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Performance Evaluation of IPv6 Header Compression over MPLS via Satellite

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Abstract

Broadband satellite is playing a main role in provision global coverage and onboard processing ability over IP networks to assess user applications. In order to lower the cost, get better security, solve IPv4 addressing limitation, expand the expected advantages of modern routing and mobility characteristics; the next-generation satellite systems ought to support IPv6 and seamlessly incorporate with terrestrial networks including wireless local loops. Satellite communication links have a number of limitations compared to terrestrial communications networks such as large delay and high header overhead for IPv6 consumes the bandwidth and causes lower transmission effectiveness; however, the quality of service (QoS) (such as delay, jitter, and goodput) is adversely influenced by these demerits. Current paper proposes UDP/IPV6 header compression over Multi-Protocol Label Switch (MPLS) via satellite scheme called (MPLSHCompViaSat). The aim of the proposed scheme is to save the required bandwidth in order to provide better network utilization and consequently improves the efficiency and QoS. For the sake of performance evaluation, the proposed scheme has been tested using Network Simulator (NS2).

Keywords: IPv4, IPv6, QoS, MPLS, NS-2 simulation**.**

تقييم اداء ضغط عنوان بروتوكول IPv6 عبر بروتوكول MPLS عبر الستلايت

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الخلاصة

تلعب الأقمار الأصطناعية ذات النطاق العريض دورا هاما لتوفير تغطية عالمية وقدرة للمعالجة عبر شبكات بروتوكول الانترنت لتقييم تطبيقات المستخدم. من اجل خفض التكلفة، والحصول على حماية افضل، وحل مشكلة محدودية العناوين ل(IPv4) ، وتوسيع المزايا المتوقعة من خصائص التوجيه والتنقل الحديثة. يجب على انظمة الاقمار الأصطناعية للجيل القادم دعم ال(IPv6) ودمجه بسهولة مع الشبكات الارضية بما في ذلك الحلقات المحلية اللاسلكية. اتصالات الأقمار الأصطناعية لديها عدد من العيوب مقارنة مع شبكات الأتصالات الارضية بما في ذلك تأخير عالي وكذلك حجم الheader لل IPv6 يكون كبير مما يستهلك عرض النطاق الترددي ويؤدي الى خفض كفاءة الارسال. ومع ذلك، فأن جودة الخدمة (مثل التأخير، الغضب، البيانات المتلقاة) تتأثر سلبا بهذه العيوب.في هذا البحث اقترحنا طريقة ضغط عنوان بروتوكول UDP/ IPv6 عبر بروتوكول MPLS خلال الأقمار الأصطناعية. الهدف من الخطة المقترحة في هذا

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البحث تقليل عرض النطاق الترددي المطلوب من اجل توفير استخدام افضل للشبكة، وبالتالي يحسن من كفاءة وجودة الخدمة. من اجل تقييم الأداء، قد تم اختبار النظام المقترح بأستخدام محاكي الشبكات (NS2).

Introduction

Satellite communication networks playing an essential part of the recently emerging national and global information infrastructures as well as in the development of telecommunication networks [1], Nowadays satellite systems are becoming deeply involved in the Internet, particularly in the areas of providing broadband access, content distribution and multicast applications, all of which can benefit from the inherent capabilities of satellite solutions [2].

The Next Generation Satellites Network (NGSN) acts a vital role in providing ubiquitous communications over the world. Its unique characteristics such as wide coverage area, quick network deployment with its enormous number of addresses and native broadcasting/multicasting services extend the Internet connectivity to a remote geographical area where a terrestrial network is not available or not economical and other new features [3]. Significant packet losses and long propagation delay often lead to performance degradation in the satellite network. Moreover, the high header overhead will severely consume the bandwidth and cause lower the transmission efficiency [4].

Related Work

Teh et. al in 2007 [5] proposed Robust Header Compression Scheme to work with Unidirectional Lightweight Encapsulation (ULE) in order to enhance the performance of existing ULE. Also provides a simulation analysis to show that the proposed method can offer a better performance in delay, throughput and overhead especially when the packet size is small.

Ang et. al in 2008 [6] introduced an investigation of performance characteristics using Robust Header Compression (ROHC) over Digital Video Broadcasting - via Satellite (DVB-S). The results of header compression demonstrated significant improvement in data throughput when the payload sizes of IP packets have been less than 512 bytes, ordinary of VOIP and other real-time traffic.

Chong, Wan in 2011 [4] suggested a header compression method across the hybrid satellite WiMAX network. The suggested header compression scheme Hybrid Robust Header Compression (Hybrid-ROHC) enables the provision of resources across the hybrid network where bandwidth is a premium. The results of their tests showed that the suggested approach could affect positively in the behavior of Real-time Transport Protocol (RTP) traffic over hybrid satellite-WiMAX network. Average one-way delay, inter-arrival jitter, and average throughput were used to show the impact of header compression mechanisms on the traffic. Their approach showed best values for all the three QoS parameters.

Mohamad in 2013 [7] proposed Label Switched Path-Payload Header Suppression (LSP-PHS), across the network backbone route that compresses the packets over Multi-Protocol Label Switch Labe l Switched Path (MPLS LSP). It avoids compression and decompression cycles per hop. The use of LSP-PHS achieves a 50% reduction in UDP maximum delay. It also reduced the packet drop for real time traffic Voice over IPv6 (VoiPv6) significantly. The conclusion is that the use of LSP-PHS helped in optimizing end to end QoS metrics for heterogeneous traffic.

Multi-Protocol Label Switch (MPLS)

MPLS works based on packet label switching mechanism, suggested to reduce the processing at the network layers. At the edges routers of an MPLS network a label added on top of IP datagram header. The intermediate nodes only look at the label to determine the destination of the next hop, no need to access the entire packet to look up the destination address [8]. Traditional IP forwarding is based on Layer 3 destination address with searches at every hop. Besides, IPv6 is the next generation protocol for networks which has a major size. As well, the introduction of the flow label field was a further main change in IPv4 header for QoS reason. Notwithstanding gigantic address space, IPv6 puts forward an important improvement concerning build in security, enhanced multicast support, and auto-configuration mobility. MPLS became prevalent due to its advantage of quick forwarding in its initial time which is no more preference due of the capacity of quick forwarding by IP Layer 3 routers. Notwithstanding, Significant advantages of layer 2.5 (MPLS) in provisioning QoS, unified network architecture, traffic engineering, optimize traffic flow, etc. IPv6 over MPLS is regarded as could be the blend of protocols on layer 2 and layer 3 for routing of packets [9].

Header Compression

The header compression diminishes the header sizes of a packet which transmit across the network [5]. Header compression is extracting the excess header and after that transmitting payload in this way helping in the decreases of the header data between respective packets. The receiver needs to reestablish the headers at the end the receiving. In numerous applications, the data nearly equivalent to that of the headers [9]. The diminishment in header sizes helps to enhance the packet transmission effectiveness. Effectiveness is significant when the transmission cost is high. Cases incorporate satellite links where the bandwidth of the satellite has the high cost. Low transmission efficiency will influence other services that can't get required network capacity. Moreover, decreasing packets overheads could likewise diminish the transit delay of packets over the link [5]. Through the end to end connections, consisted of multiples hops, these protocol headers are very important, but over only one link (hop to hop) these headers could be compressed and should be uncompressed at the other end of the link. It is potential to compress those headers [10].

The proposed method (IPv6 Header Compression Over MPLS via Satellite)

The header size of IPv6 represents overhead; therefore, the header compression is significant for IP packets with small payload size or even smaller than the header such as voice over IP. This paper presents an approach to reduce the overhead of carrying IP packets over MPLS via satellite by applying UDP/IPv6 Header Compression stream, where IP header compression provides important benefits, such as reduction in packet loss and improved interactive response time.

The IP with transport protocols such as UDP or TCP and optional application protocols such as RTP are depicted as a packet header. The data conveyed in the header helps the applications to communicate across large distances associated by multiple hops or links in the network. As long as the applications are communicating a large portion of this data conveyed in packet headers continue as before or changes in particular examples. By observing the fields which stay consistent or change in certain patterns it is conceivable either not to send them in every packet or to represent them in a littler number of bits than would have been required initially.

Typically, VoIP uses the encapsulation IP/UDP/RTP/voice. When adding the MPLS labels, this will become MPLS-label/IP/UDP/RTP/voice. In the simplest case of IPv6, total packet header size at least 60 bytes, 40 bytes for IP version 6 header, when carrying UDP (8 bytes) and RTP (at least 12 bytes). After adding 4 bytes for MPLS become 64 bytes. With voice payload sizes of 20 bytes when using the G.729 codec, the packet size becomes 84 bytes as shown in Figure-1. Size of header compared to payload has a relatively large. The use of header compression in such cases leads to significant savings in bandwidth. In the Compressions stage, the Source IP and Destination IP fields in IPv6 header that represented by 32 bytes are stripped of the received packet at the MPLS-Ingress. Then at Penultimate MPLS-node the packet size restored. In this case, 38% of packet size savings can be observed.

Typically, edge routers such as MPLS ingress or PE-LSR are considered fast hardware thus the cost of compression is not significant or neglected.

The proposed method is perfect compared to other compression methods because of the following:

- Simplicity.
- MPLS-LSP is a one direction path, thus some known compression techniques such as ROHC is not suitable for MPLS domain because ROHC requires bidirectional paths.
- MPLS ingress is considered as aggregation point and therefore need simple and fast compression algorithm.

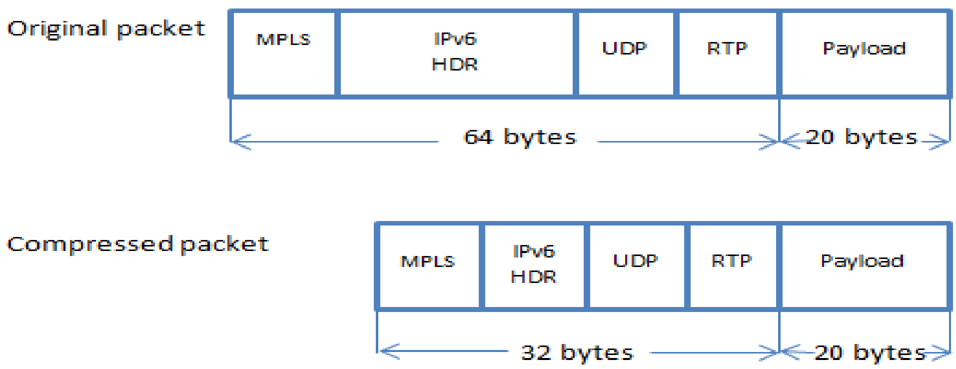

Figure1- Packet size (original and compressed packet using G.729 codec)

QoS Parameters

The set of QoS parameters that characterizing the quality of service of connection are formulated in the following section:

A- Delay: The packet suffers from many different kinds of delays at each node along the path [11]. The packet delay is calculated by subtracting the time for the packet received at the destination to the packet sending time from the sender. The average delay is calculated by summation all packets delays and divided by the total number of the packet that successfully received on the destination side as appeared in the following equation

$$End\ to\ End\ delay = \frac{\sum_{i=1}^{N} D_i}{Nr} \quad (1)$$

D_i is an end to end delay of packet i, where Di = Td_i- Ts_i, Ts_i represents the time of packet i enqueued at the source. Td_i is the time of packet i received at the destination, Nr is the number of packets that received at the destination.

B- Delay variation (jitter): can be defined as a change in the delay of the received packets. The sender sends the packets in steady flow where the spaces between packets are equal. However, due to some issues on the network the delay between the packets can change instead of remaining constant. This change will cause some issues at the receiver side. In the equation 2 shows how average jitter is calculated

$$Jitter = \frac{\sum_{i=1}^{i=n}(D_{c-}\ D_p)_i}{(P_t - 1)} \quad (2)$$

Where Dc is the delay of current received packet; D_p is delay of previous received packet; P_t is the total number of successfully received packet.

C- Goodput is the number of payload bytes received per unit time in each direction, regardless of their eventual fate. Measurements show the number of the payload data bytes (excluding all network and transport layer headers) received at the destination over the end to end, one-way transit delay of each packet.

$$\text{Goodput} = \frac{N_r \times P_s}{(T_{stop} - T_{start})} \quad (3)$$

Where N_r Is the number of packets received at the destination, P_s are packet size (byte), T_{stop} is stop time of each traffic flow, T_{start} is start time of each traffic flow [12, 13].

Performance evaluation of the (MPLSHCompViaSat)

This section focuses on MPLS cloud performance improvements over satellite. The experiment considers IPv6 header compression over label switched path of MPLS that passes over Geostationary (GEO) satellite. An end to end application performance measured according to packet transport delay, packet delay variations, and goodput. Two tests were conducted to evaluate performances of the MPLSHCompViaSat using the compound network topology of MPLS-LSP over satellite as depicted in Figure- 2.

Experiment 1: MPLSHCompViaSat using (CBR/UDP traffic)

The simulation scenario of this experiment (represented in Figure- 2 and Table- 1) is conducted to check the QoS using MPLSHCompViaSat. The topology consist of GEO satellite, two earth terminals (sender and receiver station), each terminal has various LSRs. The source stations exchange 2 Voice/UDP/IPv6 traffic with the destination station with 125 Kbps-CBR each, start at 0 sec for 100 simulations second.

Table 1 -Simulation Parameter

prameter	value
Traffic Type	UDP, TCP
bw uplink and downlink	250 kb/s
bw for terrestrial network	250 kb/s
Propagation delay for terrestrial network	10 msec
UDP rate	125, 62.5 kb/s
Satellite Type	Geostationary Satellite
start time of UDP traffic	0.0 s
start time of TCP traffic	7.0 s
Simulation time	100 s
Bit Error Rate (BER)	0.02
Physical Layer Type	Phy/Sat
Link Layer	LL/Sat
Mac Type	Mac/Sat
Queue Type	DropTail
Queue Limit	50

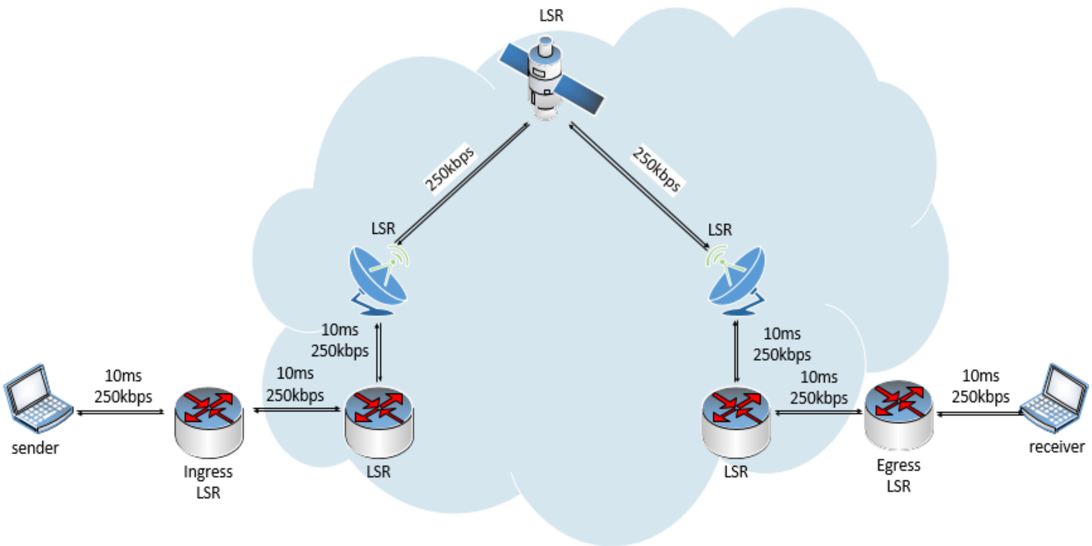

Figure 2- MPLS simulation topology

The simulation results for UDP average delay shown in Figure- 3 with and without compression. It was found that when MPLSHComViaSat activated, the average delay reduces by 11.5 % approximately. The compression lowers the packet header size, therefore improving the time exhausted to send the packet via the channel. Smaller packet header size decreases queuing delay, therefore improving the average delay. The difference between the two flows appear because of the jitter and packets queuing per hop.

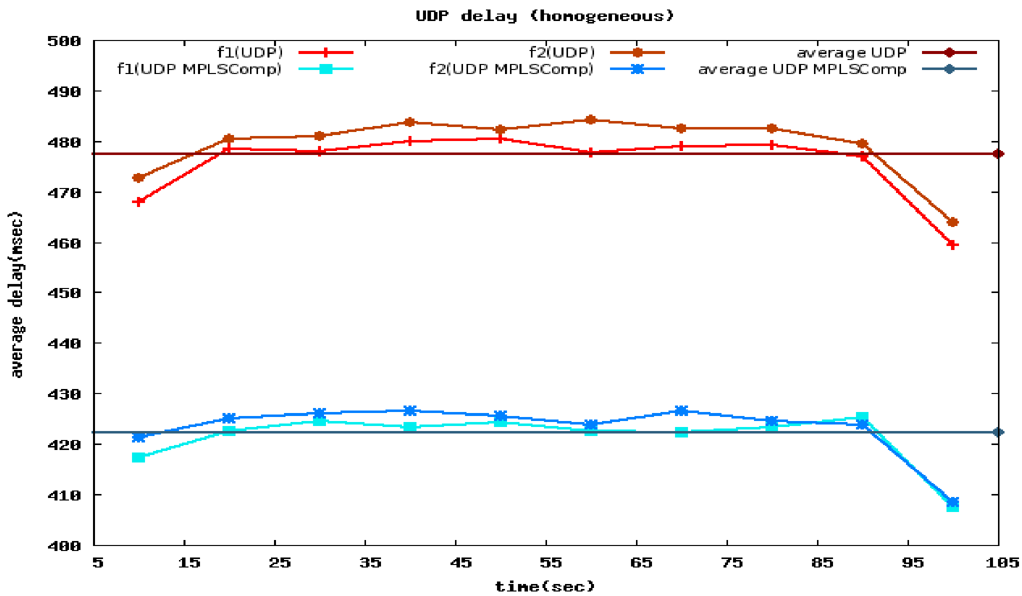

Figure 3-UDP delay for MPLSHCompViaSat

Figure- 4 shows the average of the packet delay variations (jitter) is proportional to the decrement of packet size where the reduction in header size lead to the decrease of jitter, the proposed method achieved around 19% smaller average jitter than the uncompressed packet.

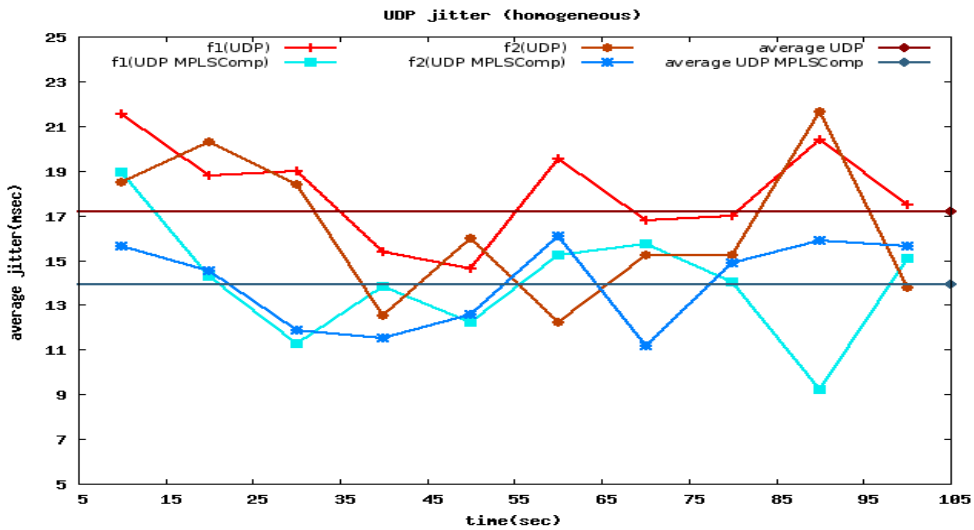

Figure 4- UDP jitter for MPLSHCompViaSat

Figure- 5 shows the goodput performance for MPLSHCompViaSat scenario. The figure shows that before compress has a goodput value of 25±1 kBits/sec for all simulation time. After using MPLSHCompViaSat increased to values of 34±1 kBits/Sec, this means the goodput increase approximately 47% when using MPLSHCompViaSat. Utilizing MPLSHCompViaSat, the number of packets that able to send through single stream increments, therefore give better efficiency in terms of goodput. However as the packet size increases, the improvement in terms of average goodput between uncompressed and MPLSHCompViaSat reduces.

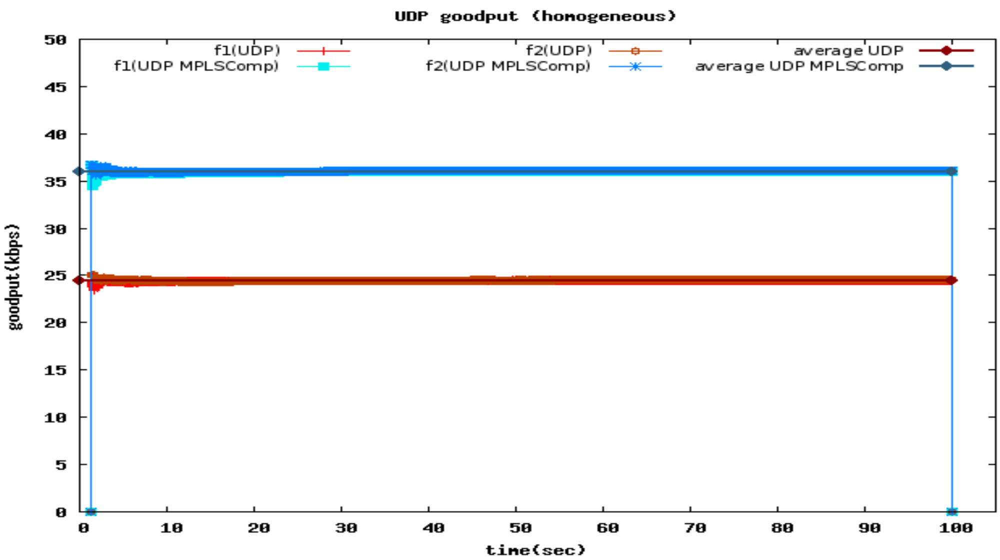

Figure 5- UDP goodput for MPLSHCompViaSat

Experiment 2: MPLSHCompViaSat using (FTP/TCP and CBR/UDP traffic)

In this test, the simulation topology is the same as the one used in the previous test (see Figure- 2 and Table-1), but with the addition of two TCP traffic started at 7th second of simulation time, with 62.5 Kb/Sec rate for each CBR traffic (i.e. a heterogeneous traffic is considered).

Figures- 6 and 7, illustrate the delay for TCP and UDP traffic when using heterogeneous topology for MPLSHCompViaSat. The average delay is decreased from 773 to 682 msec and from 674 to 582 msec for TCP and UDP traffic respectively.

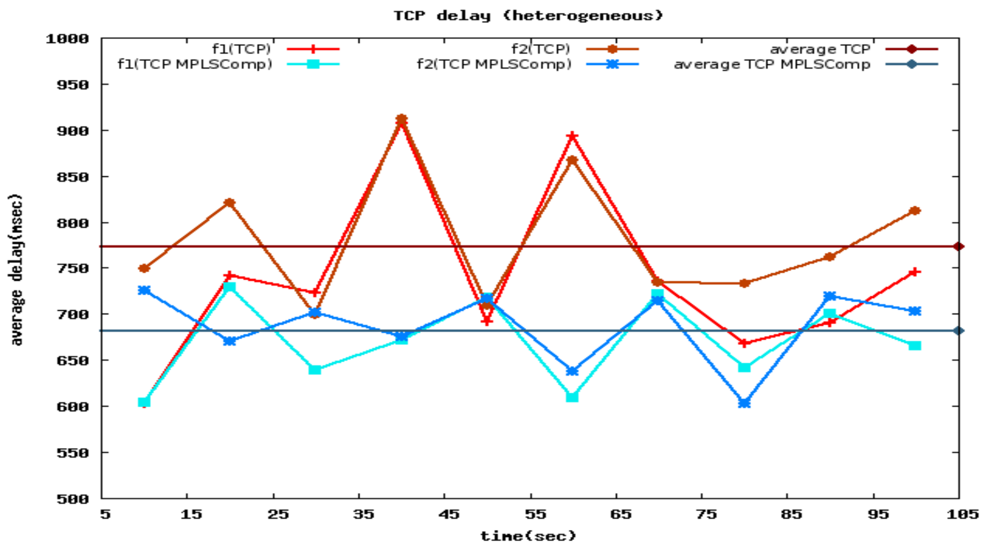

Figure 6-TCP delay for MPLSHCompViaSat using (heterogeneous traffic)

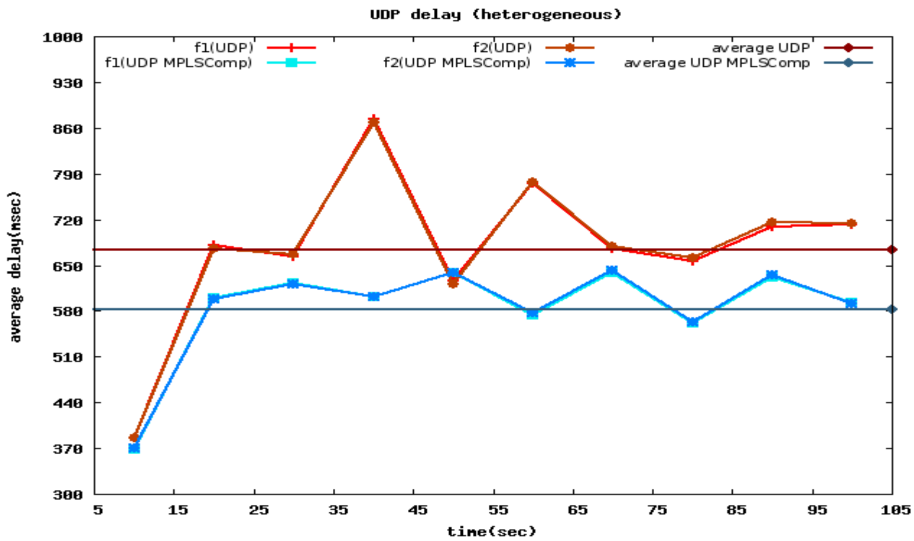

Figure 7- UDP delay for MPLSHCompViaSat using (heterogeneous traffic)

Slight differences in average jitter for both TCP and UDP traffic before and after the compression as shown in Figures- 8 and Figure -9.

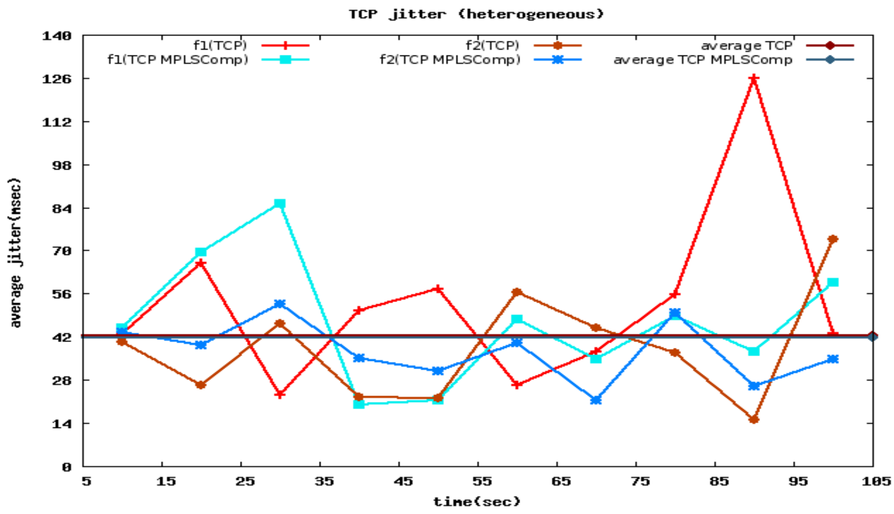

Figure 8- TCP jitter for MPLSHCompViaSat using (heterogeneous traffic)

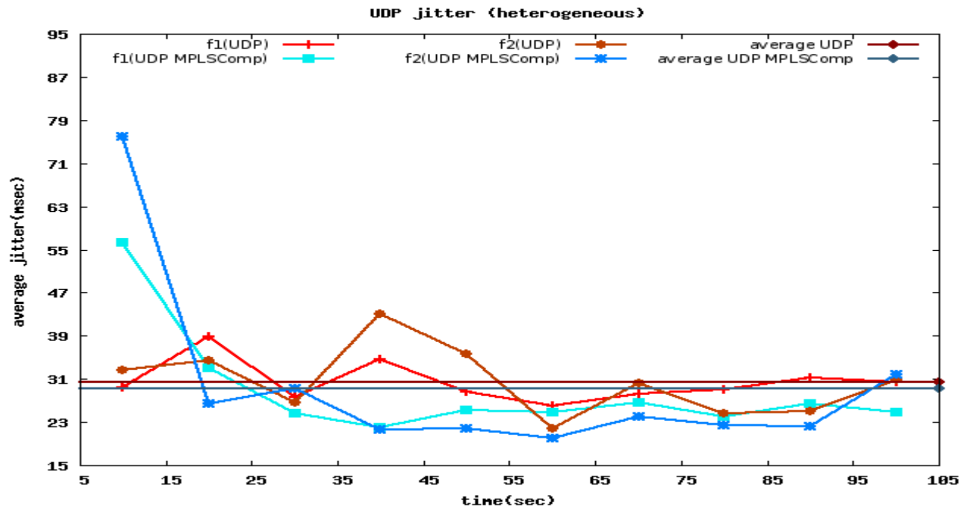

Figure 9- UDP jitter for MPLSHCompViaSat using (heterogeneous traffic)

Figures- 10 and 11 show an increase in the average goodput by10.5% for TCP traffic and by 31% for UDP traffic due to the effect of IPv6 header compression over MPLS via Satellite.

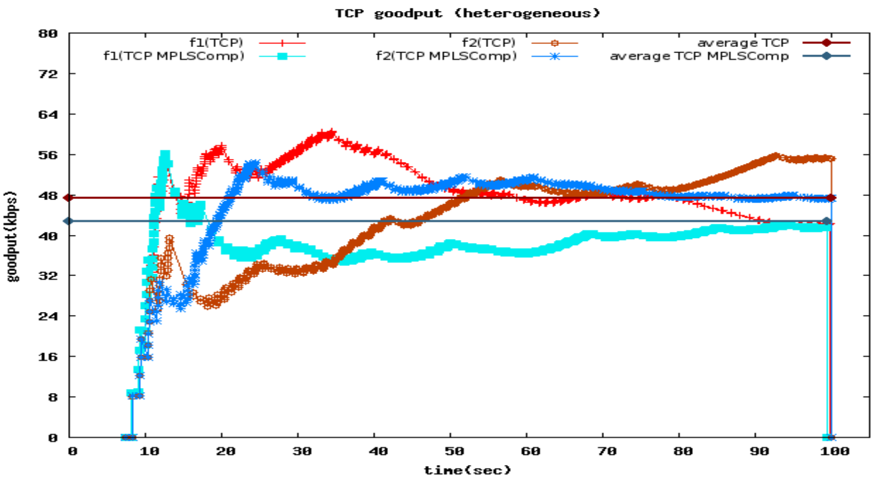

Figure 10- TCP goodput for MPLSHCompViaSat using (heterogeneous traffic)

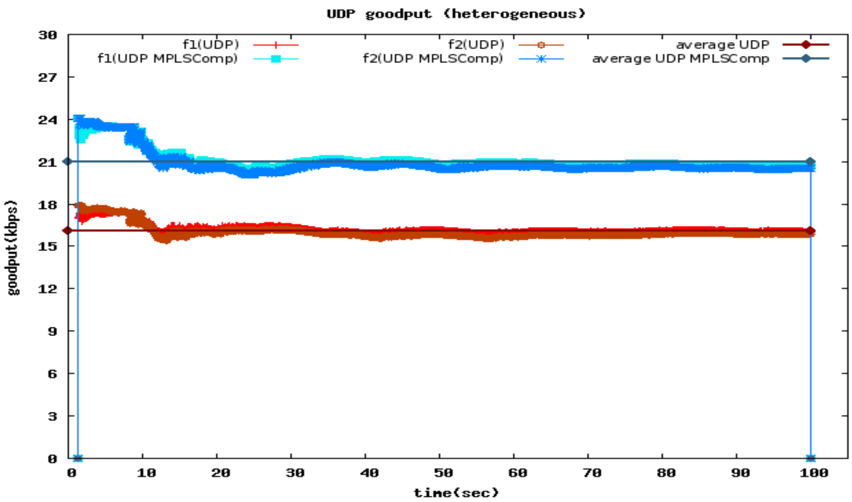

Figure 11-UDP goodput for MPLSHCompViaSat using (heterogeneous traffic)

Conclusion

This paper proposed a header compression for UDP/IPv6 over MPLS via Satellite to reduce the header sizes of a packet that transmit over the network that intended to improve the utilization of satellite bandwidths which affects the performance and QoS positively. The results of proposed scheme showed improve in each of delay, jitter, and goodput when using only UDP traffic (homogeneous traffic) and also when heterogeneous traffic used. Future work includes the implementation IP header compression over multicast for next generation satellite networks.

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