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A Review on Congestion Control in WIMAX Network

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Abstract

The Worldwide Interoperability for Microwave Access (WiMAX) technology based on the IEEE802.16-standard is a next generation Broadband Wireless Access (BWA) technology. This technology provides fixed as well as fully mobile high speed data rates along with roaming features. It provides users a thrilling Internet browsing experience. The main aim of Wimax is to provide quality of service. But providing QoS is a difficult task for mobile broadband services than for fixed. Large amount of different traffics, mobility, frequent handovers, high delays, congestion control are the complicated issues for providing portable connectivity. Various researchers discussed about congestion avoidance in WiMAX, as proposed in the WiMAX literature survey. This survey paper focus on that WIMAX is a next generation mobile network so for the next generation mobile networks, it is mandatory to consider increased throughput, sustained data rates, less delays and routing overheads and to provide QoS while maintaining the congestion on higher traffic rates and system's overall complexity. We focus on different TCP variants like TCP-Tahoe, TCP-Reno, TCP-Sack and TCP-Fack to improve quality of service in wimax.

Keywords: Wimax, BWA, congestion avoidance, TCP-Tahoe, TCP-Reno, TCP-Sack and TCP-Fack, QoS.

1. Introduction

In the mid-1990s, when the rapid growth of the internet clearly revealed that free and anonymous access to data, written communications were extremely valued by most individuals. Digital voice transmission in telephone networks was one of the first signs that came into use. For the time being, Wireless networking is by far the most popular way of communication that is available. The development of new technological devices that are made for users, they demand higher possible methods of speed, larger coverage and mobility. Thus came the existence of the technology; Worldwide interoperability for Microwave access (WiMAX). It is defined as IEEE standard 802.16. The standard was approved in April, 2002 [5]. WIMAX adopted some of its technology from WiBro, a service marketed in Korea. 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. It is similar to Wi-Fi, but it can enable usage at much greater distances. Mobile WiMAX is considered a promising next generation wireless technology because it has a long transmission range and supports high data rates and handover [1]. The WiMAX NWG has developed a network reference model to serve as an architecture framework for WiMAX deployments and to ensure interoperability among various WiMAX equipment and operators. So, far a number of specifications for WiMAX were standardized by the IEEE 802.16 Working Group[6]. The overall network may be logically divided into three parts: Mobile Station (MS) , Access Service Network (ASN), Connectivity Service Network (CSN) [10] (Fig. 1). WIMAX is called the next generation broadband wireless technology which offers high speed, secure, sophisticate and last mile broadband services along with a cellular back haul and Wi-Fi hotspots. The broadband

system stretched the WiMAX service to a wider-mile range and had the ability to disperse its network between hundreds of terminals. IEEE 802.16e Mobile WiMAX is the given standard for broadband wireless access in a metropolitan area. Many mobile carriers worldwide have been setting up Mobile WiMAX infrastructure. For interoperability testing, several WiMAX profiles have been developed by WiMAX Forum. The WiMAX forum currently has more than 470 members comprising the majority of operators, component, and equipment companies in the communications ecosystem [9].

Regardless of all these immense facilities QoS remains one major factor that most of the broadband wireless technologies lookout as a challenge. Quality of Service (QoS) is the service that is used to deliver the different services to the mobile user in appropriate time[8]. We surveyed various papers presented in this regard and come up with some congestion control algorithms of upgrading the quality of service (QoS) in the WiMAX network. Section 2 gives the introduction to various flavors of TCP congestion control variants. Section 3 covers the overview of literature survey that serves as the foundation approaches to the algorithms we surveyed. Lastly, Conclusions and future scope comes up in section 5.

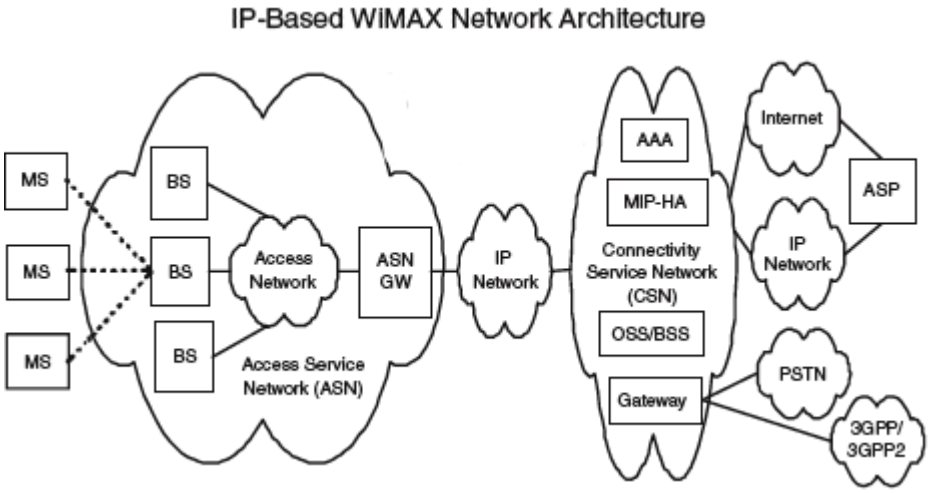

Fig. 1: IEEE 802.16 / WiMAX network architecture

Variants of TCP

TCP is a Transport layer protocols provide for end-to-end communication between two or more hosts [2]. It does not depend on the underlying network layers and, hence, design of various TCP versions is based on the properties of wired networks.

1) Tahoe

TCP Tahoe utilizes the Slow Start, Congestion Avoidance and fast retransmit algorithms [7]. In the slow start algorithm, a cwnd is added to the per-connection state. When starting or restarting after a packet loss, the cwnd is set to one packet. Thereafter, on each ACK for new data, the cwnd is increased by one packet. Congestion avoidance in TCP Tahoe relies on setting the cwnd to half the current window size on timeout. Thereafter, on each ACK for new data, the cwnd is increased by 1/cwnd. In addition, information about the receiver's advertised window and cwnd is also sent. Finally, the fast retransmit algorithm works by monitoring the reception of duplicate ACKs for the same TCP segment. From this, the TCP

sender infers that a packet loss has occurred and will retransmit lost packets without having to wait for the retransmission timer to expire.

2) Reno

The original retransmission mechanism of TCP is based on a timeout where round-trip time (RTT) and variance estimates are computed by sampling the time between when a segment is sent and when an ACK arrives [3]. It uses the Slow Start and Congestion Avoidance mechanisms. The sender window size is gradually increased until packet losses are experienced. Thereafter, the window size is halved and a linear, less gradual increase of packet transmission occurs. Consequently, this additive increase and multiplicative decrease lead to periodic oscillations in the cwnd, round-trip delay, and queue length.

3) New Reno

TCP New Reno maintains two variables, the cwnd, which initially set to 1 segment, and SS Threshold (ssthresh). At the beginning of the TCP connection, the sender enters the Slow Start (SS) phase, in which it increases the cwnd by 1 segment for every ACK it receives. When cwnd reaches the ssthresh, the TCP sender enters the Congestion Avoidance (CA) phase, in which it increases the cwnd by 1/cwnd for every ACK it receives, in order to slowly probe the available network bandwidth. This linear growth ends when cwnd reaches the receiver‘s advertized window, or by the reception of 3 DUPACKs. In the latter case, TCP infers that packets were

lost due to link congestion, and it reduces the cwnd by ½ of its current value, in an attempt to prevent network collapse (Fast Recovery).

4) SACK

Sack is a short name for selective acknowledgement. It works best when various packets got dropped from one window of data. The receiver use the ―option‖ fields of TCP header (SACK option) for notifying the sender of three blocks of non-contiguous set of data received and enqueued by the receiver. The first starting block represent the most recent packet received, and the next blocks represent the most recently reported SACK blocks. The sender keeps a

scoreboard in order to provide information about SACK blocks received so far.

5) FACK

Fack is short for Forward Acknowledgment and is based on TCP Reno with Sack. TCP FACK is using the information provided by Sack to compute a better estimate of the amount of data currently in transit(outstanding data). This information is essential for any congestion control algorithm. To estimate the amount of outstanding data, Fack introduces a new variable, fack, denoting the highest sequence number known to have been received plus 1.

6) WESTWOOD

In networks, the packet loss can occur as a result of transmission errors, but most frequently because of congestion [4]. TCP Westwood makes no attempt to correct the problem of non-congestion packet loss in wireless networks solely like Veno, but rather to improve the efficiency of TCP in all heterogeneous networks. It estimates the network‘s bandwidth by properly low-pass filtering and averaging the rate of returning acknowledgment packets per RTT. It then uses this bandwidth estimate to adjust the ssthresh and the cwnd to a value close to it when a packet loss is experienced (adaptive

decrease). In particular, when three DUPACKs are received, both the cwnd and ssthresh are set equal to the Estimated Bandwidth (BWE) times the minimum measured RTT (RTTmin); when a coarse timeout expires, the ssthresh is set as before, while the cwnd is set equal to one. The improvement of Westwood is a more realistic bandwidth estimation in comparison to TCP Vegas, which significantly increases TCP throughput over wireless links. TCP Westwood has also been tested in against handovers in simulated.

7) CUBIC

CUBIC is an enhanced version of BIC: it simplifies the BIC window control and improves its TCP-friendliness and RTT fairness. window growth function of CUBIC is governed by a cubic function in terms of the elapsed time since the last loss event. TCP-cubic function provides a good stability and scalability. Furthermore, the real-time nature of this transport protocol keeps the window growth rate independent of RTT, which keeps the protocol TCP friendly under both short and long RTT paths.

8) Tcp Veno

TCP Veno operates with the objective of distinguishing loss type, thus performing an appropriate window reduction instead of a fixed drop of window in Reno, and forcing a TCP connection to stay longer at the equilibrium by employing a proactive congestion detection method and a reactive congestion detection method together. Veno differs from the conventional TCP in two ways: 1) It dynamically adjusts the slow start threshold (ssthresh) based on the equilibrium estimation of a connection as opposed to using a fixed drop-factor window, when packet loss is encountered. 2) It uses a refined linear increase algorithm, which employs both the proactive and reactive congestion detection schemes to adjust the congestion window size during the additive increase phase.

9) Tcp Vegas

TCP Vegas is a TCP congestion control algorithm that emphasizes packet delay, rather than packet loss, as a signal to determine the rate at which to send packets. TCP Vegas detects congestion based on increasing Round Trip Time (RTT) values of the packets in the connection unlike TCP Reno which detect congestion only after it has actually happened via packet drops. The algorithm depends heavily on accurate calculation of the Base RTT value. Base RTT is set to be the minimum of all measured RTTs; it is commonly the RTT of the first segment sent by the connection.

Literature Survey

J. Cecilia Rana A.[1] proposed a mechanism for the improvement of the congestion control mechanism over mobile WiMAX in an adhoc environment. Throughputs of three different TCP congestion control algorithms namely Westwood+, Veno and New Reno Compared on the basis of handovers and random packet losses over mobile WiMAX. The mechanism enhanced the protocol with Random Early Detection (RED) policy. Ns-2 simulation results show that Enhanced Westwood+ using the handover aware algorithm has the improved performance up to 10.2% over normal TCP Westwood+.

K. Kishor and A. Sharma proposed a TCP optimization technique in mobile ad hoc networks. Packet losses in MANETs are mainly due to congestion and frequent link failures but in case of wireless networks packet losses are mainly due to congestion. To optimize TCP in MANETs author use congestion control and avoidance algorithms. In this paper study

and compare the performance of TCP traffic scenario in wimax environment. Author will be simulating the traffic congestion of TCP packets inside a network using network simulator version 2. In this simulator support many types of network protocols like as TCP, many types of Routing algorithms, MAC etc. for offering simulation results for both type of network s wired or wireless networks and Experimental results validate the ability of our proposed algorithm to successfully classify the cause of the packet loss, with low End-to-End Delay and high packet delivery ratio. The Throughput is also better.

Monika and A. Kaur proposed a mechanism that WiMAX technology is presently one of the most promising global telecommunication systems. This standard defines the Medium Access Layer and the Physical Layer of a fixed and mobile Broadband Wireless Access System. WiMAX to provide high-speed access to the Internet where the transmission control protocol (TCP) is the core transport protocol. Unlike routing, where packets are relayed hop-by-hop toward their destination, TCP actually provides reliable end to –end transmission of transport-level segments from source to receiver. As TCP was designed for wired networks it considers that all packet loss in the network is due to congestion. Wireless medium is more exposed to transmission errors and sudden topological changes. In this paper, we provides a comprehensive studies of different reliable transport layer congestion control variants of TCP is done and in addition, the current issues and future challenges that are involved in this exciting area of research are also included.

B. Subramani and T. Karthikeyan proposed Modern Telecommunication, Computer Networks and both wired and wireless communications including the Internet, are being designed for fast transmission of large amounts of data, for which Congestion Control is very important. Without proper Congestion control mechanism the congestion collapse of such networks would become highly complex and is a real possibility. Congestion control for streamed media traffic over network is a challenge due to the sensitivity of such traffic towards. This challenge has motivated the researchers over the last decade to develop a number of congestion control protocols and mechanisms that suit the traffic and provides fair maintenance for both unicast and multicast communications. This paper gives out a brief survey of major congestion control mechanisms,

Categorization characteristics, elaborates the TCP-friendliness concept and then a state-of-the-art for the congestion control mechanisms designed for network. The paper points the pros and cons of the congestion control mechanism, and evaluates their characteristics.

A. Rajpoot et al. proposed that WiMAX is a technology used for long distance wireless communication with higher data rates. It can be used as an alternative broadband. This paper covers basic information about WiMAX, WiMAX features, its network architecture, Portable WiMAX, QoS of WiMAX and its parameters.

A. Chhabra et al. proposed that Currently, WiMAX is one of the hottest technologies in wireless based on the IEEE 802.16 wireless technology which offers high throughput broadband connections over long distance that supports Point to Multi-point (PMP) broadband wireless access. The work focuses on TCP sender side mechanisms and appropriate buffer management algorithm to handle higher offered load, random losses and retransmission timeouts in high delay networks in such a way as to keep congestion window as high as possible, while keeping the congestion under control and keep retransmissions to minimal. The TCP proposed mechanisms are assessed against TCP New Reno, TCP Westwood, and

TCP CUBIC to view how they fare against congestion under higher mobility speed. Ns2 simulator is selected as the simulation tool because of the ease of use of the graphical interface provided and extensive support of TCP.

B. Jaglan and N. Pawar proposed that WiMAX has emerged as the strongest contender for broadband wireless technology with promises to offer guaranteed QoS to wireless application users. The IEEE 802.16 standard provides Broadband Wireless Access that depends on wireless medium which has higher packet error rate, and higher packet overheads that altogether limit the capacity of the network to offer guaranteed QoS. The issue is further complicated by the fact that the TCP transport protocol, mandated in the case of IEEE 802.16 standard, has provisions for resending packets in the event of interference-induced losses. So long as the interference has some degree of intermittency, a transmission can be maintained even in the face of heavy interference, though at considerable cost of speed and reduction of service quality. In this paper, we provides a comprehensive studies of different reliable transport layer protocol congestion control variants of TCP is done and in addition, the current issues and future challenges that are involved in this exciting area of research are also included.

R. Gupta proposed that Wireless network is fast growing area. Wireless network has an ability to provide a good quality of service i.e voice, data, video conferencing etc. In this research work, create a WiMAX network and that network consist of 2 base stations, app configuration, profile configuration, WiMAX configuration and 16 mobile nodes. After creating a network check the quality of network i.e Jitter (sec) and delay (sec). In this research paper we conclude that when the speed of moving mobile node is increased we obtain the low delay and low jitter in network.

G. Singh Dhaliwal et al. proposed that WiMAX is essentially a next-generation wireless technology that enhances broadband wireless access. WiMAX uses Orthogonal Frequency Division Modulation (OFDM) technology, which has a lower power consumption rate. The paper focuses on the different congestion control mechanisms implemented by the Transmission Control Protocol (TCP). Reliable transport protocols such as TCP are tuned to perform well in traditional networks where packet losses occur mostly because of congestion. However, networks with wireless and other lossy links also suffer from significant losses due to bit errors and handoffs. TCP responds to all losses by invoking congestion control and avoidance algorithms, resulting in degraded end-to-end performance in wireless and lossy systems. In this Paper, we compare several schemes designed to improve the performance of TCP in such networks. Keywords: WiMAX, **IEEE 802.16, TCP, C-TCP, TCP-CUBIC.**

Bhavsar et al. proposed that QoS framework is a fundamental component of a 4G broadband wireless network for satisfactory service delivery of evolving Internet applications to end users, and managing the network resources. Today's popular mobile Internet applications, such as voice, gaming, streaming, and social networking services, have diverse traffic characteristics and, consequently, different QoS requirements. A rather flexible QoS framework is highly desirable to be future-proof to deliver the incumbent as well as emerging mobile Internet applications. This article highlights QoS frameworks and features of OFDMA-based 4G technologies — IEEE 802.16e, IEEE 802.16m — to support various applications' QoS requirements. A few advanced QoS features such as new scheduling service (i.e., aGP), quick access, delayed bandwidth request, and priority controlled access in IEEE 802.16m are explained in detail. A brief comparison of the QoS framework of the aforementioned technologies is also provided.

Conclusion

The survey analysis shows that algorithms vary according to the demand of network. Moreover, those who have been implemented are limited to a particular environment. It is obvious that Wimax suffers with different issues and agendas. Some of the distinguished issues are bandwidth constraints and limited power of mobile devices and some other are packet's random losses and retransmission timeouts in high delay networks that leads to congestion. So the future work focus on the sender side mechanisms of TCP to handle higher traffic, random losses and retransmission timeouts in high delay networks while keeping congestion window as high as possible and also keeps the congestion under control and keep retransmissions to minimal. Most of the proposed mechanisms above schemes mentioned above lacks in handling these issues. Therefore there is unquestionably a need of congestion avoidance mechanisms that can offer a better QoS refinement in WiMAX. From the above analysis some of the TCP variants delivers effective throughput and packet delivery ratio and less delay. So the TCP proposed mechanisms are assessed against TCP SACK and TCP FACK variants to see how they fair against congestion and higher traffic in the network.

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