An End-to-End Header Compression for Multihop IPv6 tunnels with varying Bandwidth

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***Abstract*— With the exponential growth of internet it's impossible to sustain with IPv4 protocol due to its limited space capability and the only option is to move towards new next generation internet protocol IPv6. Different transition techniques have been proposed from the far to enable the smooth interoperation between the two protocols: Dual Stack, Tunneling, and Header Translation. Tunneling is the generally used solution to carry an IPv6 packet across the IPv4 network. Tunneling comes with several imperfections like inefficient routing, header overhead due to multiple headers present, Quality of service and high band width usage. These overheads could degrade the network performance especially over wireless links where there is scarcity of resources. In this paper we are addressing the header overhead issue in context of IPv6 tunnels, where the IPv6 header of 40 bytes is encapsulated inside an IPv4 header of length 20 bytes. This overhead would affect the network performance, especially over low bandwidth links, where resource is a constraint. So, it's better to compress this header and then send it over link and decompress it at the other end of the link. In this paper we have proposed a new approach to compress the IPv6 header of the packet, in context of IPv6 tunnels, which would improve the efficiency of IPv6 tunneling mechanism. Doing this we have compressed the 40 bytes of IPv6 header up to 6 bytes. We have applied this compression over multihop wired and wireless tunnels. Extensive amount of simulations are provided to compare the newly developed protocol with the standard tunneling technique. Results show that using this approach we are getting better network deliverables in terms of throughput, average end-to-end delay, Jitter, and Packet delivery ratio.**

Keywords*— *Bandwidth, Compression, Context, Decompression, Multihop tunnel.

I. Introduction

IPv6 was developed by IETF IPng (Next Generation) Working Group and promoted by the same experts within the IPv6 Forum since 1999 as the next-generation network layer protocol, to overcome the address depletion problem faced by IPv4. With 128 bits of IPv6 address provides a huge number of address pool [1]. IPv6 header is very simplified as compared to IPv4 header, as most of the header fields are moved into next header to make processing efficiently at routers. However the main problem with both the protocols is that IPv6 has no built-in backwards compatibility with IPv4, which means IPv6 networks cannot communicate with IPv4 and vice versa. If an IPv4 network wants to further support IPv6 communication, it has to carry out dedicated addressing and routing for IPv6, and update the network devices to enable IPv6 [2].

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In the current world there is lack of capable applications and IPv6-accessible contents, mostly the network resources are services and applications still remain in IPv4 [3]. IPv4 network will be into the play for a long time, but due to the address depletion problem it is impossible to sustain with IPv4. Therefore, IPv4 and IPv6 will coexist for a long period, and the transition process will be gradual. During this time transition stages comes into the play. Different technique shave been proposed from the past to enable the smooth interoperation of the two protocols [4]. Tunneling is the most widely used solution to carry packets across the network to bypass the intermediate network. It is used over the Internet for variety of purposes like security, deploying new services, transition towards IPv6 etc. Tunneling includes several drawbacks like inefficient routing, protocol header overhead due to multiple headers which results in high bandwidth usage, processing overhead, packet reordering and Quality of service [5]. All these overheads results in degradation of network performance. In this paper we are addressing the headers overhead issue for IPv6 headers and improving the efficiency of IPv6 tunneling mechanism.

Also the another issue with both the protocols is that the IP traffic is the most common in all the widely used applications like file transfer, web, emails, messaging services audio streams, and video on demand. It generates the highest overhead as the largest headers are IPv6 and IPv4 headers with a size of 40 and 20 bytes, respectively [6]. This high overhead could affect the network performance especially over low bandwidth links where resources are limited. Information contained in the header serves very useful purpose for end to end communication, but of least importance over one hop [7]. For the same flow of packets most of the information contained in the header remains constant, or vary in a similar pattern. So, these fields can be compressed due to the redundancy in header fields of the same packet as well as consecutive packets of the same packet stream. Header Compression is the process of compressing excess protocol headers and sends it over a link and then decompresses it at the other end of the link, which would result in many cases more than 90% savings, and thus save the bandwidth and use the expensive resources efficiently [8]. Header compression results in better response times, reduction in packet loss, decrease in packet header overhead and better bandwidth savings [9]. Efficient utilization of bandwidth is one of the most challenging tasks in wired and wireless networking systems. In this paper we are addressing the bandwidth issue for multihop IPv6 tunnels over varying bandwidth.

Rest of the paper is organized as follows: In Section 2 we describe the proposed methodology. In Section 3 we describe the Experimental set up and Simulation parameters. In Section 4 we present the IPv6 header compression results for wireless and wired networks with varying bandwidth. Section 5 concludes the paper.

II. PROPOSED WORK & METHODOLOGY

This section describes the proposed scheme for IPv6 header compression over multihop IPv6 tunnels. In this paper we have addressed the tunnel header overhead issue, which occurs due to multiple headers present in the tunneled packet. The tunnel we have considered is multihop wired and wireless tunnel. To achieve the objective we have compressed the IPv6 header of the tunneled packet as it incorporates the highest overhead of 40 bytes. We have done header fields classification as: Static, Dynamic and Inferred [10].

We are sending compressed packets from one end and decompressing it at the other end of the network. The main benefit of this mechanism is that we don't need to perform compression and decompression at the intermediate routers. They will forward the compressed packets without decompressing them. Only the edge routers at the sender and receiver side will perform compression & decompression.

The compressor/decompressor (C/D) entity is stored at the dual stack routers, which reduces C/D cycles. The benefit of sending dynamic and inferred information with compressed packet is that there is no need of context updation. With this we would obtain lower compression gain, but in case of packet loss there is no effect over subsequent packets which would result in overall performance improvement of the network.

To achieve our work is divided into two stages: Context Establishment, and Compression. During Context establishment state we have sent context packets to establish synchronization between sender and receiver. Initially we have sent few packets uncompressed to the destination. The number of uncompressed packets to send is depended upon the parameter "no of uncompressed packets to send=n". This n specifies how many uncompressed packets are send inside the tunnel to establish context between the edge routers of sender and receiver network. Along with this a new parameter tunnel algo to use is added at the network layer to specify which algorithm to use: either compressed or uncompressed, this uses a binary value of either 0 or 1:

If tunnel algo to use == 0;
Normal tunneling is used without header compression.
If tunnel algo to use == 1;
IPv6 header compression is used.

Once context is established then we have sent compressed packets in Compression state. Context packets are sent to establish context between the edge routers. Once context is established, then have to send compressed packets. The format for context and compressed packets are shown in figure 1.
Using this approach we have compressed the 40 bytes of IPv6 header to 6 bytes, which results in improved network performance.

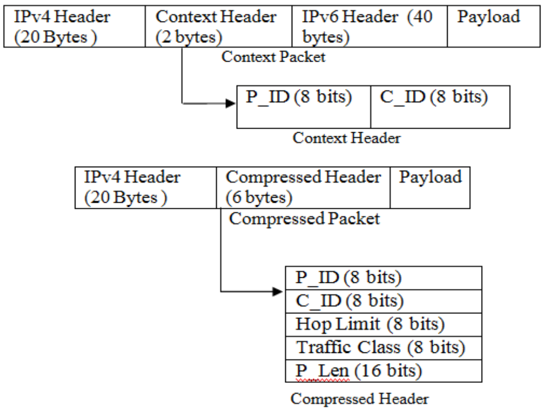

Figure: 1 Format of Context & Compressed Packets

III. EXPERIMENTAL SET UP & SIMULATION PARAMETERS

We have simulated our results over Qualnet 5.1 simulator [11]. This is a licensed tool which provides efficient outcomes for our experiments. We have tested this protocol over two different networks: wireless and wired and to generate the application layer traffic Constant Bit Rate (CBR) application is used. CBR traffic generator generates traffic at a constant rate by transmitting packets of a fixed size at a fixed rate [12]. We have used four different parameters to evaluate the performance of IPv6 header compression and comparison is done with the uncompressed tunneling mechanism.

3.1 Case-I: Wireless Network

Figure: 2 represent the scenario for multihop wireless network; here tunnel is a Multihop wireless tunnel. A Field configuration of 1500m x 1500m is used for the scenario. Here MAC protocol for wireless network is 802.11. We have used 4 constant bit rate applications to generate the traffic in the network. The sending rate is 100 packets per second and packet size is 512 bytes.

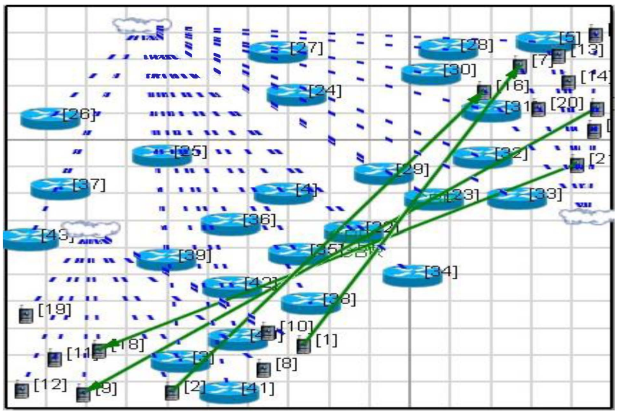

Figure 2: Scenario for Wireless Network

In this scenario we have three subnets out of which 2 subnets are IPv6 only and one is IPv4 only subnet. Router 3 and Router 5 are dual stack routers on each IPv6 subnet. Here an IPv6 host wants to communicate to another IPv6 host via an IPv4 backbone. To enable this communication, a wireless tunnel is created between both the dual stack routers which will carry an IPv6 packet inside an IPv4 packet. The intermediate routers are IPv4 only routers.

3.2 Case-II: Wired Network

Figure: 3 represent the scenario for wired network; A Field configuration of 1500m x 1500m is used for the scenario. Here MAC protocol for wired network is 802.3. We have used 4 constant bit rate applications to generate the traffic in the network. The sending rate is 100 packets per second and packet size is 512 bytes.

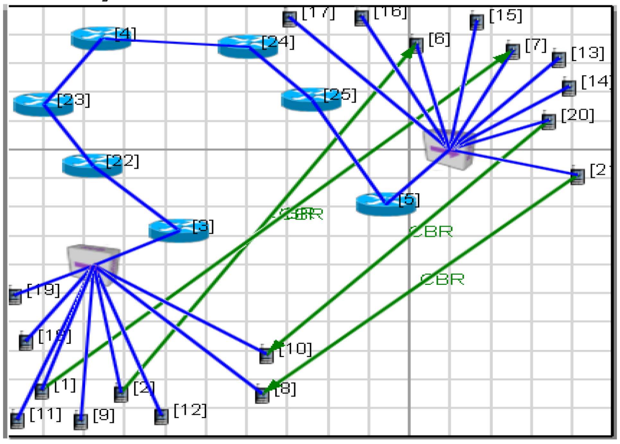

Figure 3: Scenario for Wired Network

In this case Router 3 and Router 5 are dual stack routers on IPv6 subnet. Here an IPv6 host wants to communicate to another IPv6 host via an IPv4 backbone. To enable this communication, a multihop wired tunnel is created between both the dual stack routers which will carry IPv6 packet encapsulated inside an IPv4 packet. All the intermediate routers are IPv4 only routers i.e. they understand IPv4 only packets and discard IPv6 packets.

IV. RESULTS & DISCUSSION

To evaluate the performance of newly developed protocol, we have tested is over wired and wireless network with varying bandwidth of bandwidth 0.5 MBPS, 1 MBPS, 2 MBPS, 3 MBPS, 4 MBPS, 5 MBPS. Then we have compared the results with the standard tunneling mechanism. The metric based analysis for Multihop Wireless tunnel is shown in figure 4 to 7 and metric based analysis for Multihop Wired tunnel is shown in figure 8 to 11. However there are no studies to the best of our knowledge on examining the impact of header compression for IPv6 tunneling mechanism, so we have compared this with standard tunneling technique. A comparison is made between compressed and uncompressed network, results shows that compression of IPv6 header results in better resource utilization and better bandwidth savings.

4.1 CASE-I Multihop Wireless Tunnel: Wireless Scenario

Throughput: It is evident from the figure 4 that throughput increase as bandwidth increases. Here the case is of wireless network and wireless links are highly error prone and subject to interference. Throughput is very less when bandwidth is 0.5 MBPS, and increases considerably when bandwidth is 5 mbps. Still we are getting better results in case of compressed network, because in this case fewer packets are dropped, which improves the throughput. Impact of bandwidth is directly proportional to throughput, as bandwidth increases, throughput increases. Statistics shows that the maximum improvement in throughput of 110% is achieved when the bandwidth is 0.5 MBPS, and significant improvement is observed with other bandwidth too.

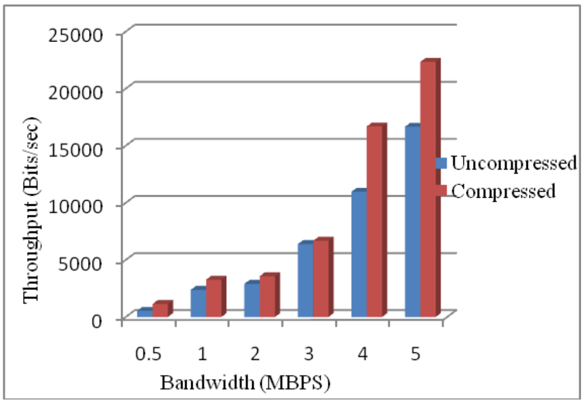

Figure 4: Throughput Vs Bandwidth

Average End-to-End Delay: It is evident from figure 5 that end-to-end delay decreases as the bandwidth increases. Result shows that end-to-end delay is very high in all the cases, because of wireless nature of links. Even with the bandwidth of 5 mbps, delay is very high. The reason for high delay is that the entire network is wireless and we are restricting the bandwidth, in which there is already bandwidth is limited. Such a high delay is not tolerable in real network. Still we are getting better results in case of compressed networks. Here we can say that impact of bandwidth is inversely proportional to delay, as bandwidth increases, end-to-end delay decreases considerably. Statistics shows that the maximum improvement in end-to-end delay of 30% is achieved when the bandwidth is 0.5 MBPS, and significant improvement is observed with other bandwidth too.

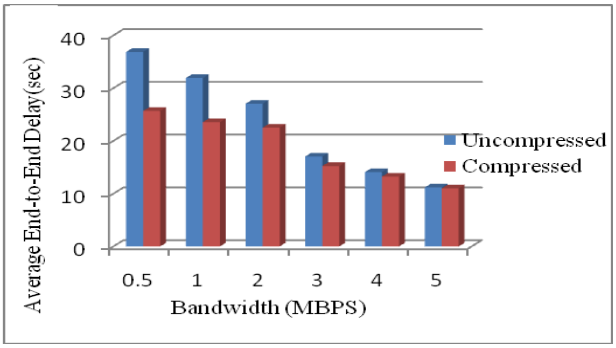

Figure 5: Average End-to-End Delay Vs Bandwidth

Average Jitter: It is evident from the figure 6 that jitter decreases as the bandwidth increases. Results show that jitter is very high for bandwidth up to 3 mbps, and decreases significantly. This is due to the fact that we are restricting the bandwidth of wireless network. So the variation in packet arrival time is increased due to which jitter is increased. We are receiving better results in case of compressed networks. Jitter is reduced in case of our algorithm due to reduced packet size which also results in reduced packet loss which could be seen in PDR graph also.

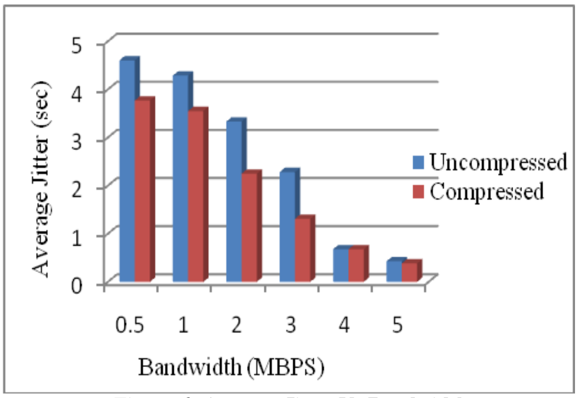

Figure 6: Average Jitter Vs Bandwidth

Packet Delivery Ratio (PDR): It is evident from the figure 7 that PDR increases as bandwidth increases. Results show that packet delivery ratio is very less in all the cases due to limited bandwidth and is almost negligible in all the cases. PDR is an important parameter for the network whose impact is shown over other parameters like jitter, delay and throughput. Better results have been obtained in case of compressed networks due to the fact that we have reduced the number of bits transmitted in the packet which results in reduced packet loss and as a result of this PDR is improved.

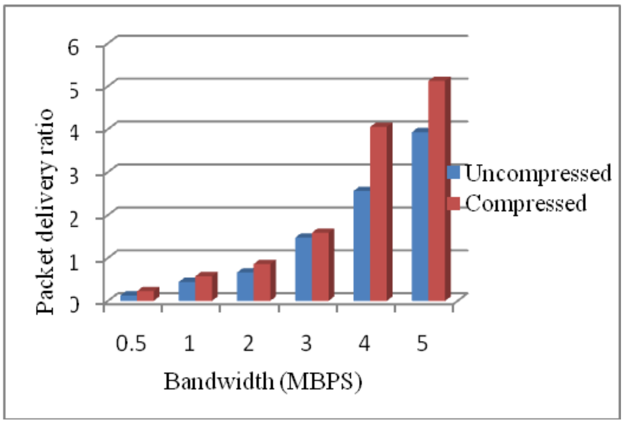

Figure 7: Packet Delivery Ratio Vs Bandwidth

4.2 CASE-II Multihop Wired Tunnel: Wired Scenario

Throughput: (bits/sec): It is evident from the figure 8 that throughput increase as bandwidth increases. Here the case is of wired network and resource is not a constraint in wired network, here even for 0.5 MBPS, throughput is high, and increases significantly as bandwidth increases, and at the highest when bandwidth is 5 mbps. Better throughput is achieved in case of compressed network, as packet loss rate is improved due to reduced number of bits transmitted.

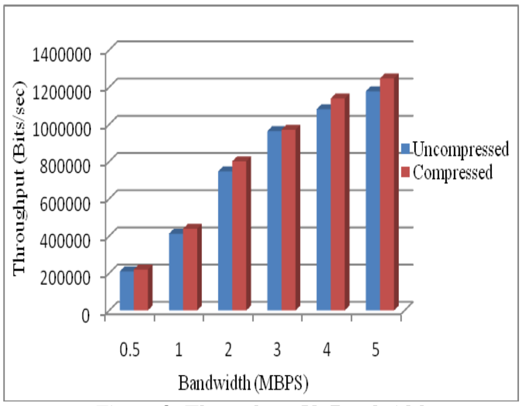

Figure 8: Throughput Vs Bandwidth

Average End-to-End Delay: It is evident from the figure 9 that delay decreases as the bandwidth increases. It is clear from the figure that for low bandwidth of 0.5 Mbps end-to-end delay is considerably very high due to limited resources, and as the bandwidth increases to 4 and 5 Mbps end-to-end delay is reduced. Here delay is less due to wired network; we are having a dedicated link for communication. We are getting reduced delay in the case of compressed networks. Here we can say that impact of bandwidth is inversely proportional to delay which can be seen form figure 9.

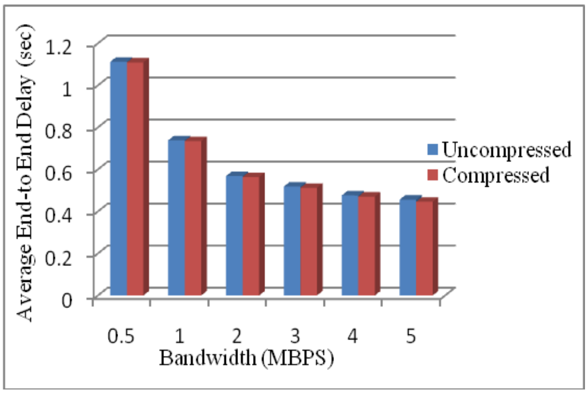

Figure 9: Average End-to-End Vs Bandwidth

Average Jitter: It is evident from the figure 10 that jitter decreases as the bandwidth increases. Results show we are experiencing less delay in all the cases of bandwidth because of the wired network. Due to reduced packet size jitter is reduced in case of compressed network as compared to uncompressed network. This is due to less number of bits transmitted the time is reduced which results in less jitter. The impact of bandwidth is inversely proportional to jitter.

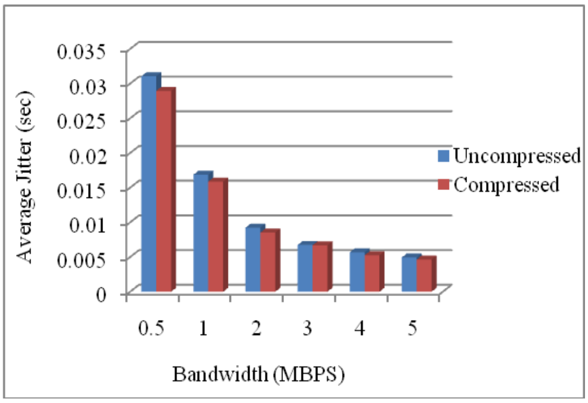

Figure 10: Average Jitter Vs Bandwidth

Packet Delivery Ratio: It is evident from the figure 11 that PDR increases as bandwidth increases. PDR is high in this case because of wired nature of links, and its impact is shown over other parameters too. We are getting better results in compressed networks, since we are sending reduced number of bits which reduces the chance of packet loss due to bit error, and hence improves the throughput. Here we can say that impact of bandwidth is directly proportional to PDR.

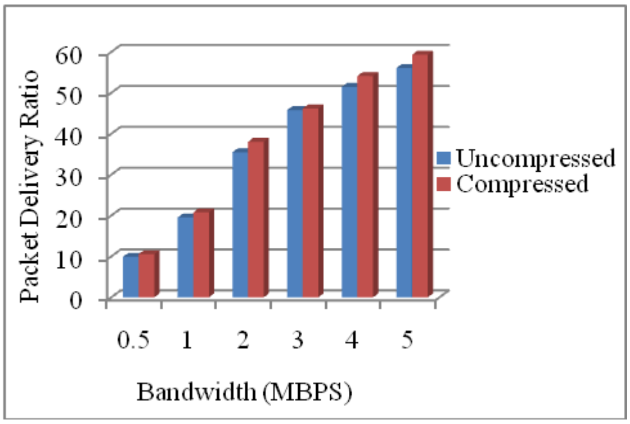

Figure 11: Packet Delivery Ratio Vs Bandwidth

V. Conclusion

The efficient use of bandwidth is one of the main challenges of wired and wireless networks. There are a number of factors that affect the transmission efficiency of IP traffic. The IP packet headers may consume a significant part of the available bandwidth, which degrades the performance of network. In this paper we have addressed the bandwidth issue for multihop IPv6 tunnels over wired and wireless network. Simulations show that using this approach we are getting better network parameters in terms of throughput, average end-to-end delay, Jitter, and Packet delivery ratio. Results show that Impact of bandwidth is directly proportional to throughput and PDR, as bandwidth increases, throughput and PDR increases. Impact of bandwidth is inversely proportional to end-to-end delay and jitter, as bandwidth increases, end-to-end delay and jitter decreases considerably. Right now we have simulated this algorithm over small scale networks with limited nodes, even better results could be obtained when tested to large scale network and other networks. Also in future we want to test this protocol for large scale networks in real time scenario. The profile specified is IPv6 only profile, in future IPv6/TCP and IPv6/UDP will be added to our work.

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