Unidirectional Lightweight Encapsulation with Header Compression for IP Based Satellite Communication over DVB-S

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Abstract. The Multi-Protocol Encapsulation (MPE) is a standard method for encapsulating IP packets into MPEG-2 TS frames. However MPE has some disadvantages in simplicity and efficiency to support next generation network. The Unidirectional Lightweight Encapsulation (ULE) is a new solution to overcome limitations of MPE. In ULE, packets are layered directly into the payload field of MPEG-2 TS frames. This is a new encapsulation method for the transport of IPv4 and other network protocol packets directly over MPEG-2 TS. In this paper, we describe the principles and the benefits of ULE and we also proposed Robust Header Compression Scheme to work with ULE in order to enhance the performance of existing ULE. This paper also provides a simulation analysis to show that the new proposed method can offer a better performance in delay, throughput and overhead especially when the packet size is small.

1 Introduction

ULE [1] is a recently published standard. A ULE packet is layered directly into the payload field of MPEG-2 TS frame. This is a new encapsulation method to transport IPv4 and IPv6 datagrams and other network protocol packets directly over ISO MPEG-2 TS [2] as TS Private Data. ULE also supports DVB architecture [3], the Advanced Television Systems Committee (ATSC) system and other similar MPEG-2 based transmission systems.

ULE can encapsulate various PDUs [1], such as IP packets, Ethernet frames or packets from other network protocol as Subnetwork Data Units (SNDU) by adding a SNDU header to the given PDU. The resulting SNDU will then be sent as the payload part of a MPEG-2 TS packet.

However, the efficiency of ULE still can be improved. It is because the Internet packets still contribute significant overhead for small packet. It is possible to compress those headers and thus save the bandwidth and use the expensive resource efficiently. Header compression is a technique that compresses excess header before transmitting them on a link and uncompressing them to their original state by de-compressor at the receiver.

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2 The Concept of Header Compression

Before a packet is transmitted over a network, each protocol layer appends its own control information into a packet in form of a header. The concept of header compression is to reduce the header sizes of a packet that transmit over the network. The header of the packet can be reduced because there is significant redundancy in the packet header [5,6]. The redundancy is due to the fact that the fields in subsequent packets are duplicated for a particular packet stream.

The reduction in header sizes will help to increase the packets transmission efficiency. Efficiency is important when the cost of transmission is high. Examples include satellite links where the cost of the satellite bandwidth is high. Low transmission efficiency will affect other services that are unable to get required network capacity. In addition, reducing packet overheads can also reduce the transit delay of packets across the link.

Compression and decompression can be performed at the presentation layer to improve the data throughput. However in order to improve the transmission efficiency, the compression and decompression must be performed at the link layer. When a packet is transmitted over a network, static header information for the packet is sent only at the initial stage, while for dynamic fields are updated only when necessary. The trade off is in term of the computational cost, because an algorithm is needed to perform the packet header compression and decompression. In addition, it also requires additional processor hardware and may introduce extra delay. In some scenarios, this cost is acceptable compared to the cost of the bandwidth and the improvement in transmission efficiency.

3 RObust Header Compression (ROHC) Scheme

The ROHC scheme is the new header compression scheme. It was standardized and developed by the ROHC Working Group of the Internet Engineering Task Force (IETF). This compression schemes is developed for error-prone environments by utilizing feedback mechanisms. The feedback mechanisms consist of error detection and a correction mechanism, making ROHC robust against bit errors for IP data based streams.

The ROHC is a scheme that is able to compress many type of header, such as IP, UDP, RTP and TCP headers. ROHC is more robust on links with high BER and long round trip time (RTT). It can achieve higher compression ratio on the packet header and thus is more efficient than other header compression schemes. Even though ROHC is more complex than other header compression schemes like IP header compression and Van Jacobson compression, it is suitable for satellite networks where radio spectrum is a very expensive resource; in comparison, processing power is very cheap. Implementation or computational simplicity of a header compression scheme is therefore of less importance than its compression ratio and robustness.

The proposed approach to enhance the current ULE encapsulation mechanism is to establish a compressor and decompressor at the sender and receiver side.

Figure 1 below is to show the protocol stack for ULE with ROHC. With ROHC, the number of the SNDU can fit into MPEG-2 TS packet will be significantly increased. The size of the SNDU will be smaller because the IP packet header is replaced by a shorter ROHC header before ULE encapsulate the IP packet into SNDU. In this paper, we only focus on the compression and decompression for IPv4 packets.

As shown at Figure 1, the ROHC is located in the standard protocol stack between the IP-based network layer and link layer, just before the ULE encapsulator. The need for saving bandwidth is limited to the satellite link from the ground station terminal to the satellite. In the simplest configuration, the ground station terminal from each side, sender and receiver will have the compressor and the decompressor. The compression and decompression must only work between these two terminals and for the rest of the Internet, this operation remains invisible.

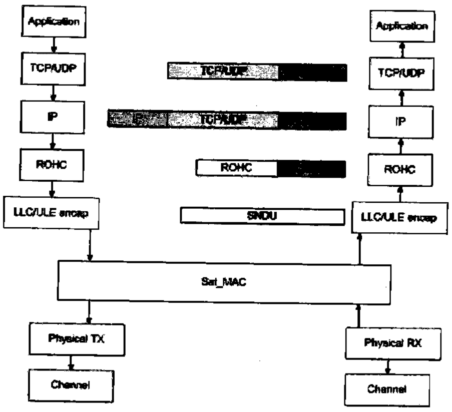

Fig. 1. Protocol Stack for ULE with ROHC

The word Robust in ROHC does not mean that the compressed traffic will be more robust than uncompressed traffic. But in fact, the compressed packet will normally offer a smaller target for bit errors. In order to achieve this goal, the ROHC compressor and decompressor need to communicate between themselves. However, the ROHC does not always work at the peak of its compression capacity. It is because sometimes the compressor needs to sacrify compression gain in order to keep the decompressor synchronized when error occurs on the link [10]. So in order to keep the tight interaction between compressor and decompressor on different level of compression and decompression, a state machine is established to increase the confident about the correctness of the initialization of the static header field and dynamic header field.

4 Use of ROHC with ULE over Uni-directional Links

In this section, the focus is on the performance of ROHC, U-mode. There are some compression parameters which need to be set in order to analyse the performance of the proposed solution-ULE with ROHC. However, the optimal values of these compression parameters were not specified in [5]. In order to analyse the parameters and how they affect the performance of ULE with ROHC, a set of simulations to simulate ULE with ROHC U-mode were performed. The compression parameters used in the simulations were varied to determine the best results. Through these simulations, some possible optimal values or best key parameters that determine the efficiency and robustness of ULE with ROHC could be defined. Henceforth, the ROHC compressor will be denoted by COMP whereas the decompressor will be denoted by DECOMP.

It should be noted that there are three compression and decompression states in ROHC which makes ROHC compression very robust and efficient. In U-mode, due to the lack of the feedback from the DECOMP, the transition between COMP states are performed based on parameters configured in COMP itself. As explained in Chapter 2 section 2.7.4, the three compression states at COMP are IR, FO and SO. During IR state, COMP will send all the static and non-static fields of the packet header to establish the DECOMP CONTEXT. While during FO state, partially compressed packet which contains information about the non-static or dynamic fields of the packet header will be sent. Finally, the full compressed packet will be sent when the COMP reach SO state.

In ROHC, the compression must start in U-mode [5], the transition between compression states are performed only on account of periodic refreshes as depicted in Figure 2. In [5], it was mentioned that the compressor will not transit to a higher compression state unless the compressor is fairly confident that the DECOMP has received sufficient information, and able to decompress the packets correctly. According to Figure 2, a transition between states happen when the COMP has consecutively sends out N packets at the corresponding states, but in [5], it does not specify or define the values for N and Refresh Rate.

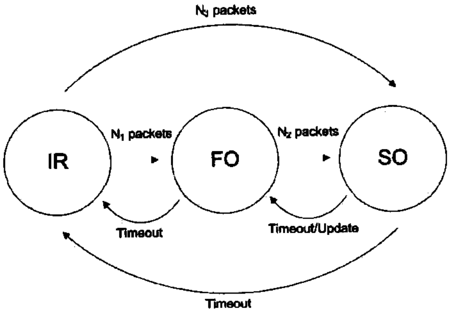

Fig. 2. State Machine of U-mode Compressor

To optimize the performance of ULE with ROHC for UDP traffic in MPEG-2 TS networks, two types of performance metrics were used as the benchmark for comparison, average lengths of the compressed headers and packet loss rate. First, the average length of compressed header for ULE in ROHC was investigated using different sets of parameters. The values of N were tested first. N is number of packets that have been decompressed correctly by DECOMP before transition between states happen. The best value of N was determined by running a series of simulations. The error conditions and long round trip time in satellite link were included in the simulation. According to [5], it is possible to start the transition after at least one packet has been correctly decompressed by DECOMP. Hence it is possible to configure the value $N_1 = N_2 = N_3 = 1$, but it is too optimistic if N =1 is used in normal satellite link where errors usually occur. Thus, a series of simulations were run to investigate the possible optimal values of N. In the simulations, the N_3 was omitted from the experiment because the fast operation mode (transitions from the IR state to the SO state directly, bypassing the FO state) could only be used in an error free satellite links. For this research project, the focus is on normal satellite links, where the BER of the satellite links is taken into account.

The result of different values of N on Average Compressed Header Length in ideal error free satellite link is shown in Figure 3. The result shows that the smaller the value of N, the smaller average compressed header length can be achieved. However, when the Refresh Rate was increasing, the average compressed header length for each different values of N become insignificant and nearly become constant after Refresh Rate exceeds 200 packets. From Figure 3, the N parameter contributes only a little to the average compressed header length when the Refresh Rate increase. It shows that parameter N only slightly affected the packet header length when the Refresh Rate was increasing. The rest of the following simulation, the value of N will be considered as a constant value of 3. This is because by using a higher value of N, it can increase the robustness of ULE with ROHC without contributed significant header length to the packet especially when the Refresh Rate is beyond 200 packets.

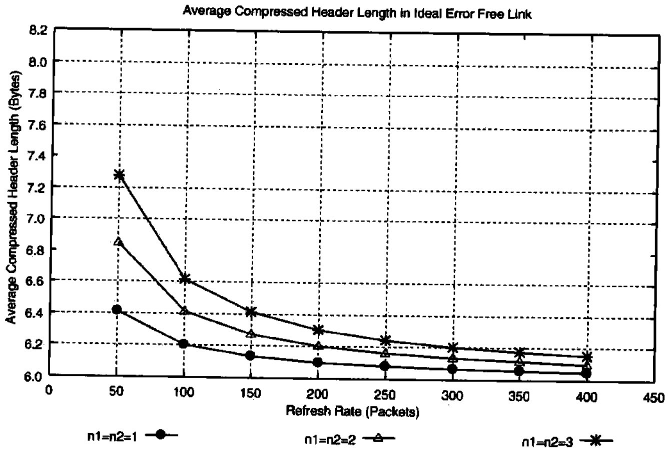

Fig. 3. Average Compressed Header Length in Ideal Error Free Link

The BER of satellite links can produce errors in compressed header. These errors in compressed header might generate a single packet loss or consecutive packets loss. A consecutive packets loss might also causing loss of packets that carry update information, and all of these errors will trigger another serious problem which is loss of CONTEXT synchronization. These errors can lead to the bad performance of the ULE with ROHC. Thus, a set of optimized parameters of ULE with ROHC needs to be defined to confront with these errors through simulation experiments. In the coming section, types of errors that will be tested in the simulation are:

1. Single Packet Drop
2. Consecutive packets drop
3. Propagation Error (Context damage)

4.1 Single and Consecutive Packet Loss with No Error Propagation

The ULE with ROHC U-mode over MPEG-2 TS networks will be studied under the condition where errors occur to the satellite link. In order to study the impact of errors in satellite link for U-mode, different error rate (BERs) will be applied in the simulation. The error model applied in the simulator generated errors affecting the header and the payload of the packets, causing packet corruption at the physical layer during the transmission in satellite link. Such packets received by the receiver will be dropped by the upper layers. Figure 4 depicts the Average Header Length of packet header over different error rate links.

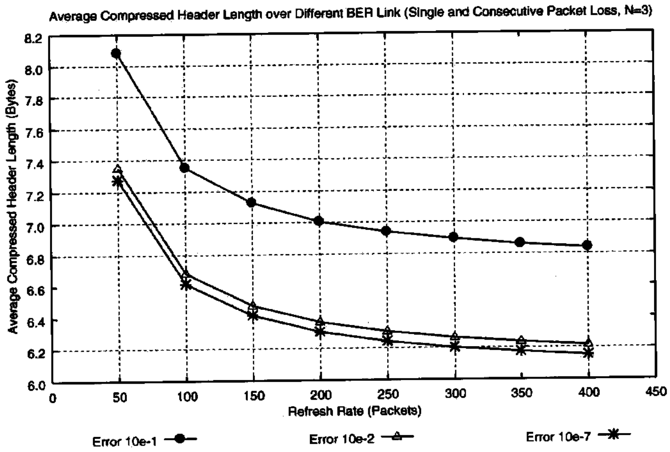

Fig. 4. Average Compressed Header Length in Different BER Link for N=3

In Figure 4, it shows that with a constant value of N=3, all the 3 different error rate show that the Average Compressed Header Length became shorter when the Refresh Rate value was increasing. From Figure 4, it also shows that when errors are applied on the link, the overall Average Compressed Header Length was slightly higher than the ideal error free link shown in Figure 3. This was because some burst errors occurred and caused a few packets loss occurred. The packets loss caused the DECOMP was unable to decompress the received packets correctly. Fortunately with the W-LSB encoding method, for a condition where only a few packets loss occurred, the DECOMP was assumed still able to decompress the newly received compressed packet correctly. This explains why the Average Compressed Header Length in Figure 3 is shorter than the Figure 4, but the difference was not so significant except for the error rate 1 x 10^{-1}. Thus, by assuming that a massive consecutive packets loss didnt occur during the transmission and the link errors didnt damage the CONTEXT packet while refreshing the DECOMP, ULE with ROHC would still be able to achieve a lower header length when the Refresh Rate was increasing.

4.2 Consecutive Packet Loss with Error Propagation

Although ULE with ROHC scheme is robust against errors, ULE with ROHC itself also has a drawback. For a DECOMP to decompress the compressed packet correctly, the CONTEXT in the DECOMP should contains the correct information for decompression. If the first loss events with a CONTEXT caused the decompression information in DECOMP to become unsynchronized with COMP, the decompression of the subsequent packets would be dropped or discarded at upper layer due to checksum error. This effect can be referred as Error Propagation. The effect of the Error Propagation in ULE with ROHC is depicted in Figure 5. The solution for Error Propagation in uni-directional link is to retransmit the uncompressed packet at regular intervals. The periodically retransmitted uncompressed packet to DECOMP was able to reduce the effect of Error Propagation, but this approach has a trade-off between compression efficiency and robustness. It is undeniable that higher Refresh Rate will reduce error propagation, but a too frequent transmission of uncompressed packet to restore the DECOMP CONTEXT will also reduce the compression efficiency. Although Error Propagation can severely degrade the compression efficiency, this can be countered by the proper choice of Refresh Rate. To study how to set these parameters, the ULE with ROHC was examined under different error conditions and Refresh Rates. The Average Compressed Header Length and Packet Drop Rate were defined as the metrics for comparison in this experiment. The results of the simulation were presented in Figure 5 and Figure 6.

Average Compressed Header Length. From Figure 5, it shows that when the link BER is too high, and Error Propagation occurred, the Average Compressed Header Length will increase rapidly when the Refresh Rate value was getting larger. This is because the ratio of incorrectly decompressed by DECOMP is high due to the Error Propagation. This shows that when CONTEXT corrupted due to the Error Propagation, the smaller the Refresh Rate is, the more robust it can be. For BER value of 1 x 10^{-7} (the average error rate of the common satellite link), the Average Compressed Header Length was decreasing slightly when Refresh Rate is increasing. In contrast, the result of BER of 1 x 10^{-1} shows the opposite behaviour.

From this experiment, it was shown that with different BER levels, Refresh Rate has contributed different compression efficiency to ULE with ROHC

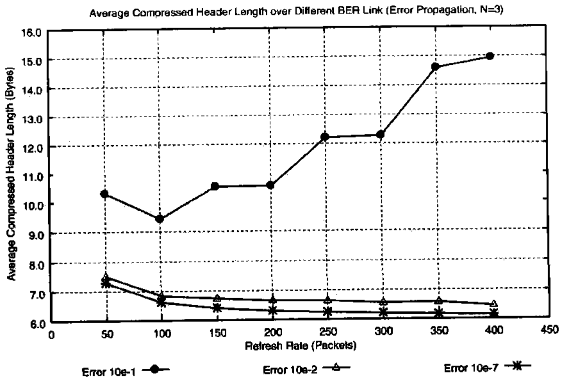

Fig. 5. Effect of Error Propagation on Average Compressed Header Length for N=3

U-mode. For the case of satellite link where the common error rate is 1 x 10^{-7}, the Average Compressed Header Length remains almost the same at the higher Refresh Rate such as 200, 250,...,400. Since the Average Compressed Header Length remains the same at higher Refresh Rate, it is recommended to use higher Refresh Rate. Based on the result in Figure 5, the Refresh Rate = 200 is advisable. The highest Refresh Rate was not selected because the compression efficiency and robustness must be balanced for ULE with ROHC. The robustness of the ULE with ROHC should not be scarified when selecting the optimized value for compression efficiency. This will be explained in more details in the next section.

Packet Drop Rate. Refresh Rate is one of the most important parameter contributing to Packet Drop Rate. It is because when consecutive packets loss occurred, and additionally if there are no other recovery mechanisms to prevent the Error Propagation, re-synchronized the CONTEXT between COMP and DECOMP can prevent the value of Packet Drop Rate getting increased. In Packet Drop Rate experiments, consecutive packets loss and Propagation Error is enabled when a different Refresh Rate in error links were used. The result of Packet Drop Rate of ULE with ROHC was presented in Figure 6.

According to Figure 6, note that for BER is 1 x 10^{-1} the Packet Drop Rate increased dramatically when the Refresh Rate was increasing. This shows that, when the CONTEXT was damaged, large number of packets were lost if a large Refresh Rate value was chosen. For the BER is 1 x 10^{-7}, the Packet Loss Rate achieved was almost 0. This was because at the low BER value, the probability of CONTEXT damage on the link was also very low.

The BER of satellite link varies over the time due to the satellite movement and multi-path fading. In the worse case, the BER in satellite link might be very high and Propagation Error might also happen. In such a case, if a large Refresh Rate value is chosen, it can cause a large number of packets drop. This problem diminished when a smaller value of Refresh Rate which is Refresh Rate =200 was selected. The Refresh Rate = 200 is sufficiently large, and able to prevent

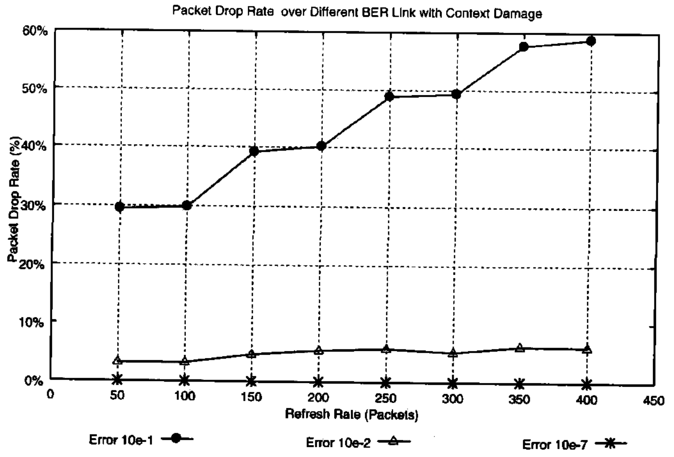

Fig. 6. Packet Drop Rate over Different BER Link with Context Damage

the consecutive undamaged packets drop too seriously. This explained why the highest Refresh Rate has not been selected in the previous section.

Conclusion of ULE with ROHC Parameters Evaluation. Compression efficiency clearly decreases when a smaller Refresh Rate is chosen. In the experiments, it shows that there were many parameters can affect the performance of ULE with ROHC. The bandwidth efficiency could be improved when more compressed header packets are sent especially in SO state, but it will also suffer from consecutive undamaged packets drop due to the occasional CONTEXT damage. Thus, to guarantee robustness, uncompressed packet in IR and FO state should be sent periodically.

As conclusion, one can see is different compression parameters can affect the performance of ULE with ROHC, when a short Refresh Rate is chosen, it resulted in a high robust performance, but unfortunately, it also degraded the bandwidth efficiency. Thus, in term of the robustness of ULE with ROHC, the efficient use of bandwidth should be taken into account. Therefore, based on the results of the experiments, a suitable values of N=3 is defined. In addition, the balance point for the values of ULE with ROHC parameters should be chosen based on the condition of the links. For the case of satellite links, Refresh Rate = 200 packets is proposed. This set of optimized compression parameters are expected to improve the ULE with ROHC performance in terms of compression efficiency and robustness for GEO satellite links.

The raw BER experienced in a GEO satellite links were in the order of 1 x 106−2 for 4.5 meters satellite dish of C-band Earth Station operated by the USM Network Research Group. However, all satellite data transmission is protected using suitable coding schemes such as Forward Error Correction (FEC), Reed Solomon (RS), and turbo codes. For USM link, it was protected using FEC $^3/_4$ and RS with 8PSK modulation, the resultant BER was 1 x 10^{-7} to 1 x 10^{-12} which is comparable to terrestrial network link.

5 Improvement of ULE with ROHC

The discussion in the previous section provides fruitful information on how to set compression parameters of ULE with ROHC to accommodate the ULE with ROHC in GEO satellite link. In this section, we will present the result from the simulation of the ULE with ROHC using the simulation configuration. This research project is analyzed using *ns2* [11] simulation tool. The existing satellite network model in *ns2* was selected as a simulation model for this research. There is an IP traffic source located behind the satellite terminal and traffic is transmitted to another satellite terminal via satellite. The simulation model that been used for study is shown in Figure 7 and it is a simple satellite access network. The fixed point to point satellite simulation model was chosen because it is a more simple approach and cut down on simulation time or complexity of the simulation, but it is sufficient for our research purpose. The traffic considered in this research is UDP traffic and it could be a voice over IP services in upper application.

In the simulation, the CBR traffic was chosen as voice traffic. The simulations were run with a different number of CBR traffic sources and CBR packet size in order to simulate various traffic loads.

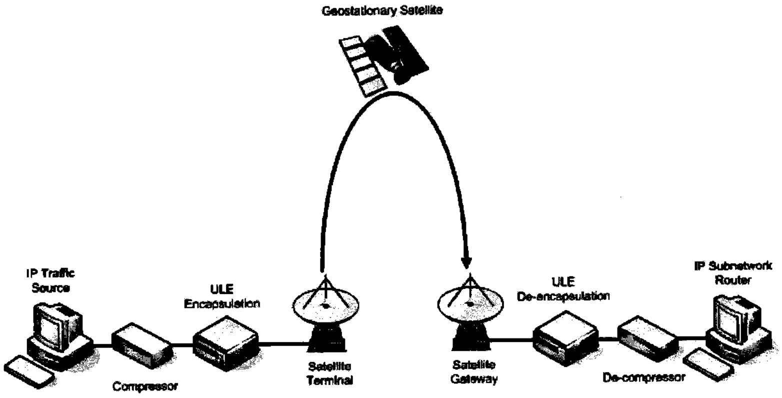

Fig. 7. Simulation Model

The results of the simulation are presented in Figure 8 to Figure 11 and discussions of the results of ULE with ROHC U-Modes are presented along with the simulation in the latter section. As can be seen from the Figure 8, ULE with ROHC has shown a better Average One Way Delay. Network delay can be affected by several different factors, such as congestion of network, transmission delay, queuing delay and others. From Figure 8(a), Average One Way Delay for ULE and ULE with ROHC is slightly reduced when the CBR transmission rate was increasing. As expected, when the traffic generation rate was increasing, the time for router to forward the packet is faster; thus, the bandwidth of the link was much greater than packet generation rate, it will show a reduction on the Average One Way Delay. However, when the CBR traffic generation rate was increasing and approaching the link capacity, the Average One Way Delay of the packets were substantially increased. This explained why the Average One Way Delay for ULE and ULE with ROHC reduced at the early stage and increased tremendously at the end.

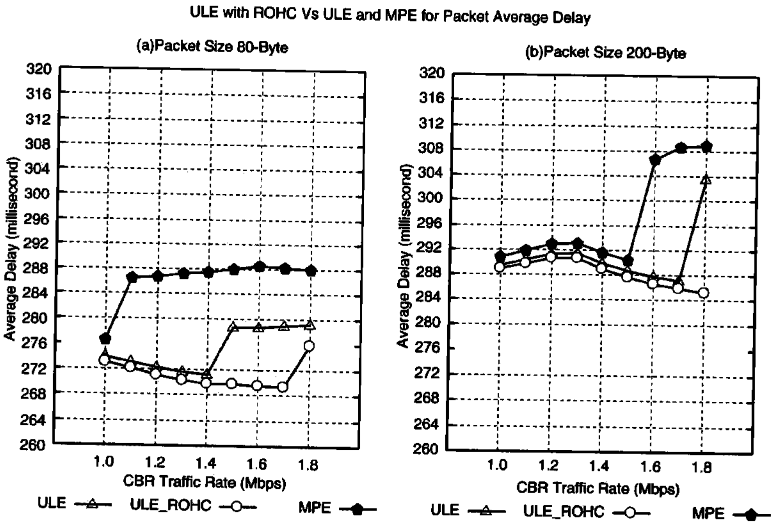

Fig. 8. Average Delay for UDP Packet with Different Encapsulation Mechanism, Traffic Generation Rate and Traffic Source

The ULE with ROHC had achieved a lower Average One Way Delay especially when packet sizes are small. Clearly, this is because after the compression of the packet headers, the packets are smaller than the original packets size. As a result, it will reduce the delay of packets transmission due to more SNDU packets can be inserted to MPEG-2 TS payload. Moreover, when the traffic generation rate was increasing, the Average One Way Delay for ULE with ROHC still performed better than ULE and MPE. This is because at the same rate of traffic generation, the packet size with header compression is relatively smaller than others without header compression.

However, the difference of the Average One Way Delay between ULE, ULE with ROHC and MPE are not significant when the packets size were increasing. This is expected because of the small ratio of packet header to the size of payload. When the packet payload size was increasing, the impact of the packet overhead is small and the transmission time for large packets is almost the same using different encapsulation mechanism. Hence the Average One Way Delay for these packets is almost similar.

The effect of the encapsulation mechanism on packet loss is another important parameter that is examined. The results in Figure 9 show that ULE with ROHC offer a better performance than ULE and MPE in heavy traffic load network environment. The results from the simulation also show that network congestion is the primary factor of the packet drop. The simulation results show that when the CBR rate was increasing, the number of packet drop also increased, especially for the small size packets. This is due to the fact that the UDP is not like TCP, the UDP doesnt has a network congestion control mechanism that can throttle the sender when the network become excessively congested. As a result, UDP traffic will still keep generating traffic at a constant rate without taking the network condition into consideration. MPE and ULE experience an earlier packet drops than ULE with ROHC. This is because with header compression, packets can be compressed into smaller size; it reduced the bandwidth required on the network.

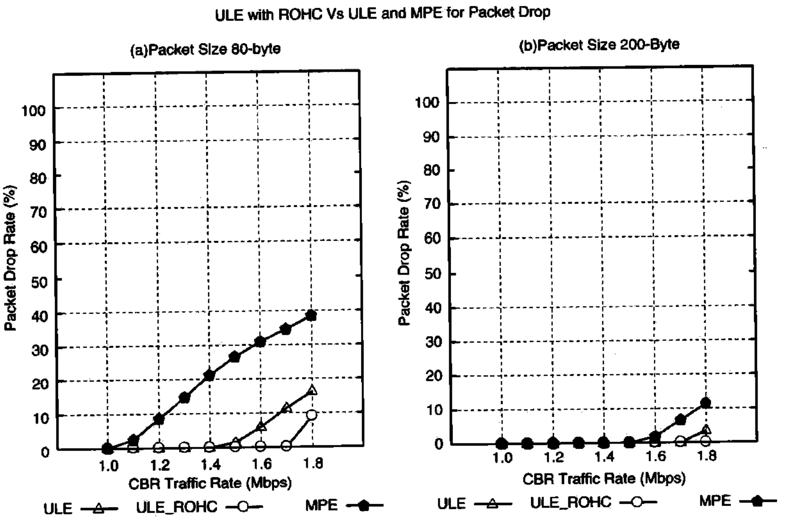

Fig. 9. Number of Packet Drop for UDP Packet with Different Encapsulation Mechanism, Traffic Generation Rate and Traffic Source

In addition, ULE with ROHC achieved lower packet drop compare to ULE and MPE (Figure 9). There are few processes before a UDP packet can be transmitted over the satellite link. Before the UDP packets are sent to the next layer for encapsulation, these packets are placed in the queue on particular node. The encapsulator will take the packet from the queue, encapsulate it and insert the encapsulated packet into MPEG-2 TS payload. When the packet generation rate of CBR was increasing, a large number of UDP packets arrived at the node, making the queue fulled. The number of encapsulated packets that can be inserted into MPEG-2 TS payload is limited due to the size of the MPEG-2 TS packet payload is constant at 184-byte. The encapsulator needs to wait for next new MPEG-2 TS packet to transmit the next UDP packets. This explained why the packets were seriously dropped when network congestion occurred.

Next, the comparison of Average Throughput for ULE, MPE and ULE with ROHC will be shown in Figure 10. The results of the simulation demonstrated that the ULE with ROHC has produced significant improvement of Average Throughput compared to ULE and MPE. The Average Throughput of ULE with ROHC was evaluated in both Single and Triple Simultaneous UDP Streams Traffic. Simulation results showed that ULE with ROHC has achieved 33% higher

Average Throughput than ULE and MPE for both Single and Triple Simultaneous UDP Streams Traffic when packet size is 80-byte. ULE with ROHC has achieved higher Average Throughput because by using ROHC, it can compress the packet header into smaller size, and therefore increased the amount of packet that can be sent through a single MPEG-2 TS in a given time period.

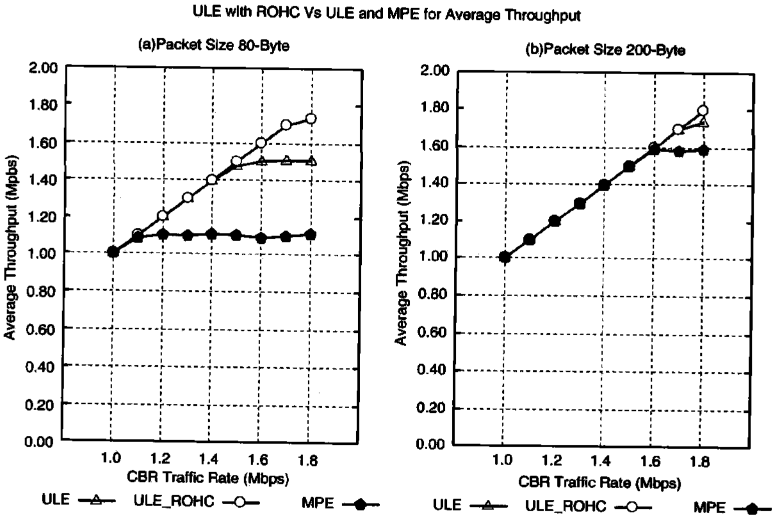

Fig. 10. Average Throughput for UDP Packet with Different Encapsulation Mechanism, Traffic Generation Rate and Traffic Source

The behaviour of the Average Throughput for Single UDP Stream Traffic with various packet sizes and packet generation rates were first evaluated. Figure 10 shows the measured Average Throughput as a function of the packet generation rate for UDP stream. According to Figure 10(a), it can be seen that both ULE and ULE with ROHC had achieved good Average Throughput when packet size is 80-byte. As shown in Figure 10, when the packet generation rate was increasing, the Average Throughput of the ULE, MPE and ULE with ROHC was increased at a linear rate but then they reach their highest Average Throughput at certain point. Then the Average Throughput for ULE, MPE and ULE with ROHC had remained at a constant level.

The UDP traffic was injected to the network at constant and fixed rate, as long as the bandwidth still able to accommodate the UDP traffic, the Average Throughput increased in linear pattern. Among the three encapsulation mechanisms, MPE achieved the lowest throughput especially for small packet size. Though the bandwidth of satellite link is 2Mbps, MPE for packet size 80-byte (Figure 10(a)) remained constant at 1.2 Mbps. The MPEs Average Throughput cant go up further is due to the early packet drop at the encapsulator queue. However, when the packet size was increasing, the difference of Average Throughput among these three encapsulation mechanism is not significant, but in generally for Average Throughput performance, the ULE with ROHC still achieved higher Average Throughput than other encapsulation mechanisms.

We next investigated the comparison of overhead percentage for ULE, MPE and ULE with ROHC. The comparison results will be shown in Figure 11. It can be seen that the ULE with ROHC had achieved a better Overhead performance when the packet size was small. However this Overhead performance was not significant when the packet size was increasing.

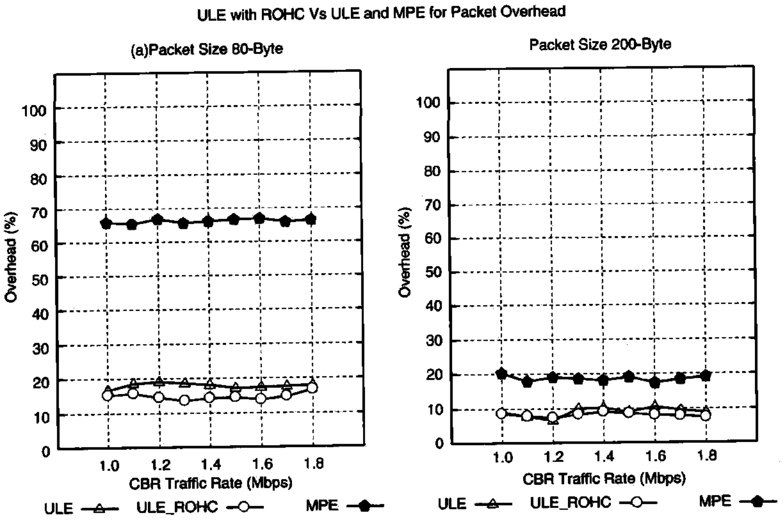

Fig. 11. Overhead for UDP Packet with Different Encapsulation Mechanism, Traffic Generation Rate and Traffic Source. Packet Size.

In Figure 10(a), we can observe that the ULE with ROHC is achieving a better overhead when the packet is relatively small in size. In comparison, ULE, MPE and ULE with ROHC achieve a similar overhead when CBR packet size is 200 bytes which is shown in Figure 10(b). This indicates that impact of the header compression on a large size packet has a little improvement on overhead and it also indicates that the packet size after the header compression is similar to the original size. Header compression only provides largest gain when the ratio of payload size to packet header size is small, thus ULE with ROHC provides significant benefits with small packets.

6 Conclusion and Future Work

We first present some improvements of the ULE encapsulation mechanism. We have presented our solutions on IP datagrams transmission over DVB-S networks that combine ULE encapsulation mechanism and ROHC header compression scheme. We have proposed to compress the packet before encapsulated by ULE in order to reduce the overhead of the packet, at the same time to increase the efficiency of the ULE encapsulation mechanism. We have introduced ROHC to reduce the header sizes of a packet that transmit over the network because there is a significant redundancy fields in the packet header before ULE encapsulate the IP packet to become SNDU. In other words, we are sending the header-compressed unicast packet over DVB-S using ULE. The overhead of headers, especially UDP packet over DVB-S using ULE is a main focus. With ROHC, the number of the SNDU packet can fit into MPEG-2 TS packet will significant increase, and it will help to increase the efficiency of the packets transmission.

In the next generation internet, the current IPv4 will soon replace by IPv6. The main difference between IPv6 packet and IPv4 packet is their length of network addresses. IPv6 addresses are 128 bits long, whereas IPv4 addresses are 32 bits long. Solution like header compression need to be implemented in order to reduce this expanded header. IPv6 datagram over MPEG2-TS in DVB-S network using ULE with ROHC can be a good future work of this research.

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