Improved Bandwidth Utilization In 802.16 Wireless Network Using Rejected Bandwidth Requests First Algorithm.

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Abstract

Bandwidth is reserved for each application to ensure the QoS. In this paper, we propose scheme, named Effective Bandwidth Utilization, to recycle the unused and free bandwidth without changing existing bandwidth reservation. The idea of proposed scheme is to allow other Subscriber Stations (SSs) to utilize the unused bandwidth when it is free. IEEE 802.16 standard was designed to support bandwidth demanding applications with quality of service (QoS). Effective utilization of scarce resources is important to managers in the telecommunications industry, and thus usage-based pricing has become an important tool to address. For variable bit rate applications, 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. We propose a scheme that effectively utilizes the unused bandwidth. The system throughput can be improved while maintaining the same QoS guaranteed services.

Keywords: *bandwidth recycling, bandwidth allocation, rejected bandwidth request first, quality of service, subsriber station.*

"1. Introduction"

The WiMax mesh networks based on IEEE 802.16 standard (2004) was developed with the goal of providing for easy, fast and cost-effective network set-up, deployment and extension.

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 standards. Modern technologies, WiMax is able to provide a 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).

In IEEE 802.16 system, two kinds of stations (fixed or mobile) are defined: base station (BS) and subscriber Station (SS). The BS coordinates all the communication in the network. The SS can deliver voice, video, and data using common interface. IEEE 802.16 standards support two operational modes: a mandatory point-to-multipoint (PMP) mode, and an optional mesh mode. In a PMP topology network, a centralized BS is capable of connecting multiple 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: uplink (from SSs to BS) and downlink (from BS to SSs)[10].

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.

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.

"2. Literature Survey"

Broadband wireless access (BWA) has gained a particular attention during the past few years. The widely successful IEEE 802.11 wireless LAN (WLAN) technologies are suitable for an indoor BWA solution but are not well suited for outdoor BWA applications. In response to this need, the IEEE 802.16 is set up to develop a new standard for BWA applications. IEEE 802.16 is an emerging suite of air interface standards combing fixed, portable, and mobile BWA specifications. The first IEEE 802.16 standard, 802.16-2001, is the original fixed wireless broadband air interface specification in the 10–66 GHz frequency band for line of sight (LOS) only wireless services. The 802.16a was completed in 2003 to extend the standard in the 2–11 GHz for non-line-of-sight (NLOS) wireless broadband services [10].

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 [5].

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.

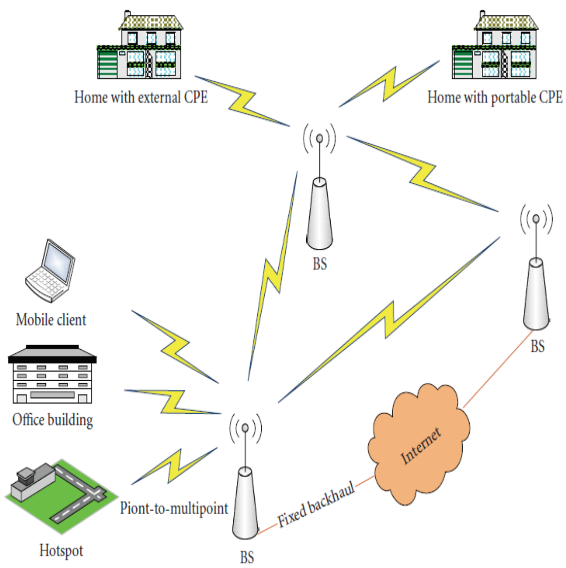
There is not enough bandwidth in use nowadays and it seems that as the more of it comes into use, the more of it could be used. Of course the performance level arises all the time, but with quality of service development the bandwidth that is in hand can be used a lot better and better applications and services can be developed for the customers.

Reliability of the transmission media plays an important role in the developed data communications equipment and in the transmission protocols. Reliability is one of the most important things when it comes to the services too. In many services, the low level of reliability makes them unusable. In a way, reliability is a component of quality of service - the more reliable the system, the higher the level of QoS. 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. 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. It can improve the utilization of bandwidth while keeping the same QoS guaranteed services and introducing no extra delay. [1]

2.1 Architecture



"Figure 1. IEEE 802.16 Architecture"[10]

Fig. 1 illustrates an example of general architecture of IEEE 802.16 networks. The fixed or mobile customer premise equipment's (CPEs) connect to the central BS, the BS receives transmissions from multiple sites and sends to internet directly or via other BSSs. End users (laptop, telephone, computer, . . . , etc.) inside the building, through in building networks such as Ethernet or WLAN, can connect to an outside CPE and then link to the IEEE 802.16 network.

"3. Proposed system"

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 the bandwidth utilization. Moreover, since the existing bandwidth reservation is not changed, the same QoS guaranteed services are provided without introducing any extra delay

3.1 Algorithm

3.1.1 Rejected Bandwidth Requests First Algorithm

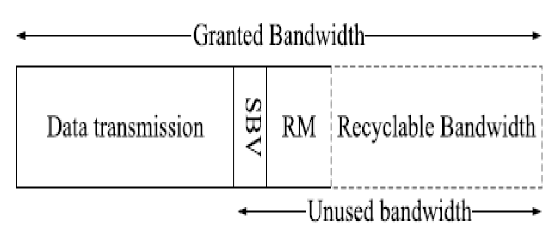
One of the factors causing recycling failures in priority based scheduling algorithm is that the CS does not have data to transmit while receiving a RM. To improve this factor, we propose to schedule SSs which have rejected BRs in the last frame because it can ensure that the SS scheduled as CS has data to recycle the unused bandwidth. This scheduling algorithm is called *Rejected Bandwidth Requests First Algorithm* (RBRFA).

Input: T is the set of TSs scheduled on the UL map. QR is the set of SSs which have rejected BRs
sent from non-real time connections in the last frame.
Output: Schedule a CS for each TS in T.

For i =1 to ‖T‖ do
a. $St \leftarrow TSi$
b. $Qt \leftarrow QR - Ot$
c. Randomly pick a SS $\in Qt$
as the corresponding CS of St
End For

3.2 Modules

3.2.1. Bandwidth utilization Module:



"Figure 2. Bandwidth utilization module"[9]

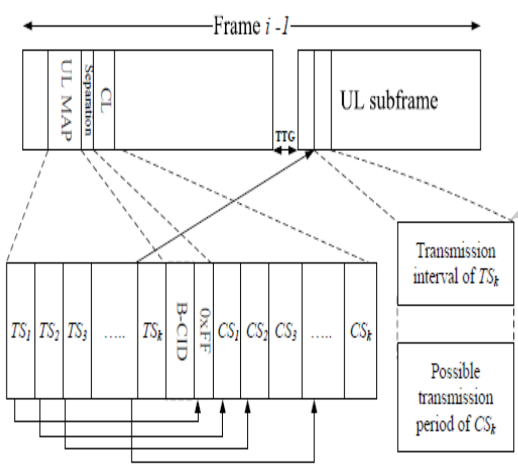
Bandwidth utilization improvements have been proposed in the literature. In, a dynamic resource reservation mechanism is proposed. It can dynamically change the amount of reserved resource depending on the actual number of active connections. The investigation of dynamic bandwidth reservation for hybrid 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 signalling cost. In the enhanced the system throughput by using concurrent transmission in mesh mode.

3.2.2. Packet creation Module:

In this module we split the Data in to N number of Fixed size packet with Maximum length of 48 Characters.

3.2.3. 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.



"Figure 3. Bandwidth recycling Module"[8][9]

3.2.4. QoS guaranteed services Module

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.

3.3. The Performance Metrics

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

3.3.1. 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 *Trecycle* and *Tno_recycle* represent the throughput with and without implementing our scheme, respectively. The higher *TG* achieved shows the higher performance that our scheme can make[1].

3.3.2 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 *Bunused_bw* and *Btotal_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[1].

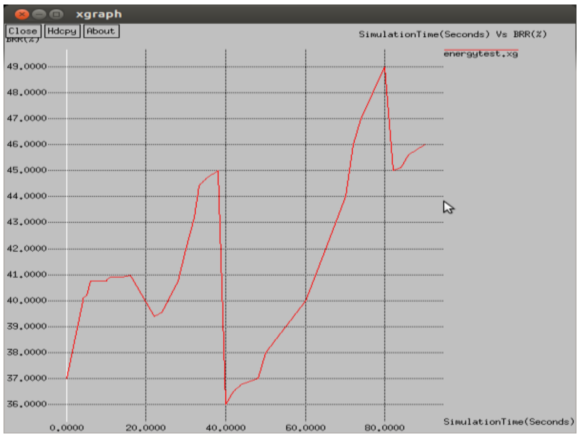
3.3.3. Bandwidth recycling rate (BRR):

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

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

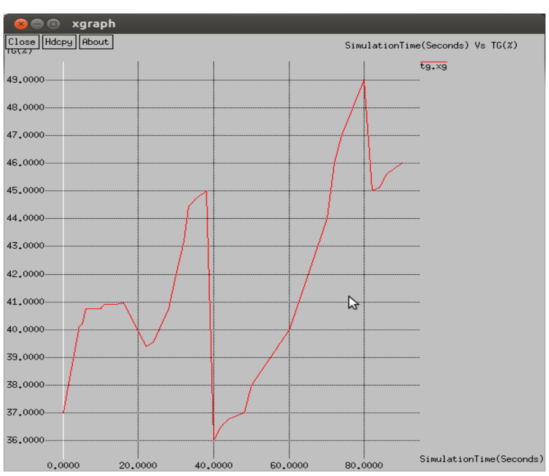
where *Brecycled* is the bandwidth recycled from *Bunused_bw*. *BRR* is considered as the most critical metric since it directly reveals the effectiveness of our scheme [1].

"4. Result"



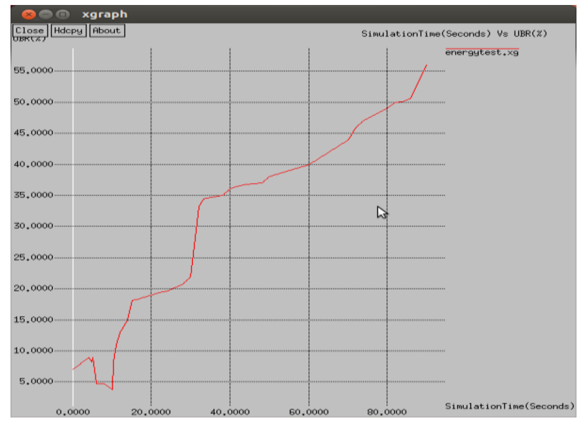
"Graph 1. Simulation Time Vs BRR"

The simulation results of recycling rate are presented in graph 1 from the graph, 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*.



"Graph 2. Simulation Time Vs TG"

Graph 2 presents the results of *TG* calculated from the cases with and without our scheme. In the figure, the *TG* is very limited at the beginning of the simulation, which is similar to the results of the *BRR*.



"Graph 3. Simulation Time Vs UBR"

Graph 3 presents the percentage of the unused bandwidth in our simulation traffic model (i.e., UBR). It shows the room of improvement by implementing our scheme. From the simulation results, we conclude that the average UBR is around 45%. In the beginning, the UBR goes down. It is because each connection still requests bandwidth from the BS. As time goes on, the UBR starts to increase when the connection has received the requested bandwidth. After 75th second of simulation time, UBR increases dramatically due to the inactivity of real time connections.

"5. Conclusion"

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. 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.

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. Our research does not change the existing bandwidth reservation to ensure that the same QoS guaranteed services are provided.

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