Analysis of Bandwidth Recycling in IEEE 802.16 Network Using PSA, RB-RFA & HSA

Nilesh M. Verulkar[#1], Dr. Umesh S. Bhadade[#2]

[#1]PG Student, [#2] Professor and Head
[#1] [#2] Department of Electronics & Telecommunication, SSBT's COET, Bhambhori,
North Maharashtra University, Jalgaon, Maharashtra (India)

Abstract— **IEEE 802.16 network protocol is designed to provide a Worldwide Interoperability for Microwave Access (WiMAX). Due to limited bandwidth and an expensive radio spectrum available for communication, it is necessary to use one bandwidth more than one time in a same network when it became unused. For that purpose "Bandwidth Recycling" concept is introduced. The spectrum (bandwidth) is specifically allocated by agency to various users, but many times it is seen that the spectrum is not fully utilized by the users in the specific interval. This unused bandwidth can be allocated to other users who demands for more bandwidth for that specific interval without changing existing bandwidth scheme.**

In this paper we analyse different algorithms which does the recycling of bandwidth as per need is presented. To recycle the unused bandwidth priority based scheduling (PSA) algorithm has been developed & to improve the recycling effectiveness rejected bandwidth request first algorithm (RBRFA) and history based scheduling algorithm (HSA) are outlined. By implementing these all algorithm in Netbean (Version 7.4) Simulator, we have evaluated the performance of our system. Our simulation and analysis result confirmed that the proposed system can recycle unused bandwidth.

Keywords— **Base Station, Subscriber station, IEEE 802.16, Transmission station, Bandwidth Recycling**

I. INTRODUCTION

A MAN (Metropolitan Area Network) covers city. The best known examples of MANs are the cable Television (TV) networks available in many cities. These systems grew from earlier community antenna systems utilized in areas with poor air TV reception. Cable TV is not only MAN, though out; recent developments in high speed wireless internet access have resulted in MAN. It has been proposed by IEEE 802.16 and is commonly known as WiMAX.

WiMAX allows the operation from 2 GHz to 11 GHz; Due to large available spectrum; WiMAX is designed to facilitate services with high information rates for multimedia applications [11]. Wireless broadband networks have recently received vital attraction. Since it has high bandwidth range, it will increases traffic demand. To with efficiently utilize

unused bandwidth and gives other users who demands for more bandwidth for a specific interval is becoming an important parameter in wireless networking [1].

In the IEEE 802.16 standard two layers are specified, physical (PHY) and medium access control (MAC) [13]. Several advanced communication technologies are used like OFDM (Orthogonal Frequency Division Multiplex) / OFDMA (Orthogonal Frequency Division Multiple Access) and MIMO (Multiple Input Multiple Output). Hence we tend to principally target IEEE 802.16 standard (networks). IEEE 802.16 standard was designed to support the bandwidth demanding applications. In IEEE 802.16 system, two kinds of stations are presented i.e. base station (BS) and subscriber Station (SS). The BS coordinates all the communication in the network. Each network has its own one BS. The SS can deliver voice, video, and data using one common interface. An IEEE 802.16 standard support two operations of modes, first is the mandatory point-to-multipoint (PMP) mode, and second is the optional mesh mode. In a PMP network, a centralized BS is capable of connecting multiple of SSs to various public networks linked to the BS, the traffics can only occur between the BS and SSs. In the mesh mode, the SSs can also serve as routers by cooperative access control in a distributed manner. The communication between BS and SSs has two directions [10]: uplink (from SSs to BS) and downlink (from BS to SSs).

After making a network and defining initial bandwidth to each SS, if anyone SS have wastage or unused bandwidth for particular interval of time, that unused bandwidth we are giving to another SS who demands for more. So at same instant if any other SS wants more bandwidth, for that condition we proposed different algorithm as listed in proposed system. The main idea of our proposed scheme is to allow the BS to schedule a backup SS for each Transmission station (TS). The backup SS is assigned to standby for any opportunities to recycle the unused bandwidth of its corresponding TS. This backup SS we called as the complementary station (CS).

This research work is divided into two objectives 1) the existing bandwidth reservation scheme is not change. 2) Our work focuses on increasing the bandwidth. For that we

analysed a scheme "Analysis of Bandwidth Recycling in IEEE 802.16 Network.", which is recycling the unused bandwidth without introducing any extra delay using different algorithm. This scheme is specially allows to those SSs they related to non-real time applications.

The rest of paper is organized as follow, in section 2 we provide the overview of IEEE 802.16 network and its related work. Protocol and scheduling algorithm regarding to recycle unused bandwidth depend on different situation are presented in section 3. In section 4, we discuss about result analysed graph. At the end conclusion, future scope is given in section 5.

II. OVERVIEW OF IEEE 802.16

A. *Role of Bandwidth*

There is not enough bandwidth in use nowadays. It is seen that because the more of it comes into use; more of it might be in used. In fact the performance level arises all the time, however quality of service development the bandwidth that's in hand are often used a higher and higher applications and services can be developed for the customers.
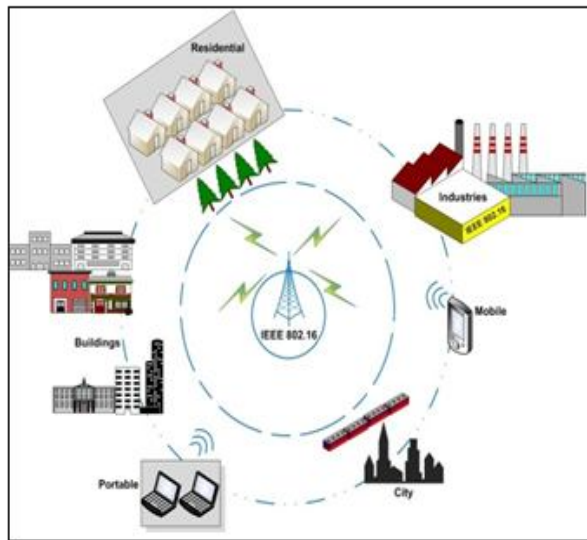

Fig. 1. Role of bandwidth requirement

Even if everybody knew that in a known period of time, the performance of systems would grow enough for the services that one would like to implement, the developed services could already be developed and tested within the recent systems with a lot of optimal usage of the resources in hand. For sure this type of an approach would lead to an advantage in the field of competition in data communications business, particularly for the service suppliers.

B. *Necessity for Recycling*

In wireless network, because of the limited bandwidth and the pricey spectrum, the demand of performance optimization became more and more vital. In most things, the optimization target is to get a higher throughput and/or lower delay system. For the delay-tolerant and contention-based applications in IEEE 802.16, the delay is not a key QoS parameter and then the uplink throughput across a set of fixed or mobile SSs stands out as the most important performance figure. Hence WiMAX is considered as a promising alternative for last mile broadband wireless access (BWA).

C. *IEEE 802.16 architecture*

The IEEE 802.16 standard common place three varieties of transmission mediums supported because the physical layer (PHY): single channel (SC), OFDM and OFDMA. There are four varieties of modulations supported point-to-multipoint (PMP) mode within which the SS is not allowed to communicate with any other SSs but the BS directly. Depending on the transmission direction, the transmissions between BS and SS's are classified into downlink (DL) and uplink (UL) transmissions. Time Division Duplex (TDD) and Frequency Division Duplex (FDD) supported in IEEE 802.16. Both UL and DL transmission scan not be operated simultaneously in TDD mode but in FDD mode [9].
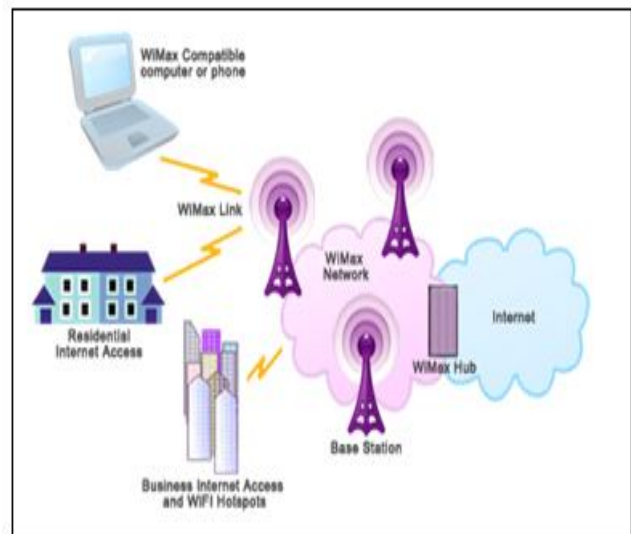

Fig. 2. IEEE 802.16 architecture

Above figure illustrates an example of general architecture of IEEE 802.16 networks. The fastened or all applications connect to the central BS, the BS receives transmissions from multiple sites and sends to net directly or

via alternative BSs. End users (laptop, telephone, computer, . etc.) inside the building, through in building networks like Ethernet or WLAN, can connect to an outside CPE and then connect to the IEEE 802.16 network.

D. *IEEE 802.16 MAC*

The frame in IEEE 802.16 standard is modeled as a stream of mini slots, which that facilitate the bandwidth simply, and is split into two sub frames as downlink sub frame and uplink sub frame. Figure shows the general frame structure of the IEEE 802.16 MAC with TDD [8]. A TDD frame has a fixed duration and contains one downlink and one uplink sub frame. The downlink sub frame is mostly broadcast and starts with preamble, downlink MAP (DL-MAP), and Uplink MAP (UL-MAP). The preamble is used by the PHY for synchronization and equalization.
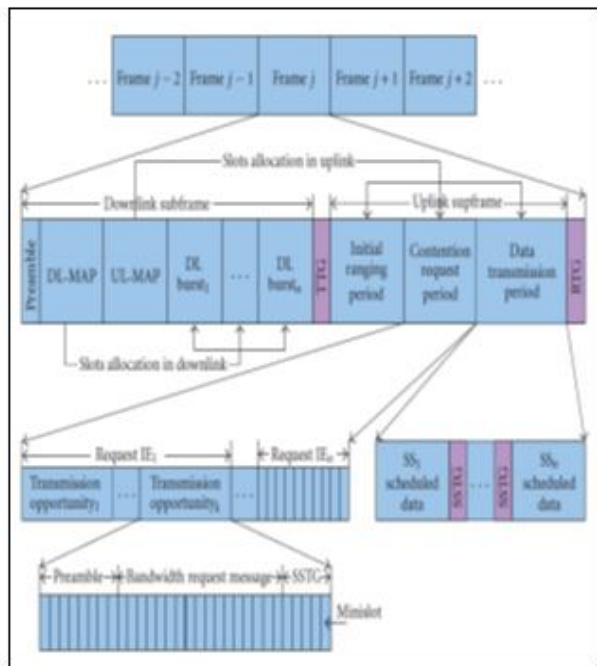

Fig. 3. IEEE 802.16 MAC [9]

The DL-MAP and UL-MAP contain the correlative information of the intervals' usage within the following downlink and uplink sub frames, respectively, and are broadcast to all SSs. The following downlink bursts carry the data to transmit to SSs and a transmit/receive time gap (TTG) in the end of the bursts to separate the downlink sub frame from the uplink sub frame.

E. *Scheduling Categories*

It represents the data handling mechanisms supported by the MAC scheduler for data transport on a given

connection. The IEEE 802.16 MAC provides QoS differentiation for the different types of applications that operate over 802.16 networks, through five defined scheduling service types.

Following table shows the comparative of all scheduling categories,

Table 1. Service Classes in WiMAX [9]

Class	Application	QoS Parameter
UGS	VOIP, E1: fixed size packet on periodic basis	Max rate, latency and jitter
rtPS	Streaming audio and video	Min rate, max rate and latency
ertPS	VOIP with activity detection	Min rate, max rate, latency and jitter
nrtPS	FTP	Min rate, max rate
BE	Date Transfer, Web, HTTP	Max rate

F. *Bandwidth Related work*

Many research works related to bandwidth utilization improvement have been proposed in the literature.

The author's investigation about the dynamic bandwidth reservation for hybrid networks is presented [2]. The authors evaluated the performance and effectiveness for the hybrid network. It also proposes efficient methods to ensure optimum reservation and utilization of bandwidth while minimizing signal blocking probability and signalling cost. In [3] dynamic resource reservation mechanism is proposed. It can dynamically change the amount of reserved resource depending on the actual number of active connections. In [4] a dynamic bandwidth request-allocation algorithm for real-time services is proposed. The authors predict the amount of bandwidth to be requested based on the information of the backlogged amount of traffic in the queue and the rate mismatch between packet arrival and service rate to improve the bandwidth utilization. The enhanced the system throughput by using concurrent transmission in mesh mode is proposed in [5]. In [6] the authors proposed a new QoS control scheme by considering MAC-PHY cross-layer resource allocation. A Comprehensive Analysis of Bandwidth Request Mechanisms in IEEE 802.16 Networks also provided the performance analysis of each BR mechanism in terms of bandwidth utilization and expected delay proposed in [7].

III. PROPOSED SYSTEM

As listed above, our proposed work is divided into two objectives 1) the existing bandwidth reservation scheme is not change. 2) This work focuses on increasing the bandwidth utilization.

There are two types of traffic in a network, variable bit rate (VBR) traffic and constant bit rate (CBR) traffic. In this project our work is based on VBR traffic, Due to its characteristics. It is very difficult for subscriber stations (SSs) to make appropriate bandwidth reservation. Therefore, the bandwidth not utilized all the time. Thus we defining following three algorithms, which used recycle the unused Bandwidth. The approach of the proposed scheme is to allow the BS to pre-assign a CS for each TS at the beginning of a frame. The CS waits for the possible opportunities to recycle the unused bandwidth of its corresponding TS. The CS information is added in a list, called complementary list (CL). The CL includes the mapping relation between each CS and TS.

For example, CSj is scheduled as the corresponding CS of TSj , where $1 \leq j \leq k$. When TSj has unused bandwidth, it performs the protocol as state below,

If CSj receives the message sent from TSj, it will transmit data by using the agreed burst profile.

The proposed scheme is divided into two parts: the protocol and the scheduling algorithm. The protocol describes how the TS identify the unused bandwidth and informs recycling opportunities to its corresponding CS. The algorithm always helps the BS to schedule a CS for each TS.

A. Protocol

In this work, we intend to recycle the unused space for data transmissions. Instead of padding all portion of the unused bandwidth in our scheme, a TS with unused bandwidth transmits only a SBV and a RM shown in Fig. 4. The SBV is used to inform the BS that no more data are coming from the TS.
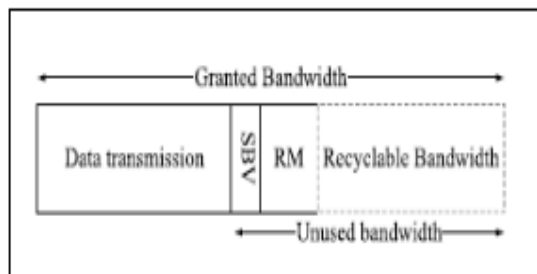

Fig. 4. Messages to release the unused bandwidth within

UL transmission interval [1]

B. Scheduling Algorithm

1. Priority-based Scheduling Algorithm

Input: T is the set of TSs.

Q is the set of SSs for nrtPS applications.

Output: Scheduling CS for all TS.

For j =1 to │T│ **do**

a. St ← TSj.

b. Qt ← Q−Ot:

c. Calculate SF for SS within Qt.

d. If any SS €Qt has zero granted bandwidth

If any SS having nrtPS traffics and zero granted bandwidth,

Choose only one running nrtPS traffics with highest CR.

Else

Choose one with highest CR.

Else

Choose one with highest SF and CR.

e. Scheduled the SS, related to CS of St.

End For

Here, Q represents the set of SSs with non-real time connections. T represents the set of TSs. For any TS, St, let Ot is the set of SSs which UL transmission interval overlaps with that of St should be in Q. Hence, the possible corresponding CS of St must be in Q−Ot. All SSs in Q−Ot are considered as candidates of the CS for St.

This scheduling algorithm, called Priority Based Scheduling Algorithm (PSA), used to schedule a SS with the highest priority as the CS. The priority of each SSs is decided based on the scheduling factor (SF). The SF is defining as the ratio of the current requested bandwidth (CR) to the current granted bandwidth (CG). Those SSs having more value of SF has more demand on the bandwidth. We are giving to offer higher priority to those SSs. If all of SSs has equal SF, That instants highest priority is given to the SSs with zero CG. The priority of SSs is giving from high to low such as nrtPS with zero CG, BE with zero CG, nrtPS with non-zero CG and BE with non-zero CG. If there are more than one SS with the highest priority, in that condition we select one with the largest CR as the CS in order.

2. Rejected Bandwidth Requests First Algorithm

If one of the factors causes recycling failure then the CS does not have data to transmit. To alleviate this factor, we propose to schedule SSs which have rejected BRs in the last frame. This scheduling algorithm is called Rejected

Bandwidth Requests First Algorithm (RB-RFA). The BS grants or rejects BRs based on its available resource and its scheduling policy. In RBRFA, if the BS grants partially amount of bandwidth requested by a BR, then this BR is also considered as a rejected BR. This algorithm is quite similar to PSA algorithm show in below,

Input: T is the set of TS.

QR is the set of SSs which have rejected BRs, nrtPS application.

Output: Scheduling CS for each TS.

For j =1 to $\lceil T \rceil$ **do**

    a. St ← TSj.

    b. Qt ← QR−Ot:

    c. Randomly select SS €Qt as the corresponding CS

    of St

End For

Here Ot represents the set of SSs which transmission period overlaps with the TS, St, in QR. All SSs in Qt are considered as possible CSs of St. the rejected BR shows that the SS must have extra data to be transmitted in the next frame and no bandwidth is allocated for these data. The RBRFA schedules those SSs as CSs on the CL.

3. History-Based Scheduling Algorithm

The other issue that will have an effect on the performance of bandwidth recycling is the probability of the RM to be received by the CS successfully. To extend this probability, a scheduling algorithm, named history-Based Scheduling Algorithm (HBSA), is projected.

Input: T is the set of TS.

QR is the set of SSs which have rejected BRs, nrtPS application.

BL is the bunch of TSs.

Output: Scheduling CS for each TS.

For j =1 to $\lceil T \rceil$ **do**

    a. St ← TSj.

    b. Qt ← Q − Ot − BLj

    c. Randomly select SS €Qt as the corresponding CS of St

    d. If the scheduled CS does not transmit data.

    Then add this CS in the BLj

End For

This algorithm is similar to the RBRFA. In HSA for every TS, the BS maintains a list. This list is called as Black List (BL). The fundamental CID (connection identity) of a CS

is recorded in the BL of the TS if this CS cannot receive RMs sent from the TS. It will collect the enough history; the BL of each TS should contain the basic CID of all SSs which cannot receive the RM sent from the TS. By removing those SS, the BS should be high probability to schedule a CS which can receive the RM successfully. Hence, HBSA will increases the probability of scheduling a SS that is in a position to receive the RM as the CS. To support the mobility, the BL of each TS should be updated regularly. Moreover, the BS changes the UL burst profile of the SS when it cannot hear to the SS clearly.

IV. RESULT ANALYSIS

This section presents the result analysis of bandwidth recycling in IEEE 802.16 and then validates our analytical model. We report on the simulation result and make the observation table. Here we only present a limited numbers cases. We build an IEEE 802.16 network simulation by using NETBEAN (V 7.4) [12]. For the simulation purpose we used nrtPS service class for transferring a file form one node to another.

In this analysis we are building a network having 10-25 SSs along with one server, called as BS. Each SSs is connected to the BS with a dedicated link. When SSs is connected with BS, the BS will assign the initial bandwidth for those SSs. Those SSs are transmitting a file called TS. The substation can be used SS or CS depending on assign condition. According to our nrtPS protocol, when SS is select in that condition it is essentially to select a load (file) on them. Then each SS will calculate its required bandwidth for the transmission of file from one station to another. Following Figure shows the simulation window for SS9 (fig. 5).
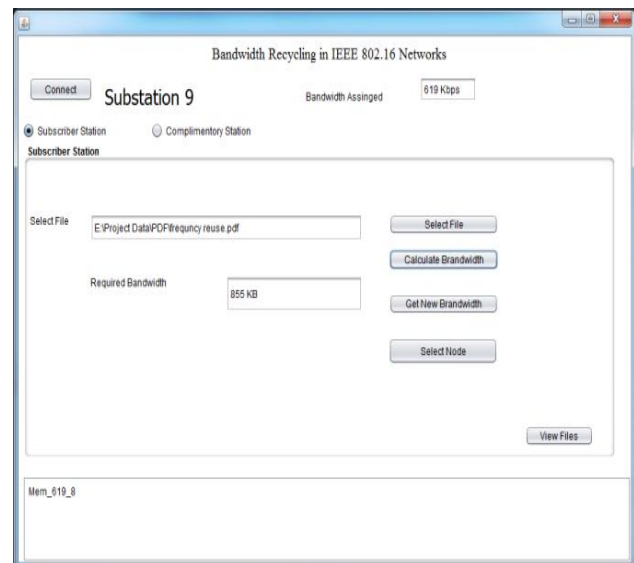

Fig. 5. Substation 9 acting as SS

BS knows the all parameter of SS and CS like as initial bandwidth, required transmission bandwidth etc. The algorithm executed by CS and will assign the priority level those SSs who demand for more bandwidth. This priority is given by SF; define as the ratio of current requested bandwidth to current granted bandwidth. Following figure 6 shows the simulation view of CS (substation 6).
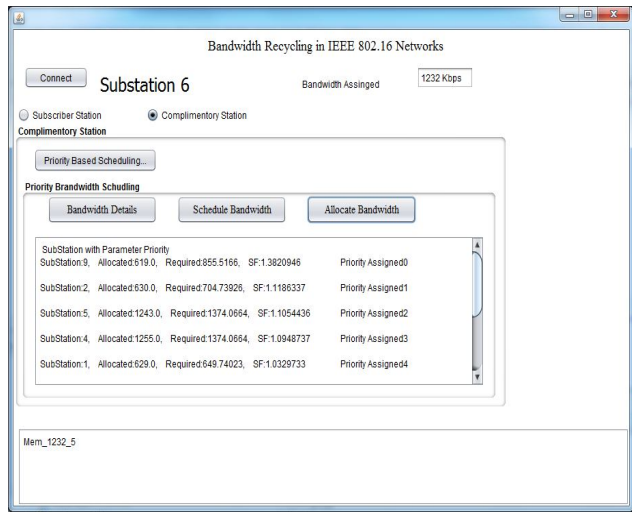

Fig. 6. Substation 6 acting as CS

The unused bandwidth of CS and other SSs, who does not, required any additional bandwidth for transferring a file. This unused bandwidth will gives to those SSs which required more bandwidth. Figure shows how BS can handle the situation and giving unused bandwidth to SSs as per priority level (fig. 7).
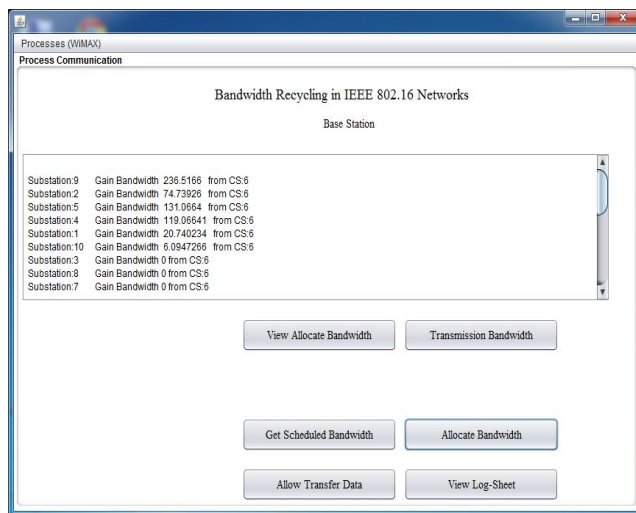

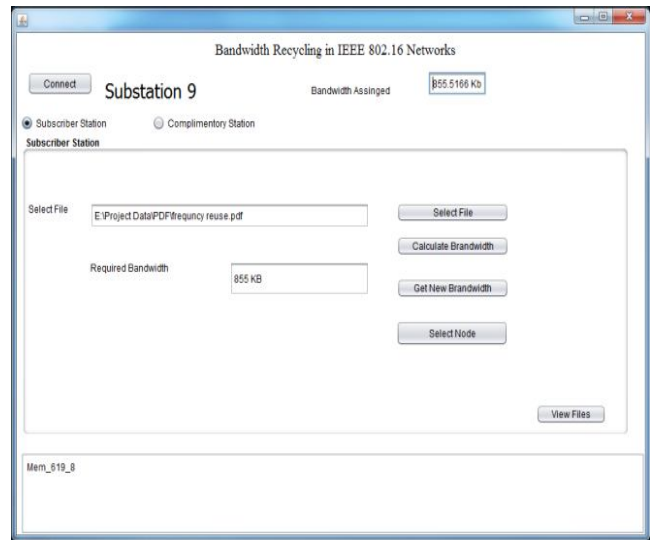**Fig. 7. Base Station or server**

Fig. 8. SS9 along with granted Bandwidth

Example: above figure shows the SS9 have initial bandwidth of 619 kbps and needed 855.51Kbps for transfer a file. After execution our algorithm it will gain remaining bandwidth from CS. At the end SS9 transfer a file with 1 second (using our scheme) (fig. 8).

Following figure shows the comparison result between initial bandwidth allocation and bandwidth allocated after using our scheme. It is clear that after using our scheme SS can get (gain) more bandwidth from CS and other SS who doesn't required any bandwidth for transferring a file (Fig. 9).
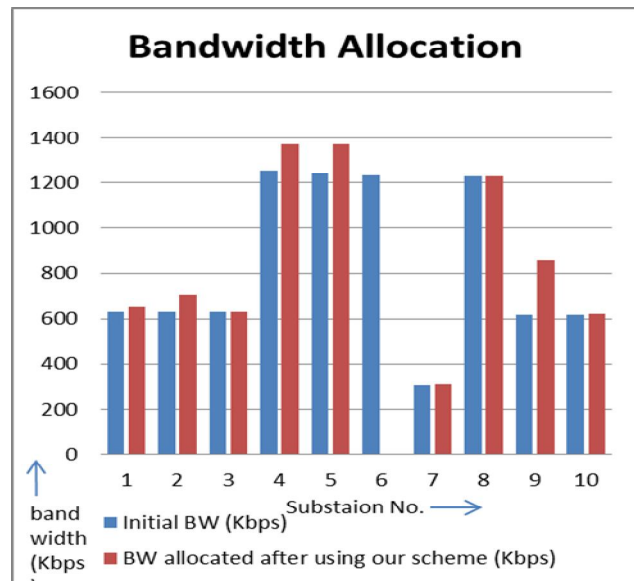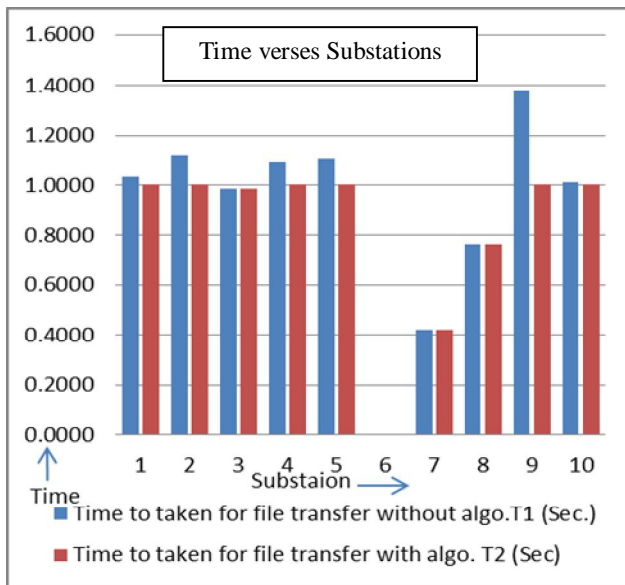

Fig. 9. Bandwidth Allocation

Fig. 10. Time verses Substations No.

Above Figure shows the relation between substations no. and time to require for file transfer without and with algorithm. After executing our scheme, time required for transfer file in a network can be minimized.

V. CONCLUSIONS

Our scheme is used to recycle the unused bandwidth once it occurs at any particular time. It permits the BS to schedule a complementary station for each transmission stations. We cannot change existing bandwidth reservation. The system can be used for non-real time application such as File Transfer Protocol (FTP). The performance of average reserved bandwidth is increases with increase in no. of substation. Due to this file can transfer with minimum time and system can also provide QoS. Our analytical results were verified by NETBEAN simulator.

A. Future Scope

It also possible to take the benefits or combining the parameter of both PSA and RBRFA to result an algorithm called Hybrid Scheduling Algorithm. This algorithm will increase the bandwidth recycling more effectively.

REFERENCES

[1] David Chuck and J. Morris Chang, "Bandwidth Recycling in IEEE 802.16 Networks", IEEE Transactions On Mobile Computing, Vol 9, Issue 10October 2010.

[2] Jianhua He, Kun Yang and Ken Guild, "A Dynamic Bandwidth Reservation Scheme for Hybrid IEEE 802.16 Wireless Networks", ICC 2008, PP 2571 – 2574.

[3] Kamal GAKHAR, Mounir ACHIR, Annie GRAVEY, "Dynamic Resource Reservation in IEEE 802.16 Broadband Wireless Networks", IEEE, 2006, PP 140-148.

[4] Eun Chan Park, Hwangnam Kim, Jae Young Kim, Han Seok Kim "Dynamic Bandwidth Request-Allocation Algorithm for Real-time Services in IEEE 802.16 Broadband Wireless Access Networks", INFOCOM 2008,p.852 – 860.

[5] J. Tao, F. Liu, Z. Zeng, and Z. Lin, "Throughput enhancement in WiMax mesh networks using concurrent transmission", In Proc. IEEE Int. Conf. Wireless Commun., Netw. Mobile Comput., 2005, p. 871V874.

[6] Xiaofeng Bai, Abdallah Shami, Yinghua Ye," Robust QoS Control for Single Carrier PMP Mode IEEE 802.16 Systems", IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 7, NO. 4, APRIL 2008, PP 416-429.

[7] David Chuck, Kuan Yu chen and J. Morris Chang," A Comprehensive analysis of Bandwidth Request mechanisms in IEEE 802.16 Networks", IEEE Transactions in 2009.

[8] Luis F. M. de Moraes and Danielle Lopes F. G. Vieira, "Analytical Modeling and Message Delay Performance Evaluation of the IEEE 802.16 MAC Protocol", 18th Annual IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems, 2010, PP 182-190.

[9] Fei Yin and Guy Pujolle, "Performance Optimization for Delay-Tolerant and Contention-Based Application in IEEE 802.16 Networks", EURASIP Journal on Wireless Communications and Networking Vol 2008, Article ID 573785, 2008.

[10] Vandana Singh Vinod Sharma, "Efficient and Fair Scheduling of Uplink and Downlink in IEEE 802.16 OFDMA Networks", WCNC, 2006, PP 984-990

[11] Gyan Prakash and Sadhana Pal, "Wimax Technology and Its Applications", International Journal of Engineering Research and Applications (IJERA), Vol. 1, Issue 2, pp.327-336.

[12] Mrs. Saba Siraj1, Mr. Ajay Kumar Gupta2, Mrs Rinku Badgujar, "Network Simulation Tools Survey", International Journal of Advanced Research in Computer and Communication Engineering Vol. 1, Issue 4, June 2012.

[13] Sanida Omerovic, "WiMAX Overview", a white paper.