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Bandwidth Recycling in WiMAX Networks

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Abstract
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 35% 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 40% in a steady network. To improve the bandwidth utilization while maintaining the same QoS guaranteed services, our researchobjective is two fold: 1) the existing bandwidth reservationis not changed to maintain the same QoS guaranteedservices. 2) our research work focuses on increasing the bandwidth utilization by utilizing the unused bandwidth.

Keywords Bandwidth utilization, Bandwidth protector, Recycling IEEE 802.16, MAC, QoS, WiMAX.

1. INTRODUCTION

The Worldwide Interoperability for Microwave Access(WiMAX), based on IEEE 802.16 standards [2], is designed to facilitate services with high transmission rates for data and multimedia applications in metropolitan areas. 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).

2.MOTIVATION AND PROBLEM OVERVIEW

In comparison to IEEE 802.11a/b/g based mesh network, the 802.16-based WiMax mesh provides various advantages apart from increased range and higher bandwidth. The TDMA based scheduling of channel access in WiMax-based multi-hop relay system provides fine granularity radio resource control, as compared to RTS/CTS-based 802.11a/b/g systems. This TDMA based scheduling mechanism allows centralized slot allocation, which provides overall efficient resource utilization suitable for fixed wireless backhaul network. (The WiMax based mesh backhaul application differs from the 802.11a/b/g based mesh, which targets mobile ad hoc networks). However, the interference remains a major issue in multi-hop WiMax mesh networks. To provide high spectral usage, an efficient algorithm for slot allocation is needed, so as to maximize the concurrent transmissions of data in the mesh. The level of interference depends upon how the data is routed in the WiMax network. In this paper, we consider the following scenario of WiMAX- based mesh deployment. A mesh network is managed by a single node, which we refer to as Mesh BS. Mesh BS serves as the interface for WiMax-based mesh to the external network. We provide an algorithm for interference-aware multi-hop route selection for a given capacity-request matrix, which leads to efficient scheduling. 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.

Table 1:
IEEE 802.16 Mesh Mode Acronyms

BS	Base Station
SS	Subscriber Station
MSH	Mesh
SN	Sponsoring Node
CN	Candidate Node
MSH-NCFG	Mesh network Configuration Message
MSH-NENT	Mesh Network Entry Message
MSH-CSCH	Mesh Centralized Scheduling Message
MSH-CSCF	Mesh Centralized Scheduling Configuration Message

3. BASIC CONCEPTS

The IEEE 802.16 network is connection-oriented. It gives the advantage of having better control over network resource to provide QoS guaranteed services. In order to support wide variety of applications, the IEEE 802.16 standard classifies traffic into five scheduling classes:

- Unsolicited Grant Service (UGS)
- Real Time Polling Service (rtPS)
- Non-real Time Polling Service (nrtPS)
- Best Effort (BE)
- Extended Real Time Polling Service (ertPS)

Each application is classified into one of the scheduling classes and establish a connection with the BS based on its scheduling class. The BS assigns a connection ID (CID) to each connection. The bandwidth reservation is made based on the CID via sending a BR. When receiving a BR, the BS can either grant or reject the BR depending on its available resources and scheduling policies.

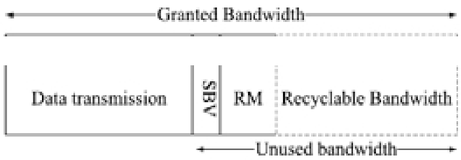

Fig. 1: Messages to release the unused bandwidth with in a UL transmission interval.

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. 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.

3.1 Bandwidth recycling

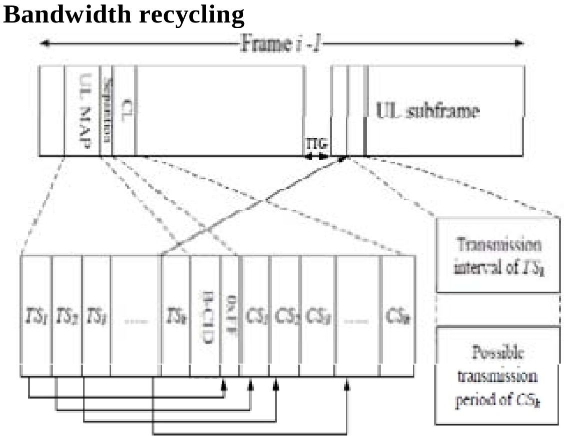

Fig. 2: The mapping relation between CSs and TSs in a MAC frame

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 CS and TS.

3.2 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.

3.3 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.

3.4 Bandwidth Monitor

Bandwidth Monitor monitors bandwidth usages through computer it's installed on. The software displays real-time download and upload speeds in graphical and numerical forms, logs bandwidth usages, and provides daily, weekly and monthly bandwidth usages reports. Bandwidth Monitor monitors all network connections on a computer, such as LAN network connection, Internet network connection, and VPN connection.

3.5 Bandwidth Monitor also offers useful built-in utilities

speeds stopwatch, transfer rates recorder, and bandwidth usage notification. And, the software supports running as a system service that monitors bandwidth usages and generate traffic reports automatically without log on. Bandwidth Monitor works with the majority network connections including modem, ISDN, DSL, ADSL, cable modem, Ethernet cards, wireless, VPN, and more.

3.6 Bandwidth Meter

Bandwidth Meter remains in tray and displays the bandwidth consumed for the session, day and month. This will be useful for people with limited bandwidth/month internet connection.

3.7 MAC Address

MAC Address is a tool for finding the MAC addresses of computers on the network. With Find MAC Address, you can find the MAC address of your computer or a remote computer or any computer within a specified range of IP addresses. Unlike similar software, Find MAC Address can find the MAC addresses of computers using four methods (ARP, NetBIOS, NetAPI, WMI).

4. BACKGROUND

Over the past ten years there has been an ongoing debate over the issue of charging Internet traffic. The growing numbers of Internet users coupled with the development of new applications that require large amounts of bandwidth has led to an explosive growth in Internet traffic resulting in frequent congestion that is widely perceived as poor service.More users are growing frustrated by slow connections and increasing packet delays (that result in slow applications like web browsing, ftp, e-mail etc.). Internet Service Providers (ISPs) are trying to solve this problem by over-provisioning (i.e., placing extra bandwidth) in the core of their backbone networks in order to alleviate the congestion experienced. Internet congestion may be reduced by a class of charging mechanisms that assign prices based only on information collected at the ingress of the network, where the user's packets enter. This paradigm is termed "edge pricing" (see Shenker et al., 1995) and it works by monitoring the packets that users send over their connection either constantly or at given intervals. 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. There are two transmission modes: Time Division Duplex (TDD) and Frequency Division Duplex (FDD) supported in IEEE 802.16. Both UL and DL transmissions cannot 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.

4.1 Theoretical Background for Effective Bandwidth In order to be able to charge customers for the use of a communications link we need to be able to identify scalars that will measure the resources they use when their packets are forwarded over the Internet. These scalars will then become the independent variables of a pricing function that will associate resource usage with a specific charge. Utilization of a traffic stream is a well defined metric and is easy to measure. However, burstiness is not so well defined. The effective bandwidth concept ties these two notions together. Effective Bandwidth is a scalar that summarizes resource usage on a communications link from a specific source in a packet-switched network.

Specifically, at a given switch in the network where many traffic streams from different sources are multiplexed on a single outgoing link fig. 3, the effective bandwidth of a specific source represents the capacity of the outgoing link used by that source.

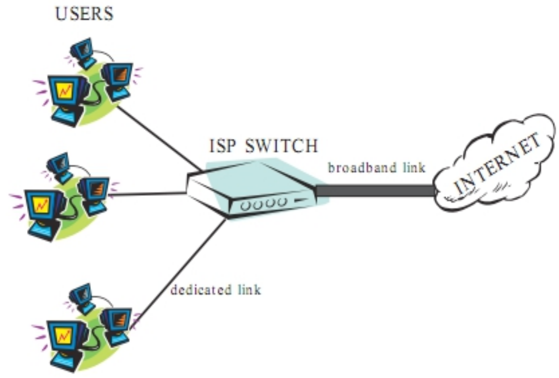

Fig. 3: Multiplexing of many sources on an outgoing broadband link

5. DYNAMIC BANDWIDTH REQUEST-ALLOCATION AND PRIORITY-BASED SCHEDULING ALGORITHM

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 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.The priority based scheduling alorgorithm explains the detailed working of the proposed scheme.

5.1 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 IITII do

1. St ← TSi.
2. Qt ← Q−Ot:
3. Calculate the SF for each SS in Qt.
4. If Any SS ∈ 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.

5. Schedule the SS as the corresponding CS of St.

End For

Assume Q represents the set of SSs serving non-real time connections (i.e., nrtPS or BE connections) and T is the set of TSs. Due to the feature of TDD that the UL and DL operations cannot be performed simultaneously, we cannot schedule the SS which UL transmission interval is overlapped with the target TS. For any TS, St , let Ot be the set of SSs which UL transmission interval overlaps with that of St in Q. Thus, 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 . A scheduling algorithm, a l l e d Priority-based Scheduling Algorithm (PSA), shown in Algorithm 1 is used to schedule a SS with the highest priority as the CS.

The priority of each candidate is decided based on the scheduling factor (SF) defined as the ratio of the current requested bandwidth (CR) to the current granted bandwidth (CG). The SS with higher SF has more demand on the bandwidth. Thus, we give the higher priority to those SSs. The highest priority is given to the SSs with zero CG. Non-real time connections include nrtPS and BE connections. The nrtPS connections should have higher priority than the BE connections because of the QoS requirements. The priority of candidates of CSs is concluded from high to low 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, we select one with the largest CR as the CS in order to decrease the probability of overflow.

6. CONCLUSION

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). 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] IEEE 802.16 WG, "IEEE Standard for Local and Metropolitan Area Network", Air Interface for Fixed Broadband Wireless Access Systems".

[2] J. Tao, F. Liu, Z. Zeng, Z. Lin, "Throughput enhancement in WiMax mesh networks using concurrent transmission", In Proc. IEEE Int. Conf. Wireless Commun., Netw. Mobile Computing., 2009, pp. 871-874.

[3] Bailey, J. P., Nagel, J., Raghavan, S, "Ex-post internet charging", In McKnight, L. W. and Wroclawski, J., editors, Internet Services, 2008.

[4] Besen, S. M., Spigel, J. S., Srinagesh, P, "Evaluating the competitive effects of mergers of internet backbone providers".

[5] M. Conti, G. Maselli, G. Turi, S. Giordano, "Cross-layering in mobile ad hoc network design", IEEE Computer, vol. 37, pp. 48-51, 2007.

[6] S. Shakkottai, T. S. Rappaport, P. C. Karlsson, "Cross-layer design for wireless networks".

[7] S. Toumpis, A.J. Goldsmith, "Capacity Regions For Wireless Ad hoc Networks", IEEE International Conference on Communications (ICC).