A Review on Qos Oriented Congestion Control and Load Balancing Algorithms over WiMAX

Monika [1], Amandeep Kaur[2]

[1] Dept. of Computer Science and Engg.
YIET.
Yamuna Nagar(Haryana), India.
[2] Asst. Professor, Dept. of Computer Science and Engg.
YIET.
Yamuna Nagar(Haryana), India

ABSTRACT

WiMAX technology is presently one of the most promising global telecommunication systems. Great hopes and important investments have been made for WiMAX, which is a Broadband Wireless Access System having many applications: fixed or last-mile wireless access, backhauling, mobile cellular network, telemetering, etc. WiMAX is based on the IEEE 802.16 standard, having a rich set of features. 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.

Keyword : - *WiMAX, IEEE 802.16, TCP.*

I. INTRODUCTION

WiMAX is not the only solution for delivering broadband wireless services. Several proprietary solutions, particularly for fixed applications, are already in the market. A few proprietary solutions, such as i-Burst technology from ArrayComm and Flash-OFDM from Flarion (acquired by QualComm) also support mobile applications. In addition to the proprietary solutions, there are standards-based alternative solutions that at least partially overlap with WiMAX, particularly for the portable and mobile applications. In the near term, the most significant of these alternatives are third-generation cellular systems and IEEE 802.11-based Wi-Fi systems.Figure 1.1 shows the evolution of these technologies.
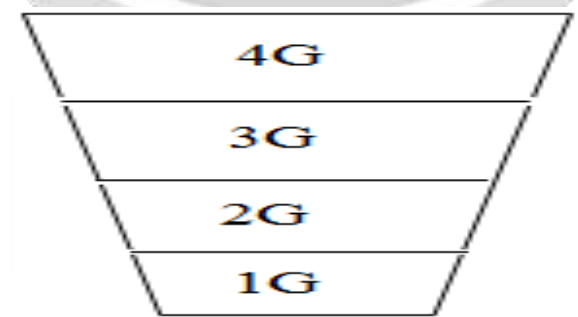

Figure1: Evolution of Digital Technologies.

1.1 WiMAX

WiMAX stands for Worldwide Interoperability for Microwave Access. It is a broadband wireless point-to-multipoint specification from the IEEE 802.16 working group. It is a telecommunications protocol that provides fixed and mobile Internet access. Although initial WiMAX deployments are likely to be for fixed applications, the full potential of WiMAX will be realized only when used for innovative nomadic and mobile broadband applications. The IEEE 802.16 standard defines two possible network topologies :

- PMP (Point-to-Multipoint) topology
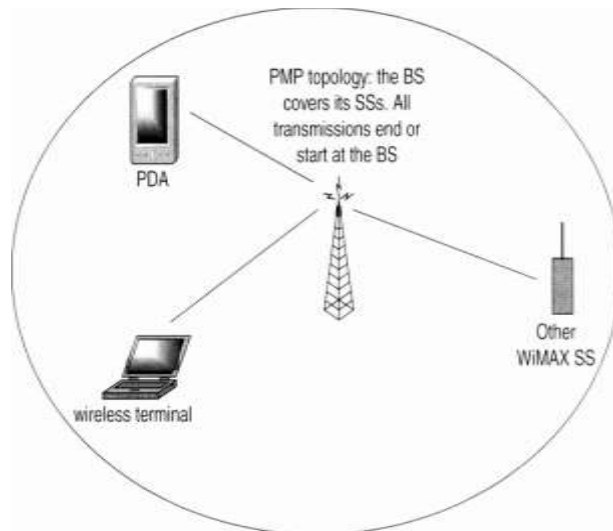
- Mesh topology or Mesh mode
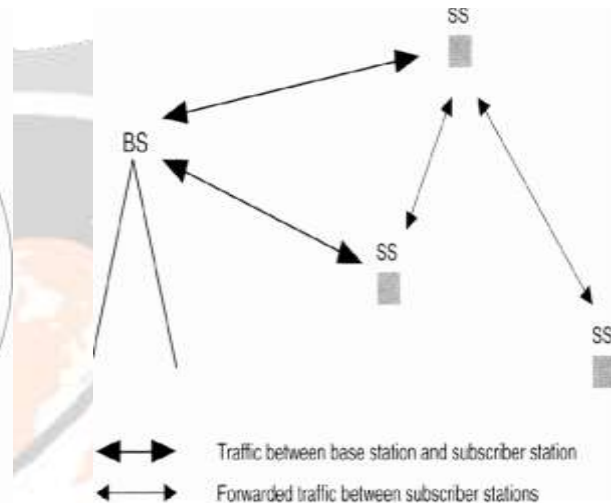
Figure 2: PMP topology   Figure 3: Mesh topology.

As endusers get accustomed to high-speed broadband at home and work, they will demand similar services in a nomadic or mobile context, and many service providers could use WiMAX to meet this demand. For WiMAX, to be able to realize the objective of high speed Internet access, it must effectively support the core transport protocol of the Internet that is Transmission Control Protocol (TCP). Standard TCP congestion control is based on the reduction of its congestion window after a packet loss. Although such behavior works fairly well in the wired networks, where packets losses are almost always caused by link congestion, it becomes rather inefficient when used for data transport in WiMAX networks. In the wireless environment the possible reasons of packet loss include fading, temporary disconnections, and handovers. Even when some losses are compensated in Data Link Layer, a part of them still appears in Transport Layer for high Bit Error Rates (BER).

1.2 TCP-CONGESTION CONTROL

When the load offered to any network is more than it can handle, congestion builds up. The Internet is no exception. Congestion can be dealt with by employing a principle borrowed from physics: the law of conservation of packets. The idea is to refrain from injecting a new packet into the network until an old one leaves (i.e., is delivered). TCP attempts to achieve this goal by dynamically manipulating the window size.

TCP congestion control consists of: slow start (SS), congestion avoidance (CA), and fast retransmit/fast recovery. The endpoint node concludes that congestion exists when an increase in end-to-end delay is observed. Retransmissions can further aggravate congestion since more packets are injected into the network. As shown in Fig. -ure 4, the TCP sender gradually increases the cwnd size by one packet upon receipt of an ACK, until the first sign of congestion is detected. Thereafter, backoff occurs and the window size is reduced to half the current window. The SS process then begins again gradually.
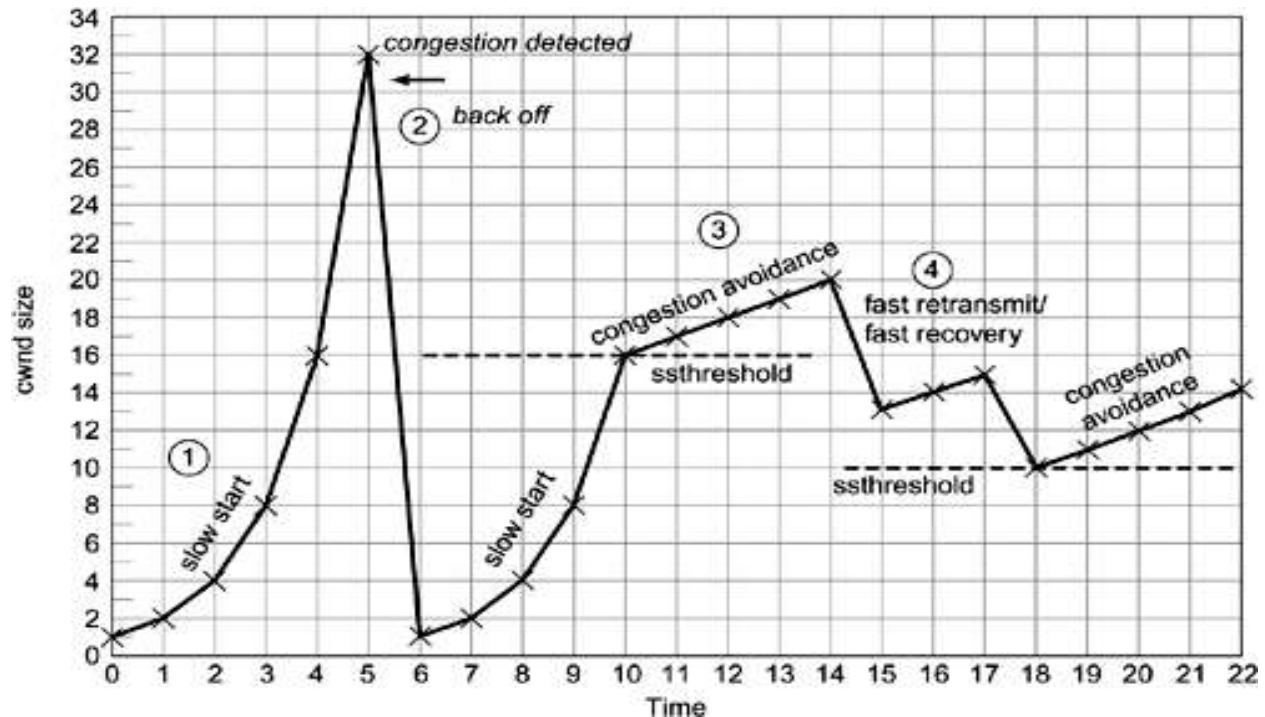
Figure 4: TCP congestion control.

Clearly, TCP provides a mechanism for reliable end-to-end transmission without requiring any support from intermediate nodes. This is done by making certain assumptions about the network. Specifically, TCP assumes that all packet losses, or unacknowledged packets and delays are caused by congestion and that the loss rate is small. This assumption is not valid in a *wireless network*, where packet errors are very frequent and caused mostly by poor channel conditions. Responding to packet errors by slowing down does not solve the problem if the errors are not caused by congestion. Instead, it serves only to unnecessarily reduce the throughput. Frequent errors will lead to frequent initiation of slow-start mechanisms, keeping TCP away from achieving steady state throughput.

1.3 Versions of TCP

The TCP protocol has been extensively tuned to give good performance at the transport layer in the traditional wired network environment. However, TCP in its present form is not well suited for ad hoc networks where packet loss due to broken routes can result in the counterproductive invocation of TCP's congestion control mechanisms.

1.3.1 TCP Tahoe

The early TCP implementations followed a Go-Back-N model using the cumulative positive acknowledgement scheme, which required a retransmit timer to expire to resend lost data. TCP Tahoe utilizes the SS, CA and fast retransmit algorithms (RFC 2001).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. This is, in fact, the congestion avoidance and control method suggested by Van Jacobson and Michael J. Karels.

1.3.2 TCP-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. This coarseness implies that the time interval between sending a segment that is lost until there is a timeout and the segment is resent is now much longer than necessary. Hence, fast retransmission and fast recovery mechanisms are incorporated into the Reno implementation. TCP Reno will not only retransmit when a coarse-grained timeout occurs, but also when it receives three ACKs from the receiver. In Reno, a duplicate ACK is sent whenever a receiver cannot acknowledge incoming new segments due to the failure of arrivals of previous segments.[16]

1.3.3 TCP-Newreno

TCP New Reno maintains two variables, the congestion window size (*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)*. This *Additive Increase Multiplicative Decrease (AIM.)*. TCP's reactive congestion control and avoidance mechanism was proved incapable of handling efficiently mixed-type packet losses happening in wired/wireless heterogeneous networks [16].

1.3.4 TCP-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. In this way the sender can conclude that whether there are missing packets at the receiver.

1.3.5 TCP 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. The variables next and una represent the first byte of data yet to be sent and the first unacknowledged byte, respectively.

1.3.6 TCP-Westwood

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 [16].

1.3.7 TCP-Cubic

CUBIC is an enhanced version of BIC: it simplifies the BIC window control and improves its TCP-friendliness and RTT-fairness. The 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..[12]

II. RELATED WORK

F. Furqan Doan et al. [1], propose a mechanism namely WiMAX Fair Intelligent Congestion Control (WFICC) to avoid congestion at the base station. WFICC ensures that the traffic is scheduled in such a way that the base station output buffer operates at a target operating point, without violating the QoS requirements of connections. A detailed simulation study is performed in ns-2 to evaluate the effectiveness of proposed algorithm to meet the QoS requirements of different Class of Services (CoSs). The results have shown that the proposed WFICC algorithm enables the base station to avoid congestion and ensures the provision of QoS of different Class of Services (CoSs) in terms of throughput, fairness and packet delay.

Georgi Kirov [2], focuses on the different congestion control mechanisms implemented by the Transmission Control Protocol (TCP). The author presents an experimental estimation of the TCP control algorithms: Slow-Start and Congestion Avoidance without Fast Retransmit, Tahoe that includes Fast Retransmit and Fast Recovery, and Reno using a modified version of the Fast Recovery. The TCP performance analysis is based on different scenarios of the network simulation with low percentages of the packet loss. The results for Reno are slightly better than Tahoe. The advantage of the Reno algorithms in comparison with Tahoe one is when packet loss is detected, the window size is reduced to one half of the current window size and the congestion avoidance, but not slow start is performed.

K. Tsiknas et al. [3], evaluate through simulations the performance characteristics of various TCP schemes namely -TCP New Reno, Vegas, Veno, Westwood and BIC, in WiMAX networks, by taking into account the effects of wireless channel errors, link congestion in both forward and They also suggest Binary Increase Adaptive Decrease (BIAD) paradigm will be benefited by both the quick window expansions of BIC and by the appropriate window adaptations of Westwood, thus offering in overall a better performance in WiMAX networks.

Gerla et al. [4], investigated the impact of the MAC protocol on performance of TCP on multi-hop networks. Chandran et al. [5] proposed the TCP-Feedback (TCP-F) protocol, which uses explicit feedback in the form of route failure and reestablishment control packets. Performance measurements were based on a simple one-hop network, in which the link between the sender and receiver failed/recovered according to an exponential model. Also, the routing protocol was not simulated.

Md. Shohidul Islam et al. [6], focuses on analysis of eleven variants-Tahoe, Full-Tcp, TCP-Asym, Reno, Reno-Asym, Newreno, Newreno-Asym, Sack, Fack, Vegas and Vegas-RBP as source and five - TCPSink, TCPSink-Asym, Sack, DelAck and Sack1-DelAck as destination, implemented in Network Simulator (NS-2). Performance of TCP versions indicates how they respond to various network parameters -propagation delay, bandwidth, TTL (time to live), RTT (round trip time), rate of packet sending and so on. Such analysis is immensely in need to be aware of which TCP is better for a specific criterion, wherefrom an appropriate one will be selected in respective network to optimize traffic goal.

P. Omprakash et al. [7], focused on how TCP will be serviced by WiMAX, and what are the issues that are still open and can be used to increase the performance of the service. First it was reviewed the throughput of TCP tahoe against time. Then, the TCP variants were compared by respective throughput against time. Some of the flavors of TCP congestion control are loss-based, high-speed TCP congestion control algorithms that uses packet losses as an indication of congestion; delay-based TCP congestion control that emphasizes packet delay rather than packet loss as a signal to determine the rate at which to send packets. The authors compared three TCP variants, namely Tahoe, New Reno and Vegas were On the basis of throughput, round-trip time (RTT) and packet loss ratio. While all the TCP variants achieve similar throughput, they do so in different ways, with different impacts on the network performance. The adverse effects of TCP window auto-tuning is identified in this environment and demonstrate that on the downlink, congestion losses dominate wireless transmission error. Several issues were revealing for this WiMAX-based networks, including limited bandwidth for TCP, high RTT and jitter, and unfairness during remote login, VoIP, and video streaming.

III. CONCLUSION

In this paper, we have covered general quality of service principles as applied to a packet network. Traditional IP based networks were designed for best-effort data and did not include any provision for QoS. Some form of QoS can be provided by relying on different end to end transport layer protocols that run over IP. TCP ensures that data is transferred end-to-end reliably without errors. Different TCP versions react with different types of behavior. Through paper, we have noted that TCP throughput decreases significantly when subscriber movement cases link failures, due to TCP's inability to recognize the difference between link failure and congestion.

REFERENCE

[1] Fatima Furqan and Doan B. Hoang, " WFICC: A New Mechanism for Provision of QoS and Congestion Control in WiMAX", The 10th Annual IEEE CCNC- Wireless Networking, IEEE, 2013.

[2] Georgi Kirov, "*A Simulation Analysis of the TCP Control Algorithms*", International Conference on Computer Systems and Technologies, *2005*.

[3]   Konstantinos Tsiknas, George Stamatelos," *Performance Evaluation of TCP in IEEE 802.16 Networks",* Wireless communication and networking conference : mobile and wireless network, IEEE, 2012.

[4]   M. Gerla, K. Tang and R. Bagrodia, "*TCP performance in wireless multi-hop networks*", Proceedings of WMCSA, IEEE, February 1999.

[5]   Kartik Chandran, Sudarshan Raghunathan, S. Venkatesan, Ravi Prakash ," A Feedback Based Scheme For Improving TCP Performance In Ad-Hoc Wireless Networks", Personal Communications, IEEE, vol. 8,pp. 34 – 39, 2001.

[6]   Md. Shohidul Islam, M.A Kashem, W.H Sadid, M. A Rahman, M.N Islam," *TCP Variants and Network Parameters: A Comprehensive Performance Analysis*", Proceedings of the International Multi-Conference of Engineers and Computer Scientists, vol. 2, pp - 978-988, 2009.

[7]   P. Omprakash, R. Sabitha," *Performance Analysis of TCP over WiMAX",* IEEE, 2011.

[8]   Fatima Furqan and Doan B. Hoang, " WFICC: A New Mechanism for Provision of QoS and Congestion Control in WiMAX", The 10th Annual IEEE CCNC- Wireless Networking, IEEE, 2013.

[9]   T. Anouar and A. Haqiq ," *Performance Analysis of VoIP Traffic in WiMAX using various Service Classes*" International Journal of Computer Applications, vol. -20, 2012, pp. 29-33.

[10]   Shraddha Bansal, Raksha Upadhyay, "*Performance Improvement of Wi-Max IEEE 802.16e in Presence of Different FEC Codes*", CICSYN, IEEE, 2009.

[11]   M. Rehan Rasheed ,*" Performance of Routing Protocols in WiMAX Networks",* International Journal of Engineering and Technology, vol.2, no.5, October 2010.

[12]   Injong Rhee, and Lisong Xu ," CUBIC: A New TCP-Friendly High-Speed TCP Variant", SIGOPS, ACM, vol.- 42,2008.