Performance Evaluation of TCP Reno, SACK And FACK Over WIMAX

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Abstract— This thesis mainly aims in the improvement of the congestion control mechanism over mobile WIMAX. Here, TCP sender side mechanisms are used to handle higher load, random packet loss and re transmission timeouts in high delay networks such a way as to keep the maximum size of congestion window, while keeping the control over congestion and re transmission at a minimal level. The TCP mechanisms are used against TCP Reno, TCP SACK and TCP FACK to see how they fair against congestion and higher offered load. Four network parameters are used to find out the best protocol for congestion control: throughput, average end to end delay, PDR & routing Load.

The base station node has been overloaded with 30 mobile nodes which will be sending their data at the same time. This will cause congestion at the network and above four parameters will be measured by using TCP congestion control mechanisms. NS2 simulator has been used as the simulation tool because of the ease of use of the graphical interface provided. The simulated graphs have been used to compare the performance of three TCP protocols used for simulation against four network parameters.

Keywords— TCP, Reno, SACK, FACK, NAM, NS2, Throughput, Average End To End Delay, Packet Delivery ratio

INTRODUCTION

Broadband wireless access (BWA) is a candidate for the next-generation wireless communication technology. Universal Interoperability for Microwave Access (WiMAX) is the organization behind interoperability and testing for the IEEE 802.16 spec[1]. Standard TCP congestion control mechanism is based on the reduction of its congestion window after a packet loss [2]. Even though such behavior works fairly well in the wired networks, where packets losses are mostly always caused by link congestion, it comes out rather ineffective when used for data transport in WiMAX networks. In the wireless environment the viable reasons of packet loss include fading, temporary detachments, and handovers. Even when some losses are recompensed in Data Link Layer, a part of them appears in Transport Layer for high Bit Error Rates. TCP New Reno improperly translates the causes of packet loss as congestion and consequently reduces its congestion window, thus exhibiting significant throughput degradation in these conditions. Another phenomenon which extremely affects performance of TCP is the network dissymmetry.

A network is assumed to be asymmetric when its characteristics in one direction greatly affect its performance in the other [3]. Asymmetry interrupts the smooth flow of ACKs in the reverse direction of traffic and subsequently the TCP ACK clocking mechanism of the TCP sender, causing expiration of timer , and continuous retransmissions, although, the packets may have correctly reached the receiver. In addition, frequent ACK delays result in timeout augments, hence, causing less protocol response to packet losses. There are several forms of dissymmetry, e.g. bandwidth , access , delay and packet loss. All packets are ingrained in WiMAX networks, especially in best-effort class of service, where TCP typically operates, due to difference of traffic among Subscriber Stations (SSs) and because the SS needs to receive a grant by the Base Station (BS) before sending any data [4].

Bandwidth dissymmetry is also very often in WiMAX networks when TDD is used. In TDD, the ratio of transmission b/w downlink and uplink direction can be adaptive & may cause starvation of bandwidth in the uplink, which in turn affect the regular flow of ACKs. A lot of research has been made to aim at suggesting different ways to improve the efficiency of TCP in wireless networks. Although, there are not pervasive comparative studies of TCP performance in WiMAX networks. In this work, we evaluate some representative TCP congestion control schemes under various traffic scenarios, which include single and multiple TCP flows through WiMAX networks in the presence of wireless channel errors, network asymmetries and various level of link congestion. The target is to find out the best performing TCP schemes and to suggest ways for further improvements.

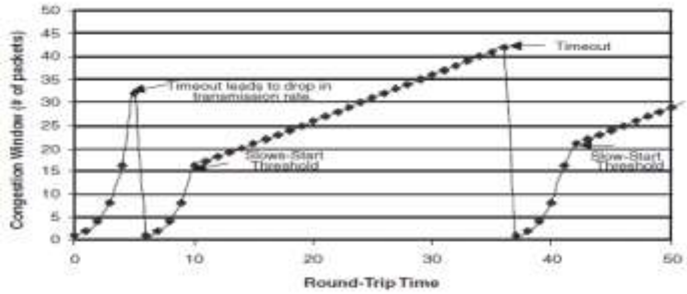

Figure 1 TCP congestion control

LITERATURE REVIEW

TCP Reno

It retains the basic principle of Tahoe, but uses the logic of duplicate acknowledgements (dupacks) to trigger Fast Retransmit. After 3 dupacks, TCP Reno takes it as a sign of segment lost and retransmit the packet immediately and enter Fast Recovery. In Fast Recovery, ssthresh and cwnd is set to half the value of current cwnd. For each subsequent dupack, increase cwnd by one and transmit a new segment if the new value permits it. TCP Reno cannot detect multiple packet loss within the same window [7].

TCP Sack

It is an extension of TCP RENO and it works around the problems face by TCP RENO, mainly detection of multiple lost packets, and re-transmission of more than one packet lost per RTT. SACK maintains the slow-start and fast retransmission of parts of RENO. It also has the crude grained timeout of Tahoe to fall back on, in case a packet loss does not get detected by the modified algorithm. SACK algorithm allows a TCP receiver to acknowledge out-of-order segments selectively rather than cumulatively by acknowledging the last correctly in order received segment [5]. If there are no such segments outstanding then it sends a new packet. Thus more than one segment lost can be sent in one RTT.

TCP Fack

It is a special algorithm that works on top of the SACK options, and is adapted at congestion controlling. FACK algorithm uses provided information from SACK to add more precise control to the injection of data into the network during recovery – this is achieved by explicitly measuring the total number of bytes of data outstanding in the network [6]. FACK decouples congestion control from data recovery thereby attaining more precise control over the data flow in the network. The main idea of FACK algorithm is to acknowledge the most forward selective acknowledgment sequence number as a sign that all the previous acknowledged segments were lost. This observation allows improving resumption of losses significantly.

SIMULATION ENVIRONMENT

In this section we will present the test setup used for comparing the above TCP mechanisms. The traffic scenarios were implemented in network simulator-2 as shown in figure 2. Network Simulator-2 (NS-2) is an open source, discrete event network simulator [8]. Table 1 shows the most important WiMAX and traffic parameters used in our simulations.

Channel type	Wireless Channel
Radio Propagation Model	Two Way Ground
Network Interface Type	OFDM
MAC Type	Mac 802.16
Antenna Model	Omni Antenna
No. Of Subscriber Nodes	30
Routing Protocol	OLSR

Table 1 Simulation Parameters

A detail simulation model based on NS-2 has been used in the interpretation, and in order to perfectly evaluate the effect of out-of-order packet while some of the TCP variants. The source-destination pairs are spread instant over the network. The data generator is FTP. Mobility models were created for the simulations using 30 nodes as shown in figure, and this model was set in such a way that first all the 30 nodes were provided Then all the nodes move within their boundary by setting their final destination and the speed that each node move with. All the simulations are run for 200 simulated seconds. Different mobile and identical traffic scenarios have been used across the protocol to collect fair results.

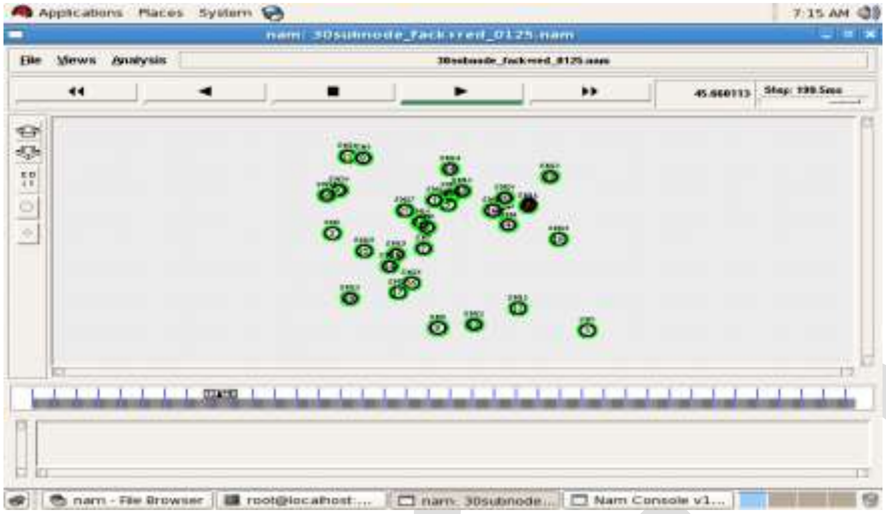

Figure 2 Nam animation trace with node deployment

SIMULATION RESULTS

In this section we present our simulation scenarios in WiMAX and consider the results obtained. With the help of graphs, the simulation has been figured out for various TCP variants based on higher offered load network scenario based on cyclic prefixes using NS-2.

Packet Delivery Ratio (PDR) :

Figure 3 shows the packet delivery ratio for TCP Reno TCP-Sack, TCP-Fack and TCP-Fack+RED when the cyclic prefix is varied. Simulation results shows that TCP-Fack gives higher performance when the value of cyclic prefix decreases. It is observed that the packet delivery ratio of TCP FACK over OLSR under higher offered load is better than both TCP-Reno and TCP-Sack.

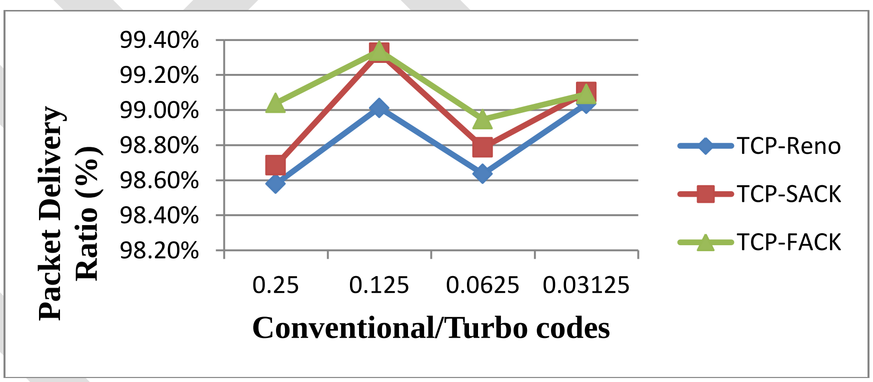

Figure 3 Packet Delivery Ratio

Throughput

The figure 4 shows the impact of mean speed on the throughput. It is observed that the throughput of TCP-FACK+ RED is better than other two TCP variants i.e TCP-Reno and TCP-Sack.

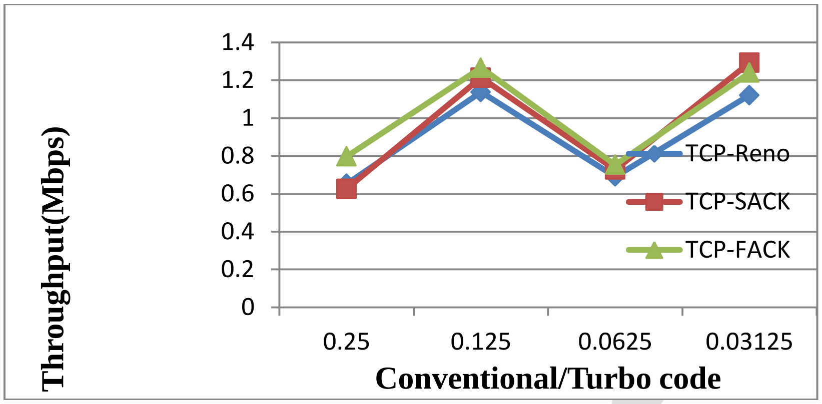

Figure 4 Throughput

Average Delay

The figure 5 showing the end-to-end delay when the number of source destination pairs are maximum.
OLSR protocol uses the route cache which many a times contains stale routes, as a result delay is comparatively higher. As the load on base station increases the delay increases. The end to end delay of TCP-FACK is higher than other TCP-variants i.e TCP-Reno and TCP-Sack.

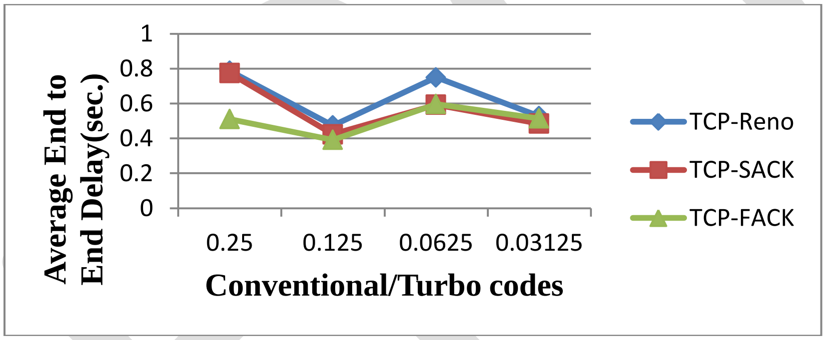

Figure5 Average End to End Delay

Routing Load

The figure 6 shows the impact of cyclic prefix on the routing load. It is noticed that the routing load of
TCP-FACK outperforms TCP-Reno and TCP-Sack variants. When cyclic prefix is kept at lower value then the value of routing load is lower as cyclic prefix increases routing load increases.

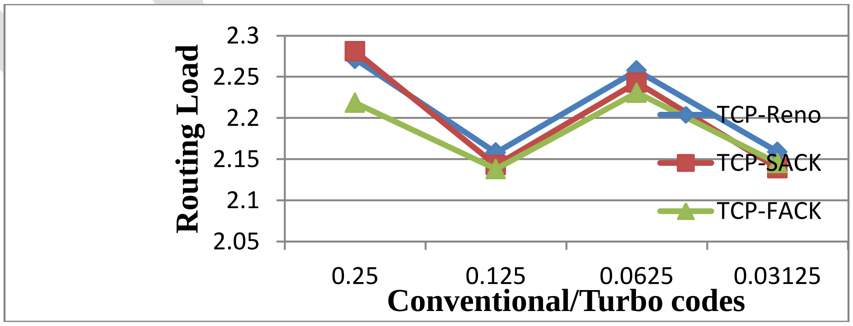

Figure6 Routing Load

CONCLUSION

It is a well known fact that TCP can experience significant performance degradation during hand-off, if multiple packet droppings, packet re-ordering or exorbitant hand-off delays occur. We have shown that the reaction on packet droppings and re-ordering is very much related to the implemented TCP version. Different TCP versions react with different types of behavior. In addition, from the perspective of transport layer, we believe that TCP will be on top of the routing protocols for reliable data transmission.

We simulated and compared the performance of various TCP algorithms viz. TCP-Reno, TCP-Sack, TCP-Fack in WiMax network by taking into account the condition of high offered load, irregular losses and retransmission timeouts that how it would affects the performance in wimax environment. We have seen that congestion and high offered load affect on TCP variants in a quite different way, Among three TCP variants, FACK outperforms other two. Since TCP has its variants, namely TCP-Reno, TCP-SACK and TCP-FACK, we performed the comparison of TCP-Reno, TCP-SACK, and TCP-FACK over OLSR under higher offered load. In summary, from the view of throughput, TCP-FACK outperforms other TCP variants. On the basis of the results obtained from simulation graphs and some trials in the literature, we can develop a bandwidth estimation technique to improve TCP-FACK performance over WiMAX environment, which is our interesting future work.

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