Efficient Bandwidth Recycling In Wireless Broadband Networks

Y.Tulasi Rami Reddy, [1] M.Jaya Babu, [2] B.J.Job Karuna Sagar, [3] N.Suresh Babu[4]

1. M.Tech Student in CSE Department, Kottam College of Engineering, Kurnool (India) 518218,
2. Assistant Professor in CSE Department, Kottam College of Engineering, Kurnool (India) 518218,
3. Assistant Professor in CSE Department, KsrmCollege of Engineering, Kadapa (India) 516003,
4. M.Tech Student in CSE Department, Sphoorthy Engineering College, Hyderabad (India) 501510,

Abstract: *Bandwidth recycling is proliferated in wireless broadband networks, in which IEEE 802.16 standard was designed to support the bandwidth demanding applications with quality of service (QoS). Bandwidth is reserved for each application to ensure the QoS. For variable bit rate (VBR) applications, however, it is difficult for the subscriber station (SS) to predict the amount of incoming data. To ensure the QoS guaranteed services, the SS may reserve more bandwidth than its demand. As a result, the reserved bandwidth may not be fully utilized all the time. In this paper, we propose a scheme, named Bandwidth Recycling, to recycle the unused bandwidth without changing the existing bandwidth reservation. The idea of the proposed scheme is to allow other SSs to utilize the unused bandwidth when it is available. Thus, the system throughput can be improved while maintaining the same QoS guaranteed services. Mathematical analysis and simulation are used to evaluate the proposed scheme. Simulation and analysis results confirm that the proposed scheme can recycle 55% of unused bandwidth on average. By analyzing factors affecting the recycling performance, three scheduling algorithms are proposed to improve the overall throughput. The simulation results show that our proposed algorithm improves the overall throughput by 60% in a steady network. to carry out research object at providing quality of network performance in Heterogeneous computing environment*

Index Terms: *QoS, WiMAX, IEEE 802.16, Bandwidth Recycling,*

1. Introduction

THE WiMAX refers to interoperable implementations of the IEEE 802.16 family of wireless-networks standards ratified by the WiMAX Forum. Similarly, Wi-Fi, refers to interoperable implementations of the IEEE 802.11 Wireless LAN standards certified by the Wi-Fi Alliance. WiMAX Forum certification allows vendors to sell fixed or mobile products as WiMAX.

Certified, thus ensuring a level of interoperability with other certified products, as long as they fit the same profile. The Worldwide Interoperability for Microwave Access.
(WiMAX), based on IEEE 802.16 standard standards [1], [2], is designed to facilitate services with high transmission Rates for data and multimedia applications in metropolitan areas.

The original IEEE 802.16 standard (now called "Fixed WiMAX") was published in 2001. WiMAX adopted some of its technology from WiBro, a service marketed in Korea.[3] Mobile WiMAX (originally based on 802.16e-2005) is the revision that was deployed in many countries, and basis of future revisions such as 802.16m-2011. WiMAX is sometimes referred to as "Wi-Fi on steroids" and can be used for a number of applications including broadband connections, cellular backhaul, hotspots, etc. It is similar to Wi-Fi, but it can enable usage at much greater distances.IEEE 802.16 is a series of Wireless Broadband standards authored by the Institute of Electrical and Electronics Engineers (IEEE). The IEEE Standards Board established a working group in 1999 to develop standards for broadband for Wireless Metropolitan Area Networks. The Workgroup is a unit of the IEEE 802 local area network and metropolitan area network standards committee. Although the 802.16 family of standards is officially called Wireless MAN in IEEE, it has been commercialized under the name "WiMAX" (from "Worldwide Interoperability for Microwave Access") by the WiMAX Forum industry alliance. The Forum promotes and certifies compatibility and interoperability of products based on the IEEE 802.16 standards. **QoS** Quality of service (QoS) in 802.16e is supported by allocating each connection between the SS and the BS (called a *service flow* in 802.16 terminologies) to a specific *QoS class*. In 802.16e, there are 5 QoS classes:

The physical (PHY) and medium access control (MAC) layers of WiMAX have been specified in the IEEE 802.16 standard.

Many advanced communication technologies such as Orthogonal Frequency- Division Multiple Access (OFDMA) and multiple-input and multiple-output (MIMO) are embraced in the standards. Supported by these modern technologies, WiMAX is able to provide large service coverage, high data rates and QoS guaranteed services. Because of these features, WiMAX is considered as a promising alternative for last mile broadband wireless access (BWA).

802.16e-2005 QoS classes			
Service	**Abbrev**	**Definition**	**Typical Applications**
Unsolicited Grant Service	UGS	Real-time data streams comprising fixed-size data packets issued at periodic intervals	T1/E1 transport
Extended Real-time Polling Service	ertPS	Real-time service flows that generate variable-sized data packets on a periodic basis	VoIP

Real-time Polling Service	rtPS	Real-time data streams comprising variable-sized data packets that are issued at periodic intervals	MPEG Video
Non-real-time Polling Service	nrtPS	Delay-tolerant data streams comprising variable-sized data packets for which a minimum data rate is required	FTP with guaranteed minimum throughput
Best Effort	BE	Data streams for which no minimum service level is required and therefore may be handled on a space-available basis	HTTP

To improve the bandwidth utilization while maintaining the same QoS guaranteed services, our research objective is twofold: 1) the existing bandwidth reservation is not changed to maintain the same QoS guaranteed services. 2) our research work focuses on increasing the bandwidth utilization by utilizing the unused bandwidth. We propose a scheme, named *Bandwidth Recycling*, which recycles the unused bandwidth while keeping the same QoS guaranteed services without introducing extra delay. The general concept behind our scheme is to allow other SSs to utilize the unused bandwidth left by the current transmitting SS. Since the unused bandwidth is not supposed to occur regularly, our scheme allows SSs with non-real time applications, which have more flexibility of delay requirements, to recycle the unused bandwidth. Consequently, the unused bandwidth in the *current* frame can be utilized. It is different from the bandwidth adjustment in which the adjusted bandwidth is enforced as early as in the next coming frame. Moreover, the unused bandwidth is likely to be released temporarily (i.e., only in the current frame) and the existing bandwidth reservation does not change. Therefore, our scheme improves the overall throughput while providing the same QoS guaranteed services.

In computer networking and computer science, the words bandwidth, network bandwidth, data bandwidth, or digital bandwidth are terms used to refer to various bit-rate measures, representing the available or consumed data communication resources expressed in bits per second or multiples of it (bit/s, kbit/s, Mbit/s, Gbit/s, etc.).

1.1 Network bandwidth capacity

Bandwidth sometimes defines the net bit rate (aka. peak bit rate, information rate or physical layer useful bit rate), channel capacity, or the maximum throughput of a logical or physical communication path in a digital communication system. For example, bandwidth tests measure the maximum throughput of a computer network. The reason for this usage is that according to Hartley's law, the maximum data rate of a physical communication link is proportional to its bandwidth in hertz, which is sometimes called frequency bandwidth, spectral bandwidth, RF bandwidth, signal bandwidth or analog bandwidth.

1.2 Network bandwidth consumption

Bandwidth in bit/s may also refer to consumed bandwidth, corresponding to achieved throughput or good put, i.e., the average rate of successful data transfer through a communication path. This sense applies to concepts and technologies such as bandwidth shaping, bandwidth management, bandwidth throttling, bandwidth cap, bandwidth allocation (for example bandwidth allocation protocol and dynamic bandwidth allocation), etc. A bit stream's bandwidth is proportional to the average consumed signal bandwidth in Hertz (the average spectral bandwidth of the analog signal representing the bit stream) during a studied time interval.

Channel bandwidth may be confused with data throughput. A channel with *x* bps may not necessarily transmit data at *x* rate, since protocols, encryption, and other factors can add appreciable overhead. For instance, a lot of internet traffic uses the transmission control protocol (TCP) which requires a three-way handshake for each transaction, which, though in many modern implementations is efficient, does add significant overhead compared to simpler protocols. In general, for any effective digital communication, a framing protocol is needed; overhead and effective throughput depends on implementation. Actual throughput is less than or equal to the actual channel capacity plus implementation overhead.

1.3 Asymptotic bandwidth

The asymptotic bandwidth for a network is the measure of useful throughput, when the packet size approaches infinity.

Asymptotic bandwidths are usually estimated by sending a number of very large messages through the network, measuring the end-to-end throughput. As other bandwidths, the asymptotic bandwidth is measured in multiples of bits per second.

1.4 Multimedia bandwidth

Digital bandwidth may also refer to: multimedia bit rate or average bitrate after multimedia data compression (source coding), defined as the total amount of data divided by the playback time.

1.5 Bandwidth in web hosting

In website hosting, the term "bandwidth" is often [citation needed] incorrectly used to describe the amount of data transferred to or from the website or server within a prescribed period of time, for example bandwidth consumption accumulated over a month measured in gigabytes per month. The more accurate phrase used for this meaning of a maximum amount of data transfer each month or given period is monthly data transfer.

Variable bit rate (VBR) is a term used in telecommunications and computing that relates to the bit rate used in sound or video encoding. As opposed to constant bit rate (CBR), VBR files vary the amount of output data per time segment.

VBR allows a higher bit rate (and therefore more storage space) to be allocated to the more complex segments of media files while less space is allocated to less complex segments. The average of these rates can be calculated to produce an average bit rate for the file.

2.1 OVERVIEW OF WIMAX/IEEE 802.16 STANDARDS

Worldwide Interoperability for Microwave Access (WiMAX) is known as a metropolitan area network technology whose goal is to one day provides last-mile broadband wireless access to the general population. The WiMAX technology is based on the IEEE 802.16 standard and is capable of providing a platform to deliver the applications for the convergence of data, voice and video services. The WiMAX protocol is designed to accommodate several different methods of data transmission, one of which is Voice over Internet Protocol (VoIP). The use of VoIP could increase dramatically when WiMAX-compatible devices become common. WiMAX gives hope to millions of people to access the Internet cheaply and easily. The WiMAX forum was created by industry leaders in 2000 in order to promote deployment of broadband wireless access networks by using the IEEE 802.16 standard and certifying interoperability and standards compliance of products and technologies manufactured by member companies. The IEEE 802.16, which is called the Wireless Metropolitan Area Network (WMAN) standard, will enable a single base station to support both fixed and mobile Broadband Wireless Access (BWA). It aims to fill the gap between high data rate Wireless Local Area Networks (WLAN) and high mobility cellular Wide Area Networks (WAN). The IEEE 802.16 extends this coverage of WLAN, which is known as IEEE 802.11, while offering the features consistent with the stringent demands of operators in a wide variety of deployment scenarios.

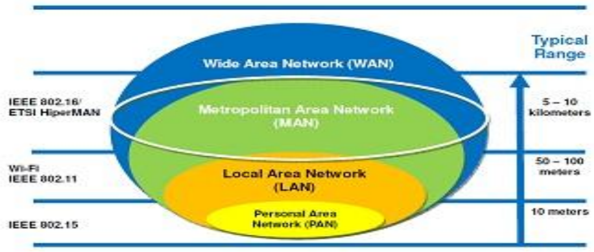


Figure 2.1 WiMAX bridges the gap between LAN and WAN

2.2 WiMAX/IEEE 802.16 Architecture

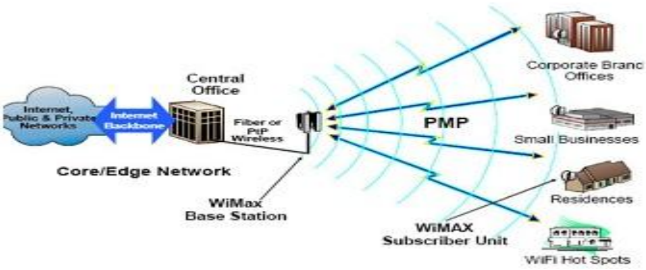


Figure 2.2 shows that a typical IEEE 802.16 network in PMP mode comprising of a BaseStation (BS) that communicates with one or more Subscriber Stations (SS) known as Customer Premises Equipment (CPE). IEEE 802.16 specifies the following modes of deployment architectures:

• **Point-to-point (PTP):** A connection between one BS and one SS. The PTP mode extends the range over the PMP mode.

• **Point-to-multipoint (PMP):** A connection between one BS and multiple SS nodes. The BS always coordinates the uplink and downlink transmission. This mode supports multicast communication.

• **Point-to-consecutive point (PTCM):** It involves the creation of a closed loop through multiple PTP connections.

• **Mesh:** SSs can communicate with each other without the coordination of a BS

2.3 WiMAX Advantages

• **Good standard:** IEEE Standard and WiMAX interoperability certification. WiMAX can support mobility, roaming and meshing.

• **Long range:** WiMAX forum points out that the most significant advantage of WiMAX is the range it provides compared to existing wireless technologies. WiMAX can provide a communication range of up to 30 miles.

• **Low cost:** WiMAX reduces the capital expenditures required for network expansion and reduces fixed broadband prices.

• **Quality of Service (QoS) support:** WiMAX MAC protocol supports high QoS and guaranteed service levels.

• **High number of simultaneous sessions:** WiMAX MAC is designed to support thousands of users.

The WiMAX/IEEE 802.16 standard specifies a system comprising of two core components: the Subscriber Station (SS) or Customer Premises Equipment (CPE), and the Base Station (BS). The 802.16 MAC protocol is designed to support different QoS requirements for different applications at the MAC layer. The mechanisms for supporting QoS in the IEEE 802.16 MAC layer are presented in this section. The overview of the WiMAX/IEEE 802.16 standard and MAC protocol aims to clarify the research background of this study.

III. BACKGROUND INFORMATION

The IEEE 802.16 standard specifies three types of transmission mediums supported as the physical layer (PHY): single channel (SC), orthogonal frequency-division multiplexing (OFDM) and Orthogonal Frequency-Division Multiple Access (OFDMA). We assume OFDMA as the PHY in our analytical model since it is employed to support mobility in IEEE 802.16e standard and the scheme working in OFDMA should also work in others. There are four types of modulations supported by OFDMA: BPSK, QPSK, 16-QAM and 64-QAM.

This paper is focused on the point-to-multipoint (PMP) mode in which the SS is not allowed to communicate with any other SSs but the BS directly. Based on the transmission direction, the transmissions between BS and SSs are classified into downlink (DL) and uplink (UL) transmissions. The former are the transmissions from the BS to SSs. Conversely, the latter are the transmissions in the opposite direction. There are two transmission modes: Time Division Duplex (TDD) and Frequency Division Duplex (FDD) supported in IEEE 802.16. Both UL and DL transmissions can not be operated simultaneously in TDD mode but in FDD mode. In this paper, our scheme is focused on the TDD mode. In WiMAX, the BS is responsible for scheduling both UL and DL transmissions. All scheduling behavior is expressed in a MAC frame.

There are two types of BRs defined in the IEEE 802.16 Standard: incremental and aggregate BRs. The former allow the SS to indicate the extra bandwidth required for a connection. Thus, the amount of reserved bandwidth can be only increased via incremental BRs. On the other hand, the SS specifies the current state of queue for the particular connection via a aggregate request. The BS resets its perception of that service's needs upon receiving the request. Consequently, the reserved bandwidth may be decreased.

IV. MOTIVATION AND RELATED WORK

Bandwidth reservation allows IEEE 802.16 networks to provide QoS guaranteed services. The SS reserves the required bandwidth before any data transmissions. Due to the nature of VBR applications, it is very difficult for the SS to make the optimal bandwidth reservation. It is possible that the amount of reserved bandwidth is more than the demand. Therefore, the reserved bandwidth cannot be fully utilized. Although the reserved bandwidth can be adjusted via BRs, however, the updated reserved bandwidth is applied as early as to the next coming frame and there is no way to utilize the unused bandwidth in the current frame. In our scheme, the SS releases its unused bandwidth in the current frame and another SS pre-assigned by the BS has opportunities to utilize this unused bandwidth. This improves IEEE TRANSACTIONS ON MOBILE COMPUTING VOLUME 9, ISSUE 10 (OCTOBER 2010)3 the bandwidth utilization. Moreover, since the existing bandwidth reservation is not changed, the same QoS guaranteed services are provided without introducing any extra delay. A dynamic bandwidth request-allocation algorithm for real-time services is proposed in [7]. 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 research works listed above improve the performance by predicting the traffic coming in the future. Instead of prediction, our scheme can allow SSs to accurately identify the portion of unused bandwidth and provides a Method to recycle the unused bandwidth. It can improve the utilization of bandwidth while keeping the same QoS guaranteed services and introducing no extra delay.

4.1 Existing Scheme

Bandwidth transmitted data may be more than the amount of transmitted data and may not be fully utilized all the time. Before it is different from the bandwidth adjustment in which the adjusted bandwidth is enforced as early as in the next coming frame. Moreover, the unused bandwidth is likely to be released temporarily (i.e., only in the current frame) and the existing bandwidth reservation does not change. The ad hoc networking community assumes that the underlying wireless technology is the IEEE 802.11 standard due to the broad availability of interface cards and simulation models.

V. PROPOSED SCHEME

The IEEE 802.16 network is connection-oriented. It gives the advantage of having better control over network resource to provide QoS guaranteed services. To improve the bandwidth utilization while maintaining the same QoS guaranteed services, our research objective is two fold: 1) the same QoS guaranteed services are provided by maintaining the existing bandwidth reservation. 2) The bandwidth utilization is improved by recycling the unused bandwidth. To achieve these objectives, our scheme named Bandwidth Recycling is proposed.

The existing bandwidth reservation is not changed to maintain the same QoS guaranteed services. Our research work focuses on increasing the bandwidth utilization by utilizing the unused bandwidth we propose a scheme, named Bandwidth Recycling, which recycles the unused bandwidth while keeping the same QoS guaranteed services without introducing extra delay. The general concept behind our scheme is to allow other SSs to utilize the unused bandwidth left by the current transmitting SS. Since the unused bandwidth is not supposed to occur regularly, our scheme allows SSs with non-realtime applications, which have more flexibility of delay requirements, to recycle the unused bandwidth. In this system they are using 802.11 MAC layer to evaluate the correct bandwidth. This method combines channel monitoring to estimate each node's medium occupancy. Synchronization between nodes, estimation of the collision probability between each couple of nodes, and variable overhead's impact estimation.

5.1 Module Design and Organization

5.1.1 Bandwidth utilization Module

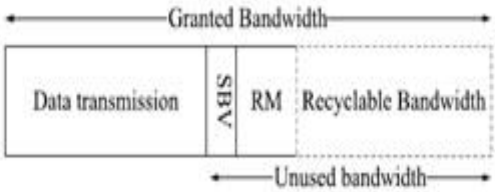


Figure 5.1.1 Bandwidth Utilization Module

Bandwidth utilization improvements have been proposed in the literature. In, a dynamic resource reservation mechanism is proposed. It can dynamically change the amount of reserved resource depending on the actual number of active connections. The investigation of dynamic bandwidth reservation for hybrid networks is presented in. Evaluated the performance and effectiveness for the hybrid network, and proposed efficient methods to ensure optimum reservation and utilization of bandwidth while minimizing signal blocking probability and signaling cost. In, the enhanced the system throughput by using concurrent transmission in mesh mode

5.1.2 Packet Creation Module

In this module we split the Data in to N number of fixed size packet with Maximum length of 48 Characters. As result of packet creation module, the splitting data can be easily transmitted to great extent with out interruption in network bandwidth across the different nodes.

5.1.3 Bandwidth Recycling

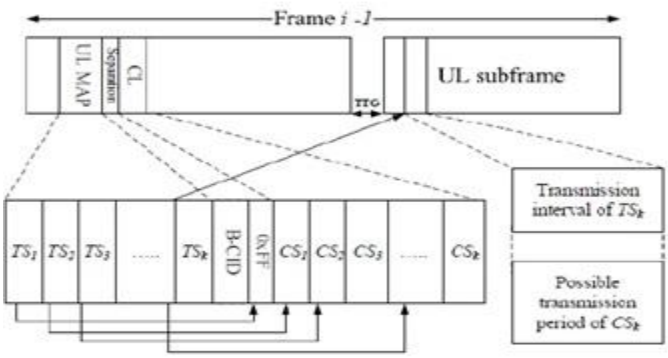


Figure 5.1.3 Bandwidth Recycling Module

The complementary station (CS). Waits for the possible opportunities to recycle the unused bandwidth of its corresponding TS in this frame. The CS information scheduled by the BS is resided in a list, called complementary list (CL). The CL includes the mapping relation between each pair of pre-assigned C and TS.

5.1.4 QoS Guaranteed Services:

It is different from the bandwidth adjustment in which the adjusted bandwidth is enforced as early as in the next coming frame. Moreover, the unused bandwidth is likely to be released temporarily (i.e., only in the current frame) and the existing bandwidth reservation does not change. Therefore, our scheme improves the overall throughput while providing the same QoS guaranteed services.

5.1.5 Traffic and Packet Performance

The Packet mean data rate of each application but make the mean packet size randomly selected from 512 to 1024 bytes. Thus, the mean packet arrive rate can be determined based on the corresponding mean packet size. As mentioned earlier, the size of each packet is modeled as Poisson distribution and the packet arrival rate is modeled as exponential distribution. The other factor that may affect the performance of bandwidth recycling is the probability of the RM to be received by the CS successfully.

5.2 Algorithms

❖ Dynamic bandwidth request-allocation algorithm and Priority-based Scheduling Algorithm

A dynamic bandwidth request-allocation algorithm for real-time services is proposed in. 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 research works listed above improve the performance by predicting the traffic coming in the future. Instead of prediction, our scheme can allow SSs to accurately identify the portion of unused bandwidth and provides a method to recycle the unused bandwidth. It can improve the utilization of bandwidth while keeping the same QoS guaranteed services and introducing no extra delay

Algorithm 1 Priority-based Scheduling Algorithm
Input: T is the set of TSs scheduled on the UL map.
Q is the set of SSs running non-real time applications.
Output: Schedule CSs for all TSs in T.
For i =1 to ∥T∥ do
 a. $St \leftarrow TSi$.
 b. $Qt \leftarrow Q-Ot$:
 c. Calculate the SF for each SS in Qt.
 d. **If** Any SS $\in Qt$ has zero granted bandwidth,
If Any SSs have nrtPS traffics and zero granted
 Bandwidth,
 Choose one running nrtPS traffics with the
 Largest CR.
Else
 Choose one with the largest CR.
Else
 Choose one with largest SF and CR.
e. Schedule the SS as the corresponding CS of St.
End For

VI. ANALYSIS

The percentage of potentially unused bandwidth occupied in the reserved bandwidth is critical for the potential performance gain of our scheme. We investigate this percentage on VBR traffics which is popularly used today. Additionally, in our scheme, each T should transmit

A RM to inform its corresponding CS when it has unused bandwidth. However, the transmission range of the TS may not be able to cover the corresponding CS. It depends on the location and the transmission power of the TS. It is possible that the unused bandwidth cannot be recycled because the CS does not receive the RM. Therefore, the benefit of our scheme is reduced. In this section, we analyze mathematically the probability of a CS to receive a RM successfully. Obviously, this probability affects the bandwidth recycling rate BR.BBR stands for the percentage of the unused bandwidth which is recycled. Moreover, the performance analysis is presented in terms of throughput gain (TG). At the end, we evaluate the performance of our scheme under different traffic load.

6.1 Analysis of potential unused bandwidth

Based on the traffic generation rate, the applications can be classified into two types: constant bit rate (CBR) and variable bit rate (VBR). Since CBR applications generate data in a constant rate, SSs rarely adjust the reserved bandwidth. As long as the reasonable amount of bandwidth is reserved, it is hard to have unused bandwidth in this type of applications. Therefore, our scheme has very limited benefit on CBR traffic. However, VBR applications generate data in a variable rate. It is hard for a SS to predict the amount of incoming data precisely for making the appropriate bandwidth Reservation. Thus, in order to provide QoS guaranteed services, the SS tends to keep the amount of reserved bandwidth to serve the possible bursty data arrived in the future. The reserved bandwidth may not be fully utilized all the time. Our analysis focuses on investigating the percentage of potentially unused bandwidth of VBR traffics. The relation between W and B can be formulated as:

$$W = BDf \leq Wmax \quad (1)$$

Suppose $Xi-1$ represents the amount of data arriving in the frame $i-1$ (in terms of bytes), where $1 \leq i \leq N-1$ and N is the total number of frames we analyze. If we
Have unused bandwidth in frame i, then the amount of
Data in queue must be less than the number of assigned
Bandwidth. By considering the inter-frame dependence
(i.e., the number of data changed in the previous frame
Affects the number of data in queue in the current frame),

It can be represented as the the following condition:

$$X_{i-1} < W_i - \max\{0; Q_{i-1} - W_{i-1}\} \quad (2)$$

Where Q_{i-1} is the amount of data stored in queue before transmitting frame $i-1$. W_i and W_{i-1} are the amount of bandwidth assigned in frame i and $i-1$, respectively. Again, both W_i and W_{i-1} are at most W_{max}. Max $\{0; Q_{i-1} - W_{i-1}\}$ represents the amount of queued

Data arriving before frame $i-1$.

As mentioned, X_{i-1} is the amount of data arriving in the frame $i-1$. Thus, X_{i-1} must be nonnegative. Consequently, the probability of having unused bandwidth in frame i, $P_u(i)$, is derived as:

$$p_u(i) = \int_0^{x_{i-1}} p(X)\,dX. \quad (3)$$

Thus, the expected amount of unused bandwidth in

Frame i, $E(i)$, can be derived as:

$$E(i) = \int_0^{x_{i-1}} Xp(X)\,dX. \quad (4)$$

Finally, by summing the expected unused bandwidth

In all frames, the ratio of the total potentially unused bandwidth to total reserved bandwidth in N frames, R_u, can be presented as:

$$R_u = \frac{\sum_{i=0}^{N-1} E(i)}{\sum_{i=0}^{N-1} W_i} \quad (5)$$

VII. SIMULATION RESULTS

Our simulation is conducted by using Qualnet 4.5 [11].

In this section, we first present our simulation model followed by introducing the definition of performance Metrics used for measuring the network performance.

The simulation results are shown as the third part of this section. At the end, we provide the validation of Theoretical analysis and simulation results.

The simulation for evaluating the performance of the proposed scheme is based on the three metrics:

1) *Throughput gain (TG):*

It represents the percentage of throughput which Is improved by implementing our scheme. The Formal definition can be expressed as:

$$TG = \frac{T_{recycle} - T_{no\ recycle}}{T_{no\ recycle}}$$

Where $T_{recycle}$ and $T_{no\ recycle}$ represent the Throughput with and without implementing our Scheme, respectively. The higher *TG* achieved shows the higher performance that our scheme can make.

2) *Unused bandwidth rate (UBR):*

It is defined as the percentage of the unused bandwidth Occupied in the total granted bandwidth in the system without using bandwidth recycling. It can be defined formally as:

$$UBR = \frac{B_{unused\ BW}}{B_{total\ BW}}$$

Where $B_{unused\ BW}$ and $B_{total\ BW}$ are the unused Bandwidth and total allocated bandwidth, respectively.

The *UBR* shows the room which can be improved by our scheme. The higher *UBR* means The more recycling opportunities.

3) *Bandwidth recycling rate (BRR):*

It illustrates the percentage of bandwidth which is Recycled from the unused bandwidth. The percentage Can be demonstrated formally as:

$$BRR = \frac{B_{recycled}}{B_{unused\ BW}}$$

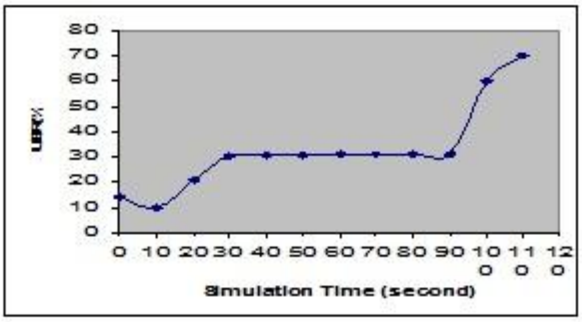


Fig 7.1 Simulation results of UBR

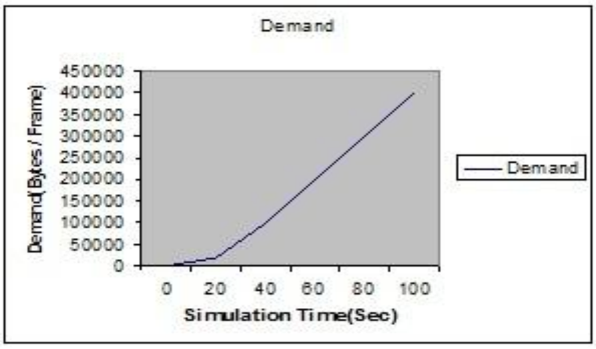


Fig 7.2 Total Bandwidth demand.

The simulation results of recycling rate are presented from the above figures we observe that the recycling rate is very close to zero at the beginning of the simulation. It is because that only a few connections transmit data during that time and the network has a light load. Therefore, only few connections need to recycle the unused bandwidth from others. As time goes on, many active connections join in the network. The available bandwidth may not be able to satisfy the needs of connections. Therefore, there is a high probability that the CS recycles the unused bandwidth. It leads a higher *BRR*. The total bandwidth demand requested by SSs during the simulation. In the figure, the dashed line indicates the system bandwidth capacity. During the simulation, the BS always allocates the bandwidth to satisfy the demand of real time connections due to the QoS requirement. Therefore, the amount of bandwidth allocated to non-real time connections may be shrunk. At the same time, the new non-real time data are generated. Therefore, the non-real time data are accumulated in the queue. It is the reason that the demand of bandwidth keeps increasing.

As our investigation, one of the factors causing recycling. Failures are that the CS does not have data to transmit while receiving a RM. The other factor that may affect the performance of bandwidth recycling is the probability of the RM to be received by the CS successfully. To increase this probability, a scheduling algorithm, named history-Based Scheduling Algorithm (HBA), is proposed. According to our protocol, the CS transmits data or pad the rest of transmission interval if a RM is received.

VIII. RESULTS

The results consists of the output screens for the given Transmission nodes and Complementary nodes in wireless broadband networks for recycling the bandwidth usage. The Home page for starting the application is as shown below.

Screen 1 for Bandwidth Recycling in IEEE802.16 Networks

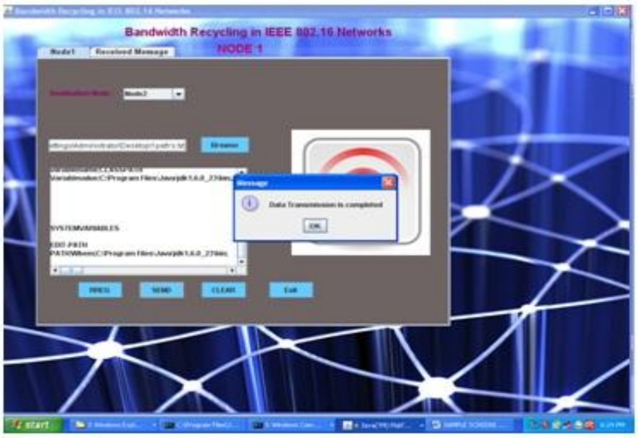
.

Screen 2 for selecting the destination Node

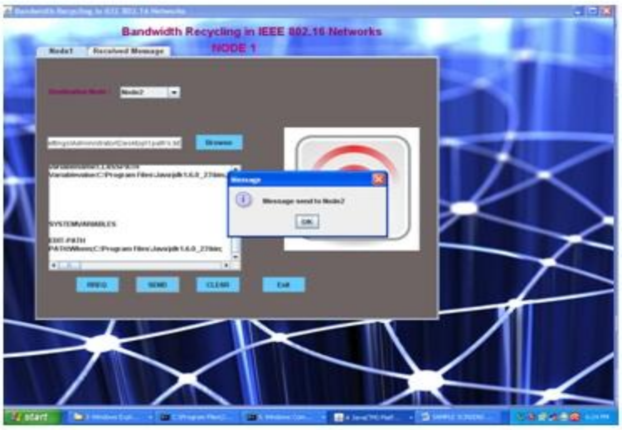
Screen 3 for selecting the another destination Node

Screen 4 for Sending the RREQ (recycling request) to Node2

Screen 5 for Receiving the Response (RREP) from Node2



Screen 6 for Message send to Node2



Screen 7 for Completing the Data Transmission.

Screen 8 for Clear History about Recycling Bandwidth

Screen 9 for Transmission of packets from Node2

IX. CONCLUSIONS

Variable bit rate applications generate data in variant rates. It is very challenging for SSs to predict the amount of arriving data precisely. Although the existing method allows the SS to adjust the reserved bandwidth via risk of failing to satisfy the QoS requirements. Moreover, the unused bandwidth occurs in the current frame cannot be utilized by the existing bandwidth adjustment since the adjusted amount of bandwidth can be applied as early as in the next coming frame. Variable bit rate applications generate data in variant rates. It is very challenging for SSs to predict the amount of arriving data precisely. Although the existing method allows the SS to adjust the reserved bandwidth via bandwidth requests in each frame, it cannot avoid the risk of failing to satisfy the QoS requirements. Moreover, the unused bandwidth occurs in the current frame cannot be utilized by the existing bandwidth adjustment since the adjusted amount of bandwidth can be applied as early as in the next coming frame. Our research does not change the existing bandwidth reservation to ensure that the same QoS guaranteed services are provided. We proposed *bandwidth recycling* to recycle the unused bandwidth once it occurs. It allows the BS to schedule a complementary station for each transmission stations. Each complementary station monitors the entire UL transmission interval of its corresponding TS and standby for any opportunities to recycle the unused bandwidth. Besides the naive priority-based scheduling algorithm, three additional algorithms have been proposed to improve the recycling effectiveness.

Our mathematical and simulation results confirm that our scheme can not only improve the throughput but also reduce the delay with negligible overhead and satisfy the QoS requirements.

We proposed bandwidth recycling to recycle the unused bandwidth once it occurs. It allows the BS to schedule a complementary station for each transmission stations. Each complementary station monitors the entire UL transmission interval of its corresponding TS and standby for any opportunities to recycle the unused bandwidth. Besides the naive priority- based scheduling algorithm, three additional algorithms have been proposed to improve the recycling effectiveness. Our mathematical and simulation results confirm that our scheme can not only improve the through put but also reduce the delay with negligible overhead and satisfy the QoS

9.1 Future Enhancements

Our research does not change the existing bandwidth reservation to ensure that the same QoS guaranteed services are provided. We proposed bandwidth recycling to recycle the unused bandwidth once it occurs. It allows the BS to schedule a complementary station for each transmission stations. Each complementary station monitors the entire UL transmission interval of its corresponding TS and standby for any opportunities to recycle the unused bandwidth. Besides the naive priority-based scheduling algorithm, three additional algorithms have been proposed to improve the recycling effectiveness. Our mathematical and simulation results confirm that our scheme can not only improve the throughput but also reduce the delay with negligible overhead and satisfy the QoS requirements.

REFERENCES

[1] Sri M.Jaya Babu, Sri K.Gopinath Y.Tulasi Rami Reddy, "Data Caching between Mobile nodes in wireless adhoc networks", International Journal of Modern Engineering Research, Vol.2, Issue.5, pp 3841-3849., ISSN: 2249-6645., Sep-Oct-2012.

[2] 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

[3] IEEE 802.16 WG,"IEEE Standard for Local and Metropolitan Area Network Part 16: Air Interface for Fixed Boardband Wireless Access Systems" IEEE Std 802.16-2004 p.1 - p.857

[4] IEEE 802.16WG,"IEEE standard for local and metropolitan area networks part 16: Air interface for fixed and mobile broadband wireless access systems, Amendment 2," IEEE 802.16 Standard, December 2005.

[5] Jianhua He, Kun Yang and Ken Guild"A Dynamic Bandwidth Reservation Scheme for Hybrid IEEE 802.16 Wireless Networks" ICC'08 p.2571-2575.

[6] 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.

[7] Kamal Gakhar, Mounir Achir and Annie Gravey,"Dynamic resource reservation in IEEE 802.16 broadband wireless networks", IWQoS, 2006. p.140-148

[8] Thomas G. Robertazzi"Computer Networks and Systems: Theory and Performance Evaluation." Springer-Verlag 1990

[9] Xiaofeng Bai, Abdullah Shami and 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, p.416-429

References Made From:

1. Professional Java Network Programming
2. Java Complete Reference
4. Data Communications and Networking, by Behrouz A Forouzan.
5. Computer Networking: A Top-Down Approach, by James F. Kurose.
6. Operating System Concepts, by Abraham Silberschatz.

AUTHORS LIST

Y.TULASI RAMI REDDY (M.Tech) pursuing M.Tech CSE final year Kottam College of Engineering, Affiliated to JNTU Anantapur, approved by AICTE, New Delhi. Chinnatekur, Kurnool, His research Areas of interest are Computer Networks and Data Mining.

M.JAYA BABU. M.Tech. Assistant Professor in CSE Department, Kottam College of Engineering, Kurnool. Received his M.Tech, in Computer Science from (JNTU, Kakinada) His area of intrest include Computer Networks and Data Mining.

B.J.JOB KARUNA SAGAR. M.Tech, Assistant Professor in CSE Department, *KSRM* College of Engineering, Kadapa. Received his M.E, in C.S.E from SathyaBama University, Chennai. He is currently working towards the PhD Degree in C.S.E at Bharthiar University. His areas of intrest include Wireless Networking and Resource Allocation.

N.SURESH BABU. ***(M.Tech.)*** Pursuing M.Tech CSE final year in Sphoorthy Engineering College, Affiliated to, JNTU, HYD, approved by AICTE, New Delhi. Vanasthalipuram, Hyd. His area of intrest include Computer Networks and Data Mining.