Performance Comparison of UDP and UDP-Lite for Different Video Codecs

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ABSTRACT
In recent years, usage of Mobile Ad-hoc Networks (MANETs) for communication has grown at a faster rate due to its ease of implementation and flexibility. Also,transmission of multimedia contents over Internet isone of the most widely used technologies being used globally. According to the ongoing trends in technology, most of the contents (data) sent over the Internet are interactive multimedia contents, which prefer to be delivered in error-state than being discarded or arriving late.To avoid network congestion, it is preferred to transmit the data without any overhead of prior connection establishment. A solution to both the problems is to use UDP as transport protocol, which provide no reliability and have low protocol processing overhead. An enhanced version of UDP, called UDP-Lite was also introduced a decade ago, which has been specifically designed for real-time multimedia applications. The aim of this paper is to compare the performances of UDP and UDP-Lite by changing various network parametersfor transmitting various video codecs.

Keywords: MANETs, UDP, UDP-Lite, video codecs, OPNET Modeler.

1. INTRODUCTION
Mobile communications and real-time multimedia applications are the most common and widely used technologies nowadays [15]. Mobile Ad-hoc Networks (MANETs) have become one of the most promising and successful technologies in recent years. The usage of Mobile Ad-hoc Networks without infrastructure is increasing because they provide the facility to connect anytime at any place. MANETsprovide free wireless connectivity to end users, offering an easy and viable access to the network and its services. Another trend is increased use of interactive multimedia applications, like voice and video over the wireless networks [3].

As the technology is improving, so are the demands of end-users increasing. A wide variety of new applications are being invented daily. High bandwidth Internet connectivity has become a basic requirement to the success of almost all of these applications [5]. In past few years, YouTube has accounted for 27% of all video traffic sent and received over the Internet. The emerging technologies of video compression are currently a very exciting and challenging area of research. MPEG-4, H.261, H.263, H.236+, H.264 etc. are the various video codecs used widely over the Internet [4]. Various types of networks are used to send and receive multimedia over the Internet among which MANETs are preferred among others because of ease of installation and decreased headache of physical connections such as wiring. Transportation and on-time delivery of these real-time multimedia applications is of major concern. Most popular transport protocols used for these delay sensitive applications are UDP and UDP-Lite. Both protocols provide unreliable and connectionlessservices; involve less protocol processing and help delivering multimedia applications more efficiently. In UDP, either whole packet is check-summed, i.e. the data sent is also checked for errors or none of it. Whereas, UDP-Lite is an extended version of UDP in which the idea of partial checksum of packets is introduced[11]. In this manner, the corrupted data delivered to the destination is also accepted, making this protocol more favorable to be used in sending and receiving various multimedia applications that require on-time delivery.

In this paper, performance of UDP and UDP-Lite is evaluated and compared for various network parameters and multimedia applications. OPNET Modeler 14.0 has been used to compare the performance of UDP and UDP-lite for various video codecs by altering various network parameters like nodes, traffic, bandwidth and mobility for media access delay, retransmission attempts and network throughput.

The paper has been organized as follows. The literature review is presented in section two. Section three presents the basic overview of UDP and UDP-Lite. Section four includes a detailed explanation of video codecs used. A description of the OPNET Modeler 14.0 is analyzedin fifth section. All assumptions and requirements and simulation results are also presented in this section. Finally, the conclusion is given in section six.

2. LITERATURE REVIEW
Researchers have done a lot of work concerned to the evaluation and comparison of the performance of UDP and UDP-Lite, and various multimedia applications on the basis of bit error rate, audio and video quality, on-time delivery, delays, check-summing etc.

A simple, connectionless, transport layer protocol, UDP was proposed which provided minimum protocol mechanism, no delivery and duplicate protection to the packets once sent, for on-time transmission of specific time-restricted applications over the Internet like various multimedia contents, text, audio, graphics, video etc. [6].A lightweight version of UDP transport protocol was introduced with increased flexibility in the form of partial checksum. [11].

Video-based web traffic continues to grow and dominate the Internet through social networking and catch up TV. In past few years, YouTube has accounted for 27% of all video traffic sent and received over the Internet. The emerging technologies of video compression are currently a very exciting and challenging time for this area of research [4].Lars-Åke Larzon et al. compared and analyzed the performance of UDP andUDP-Lite for an audio coding (24 bytes of data) and a PCM audio (8 kHz sampling frequency) for various transmission methods i.e. UDP, UDP + CRTP, UDP-lite and UDP-lite + CRTP [9]. UDP-lite gave better results as compared to UDP if quality is compromised to some extent.The effects of wireless channel on the quality of the transmitted real-time Ultrasound Video by using UDP and UDP-lite as transport layer protocols respectively were studied, and the efficiency of using both is evaluated on the basis of Bit Error Rate (BER) and Peak Signal to Noise Ratio (PSNR) [3]. Flexible check-summing schemes supporting bit-error resilient codecsfor wireless network architecturewere proposed by Amoolya Singh et al. [1]. They modified the transport layer protocols by implementing UDP-lite and PPP-lite to the transport and link layer protocols respectively. As a result, UDP-lite gave better results and significantly better video quality than UDP.An approach was suggested to the use of MPEG-4 and UDP-Lite for the next generation transport for IP multimedia. The authors concluded that UDP-Lite provides more flexibility by enabling delivery of partially corrupted packets and also could provide better video quality especially over an error prone environment [15].

OPNET (Optimized Network Engineering Tool) provides a comprehensive development environment for the specification, simulation and performance analysis of communication networks. Xinjie Chang has compared several network simulators like;REAL, INSANE, NetSim, OPNET Modeler, NS-2, VINT, U-Net and Harvard simulator are also discussed. A network simulation scenario containing several Ethernet subnets connected by an ATM network backbone has been modeled to compare end-to-end delay and packet loss ratio [18]. OPNET (Optimized Network Engineering Tool) was stated as the most powerful software simulation package.

3. OVERVIEW OF UDP AND UDP-Lite

In this section, a brief discussion about the transport protocols, UDP and UDP-Lite is given. The header formats of both the protocols are discussed in detail.

User Datagram Protocol (UDP)

UDP is a widely used transport layer protocol. It is a connectionless protocol i.e. no prior connection is required for data transmission.Any delivery and duplicate protection of the packets sent are not guaranteed. They mayarrive in-sequence, appear duplicated, or go missing without notice.UDP has protocol identification number(protocol identifier), 17, when used in the Internet Protocol [6].

The UDP Header is of 8 bytes with four fields of 2 bytes each. It is as shown in figure 1.

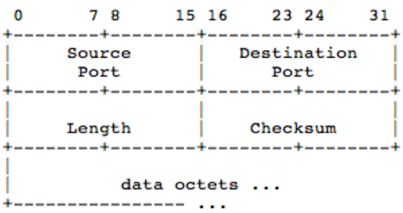

Figure 1: UDP Header Format [6].

The fields in the header format of UDP are as described below [18]:

- **Source Port**: It indicates the port of the sending application process. It is assumed to be the port to which a reply should be sent back in the absence of any other information. It is an optional field.
- **Destination Port:**It is the port of the receiving processof a particular Internet destination address.
- **Length**: It includes the header and the data sent along with (if any). (This means the minimum value of the length is eight.)
- **Checksum:** It is the 16-bit one's complement of the one's complement sum of the pseudo header of information (UDP pseudo header) encapsulated in the IP header.

UDP-Lite

UDP-lite (Lightweight User Datagram Protocol) is also a simple and connectionless transport layer protocol, similar to the User Datagram Protocol. UDP-Lite includes a checksum, which provides an optional partial coverage of the packet to be sent, i.e. a packet is divided into two parts, a sensitive part (covered by the checksum) and an insensitive part (not covered by the checksum). Any error(s) in the insensitive part will not cause the packet to be discarded by the receiver. When the checksum covers the entire packet (header + data), UDP-Lite is semantically identical to UDP [12].

UDP and UDP-Lite areconsidered similar in terms of syntax and semantics. Applications designed for UDP can therefore use UDP-Lite without any compatibility conflicts. UDP-Lite is an easy to implement protocol, since only minor modifications are needed to an existing UDP implementation. [9].

The UDP-lite header format also eight bytes long, containing four fields of two bytes each. It is as shown in the figure 2.

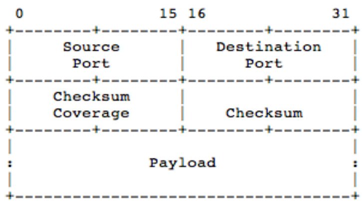

Figure 2: UDP-Lite Header Format [11].

The various fields are as described below [11]:

- **Source Port**: It indicates the port of the sending process. It is and optional field.
- **Destination Port:**It is the port of the receiving processof the particular destination address mentioned in the IP header.
- **Checksum Coverage:** It is the number of octets being covered by the checksum. The UDP-Lite header (8 bytes) must always be covered by the checksum. If Checksum Coverage is zero, it indicates that the entire UDP-Lite packet (header + data) is covered by the checksum. If the value of Checksum Coverage field is 8, only UDP-Lite header is covered by the checksum. The receiving end must discard an UDP-Lite packet with a Checksum Coverage value of 1 to 7.
- **Checksum:**This field is the 16-bit one's complement of the one's complement sum of the pseudo-header of information (UDP-Lite pseudo header) mentioned in the IP header. It indicates the number of octets specified in the Checksum Coverage (starting at the first octet in the UDP-Lite header.

4. VIDEO CODECS

Numerous formats are available in the market for video production. To transmit these video formats over the Internet, video codecs are used. A video codec is a hardware device or software that performs video compression and/or decompression for digital videos. The compression methods usually make use of lossy data compression [15].

Video codecs tend to represent an analog data set in digital format. Compression of the encoding process of the video is usually done to send it over the Internet more efficiently. The decoding process comprises of an inversion of each stage executed in the encoding process. The one stage that cannot be exactly inverted in the decoding process is the quantization stage. A best-effort approximation of inversion is performed to achieve high quality decoded video. This part of the process is often called "inverse-quantization" [12].

The whole process of coding and decoding is shown in figure 3.

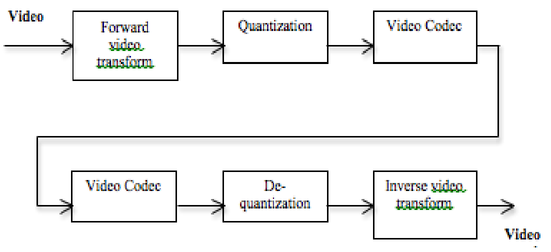

Figure 3: Video Coding and Decoding.

List of video codecs used is as given below [16]:

H.263+: It is the informal name of the second edition of the ITU-T H.263 international video-coding standard. It contains the enhanced H.263 capabilities by adding several annexes for improvement in encoding efficiency and provides capabilities, such as enhanced robustness against data loss in the transmission channel.

H.263: It was developed by the ITU-T Video Coding Experts Group (VCEG) in 1995/1996. Itwas originally designed as a low-bitrate compressed format for videoconferencing. H.263 has since found many applications on the Internet (on sites such as YouTube, Google Video, MySpace, etc.).

H.261: It is an ITU-T video-coding standard, ratified in November 1988. It was the first video codec that was useful in practical terms. It was originally designed for transmission over ISDN lines on which data rates are multiples of 64 kbps.

MPEG-4: Itis a video compression technology developed by MPEG. It is a discrete cosine transform compression standard, similar to previous standards such as MPEG-1 and MPEG-2. Several popular codecs such as, DivX, Xvid and Nero Digital implement this standard.

5. SIMULATION AND RESULTS

To compare the performance of UDP and UDP-Lite by changing various network parameters, OPNET Modeler 14.0 has been used.

The OPNET Modeler is a GUI based modular suite for simulating networks, from physical links up to application demands.

For the base simulation, a data rate of 11 Mbps is chosen. The various MAC and PHY parameter values used are according to IEEE 802.11b default values. The various simulation parameters are given in Table 1.

Table 1: Simulation Parameters and their Value(s)

S. No.	Simulation Parameter	Value
1	Number of nodes	40
2	Simulation time	1 hr.
3	Area covered	4000x4000m
4	Traffic Source	CBR
5	Mobility Model	None
6	Operational mode	802.11g
7	Data rate	11 mbps
8	Command Mix (Get/Total) for ftp	50%
9	Videoconferencing	30 fps
10	Audio	G.711 silence

To compare the performance of UDP and UDP-Lite, six scenarios have been created by changing the number of nodes, bandwidth, traffic and mobility in the base network scenario for MANET.Various scenarios implemented as shown in Table 2.

Table 2: Various Network Scenarios.

S. No.	Scenario No.	No. of nodes	Data Rate	Traffic	Mobility speed
1.	Scenario 1	40	11 mbps	CBR	20 m/s
2.	Scenario 2	20	11 mbps	CBR	20 m/s
3.	Scenario 3	40	2 mbps	CBR	20 m/s
4.	Scenario 4	40	5.5 mbps	CBR	20 m/s
5.	Scenario 5	40	11 mbps	CBR (additional voice traffic)	20 m/s
6.	Scenario 6	40	11 mbps	CBR	40 m/s

The simulations have been run for 1 hour for each scenario and the results obtained from them have been compared for media access delay, retransmission attempts and throughput. Media access delay is the delay calculated for the time interval when the data is successfully transmitted from when it reaches the MAC layer. Retransmission attempts are the number of attempts made until the data successfully reaches to its destination. Throughput is calculated as the rate of successful data delivery on the network. Like, for Scenario 1, 10 simulations of 1 hour each has been done to obtain the result graphs for UDP. The same techniques are repeated for other scenarios and in case of UDP-Lite scenarios also. After that, the results are averaged to evaluate and compare their performance for various scenarios.

Media Access Delay

Access delay is measured as the time from when the data reaches the MAC layer until it is successfully transmitted out on the wireless medium. The reason for studying average access delay is that many real-time applications have a maximum tolerable delay, after which the data will be useless. Therefore, it is important to provide low delay for real-time flows. It is measured in seconds (sec.). The graphs obtained for media access delay for each scenario are described as below.

For all the six scenarios built, the graphs comparing media access delay using UDP and UDP-lite are given. In Figure 4, the media access delay for Scenario 1 (2mbps data rate) is shown. For the first 10 minutes of simulation the media access delay for both protocols increases at equal pace, and then after that, UDP-Lite suffers somewhat lesser access delay than UDP. The increase in the medium access delay for both protocols is due to increase in the number of nodes competing to gain access of medium.

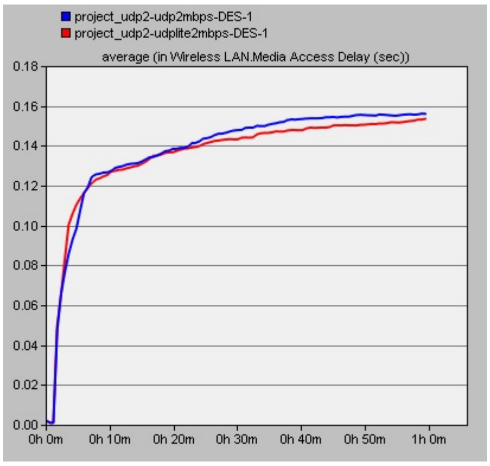

Figure 4 Average Media Access Delay - Scenario 1.

In Figure 5, the media access delay for Scenario 2 (5.5 mbps data rate) for both protocols increases at equal pace throughout the simulation.

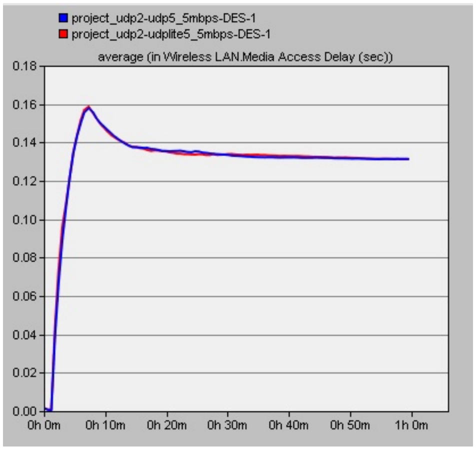

Figure 5 Average Media Access Delay – Scenario 2.

In Figure 6, the media access delay for protocols, UDP and UDP-Lite increases at equal pace for throughout the simulation for Scenario 3 (20 nodes). In comparison with media access delay calculated for Scenario 2, it is almost 0.4 seconds less for this scenario.

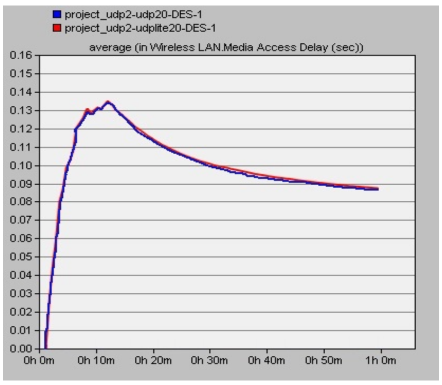

Figure 6 Average Media Access Delay – Scenario 3.

In Figure 7, it is clearly visible that the media access delay curve of UDP is marginally higher than that of UDP-Lite with an average difference of 0.25 seconds.

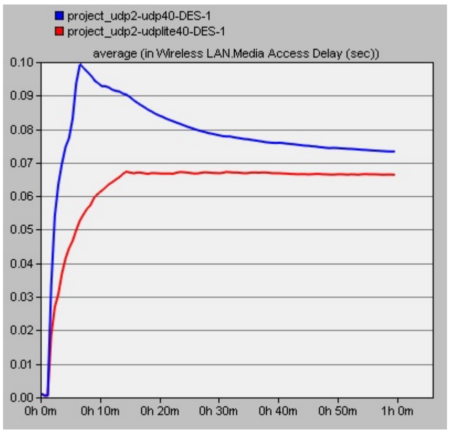

Figure 7 Average Media Access Delay – Scenario 4.

In Figure 8, for the first 7 minutes of simulation the media access delay for both protocols increases at equal pace. After that, UDP suffers somewhat lesser access delay than UDP-Lite.

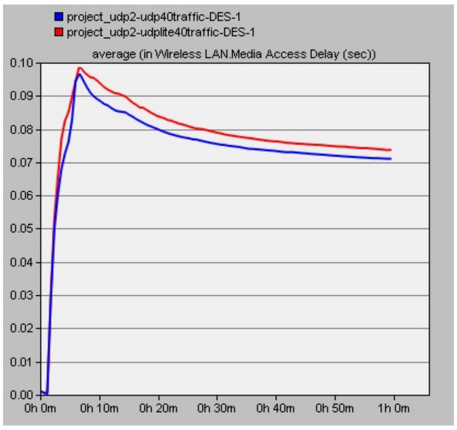

Figure 8 Average Media Access Delay – Scenario 5.

In Figure 9, the media access delay curve of UDP is quite higher than that of UDP- Lite with an average difference of around 0.2 seconds.

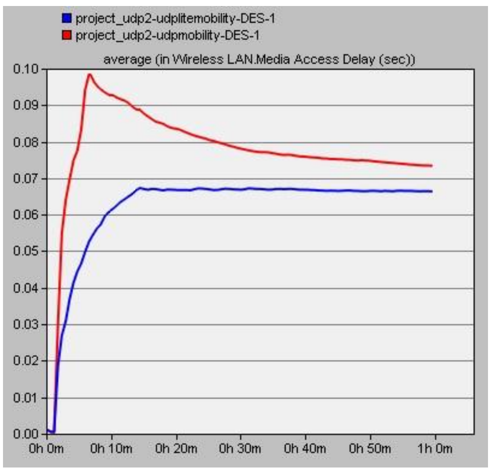

Figure 9 Average Media Access Delay – Scenario 6.

The above comparisons are evaluated and the protocol with better performance is listed in Table 3 for each scenario. For Scenario 1 (2 mbps data rate), Scenario 4 (base scenario) and Scenario 6 (mobility), UDP-Lite performed better. For Scenario 5 (increased traffic), UDP has better performance. For Scenario 2 (5.5 mbps data rate) and Scenario 3 (20 nodes), both protocols have relative same performance.

Table 3 Results –Average Media Access Delay.

Scenario No.	Protocol (With lesser Media Access Delay)
Scenario 1	UDP-Lite
Scenario 2	UDP, UDP-Lite
Scenario 3	UDP, UDP-Lite
Scenario 4	UDP-Lite
Scenario 5	UDP
Scenario 6	UDP-Lite

Retransmission Attempts

Total number of retransmission attempts by all wireless LAN MACs in the network until either packet is successfully transmitted or it is discarded as a result of reaching short or long retry limit. The Retransmission Attempt counts recorded under this statistic also include retry count increments due to internal collisions. This factor plays an important role in the performance of a wireless LAN. Higher retransmission attempts degrade the performance of the network or the entity being evaluated

In Figure 10, in the first 10 minutes of simulation, retransmission attempts for both UDP and UDP-Lite are high, but then after that, it decreases with time and stabilizes for both protocols. There is a quite noticeable difference between curves of retransmission attempts of UDP and UDP-Lite protocol. That difference implies that the overall retransmission attempts made in UDP-Lite protocol are lesser than UDP protocol.

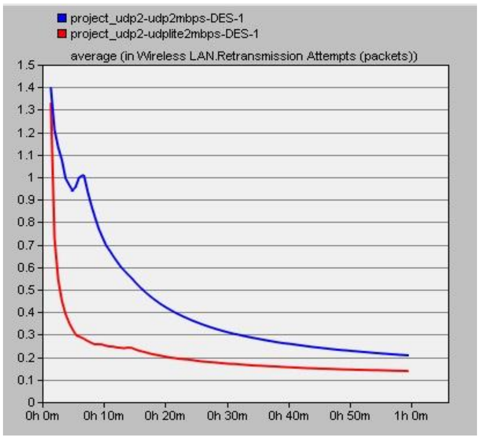

Figure 10 Average Retransmission Attempts – Scenario 1.

In figure 11, the retransmission attempts curve in UDP-Lite protocol is lesser than UDP protocol.

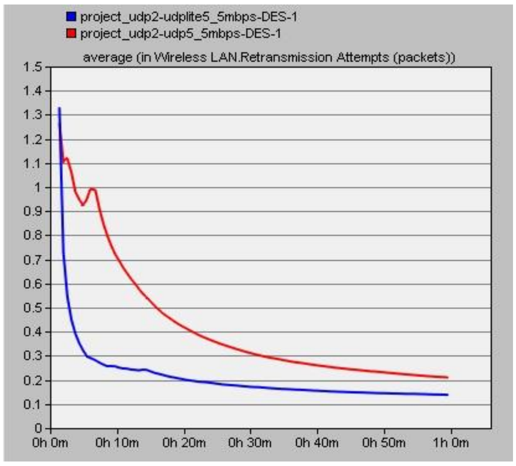

Figure 11 Average Retransmission Attempts - Scenario 2.

In Figure 12, in the first 5 minutes of simulation, retransmission attempts for both UDP and UDP-Lite are high, but then after that, it decreases with time and stabilizes for both protocols with UDP-Lite showing lesser retransmission attempts.

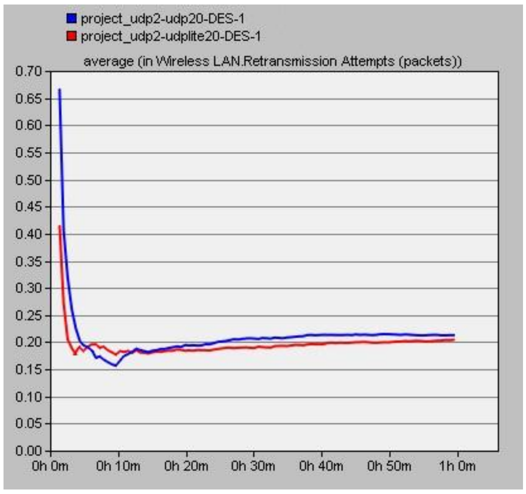

Figure 12 Average Retransmission Attempts – Scenario 3.

In figure 13, the difference between curves of retransmission attempts implies that the overall attempts made in UDP-Lite protocol are lesser than UDP protocol.

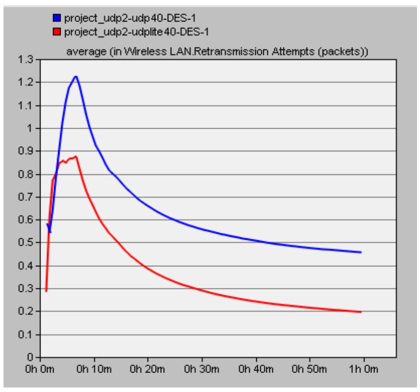

Figure 13 Average Retransmission Attempts – Scenario 4.

In Figure 14, in the first 5 minutes of simulation, the retransmission attempts for UDP-Lite are higher, but decreases afterwards showing a difference of 0.2 seconds.

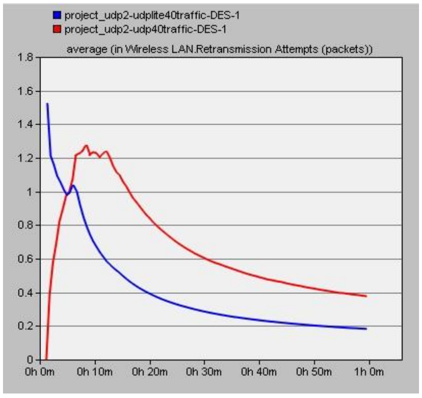

Figure 14 Average Retransmission Attempts – Scenario 5.

In Figure 15, there is a noticeable difference between curves of retransmission attempts of UDP and UDP-Lite protocol. But afterwards, it decreases with time and the retransmission attempts are almost same for both protocols.

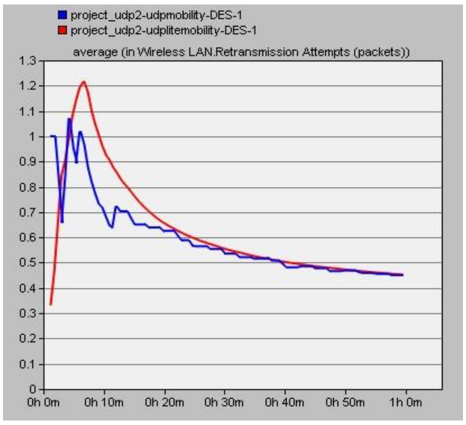

Figure 15 Average Retransmission Attempts – Scenario 6.

The above comparisons are evaluated and the protocol with better performance is listed in Table 4for each scenario. UDP-lite performed better for Scenario 1 (2mbps data rate), Scenario 2 (5.5mbps data rate), Scenario 3 (20 nodes) and Scenario 6 (base scenario). However, UDP performed better in case of, Scenario 5 (increased traffic) and Scenario 6 (mobility).

Table 4 Results – Average Retransmission Attempts.

Scenario No.	Protocol (With lesser Retransmission Attempts)
Scenario 1	UDP-Lite
Scenario 2	UDP-Lite
Scenario 3	UDP-Lite
Scenario 4	UDP-Lite
Scenario 5	UDP
Scenario 6	UDP

Throughput

Throughput or network throughput is the average rate of successful message delivery over a communication channel. It measured in bits per second (bit/s or bps), and sometimes in data packets per second. Throughput is synonymous to digital bandwidth consumption. Wireless bandwidth is a scarce resource, so efficient use of it is vital.

It is observed from Figure 16 that in the first 10 minutes of simulation, throughput of both UDP and UDP-Lite is increasing at fast pace, and then after that, it stabilizes for both protocols. Throughput in first 30 seconds is high due to less retry threshold. The overall throughput of UDP and UDP-Lite is same for this scenario.

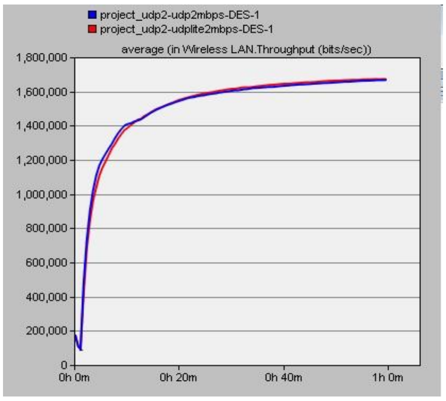

Figure 16 Average Throughputs – Scenario 1.

In Figure 17, the throughput of protocols, UDP and UDP-Lite is increasing continuously throughout the simulation with UDP showing slight better results.

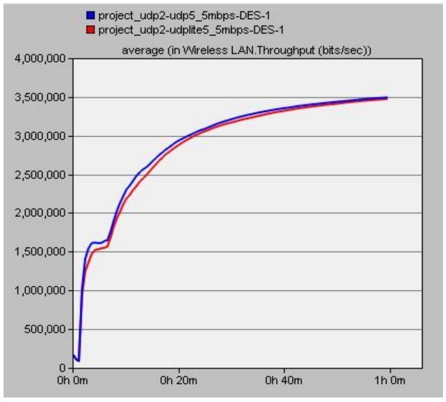

Figure 17 Average Throughputs – Scenario 2.

In Figure 18, from graph analysis, it is clearly visible that throughput curve of UDP-Lite is marginally higher than that of UDP.

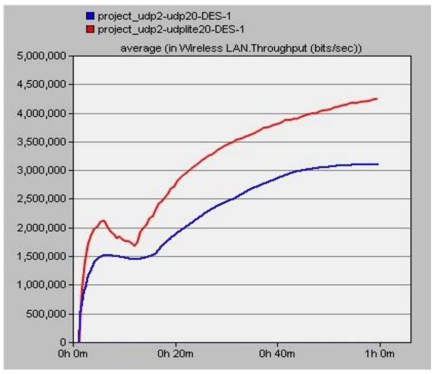

Figure 18 Average Throughputs – Scenario 3.

In Figure 19, the throughput curve of UDP-Lite is visibly higher than that of UDP.

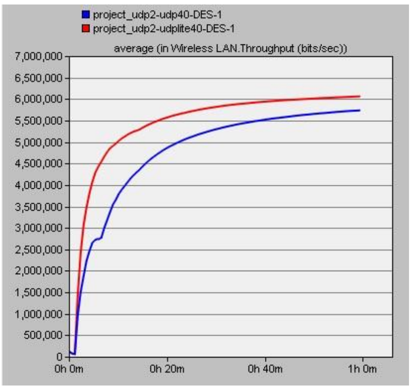

Figure 19 Average Throughputs – Scenario 4.

In Figure 20, the throughput curves for protocols, UDP and UDP-Lite are increasing with same pace throughout the 1 hour simulation.

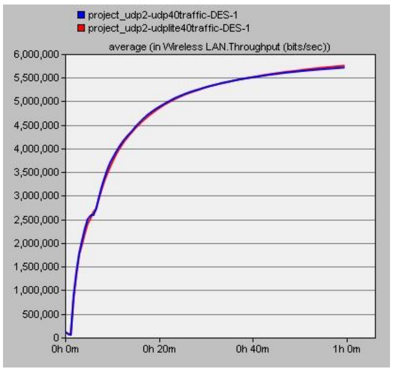

Figure 20 Average Throughputs – Scenario 5.

In Figure 21, the throughput is increasing for both protocols. The throughput curve in case of UDP-Lite is visibly higher than that of UDP, showing UDP-Lite have better throughput than UDP.

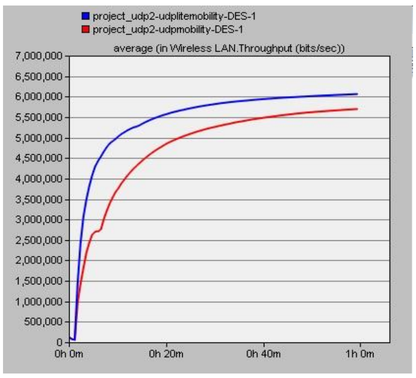

Figure 21 Average Throughputs – Scenario 6.

The protocol with better performance is listed in Table 5 for each scenario. UDP-Lite has better performance in terms of network throughput as compared to UDP. However, Both protocols have almost similar throughput for Scenario 1 (2mbps data rate), Scenario 2 (5.5mbps data rate) and Scenario 5 (increased traffic).

Table 5 Results – Average Throughput.

Scenario No.	Protocol (With lesser Throughput)
Scenario 1	UDP, UDP-Lite
Scenario 2	UDP, UDP-Lite
Scenario 3	UDP-Lite
Scenario 4	UDP-Lite
Scenario 5	UDP, UDP-Lite
Scenario 6	UDP-Lite

6. CONCLUSION

At present, mobile networking and usage of interactive multimedia are the most widely used technologies for communication practiced by users. Among various multimedia content forms, the transportation of video multimedia content is very crucial. Transport protocols UDP and UDP-Lite are known to be well suited for transmitting multimedia over the Internet. Various network simulations have been performed, by changing various network parameters, to analyze and compare the performances of both protocols for various video codecs. It has been found that the overall performance UDP-Lite is marginally well than UDP (under the used simulation conditions in this particular study), in terms of media access delay, retransmission attempts and throughput. By decreasing the physical data rate, number of active users UDP-Lite has performed better for these network performance parameters than UDP. Whereas, by increasing the traffic and mobility speed, UDP showed better performance in terms of retransmission attempts than UDP-Lite.

Future work may be done to analyze and compare the performance of UDP and UDP-Lite for various other network parameters, such as Quality of Service (QOS), Bit Error Rate (BER), Peak Signal to Noise Ratio (PSNR), Terrain Modeling Module (TTM, specified in OPNET Modeler), etc. Also, the protocols, UDP and UDP-Lite may be compared for various latest multimedia technologies being developed and invented.

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