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ENHANCING TCP PERFORMANCE OVER SATELLITE LINKS

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ABSTRACT

The paper presents the study and analysis of performance offered by TCP protocol variants over GEO satellite link. The long Delay-Bandwidth characteristic of satellite network has big impact on TCP performance and it doesn't fulfill the criteria for given QoS. The drawbacks of TCP may be mitigated in satellite environment by properly tuning some of the TCP parameters. So aim of this paper is to study different variants of TCP protocol in satellite environment and propose modifications to enhance its performance over satellite link. At this time, all mitigations discussed in this document are IETF standards track mechanisms (or are compliant with IETF standards) along with some suggestions by researchers. Effect of parameters like buffer length and initial congestion window has been observed here to propose modified version of TCP suitable for satellite environment. The experiment reported here has been conducted using FTP client and server applications running on top of TCP variants. The performance is measured in terms of throughput and overall transmission time over satellite link. The simulation results are obtained using NS-2 simulation package.

Keywords: GEO, TCP,FTP,IETF.

INTRODUCTION

There is growing demand now days for using satellite links for providing high speed internet connection and multimedia services over satellite networks. The paper aims at analyzing the problems related to a satellite or terrestrial/satellite interconnection, from the point of view of transmission protocols. This work is small part of research project which aims for delivery of multimedia services and web based applications for country wide low cost distance learning programme which is the urgent need of fastest growing developing country like India Part of this project is being funded by BCUD-University of Pune under research proposals scheme.

The characteristics of a satellite network are very different from wired or wireless networks. The protocols designed for wired and wireless networks perform badly for long bandwidth delay satellite links[1]. For instance, the delay of a remote login or FTP session in a satellite environment may be unacceptable for the user. So, when constructing a network containing a satellite link there are many considerations to take into account. An important issue is the performance of the transport protocol. If the transport protocol does not offer high performance, the network throughput may become really low and, as a consequence, the quality perceived by the users may be poor. The objective of the paper is the investigation of the transport protocol and the proposal of some modifications to improve performance. TCP has been chosen as transport protocol. A review of the problems due to the utilization of TCP in a satellite environment is presented. We have investigated TCP performance by tuning two TCP parameters, namely the buffer dimension and the initial congestion window for which simple FTP like application is used and simulation environment created for GEO using network simulator and the real experimental measurements will be taken over real test bed for GEO satellite network once it is available[2]. We are also trying to create software based satellite emulator.

TCP FOR SATELLITE

The Transmission Control Protocol (TCP) provides reliable delivery of data across any network path, including network paths containing satellite channels. While TCP works over satellite channels there are several IETF standardized mechanisms that enable TCP to more effectively utilize the available capacity of the network path. This research proposal outlines some of these TCP mitigations, related issues and ways to enhance its performance over the satellite networks. At this time, all mitigations discussed in this paper are IETF standards track mechanisms (or are compliant with IETF standards).Satellite channel characteristics may have an effect on the way transport protocols, such as the Transmission Control Protocol (TCP) behaves. When protocols, such as TCP, perform poorly, channel utilization is low. While the performance of a transport protocol is important, it is not the only consideration when constructing a network containing satellite links. For example, data link protocol, application protocol, router buffer size, queuing discipline and proxy location are some of the considerations that must be taken into account.

This paper discusses research activities and techniques carried out in mitigating the problems TCP faces in the satellite environment[4]. It's not possible here to give complete review of all the research activities related to above topic therefore some of the techniques are outlined here which makes aware about current work and progress being done in TCP research related to satellite networks.

A.TCP for transaction

TCP uses a three-way handshake to setup a connection between two hosts. The start time here can be eliminated by using TCP extensions for transactions.

Major implementation issue here is TCP requires changes in stacks of both the data sender and the data receiver.

Slow start

The slow start algorithm is used to gradually increase the size of TCP's congestion window (cwnd) [3]. The algorithm is an important safe-guard against transmitting an inappropriate amount of data into the network when the connection starts up. However, slow start can also waste available network capacity, especially in long-delay networks[3]. Several proposals have suggested ways to make slow start less time consuming. These proposals are briefly outlined below and references to the research work given.

Larger Initial Window

One method that will reduce the amount of time required by slow start is to increase the initial value of cwnd[3]. The experimental TCP extension outlines in [AFP98] allows the initial size of cwnd to be increased from 1 segment to that given in equation.

Min (4*MSS, max (2*MSS, 4380 bytes))

Several researchers have studied the use of a larger initial window in various environments [KAGT98] show a reduction in WWW page transfer time over satellite links. It has been shown that using an initial cwnd of 4 segments, does not negatively impact overall performance.

Using larger window size of 4 may help in avoiding the congestion in the network but it will degrade performance of the network.

Byte Counting

Using byte counting the congestion window increase is based on the number of previously unacknowledged bytes covered by each incoming ACK, rather than on the number of ACKs received. Here two forms of byte counting are studied Unlimited Byte Counting (UBC) and Limited Byte Counting(LBC).

Delayed ACKs after Slow Start

In this technique TCP uses number of ACKs to increase the number of window size during slow start. Research done by [8] shows that in simulation using delayed ACKs after slow start improves transfer time when compared to a receiver that always generates delayed ACKs

Major issue here is that the receiver has to know when the sender is using slow start algorithm. Implementation of DASS is an open issue.

Terminating Slow Start

It has been shown that estimating ssthrash improve performance and decreases packet loss in simulations [4].However obtaining an accurate estimate of the available bandwidth in a dynamic network is very challenging especially attempting to be on the sending side of the TCP connection. Therefore before this mechanism is widely deployed bandwidth estimation must be studied in a more detail.

Loss Recovery

Congestion Avoidance

Implementation of the either the "Constant-Rate" or "Increase-by-K" policies requires a change to the congestion avoidance mechanism at the TCP sender.

This above discussed mitigation techniques may be able to enhance performance problems associated with TCP in networks containing satellite links. Though these are not IETF standards[5] they require more study before being implemented. The research community is encouraged to examine above mitigations in an effort to determine which are safe for use in satellite networks such as the Internet. Several of the above sections noted specific security concerns which a given mitigation aggravates.

TEST NETWORK

Here we have created simulation environment connecting two hosts using satellite link.TCP/IP protocol stack is used with the utilization of a sequential channel coding with a code rate of ½ to reduce transmission channel errors.

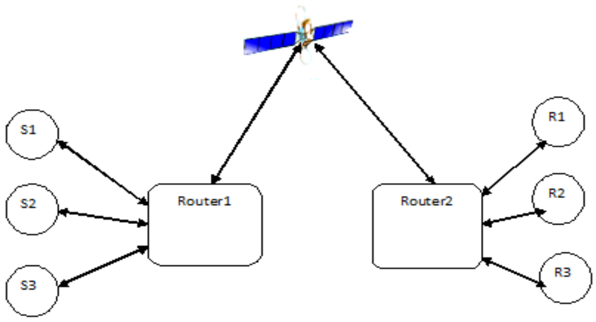

Fig.1 Test Network.

It consists of three senders S1,S2,S3 and receivers R1,R2,R3 along with Intermediate Router1 and Router2.The results in this paper are obtained using NS-2 with FTP as the simulation application and Routers with finite capacity if not specified can be set to BDP (Bandwidth Delay Product).The experiment is also performed using different file sizes. The receiver issues ACKs with every data packet received. Receiver advertised window is always large so that actual sending window is always equal to *cwnd* (congestion window).For convenience window size is measured in number of packets and the packet size is 1000 bytes. The initial ssthresh is set to 32 packets equal to 32Kbytes.We are using here access link capacity same as bottle neck capacity between the routers which is 10 Mbps. If the receiver acknowledges every packet capacity then after n RTT, *cwnd* will be 2^n. As access capacity is same as bottleneck capacity 2^n packets will arrive back to back at the same speed that of bottleneck link. So if capacity of links alters then accordingly buffer size will be required to avoid multiple losses. Larger buffer sizes are not used as they will saturate intermediate routers. So buffer sizes up to 160Kbytes are preffered to provide preferential gain. As evident from the tables the gain is light for short files. Since the buffer doesn't represent a bottleneck for the system and IW rules the efficiency while it is meaningful for larger transfers.

SIMULATIN RESULTS

The effect of IW on transmission time is tabulated here. The IW used in TCP in practical cases is set to usually 1 but we have tasted the performance by varying IW=1,2,4,6,8 etc. The overall effect is reduction in transmission time and improvement in the overall performance. Percentage gain is calculated with reference to initial reading. The advantage of using an increased IW is more evident for shorter transfers. The tables shows overall transmission time for different values of IW and Buffer Sizes. The improvement obtained in gain is noticeable. The best results for shorter files are due to initial congestion window behavior. If IW starts from higher value more data can be sent without a too long time. The tuning of the initial congestion window allows to mitigate the problem introduced by the channel delay. The gain in percentage is obtained with respect to the reference.

Overall transmission time for different values of IW (Initial Congestion Window)
Buffer=64 Kbytes
Table-I
Data Size=1Kbytes

IW	Transmission Time (ms)	%Gain
1	61	0.00
2	45	26.22
4	38	37.70
6	29	47.53
8	21	65.57

Table-II
Data Size=10Kbytes

IW	Transmission Time (ms)	%Gain

1	551	0.00
2	420	22.77
4	327	41.01
6	289	47.54
8	245	55.53

Table-III
Data Size=100Kbytes

IW	Transmission Time (s)	%Gain
1	4.73	0.0
2	3.87	18.18
4	3.19	32.55
6	2.79	41.01
8	2.71	42.70

Table-IV
Data Size=1 Kbytes

Buffer Size	Transmission Time (ms)	%Gain
32	67	0.00
64	54	19.40
96	43	35.82
128	39	41.79
160	32	52.23

Table-V
Data Size=10 Kbytes

Buffer Size	Transmission Time (ms)	%Gain
32	378	0.00
64	330	12.69
96	287	24.07
128	245	35.18
160	231	38.88

Table-VI
Data Size=100 Kbytes

Buffer Size (Kbytes)	Transmission Time (ms)	%Gain
32	4.21	0.00
64	3.19	24.22
96	2.87	31.80
128	2.11	49.88
160	1.98	52.96

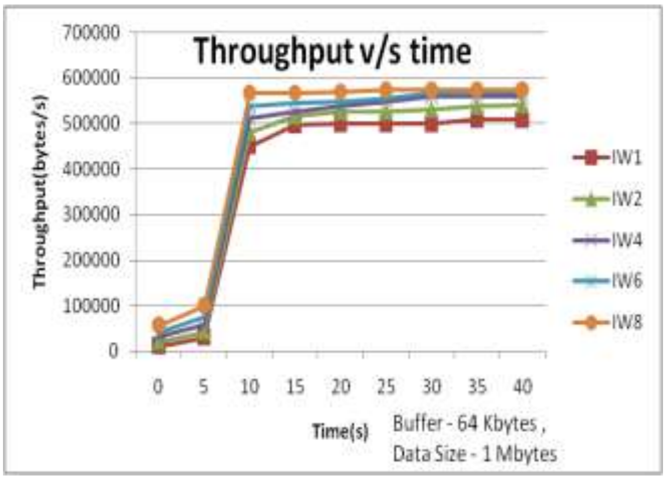

Fig. 2 Overall transmission time for different values of IW

Throughput

The throughput is the main performance measure for the efficiency of the protocol. The paper analyses TCP SNACK throughput in GEO satellite space links under varying packet error rates. Figure 6.9 is the throughput measurement for the GEO Repeater plotted for BERs ranging from 8e-8 to 8e-4. As we see, all the TCP flavors perform equally well at the smaller BERs because there are hardly any errors in the data packets at such low BERs, then the throughput decreases as the BER increases, the decrease is very prominent at BERs like 10^{-5} for a satellite channel, but even in this case, the TCP SNACK performs better than the regular TCP.

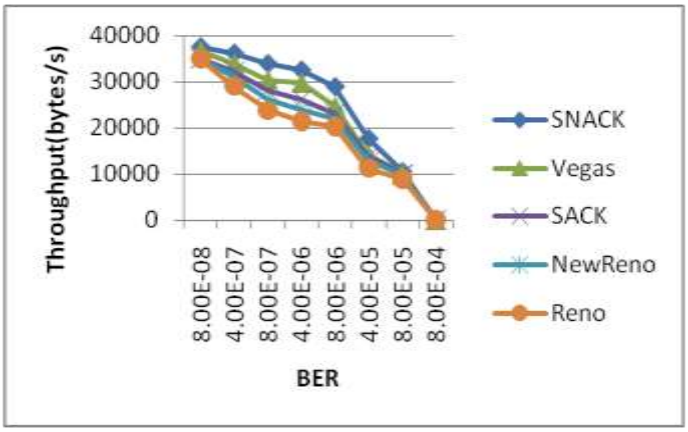

Fig. 3 GEO Satellite Throughput v/s BER

Link Utilization

Figure 6.10 is the link utilization measurement for the GEO repeater. It can be seen that the link utilization of SNACK is much better than TCP flavors, and it proves that SNACK does provide some improvement to TCP in space.

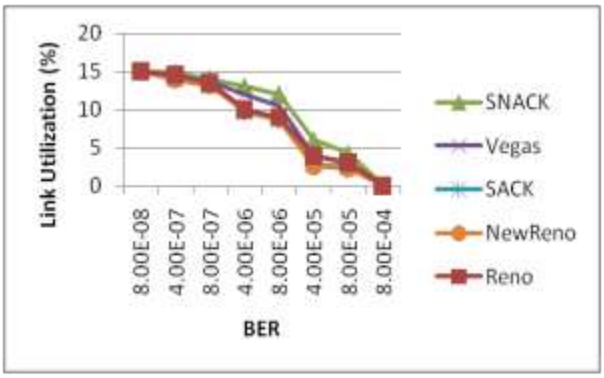

Fig. 4 GEO Satellite Link Utilization v/s BER

CONCLUSION

A short buffer drastically limits performance, but an excessively long buffer makes the system congested. Highest gain improvement of around 65% is obtained for IW=8 and for shorter file transfers. Performance in terms of throughput improves drastically making better channel utilization.
The research takes the regular TCP and TCP SNACK which is the extension modification of TCP using in space communication for investigation. From the simulation results, it can conclude that SNACK does provide some improvement to the regular TCP when using in GEO satellite networks communication. It must be paid attention that SNACK is just a small part of the TCP extensions, so we may not be able to see a huge performance variation here, the other options of extensions will be taken into consideration in the future research work.

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