Performance Evaluation of Robust Header Compression over Mobile WiMAX

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***Abstract*- IEEE 802.16e Mobile WiMAX provides mobile wireless broadband services for communication. Efficiency is extremely vital once the value of transmission is extremely high. In order to improve the utilization of network bandwidth in multimedia environment, ROHC header compression scheme have been proposed. This paper present performance analysis after deploying ROHC over Mobile WiMAX environment.**

***Keyword*- Mobile WiMAX, Robust Header Compression (ROHC).**

I. Introduction

The future telecommunication network will be certainly characterized by the convergence of mobile technology and Internet protocols, achieved through a network platform totally based on TCP/IP [1]. Mobile WiMAX will be the most important realization of this concept [2]. Mobile WiMAX was designed to meet the requirements for delivering the broadband data services including voice, data, and video, using IP protocol. In order to achieve successful communication, encapsulation process of each layer of the hierarchical TCP/IP architecture, fairly large amount of bandwidth will be ruined for transmission of control information (i.e. header).On the other hand, the effective payload of real-time business environment is small, such as voice or video services over IP. Besides the link layer header, there are 20 bytes of IPv4 header. But the effective payload of data packets in real-time multimedia services is usually 15-20 bytes, so only 27% -33% of the bandwidth is used to transmit the actually useful data, and a lot of bandwidth is used to transmit the protocol headers [3]. Thus, it is essential to find a way to improve the network bandwidth utilization. Robust Header Compression (ROHC) can significantly decrease header size by capitalizing on static or rarely changing header field among all other traditionallywidely used header compression schemes [4, 5]. In this paper we propose to deploy ROHC in Mobile WiMAX environment and simulate to analyses the performance parameter.

The rest of this paper is organized as follows. In Section 2, we brief overview of Mobile WiMAX. ROHC and its operation briefly describe in Section 3. We present our testbed for simulation scenario in section 4 and conclude this in Section 5, outlining items of future work.

II. Overview of Mobile WiMAX

Consumers are increasingly using mobile devices such as smart phones and tablets to access the Internet, outcome of this high bandwidth range is required. WiMAX (Worldwide Interoperability for Microwave Access) referred as IEEE802.16 fill this gap by delivering bandwidth at large ranges to highly mobile users. WiMAX physical layer (PHY) is based on OFDM (orthogonal frequency division multiplexing) that provided good resistance to multipath and high data rate up to 74 Mbps. WiMAX support for adaptive modulation and deliver all- IP based platform.IN this paper, for testbed we take small scale WiMAX.

III. Feasibility Study of IP Header Compression

After the keen observation of the IP packets in transmission process, we analysis that header field such as routing field (i.e. source and destination address) are design for routing purpose. They are helpful to ensure the successful transmission throughout the Internet. But they are of no use in the single hop packet transmission of wireless links. Therefore, these fields can be compressed to improve the efficiency of the network. On the other hand, there are also some redundancy is present in header packet. After the analysis of the IP packet, we can find some connection between header fields, and it means that we can infer some of the fields with the use of some other fields [3]. In the IPV4 header fields remain static between consecutive packets belonging to the same packet stream, which results in greater redundancy. This is mainly because these header fields are often unchanged, or they are changed according to certain rules, instead of random variation. The basic principle of header compression is to send only context on behalf of complete header until there is no changes occur in static field. This context contains the last correct update of the original header and the redundant information in the stream. This context is kept both in the compressor and in the decompressor in order to ensure the robustness of the mechanism. If any changesfound in static field, required to update the context and enable the decompressor to extract the compressed packets with the correct context information. We can be divide IP header filed into three categories:

a) Static fields: the value of these fields will not change during the entire transmission of the data stream, such as version, header length, and addresses.

b) Inferable fields: the fields that can be inferred by other header fields, such as the length field and checksum. The inferable fields will never be sent in header compression schemes.

c) Dynamic fields: these fields will change between the packets in a data stream, in accordance with certain rules or randomly, such as identification. It is necessary to compress the changed fields by using some of the compression algorithms.

IV. OVERVIEW OF ROHC

ROHC [6] is a versatile header compression scheme evolved by the IETF's ROHC working group for RTP/UDP/IP, UDP/IP, and ESP/IP packet headers. It is based on mode and state transitions. In ROHC, we eliminate redundancy field from most of the messages, exploiting dependencies and the predictability of other fields, the total header size can be reduced significantly depending on the profile and mode used. A header compression profile is defined for every kind of packet flows over wireless channel. In our study, we utilized the only IP profile of ROHC which defines the methods for compressing IP headers.

A. ROHC Functioning

ROHC header compression framework can be describe as a process of interaction between two finite state machines-compressor state machine and decompressor state machine, which are described by their context respectively [3]. Both state machines began to transfer from the lowest state to higher states. The state transfer does not need to be synchronized at both ends.

1) ROHC Compressor FSM

ROHC compressor has three states, which are the state of Initialization and Refresh (IR), First Order (FO), and Second Order (SO) [7]:

- The IR state is responsible for initializing the static parts of the context. Headers sent from the compression end are in uncompressed form.
- The FO state signifies partial context established between decompressor and compressor. The FO state provides the means for efficient communication of anomalies in the packet stream. Thus, headers sent by the compressor are only partially compressed.
- The SO compressor state signifies a link with optimal header compression.

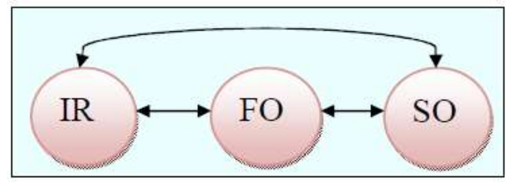


Fig. 1 ROHC Compressor Finite State Machine

In figure 1, primarily the ROHC compressor in IR state and then gradually transfers to higher states, figure 1 illustrate that. As long as the compressor determines that the decompressor has sufficient information to extract the compressed packets successfully, the compressor will try to maintain the higher state.

The compressor will transfer its states mainly due to the following reasons [3]:

(1) The change of packet headers.
(2) Receiving positive feedback information from the decompressor.
(3) Receiving negative feedback information from the decompressor.

2) ROHCDecompressorFSM

ROHC compressor has three states, which are the No Context (NC), Static Context (SC) and Full Context (FC) states:

- The first state is No Context (NC), the decompressor stays initially where there is no context and reached it when the context is lost. In this state only the IR header, format packets are decompressed and any other header format packet is dropped. In other words, NC indicates that the decompressor has yet to successfully decompress a compressed header.
- The decompressor changes to Full Context (FC) state when correct decompression (successful) of a header takes place (verified by CRC) or if the context is established.
- The Static Context (SC) state is not reached except when there is an error and the dynamic part of the header is lost.

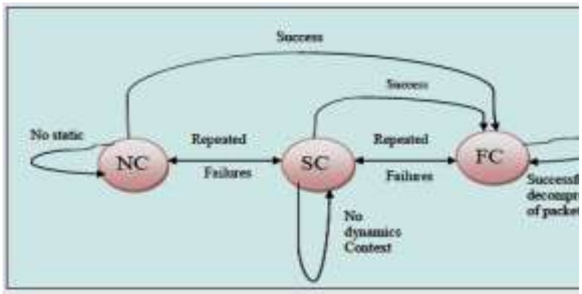


Fig. 2 Decompressor Finite State Machine

At the beginning, the decompressor is in the NC state and then gradually shift to higher states. Figure 2 summarizes the decompressor states and transitions. Once the decompressor enters the highest state of Full Context, it generally will not leave this state. If an unsuccessful decompression happens while the decompressor is in FC state, it will transition back to the SC state. At this point in time, if a compressed FO header is successfully decompressed, the decompressor will transit back to the FC state; however, if a compressed FO header is unsuccessfully decompressed, the decompressor will transit to the NC state.

B. ROHC Operation mode

There are three modes of operations in ROHC, called Unidirectional (U), Bi-directional Optimistic (O), and Bidirectional Reliable (R) mode [7].

- Unidirectional mode (U-mode) specifies compression over a unidirectional link in which packets are sent only from the compressor to the decompressor.ROHC compression must start in the U mode. In this mode, ROHC can be applied to the link that there is no feedback channel or the feedback channel is not ideal. After receiving a packet from the compressor, then the decompressor can control the mode of operation by sending feedback packets with mode indication. Based on the decompressor's knowledge of header fields, the compressor gradually transit from the IR state to the FO state, or "optimistically" transit to the SO state. In U-mode, the compressor state conversion is controlled by the periodic timeout and irregular changes in header field's patterns.Effect of this compressor transition from the higher SO state to the lower FO and IR states periodically to send a full header, this is required because the compressor receives no context synchronization feedback from the decompressor. Because of the cyclical return to lower states and no feedback that can be used for errors recovery. Generally, U-mode mode is not efficient as O-mode. It is provide lower transmission rate across the channel. When the compressed packet transmitted to the decompressor, ROHC can be converted in O-modeand the decompressor will send a feedback packet, expressing that ROHC hopes a mode conversion.
- O-mode specifies an ROHC scheme over a bidirectional link between the compressor and decompressor. O-mode is similar as U-mode, but in O-mode feedback channel is present from the decompressor to the compressor.The feedback channel can be used to send errors recovery requests from decompressor, and in some cases, it can convey the important acknowledgement of significant context update from the decompressor to the compressor. O-mode will no longer shift down to lower states periodically [3]. O-mode's purpose is to maximize header compression and increase the usage rate of the feedback channel. It will send control packets whose headers are damaged because of residual errors and context failures for error recovery and context resynchronization. The possibility of context failures in the O-mode may be higher than the R-mode.
- R-mode specifies an ROHC scheme over a bidirectional link between the compressor and decompressor. Compared to O-mode and U-mode, it is provided higher usage rate of the feedback channel and maximize robustness in lost/damaged packet and less error propagation, resulting in a minimization of context invalidation between ends. This is achieved with frequent usage of the feedback channel and stricter logic at both ends. However, this reliability comes at a cost, as the magnitude of compression used in R-mode is less than the amountachieved by O-mode. We found less minimum rate of context failures than the O-mode, but drawback is more packets with damaged headers may be sent to the link when the context is actually invalid.

We summarize ROHC operation mode and gradually state transition by using FSM which is described in figure 3 [7].

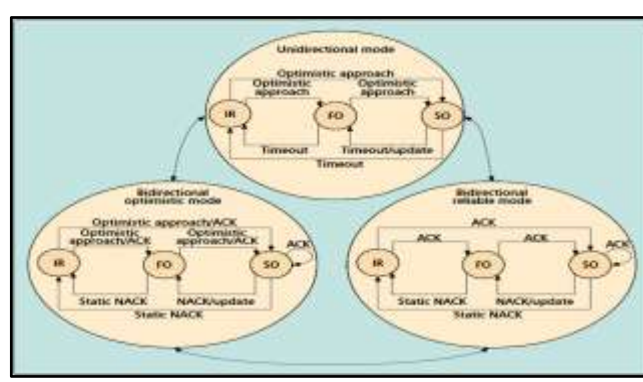


Fig. 3 ROHC Operation Mode [7]

C. ROHC Compression Process

The compressor will receive three types of packets, including the RTP / UDP / IP packets from the upper layers but in our study we only specify IP packet, the feedback packets from the feedback channels. We uses a ROHC profile 4 which is compress only IPV4/V6. When IP packet contain a control information, the ROHC recommend to do nothing with them and send them directly.Each flow in a channel has its context, which is identified by a CID (Context Identifier) which is a number that differentiate the flows in a channel, and the context in compressor anddecompressor. We summarize ROHC compression process in figure 4. In ROHC compression process we perform three basic task [3]:

1) Compress the receiving IP packets into the appropriate compressed packets and send them to the decompressor.
2) Deal with the feedback information from the decompressor, and gradually changes states and modes.
3) Manage the CIDs reasonably and effectively by using control packet like IR, IR-DYN Packets etc.

Fig. 4 ROHC Compression Process [3]

D. ROHC Decompression Process

When decompressor receive a packet, then [3]:

- Firstly, it checks whether there is feedback information in the packet, and if the answer is yes, the decompressor sends the feedback information to the corresponding compressor.
- Secondly,the decompressor checks whether the compressed packet is legitimate. If not, the decompressor evaluate whether the current mode is the U mode, and if it is U mode, discard the packet. Also if not, send the feedback information back before discarding it. If the compressed packet is legitimate, evaluate its type, restore the compressed packet and do the CRC checksum. If the CRC checksum is right, update the context. And if it is wrong, process the feedback information.
- Thirdly, pass the decompressed packet to the upper layer. The decompressor perform the mode and states conversion according to the received information.

Figure 5 specify this process by a flow chart.

E. Window-Based Least Significant Bit Encoding

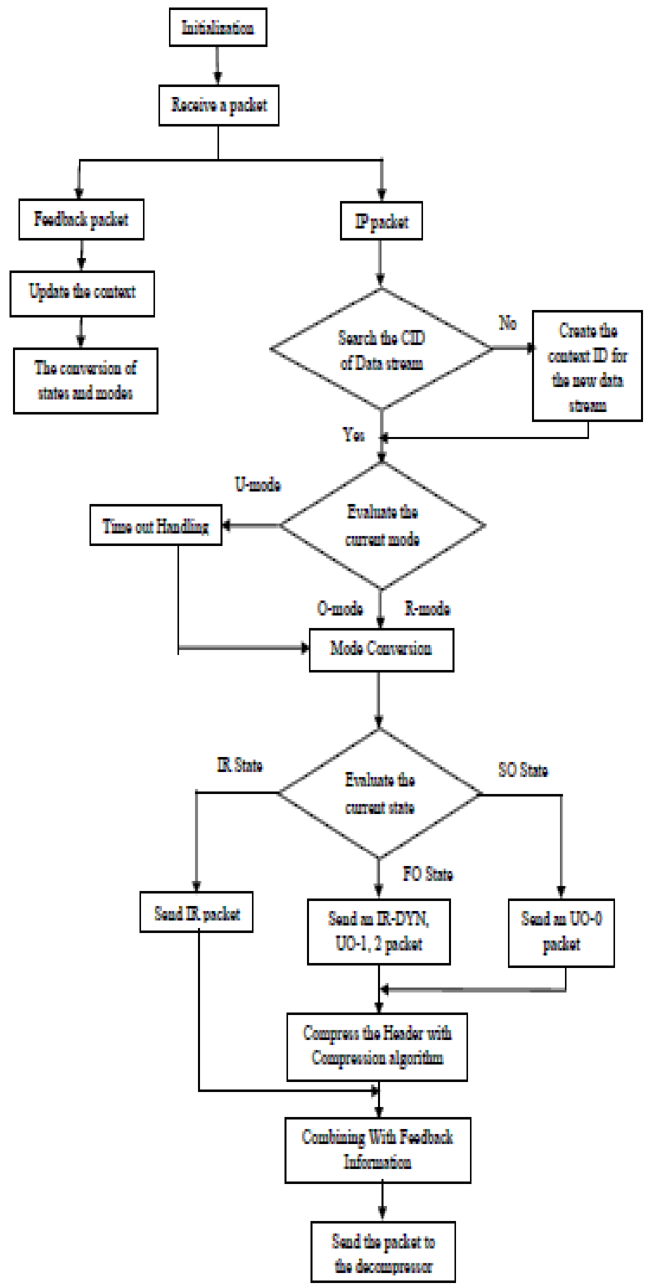


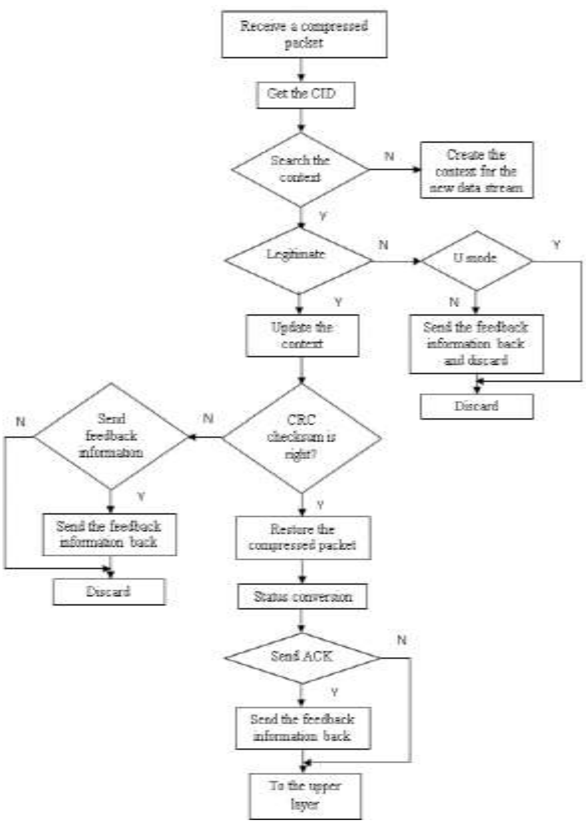
Fig. 5 ROHC Decompression Process [3]

ROHC proposes an improved windowbasedleast significant bit (W-LSB) encoding technique for compression of dynamic headerfields [7].The W-LSB encoding scheme is advantageousin that if several sequential packets arelost, context can be resynchronized immediately.With W-LSB encoding, the least significant kbits of the header field are transmitted. Upon reception of the k LSBs, the decompressor is able to reconstruct the actual value of the header field.

$$LSBs(K) = Ceiling(\log_2(2 * R + 1)$$

R: range$R = MAX(|W - Wmin|, |W - Wmax|)$
W: CID of current packet.
W_{min}: minimumCID of the packet in sliding Window.
Wmax: Maximum CID of the packet in sliding Window.

We summarize the W-LSB encoding in figure 6. In this example compressor send only LSBs bits to decompressor in CID value. When the synchronization is lost, decompressor optimistically evaluate the CID values, the value which is nearest to the previous CID is



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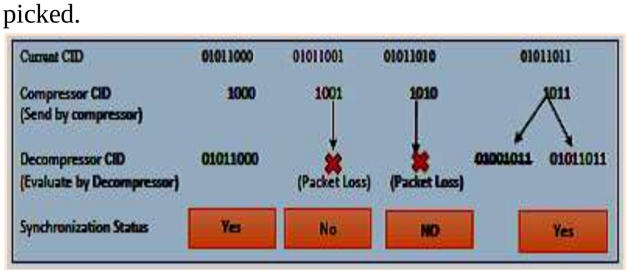


Fig. 6 W-LSB Working

F. Context Synchronization Functioning

In ROHC, compressor and decompressor dealing with initialization and context synchronization on the basis of feedback mechanism and we summarize this in figure 7 which is in ref [7]:

1) The compressor sends an initialization packet that initiates the ROHC mechanism, and associates static and dynamic header fields with a context identifier.
2) The decompressor successfully receives the packet, transitions to FC state, and for responsesend an acknowledgment (ACK). Within the ACK, the decompressor expressesthe intent to operate in O-mode.
3) Upon receiving of the ACK by the compressor, the overarching ROHC operation transitions to O-mode, and the compressor FSM (optimistically) transitions to the SO state. With the next packet, the compressor sends only the established CID as a header and the packet payload.
4) However, the decompressor is unable to successfully decompress the received packet header. The decompressor discards the packet, transitions to the SC state, and consequently sends a negative ACK (NACK).
5) Upon reception of the NACK, the compressor undergoes a downward transition to the FO state. The compressor transmits the next packet, whose header consistsof dynamic header fields along withthe CID.
6) The decompressor successfully decompresses the compressed header, transitions back to the FC state, and replies with an ACK.
7) The compressor receives the ACK, and returns to the SO state. The compressor then transmits the subsequent packet with only a CID as a header and the packet payload.
8) The compressor transmits another packet with only a CID as a header and the packet payload because of the overarchingROHC scheme is in O-mode, the compressordoes not necessarily expectan ACK for each transmitted packet.

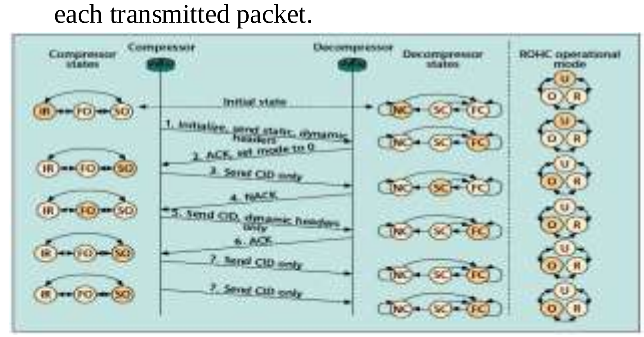


Fig. 7 ROHC Mechanism [7]

V. TESTBED FOR SIMULATION

In this paper, we propose to deploy ROHC in mobile WiMAX. We study how to configure ROHC compression for mobile WiMAX environments. In order to test the performance of ROHC over mobile WiMAX radio link, we implemented the ROHC within WiMAX network layer. The ROHC module runs on both the base station and the mobile WiMAX client device. We had simulations to evaluate the efficiency and robustness of ROHC over mobile WIMAX environments. The simulation is done with Network Simulator. Testbed

Performance Metrics	WiMAX without ROHC	WiMAX with ROHC
Average Throughput	4743.36492	8632.84009
Packet Delivery Fraction	0.999555753	0.999555753
Average End-to-End Delay	0.00191178	0.001663323
Packet Lost(per 1000)	1	1

topology for our simulation is specify in figure 8.

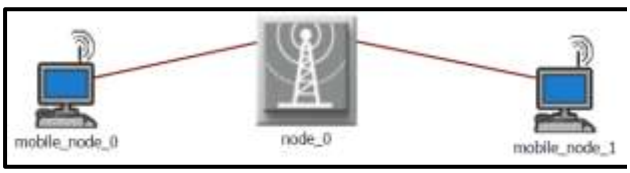


TABLE1 WIMAX TESTBED PARAMETER

Description	Parameter
Routing Protocol	DSDV (With 15s interval)
Antenna	Omnidirectional
Propagation Model	OFDMA
Traffic Model	CBR
Link Capacity	100Mbps
Mobility	Random

Fig. 8 Network Topology

The values of parameters for mobile WiMAXare set according to the definitions specified in IEEE 802.16 standard [2]. Table 1 shows parametersassociated with the network topology.

VI. RESULTS

The results of the simulations are shown in Figs. 9 and 10.We first evaluate the Average Throughput in without and with ROHC. We also evaluate e2e delay with and without ROHC. Figure 9 a shows that Average Throughput performance is better than without header compression. Figure 10 shows that e2e delay is reduces in ROHC.

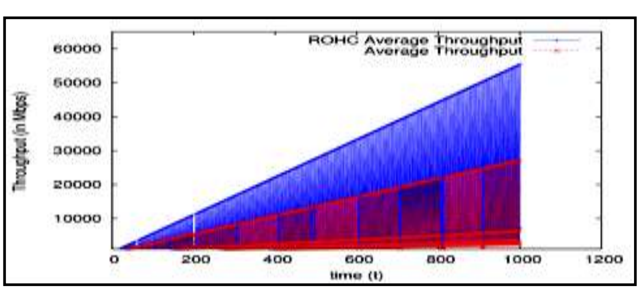


Fig. 9 Comparison of With and Without ROHC in Throughput

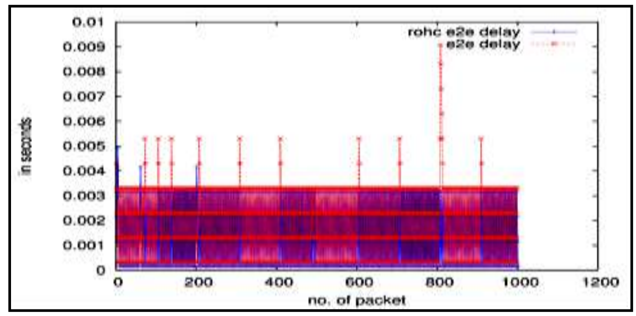
Fig. 10 Comparison of with and Without ROHC in e2e delay

We also compare other parameter metrics like PDF and no. of packet lost. We show all the result in Table 2.

Table 2 Outcomes of the Testbed

VII. CONCLUSION

In this paper, we have analyzed the performance of ROHC over mobileWiMAXusing NS2



simulator.Experiments showed that ROHC is able to provide moreefficient use of radio resource comparedto without header compression.According to analysis of plot and tables for experimental setup we verify that throughput increases by 80% and e2e delay reduces by 14% plot verify the increment in performance of WiMAX network (Fig. 9 & 10) but no changes found in PDF and packet loss. This paper represented a use of ROHC Header compression algorithm and experimental result verify this solution and specify in figure 11.

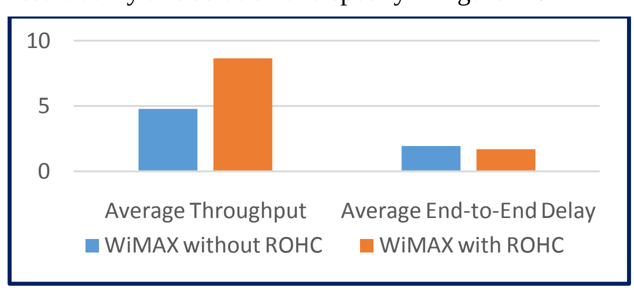


Fig. 11 Performance Comparison

VIII. FUTURE WORK

In the future, it can be expected that header compression techniques based on the ROHC framework will be able to achieve a reasonable compression ratio on different types of wireless network.In present communication network IPV4 and IPV6 both are simultaneously used, tunneling technology providing platform for this working. ROHC header compression algorithm will providing good efficiency in IP tunnels.Apart from the performance metrics like throughput and E2E delay several other parameter can be analyzed practically.

REFERENCES

[1] T. Socolofsky and C. Kal, "A TCP/IP Tutorial", RFC 1180, 1991.
[2] J. Jee,S. Madanapalli,J. Mandin"IP over IEEE 802.16 Problem Statement and Goals"RFC5154,2008.
[3] Chen, Xiuliang, FuliangGuo, Ping Dang, and Libing Wu. "A Survey of ROHC Header Compression Schemes, IEEE Conference, 2012, 331-335.
[4] Raj Shivare, Manish, Yogendra PS Maravi, and Sanjeev Sharma. "Analysis of Header Compression Techniques for Networks: A Review." International Journal of Computer Applications 80 (2013).
[5] Casner, S., and Jacobson, V. 'Compressing IP/UDP/RTP headers for low-speed serial links' RFC2508, February 1999
[6] C. Bormann, Ed., "Robust Header Compression (ROHC),"RFC 3095, June 2001
[7] Ertekin, Emre, and C. A. Christou. "Internet protocol header compression, robust header compression, and their applicability in the global information grid." Communications Magazine, IEEE 42, no. 11 (2004): 106-116.