PMP operational modes which is subjected by BS. This transmission can be accomplished through the downlink and uplink channel. The downlink channel is employed only by the BS where the transmission is from BS to SS. Whereas, the uplink channel is used for transmitting the data from SS to BS. Even if there is no direct LOS, WiMax can afford connectivity to users within a 31 mile radius. Therefore, it is structured as a wireless alternate to Digital Subscriber Line (DSL) and cable for last mile broadband access.

In the proposed work, the joint scheduling and resource allocation is introduced. The architecture of WiMax (IEEE 802.16) is used for unicasting process. Initially, the route request (RREQ) is collected from the receiver. Subsequently, the route is discovered and the data rate is calculated. While allocating the route, the time slot is also allotted. After the evaluation of data rate, it checks for an availability of resources. If the corresponding resource is high, then it backtracks to collect the RREQ from the receiver. Otherwise, it follows the sub-section of resource allocation algorithm when the time slot is free.

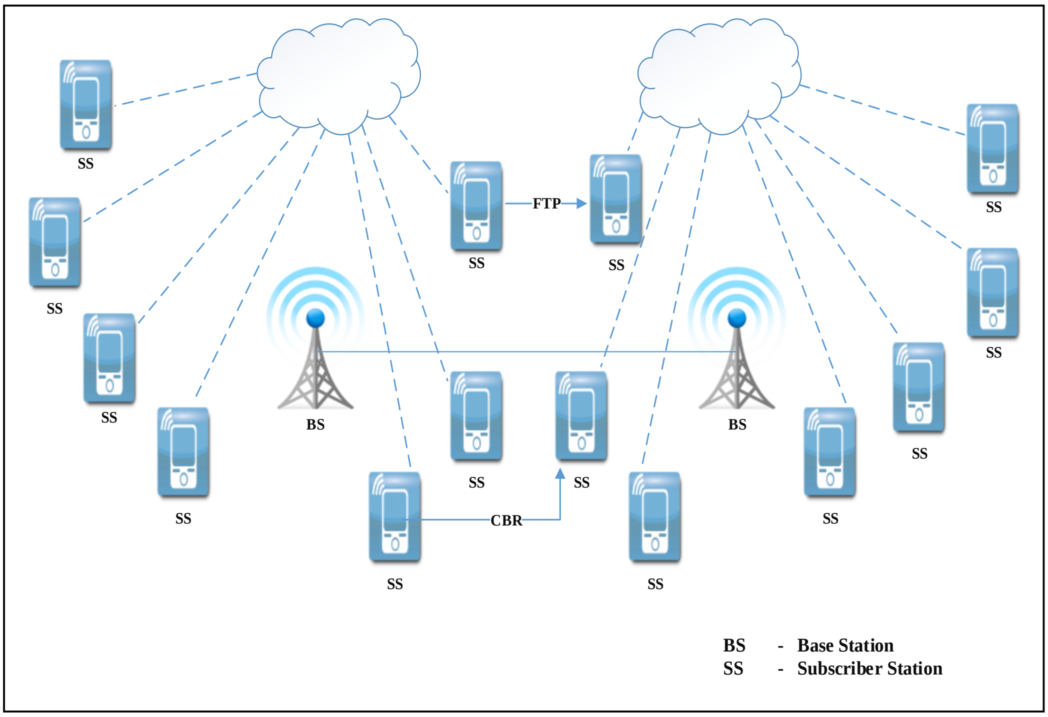

Figure 1. Architecture of WiMax

In the proposed work, the joint scheduling and resource allocation is introduced. The architecture of WiMax (IEEE 802.16) is used for unicasting process. Initially, the route request (RREQ) is collected from the receiver. Subsequently, the route is discovered and the data rate is calculated. While allocating the route, the time slot is also allotted. After the evaluation of data rate, it checks for an availability of resources. If the corresponding resource is high, then it backtracks to collect the RREQ from the receiver. Otherwise, it follows the sub-section of resource allocation algorithm when the time slot is free.

The rest of the paper is systematized as follows. Section II briefly overview the related works in the scheduling and resource allocation in WiMax wireless networks. Section III involves the detailed explanation about the proposed method. Section IV describes the implementation details. Section V summarizes with a brief conclusive remark and discussion on future works.

II. Related Work

This section deals with the related work based on WiMax wireless networks. This also describes the scheduling and resource allocation methodologies in WiMax. Kim et al focused on the difficulties of resource allocation in 802.16j based networks. This was enhanced with non-transparent relay stations (RSs). Initially, an optimal scheme for two-hop relaying networks was proposed. This scheme maximizes the throughput of the cell and also provides lower outage performance [2]. Tarhini et al introduced a new density-based admission control scheme. A novel QoS-oriented resource allocation approach was utilized to reduce the higher dropping rate. It was the combination of streaming (for instance voice) and elastic (data) flows in IEEE 802.16e mobile WiMax. These flows were more tolerant to delay [3].

Ng et al suggested the design of resource allocation and scheduling for orthogonal frequency division multiple access (OFDMA) decode-and-forward (DF) relay networks. A distributed resource allocation algorithm was proposed for secrecy and channel outage [4]. Afolabi et al proposed channel-aware multicast scheduling and resource allocation (MSRA) technique. This also explained the formation of the multicast group. This technique was processed for downlink multicast services in ODFMA systems. It maximizes the throughput and better performance [5]. Ng et al addressed the scheduling difficulty in multi-cell OFDMA systems with DF relaying. A time slot strategy was integrated to alleviate the interference. It provides higher computational complexity and also signaling overhead using semi-distributed algorithm [6].

Li et al introduced a novel proximal optimization algorithm. It also addressed the difficulty of joint multi-path QoS routing and scheduling in wireless mesh network. It solved the subproblem of routing and scheduling using dual decomposition [7]. Lu et al studied the impact of relay station (RS) placement on IEEE 802.16j WiMax network. An effective heuristic algorithm was introduced to describe (a) the resource allocation schemes, (b) location of RS deployment. The RS placement problem was formulated using an Integer Linear Programming (ILP) model. It attains higher throughput [8]. Karimi et al proposed a two-level scheduling mechanism which was an integration of Priority Queuing (PQ), Weighted Round Robin (WRR), and First come, First served (FCFS). It provides better performance for best effort (BE) service class. Also accomplish high throughput of the network[9].

Huang et al presented a novel opportunistic layered multicasting (OLM) which was a joint user scheduling and resource allocation methodology. It also contributed the formulation for efficient multicasting of layered video over mobile WiMax. It was applicable to 4G technology based on OFDMA in the downlink distribution [10]. Font-Bach et al proposed a multi-antenna WL communications testbed, namely, Generic hardware demonstrator for multi input multi output (MIMO) systems (GEDOMIS). This estimates the formation of the whole PHY-layer of a real-time MIMO mobile WiMax receiver [11]. Zubow et al designed an SDMA-OFDMA Greedy Scheduling Algorithm (sGSA) for WiMax networks. A new complexity algorithm was described to predict the signal-to-interference-plus-noise ratio (SINR). It decreases the overall computational load [12].

Sheu et al presented a bounded greedy weighted algorithm (BGWA), which prevent redundant bandwidth allocation. It minimizes computational complexity and maximizes the throughput of network and satisfied users [13]. Esmailpour et al proposed the Radio Resource Management (RRM) methods in WiMax. It also introduced two WiMax QoS metrics (fairness and utilization). It provides better performance [14]. Hwang et al suggested a new adaptive downlink bandwidth allocation method (DBAM). It also introduced the hierarchical priority queuing with weighted round robin (HPWRR) scheduling algorithm. It attains greater resource utilization and also improves the multicast traffic [15].

Yousefi et al proposed a multicast interference-aware scheduling mechanism for WiMax mesh networks. It leads to a better throughput and delay which supported by the spatial mini-slot [16]. Lawal et al investigated the distributed QoS-oriented model. It improvises the performance of network for fixed WiMax. Also develop the system of point-to-point and point-to-multipoints [17]. Huang et al addressed the sleep scheduling problem in IEEE 802.16j networks. To tackle this problem, an energy efficient sleep scheme was introduced [18]. Chang et al proposed an effective relay placement mechanism. It minimizes the number of relay stations, improves the network throughput, and minimize the cost of deploying BS [19]. Chen et al presented the new DL (Downlink) and UL (Uplink) Alignment (DUAL) scheme. The effect of energy conversation was improved using DUAL [20].

III. Joint Scheduling and Resource Allocation (JSRA) Methodology for Unicasting

This section explains the comprehensive description of the proposed methodology. Figure 2 depicts the overall flow where the architecture of WiMax (IEEE 802.16) is used for unicasting process. Initially, the route request (RREQ) is collected from the receiver. Subsequently, the route is discovered and the data rate is calculated. While allocating the route, the time slot is also allotted. After the evaluation of data rate, it checks for an availability of resources. If the corresponding resource is high, then it backtracks to collect the RREQ from the receiver. Otherwise, it follows the sub-section of resource allocation algorithm when the time slot is free.

A. Framework of Resource Allocation

In WiMax networks, the time slot is allocated for downlink sub-frames. Let T refers to the number of time slots allotted for unicast service in a subframe of the downlink. The data rate accompanying for each and every profile is ordered by ascending, and the number of time slots depleted for sending the similar quantity of data is ordered by descending. The base station (BS) requisite to allocate the resources while the resource is inadequate. It maximizes the total system utilization.

B. JSRA Algorithm for unicasting

Let j be the layer and i be the program for each unicast subsession. The base station chooses cluster members one by one for service in descending order. In accordance with the standard of IEEE 802.16, the data are transmitted over selected user in each cluster.

1) JSRA Function

Let pi, j represents the necessary data rate for the allocation of unicast layer [i, j]. Assume JSRAi,j(k) refer to the total service for allocating k users. The JSRA envelop JSRA*i,j(k) and its marginal envelop ∆JSRA*i,j(k) are described as follows:

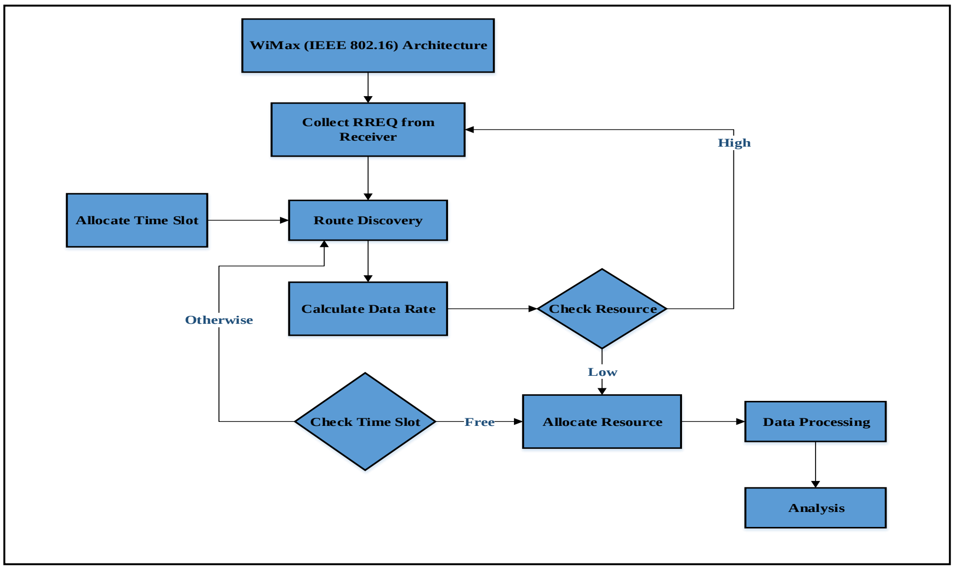

Figure 2. The overall flow diagram of the proposed methodology.

$$\Delta JSRA{*}i,j(k)=\max_{K_{i,j}\geq a\geq k}\left\{\frac{a.ue_{i,j}-JSRA^{*}i,j(k)}{t_{i,j}(a)-t_{i,j}(k-1)}\right\} \quad (1)$$

JSRA*i,j(k)= JSRA*i,j(k-1)+Δti,j(a). ΔJSRA*i,j(k) (2)

where Ki, j is the total number of users in layer [i, j].

Probably, JSRA*i,j(k) is determined by interpolation from the slope

$$\max_{K_{i,j}\geq a\geq k}\left\{\frac{a.ue_{i,j}-JSRA^{*}i,j(k)}{t_{i,j}(a)-t_{i,j}(k-1)}\right\} \quad (3)$$

Technique: Joint_Scheduling and Resource_Allocation Function *($\Delta JSRA_{i,j}(k)$)*
Find: *$JSRA^{*}_{i,j}(k)$, $\Delta JSRA^{*}_{i,j}(k)$*

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1. Let $\Delta JSRA^{*}_{n}(0)\leftarrow 0$;
2. **for** $a=1$ *to* $K_{i,j}-1$,

   let $\Delta JSRA^{*}_{i,j}(k) \leftarrow \max_{K_{i,j}\geq a\geq k}\left\{\frac{a.ue_{i,j}-JSRA^{*}i,j(k)}{t_{i,j}(a)-t_{i,j}(k-1)}\right\}$

   let $JSRA^{*}_{i,j}(k) \leftarrow JSRA^{*}_{i,j}(k-1)+\Delta t_{i,j}(a).\ \Delta JSRA^{*}_{i,j}(k)$

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2) Resource Allocation based on JSRA Function

The proposed resource allocation algorithm called Joint Scheduling and Resoure Allocation (JSRA) for unicast service over WiMax. the system assists the necessary layers from all the contributed programs. The rest of the time slots are then allocated to the other layers of every program wherein there are others waiting for the users. Depends upon the data rate, the quantity of resource allocated to a cluster is determined. To enlarge the total service of the system, the system must describe (a) the number of users comprised in each layer and (b) which layer should be served for remaining wireless resources.

This algorithm depends upon the JSRA function and its marginal JSRA function. For every layer [i, j], it initially finds an unserved user. Let Smax be the layer that contributes the candidate user whose marginal JSRA envelope is the greatest among all users in all layers. The cluster selected by the algorithm for service is evaluated by discovering Smax iteratively until all the time slots have been allotted. The base station then schedules corresponding layers in which there are users chose by the algorithm and transmits that required layers by using the selected users in each cluster. Ki, j be the total number of users accomplished by receiving subsession from layer [i, j], and ki , j is the number of users that essentially selected by the system for service for cluster [i, j].

Algorithm: Joint Scheduling and Resource Allocation (JSRA) for Unicasting
Input: *I*, *J*, *L* and *T*
Find: Slot time allocation T, where $T_i=\{t_{i,j}: t_{i,j} \geq 0, j=1,2,\ldots,L\}$

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1. Let $T_c \leftarrow T$;
   for each unserved compulsory layer $[i, j]$, $\forall i, j,\ l \leq i \leq M,\ l \leq j \leq L,$
   let $k_{i,j} \leftarrow K_{i,j}$;
   let $T_c \leftarrow T_c - t_{i,j}(K_{i,j})$;
   end for;
2. **for** each unserved non-compulsary layer [i, j], $\forall i, j,\ l \leq i \leq M,\ l \leq j \leq L,$
   let $k_{i,j} \leftarrow 0$;
   $\Delta JSRA^*_{i,j}(.) \leftarrow$Joint_Scheduling_Resource_Allocation Function $(\Delta JSRA_{i,j}(.))$;
   end for;
3. **do**
   let $S_{max} \leftarrow$NULL;
   let $S_{max} \leftarrow arg_{\forall i,j|\ j=0 \cup k_{i,j} < k_{i,j-1}} \max \{\Delta JSRA^*_{i,j}(k_{i,j})\}$;
   If $(S_{max} \neq NULL)$ **then**
   If $(T_c > \Delta t_{Smax}(k_{Smax}+1))$ **then**
   let $k_{Smax} \leftarrow k_{Smax}+1$;
   let $T_c \leftarrow T_c - \Delta t_{Smax}(k_{Smax})$;
   let $t_{Smax} \leftarrow t_{Smax} + \Delta t_{Smax}(k_{Smax})$;
   else let $T_c \leftarrow 0$;
   end if;
   end if;
   loop until ($T_c=0$ *or* S_{max} = NULL);
   end do;
   return T;

IV. Performance Analysis

A. Amount of Bandwidth vs. Network Throughput

The network throughput is denoted as the degree of effective message delivery over a communication channel. It is measured in terms of bits per second (bps). Figure 3 represents the performance analysis of the network throughput with respect to the amount of bandwidth. It analyzes the existing methods: greedy approach, bounded greedy weighted algorithm (BGWA), call admission control (CAC) with the proposed joint scheduling and resource allocation (JSRA) methodology. The proposed approach attains higher network throughput than the existing methods.

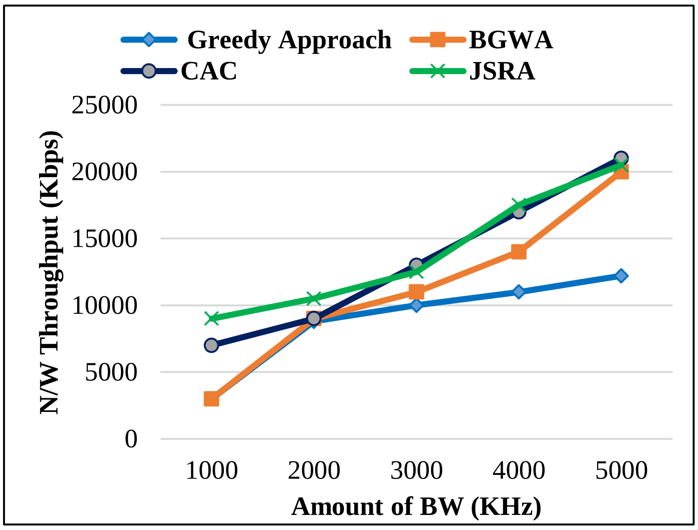

Figure 3. The result of network throughput as to the amount of bandwidth for existing greedy approach, BGWA, CAC and the proposed JSRA approach.

B. Amount of Bandwidth vs. Network Throughput to Bandwidth Consumption Ratio

The bandwidth is defined as the data rate maintained by a network connection or interface. The higher the capacity, the greater the performance. Figure 4 describes the performance analysis of the network throughput of bandwidth consumption ratio with respect to the amount of bandwidth. It analyzes the existing methods: greedy approach, bounded greedy weighted algorithm (BGWA), call admission control (CAC) with the proposed joint scheduling and resource allocation (JSRA) methodology attains lower network throughput to BW consumption ratio than existing.

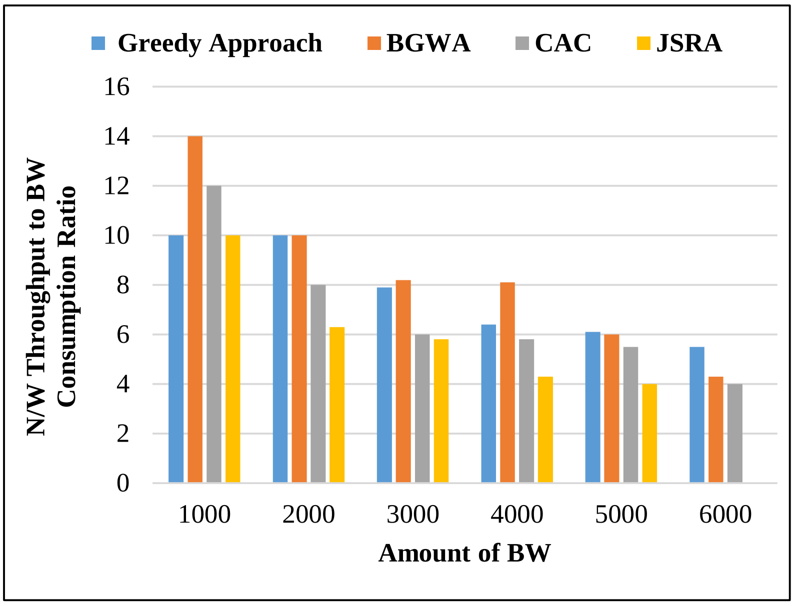

Figure 4. The result of network throughput to bandwidth consumption ratio with regard to the amount of bandwidth for existing greedy approach, BGWA, CAC and the proposed JSRA approach.

C. Number of SSs vs. Network Throughput

Figure 5 depicts the performance analysis of the network throughput with respect to the number of subscriber stations (SSs). It analyzes the existing methods: greedy approach, bounded greedy weighted algorithm (BGWA), call admission control (CAC) with the proposed joint scheduling and resource allocation (JSRA) methodology. The proposed approach achieves higher network throughput than the existing methods.

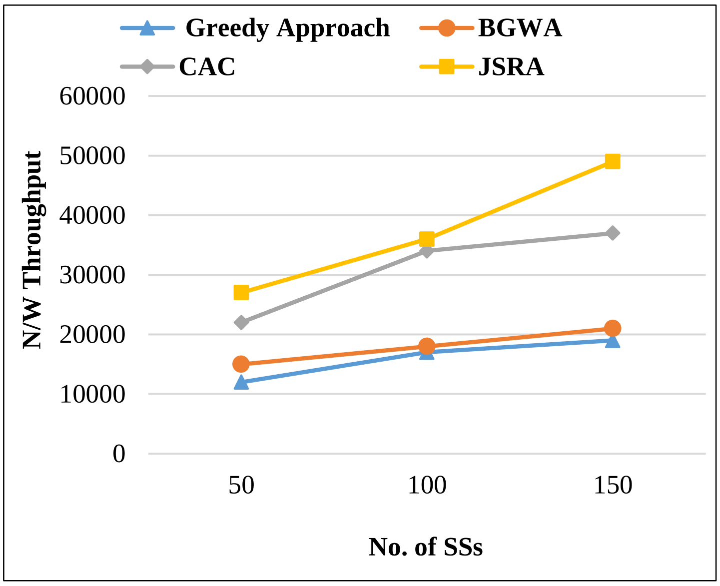

Figure 5. The result of network throughput as the number of SSs for existing greedy approach, BGWA, CAC and the proposed JSRA approach.

D. Number of SSs vs. Network Throughput to Bandwidth Consumption Ratio

Figure 6 shows the performance analysis of the network throughput of bandwidth consumption with respect to the number of subscriber stations (SSs).

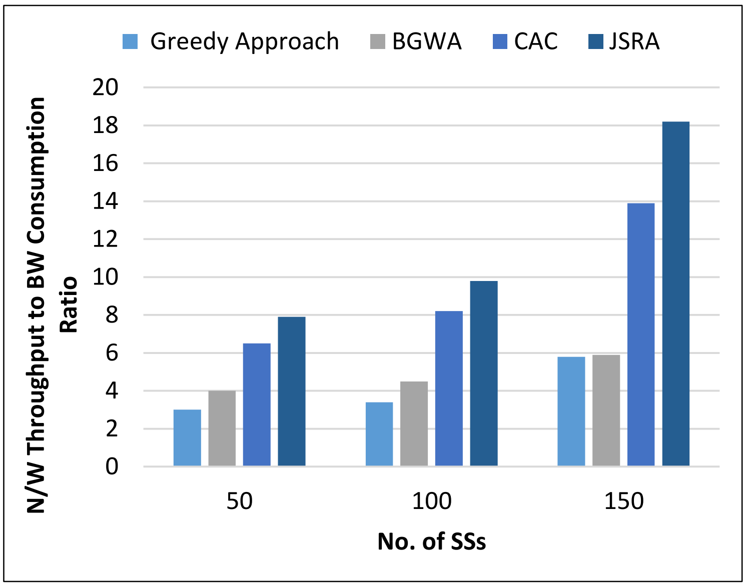

Figure 6. The result of network throughput to bandwidth consumption ratio with respect to the number of SSs for existing greedy approach, BGWA, CAC and the proposed JSRA approach.

It analyzes the existing methods: greedy approach, bounded greedy weighted algorithm (BGWA), call admission control (CAC) with the proposed joint scheduling and resource allocation (JSRA) methodology. The proposed approach accomplish greater network throughput to BW consumption ratio than the existing methods.

V. Conclusion and Future Work

In the proposed work, the Joint Scheduling and Resource Allocation (JSRA) is introduced to maximize the network throughput and provides the robust resource allocation in WiMax wireless networks. This major goal of this proposed approach is to accomplish the maximum user satisfaction for the user. Meanwhile, the time slot is allotted for each and every authenticated user for reducing the waiting time. After allocating the resources, the data are processed and further it performs the analysis. The experimental results explained above contributes the highest network throughput among the amount of bandwidth than the existing greedy approach, bounded greedy weighted algorithm (BGWA), call admission control (CAC). In future enhancement, 4G cellular network are intended to provide a variety of service, high quality of audio and video calling, and high data rates through wireless channels.

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