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Performance Analysis of Real and Non-real Time Traffic under MANET Routing Protocols

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***Abstract* - Technologies like Voice, video, ftp, etc. have made Mobile Ad hoc Networks (MANET) important in our Real life. MANET is a distinctive type of ad-hoc network that has stations changing their locations frequently, and automatically configuring themselves. Nodes can move freely in MANET while transmitting and receiving the data traffic by using wireless radio waves. Consequently, routing has become a vital factor and a key challenge for finding the best route in many MANET environments. The main focus of this paper is to analyze the impact of real time traffic (voice, video conference) and non-real time traffic (HTTP, FTP, Email) on the four routing protocols, Optimized Link State Routing (OLSR), Dynamic Source Routing (DSR), Ad-hoc On-demand Distance Vector (AODV), and Geographical Routing Protocol (GRP) over MANETs and also investigate their performance based on the average end-to-end delay and throughput. It is shown with extensive simulation results that OLSR protocol produces the highest throughput and the lowest delay compared to other protocols for non-real time and real time video traffic. It is also shown that OLSR protocol produces the lowest delay and acceptable throughput for real time voice traffic.**

***Keywords* - MANET, Routing Protocols, Real time traffic, Non-real time traffic**

I. INTRODUCTION

A MANET is an independent set of wireless mobile devices that can dynamically form a network connected by wireless links to exchange information without using any pre-existing fixed network infrastructure. The network topology always changes rapidly and unpredictably since the devices are free to move randomly. Such networks can operate independently or can also be connected to larger networks such as internet. There are many applications such as, missions for search and rescue, collecting the data information, virtual conferences and classes using tablets, laptops, or other wireless equipment in wireless communication that make this technology needed to be used [1]. Mobile hosts in a MANET forward the incoming traffic of the neighbor to destination host acting like a router. Therefore there is no need for access point (AP), base station or any physical wired infrastructure. Each wireless node communicates with other wireless nodes within its wireless range. That is the main reason why such a network structure is called as MANET. The leading aim for developing routing protocols for the ad-hoc networks is to conquer MANET’s dynamic nature. Due to the mobility and the joining and leaving processes in a wireless network, the nodes waste high amount of energy [2]. The ad-hoc routing protocols efficiency can be specified by the consumption of the battery power.

Many research studies have been carried out for the performance evaluation of routing protocols regarding different traffic types by the use of network simulators such as Equipment Training (OMNET), Network Simulator (NS-2) and Optimized Network Engineering Tool (OPNET). It is shown in [3] that DSR protocol illustrates the poorest VoIP application performance compared to GRP and OLSR routing protocols. The studies in [4] shows that AODV protocol achieves better performance than OLSR protocol in scalable video communication over MANET. DSR and AODV routing protocols are compared in [5] for real time audio and video data, and simulation studies demonstrate that AODV has slightly better performance than DSR protocol. The main objectives of this study is to get accurate understanding of the existing MANET routing protocols and discuss the performance evaluations with different traffic types under the same environmental conditions. The main contribution of this paper is to use and compare a real time traffic such as video, and voice that has a strict delay requirement, with a non-real time traffic such as Hyper Text Transfer Protocol (HTTP), File Transfer Protocol (FTP), e-mail that has a higher tolerant for some transmission delay in MANET, where such a comparison has not been done before for real and non-real time traffic together. The paper aims to present extensive computer simulation results and discuss different aspects of network design, to find the best behavior for the performance.

The paper is organized as follows. In the next section information about routing protocols is presented. Section 3 discusses the performance parameters and software environment. The simulation results illustrating the performance of routing protocols are given in Section 4. Finally conclusions are presented in the final section.

II. MANET ROUTING PROTOCOLS

Routes in ad-hoc networks are enabled using multi-hop between the nodes, limited by the wireless radio propagation range [6]. When the nodes are busy in traversing packets over MANET, they are not aware of the network topology. Discovery of the network topology is done with the routing protocols, where the broadcast messages are received from the same network neighboring nodes and comply with them. Routing protocols are categorized into two sets, reactive and proactive, depending on the routing information update time. In addition, the third set called hybrid routing protocol is a combination of both reactive and proactive approaches. In real-time applications such as video and voice conference, end-to-end delay is an important factor. It is not only enough for the routing protocol to be reliable but also important to deliver data packets inside an acceptable delay borders. For exceeding the delay limits, the packets received are unusable and it cannot be used in decoding the voice or video frames.

1. Reactive Routing Protocols

Reactive routing protocols are also called on-demand protocols [7], where there is no pre-defined route between the nodes for routing. Whenever a transmission is required, a sender node demands for the route discovery phase to determine a fresh route. The mechanism of route discovery depends on the flooding algorithm acting on the technique that a source/sender node broadcasts just its data packet to all of its neighbor nodes, and intermediate nodes simply forward that data packet to their neighbors. Reactive techniques have higher latency but shorter routing. AODV and DSR routing protocols are discussed more extensively as examples of reactive routing protocols in the following sections.

1.1 Ad-hoc on Demand Distance Vector (AODV)

AODV is an on-demand approach [8] that sets up routes when the sender node needs to transmit data, where a sequence number is used to guarantee the route freshness. When AODV sender wants a route to the destination, it broadcasts a route request (RREQ) packet that includes the node's IP address, broadcast ID and the recent sequence number for the destination node. When the RREQ message is received by the destination node it unicasts a route reply (RREP) packet through the reverse route that sets up by the intermediate nodes in the route discovery process time. In link failure case, a message packet called route error (RERR) is transmitted back to the sender and receiver node. The advantage of using sequence numbers is to find and maintain new valid routes on demand.

1.2 Dynamic Source Routing (DSR)

DSR is another on-demand approach that sets up routes to the destination node when the DSR sender requests a route to send data. DSR protocol uses a strategy of source routing where the sender node defines complete sequence of nodes that all the data will be sent through. The DSR sender node starts a route discovery process and broadcasts the RREQ packet. If the process is positive, the sender receives a reply back with a list of the nodes that the destination can reach. The RREQ packet also includes a record field that accumulates the sequence of nodes that visited through the query propagation in the network.

2. Proactive Routing Protocols

Proactive routing protocols [9] are also called table-driven protocols, where the routes between the nodes are maintained in routing table and the packets of the source/sender node are transferred over the predefined route given in the routing table. During this scheme, the packets forwarding is done quicker, however the routing overhead is larger. As a result, before transferring the packets, all of the routes need to be defined and maintained at all the times. Therefore proactive approach has smaller latency. OLSR and GRP protocols are considered and explained as an example of table-driven protocols.

2.1 Optimized Link State Routing Algorithm (OLSR)

OLSR protocol as a table-driven approach [10] uses three types of mechanisms for routing, a periodical HELLO message that is used for sensing neighbors, a flooding control packet that uses Multi Point Relay (MPR), and a path selection using algorithm of shortest path first. When using two hop neighbors, each network node selects a group of MPRs that have accessible two hop neighbors. After that nodes re-broadcast just the received messages from the nodes that have been selected as an MPR. The advantage of this mechanism is to reduce the broadcast control overhead. Therefore each node contains a part graph of the all network topology. The nodes selected as MPR send messages known as Topology Control (TC) that include the original node address and MPR selector group, to broadcast the nodes presence to the group of MPR selectors. When the routes are available to the sender node, the optimum route is selected using the algorithm of shortest path first.

2.2 Geographic Routing Protocol (GRP)

As a proactive protocol, the source/sender node gathers all network information with the lowest number of control overheads. The source node can find the best route depending on the gathered position information and transmit the data continuously even if the current route is disconnected. This helps to achieve a fast transmission with lowest control massages as overhead. In GRP the network is divided into quadrants to optimize the flooding. When a network node moves and crosses a quadrant then it updates its flooding position. Other network nodes identify their positions by exchanging the HELLO packets.

III. Performance Parameters and Software Environment

The study of this paper is conducted by using OPNET discrete event simulator with the parameters set as in Table 1. A network is modeled with a size of 1,000×1,000 m^2 that contains 60 nodes where one node is specified as server. The nodes are assumed to move with a speed of 5 m/s. the simulations are repeated ten times for each scenario in all categories for the routing protocols performance, with different constant seeds of the pseudo random number generator (PRNG). The connections between the nodes are established by the use of AODV, DSR, OLSR, and GRP routing protocols for real and non-real time traffic such as HTTP, FTP, e-mail, voice and video conference.

Table 1: Simulation Parameters

Parameter	Value
Simulation time	600 seconds
Routing protocols	AODV, DSR, OLSR and GRP
Topology size	1,000 m × 1,000 m
Number of mobile nodes	60
Start and pause time	0, 50 sec.
Speed	5 m/s
Traffic type	HTTP, FTP, e-mail, video and voice
Packet size	512 bytes
Address mode	IPv4
Data rate	5.5 Mbps
Mobility model	Random way point
Physical characteristics	Extended rate PHY 802.11g
Fragmentation threshold	None
Buffer Size	256000 bits

The traffic load in the network can be described as the follows:

A. Non-Real Time Traffic

HTTP, FTP and e-mail are examples of non-real time data traffic. HTTP is used with web browsers and servers for providing secure communication. FTP is commonly used for transferring internet pages from server to another server or downloading many files from the server to the user computer. In the simulations, light HTTP traffic load is used with a page size of 500 bytes and 5 small size images, light FTP traffic load is used with a file size of 1,000 bytes and light e-mail traffic is used with a size of 500 bytes.

B. Real Time Traffic

Video conferencing and voice is real time data traffic that has small tolerant to delay. It is a telecommunication technology that combines video, audio or together between two or more nodes. In the simulations, the voice scheme is used as land phone conversation with a size of 1 voice frame per packet, while the size of video frame is 352 × 240 pixels with 30 frames/s.

3. Performance Metrics

These parameters present the effectiveness of MANET protocols in finding the best route to the destination, such as the average throughput and the end-to-end delay where they can be described as follows:

End-to-end delay - The time (in seconds) required as the source/sender node to generate and transmit a data packet across the network, until it is received by the destination node. It is also known as latency. Real time traffic such as video or voice applications is sensitive to the data packet delays, and needs delay as low as possible. However, the FTP and HTTP traffic is tolerant to a specific level of delay.

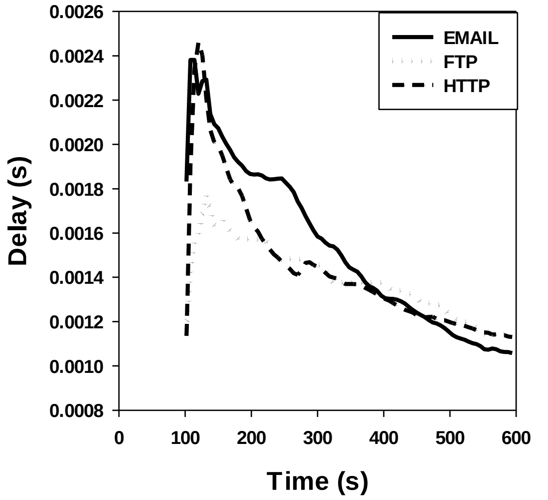
Throughput - The amount of the data packets (in seconds) that are transmitted over a communication channel to the final destination node successfully. In every network it is desirable to have a high throughput. In this paper throughput is defined as in equation (1):

$$\text{Throughput} = \frac{No.of\ DF\ x\ PS\ x\ 8\ bit}{TDS} \ \ldots (1)$$

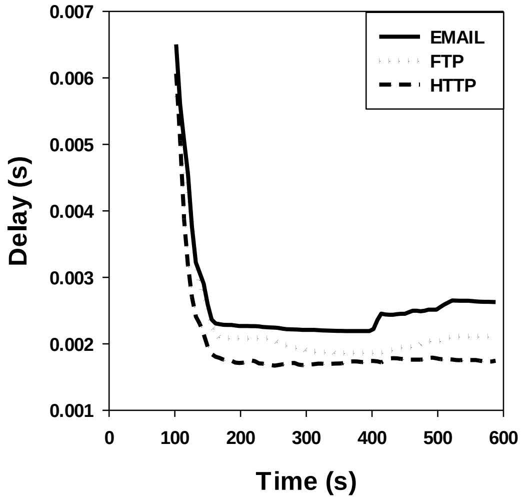
Where, the no. of DS is the number of successfully delivered packets, PS is the packet size transferred from the source to the destination, and TDS is the total duration time for the simulation. In (1) the number of delivered packets does not only include the HTTP or FTP data but also routing protocol's Hello, control packets and topology information.

IV. Simulation Results and Analysis

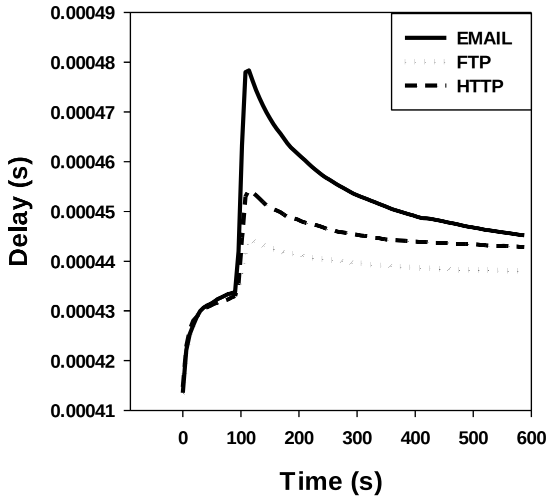
The most significant routing protocol metrics are the delay and throughput of the network. In this paper the performances of DSR, AODV, OLSR and GRP routing protocols are investigated in terms of these metrics. The results in Figure 1 and 2 show the end-to-end average delay of the network for non-real and real time traffic respectively. The results in Figure 1 present that the OLSR and GRP protocols end with lower end-to-end average delay, because they set up quick connections between network nodes without creating major delays, therefore they do not need much time in a route discovery mechanism, because the routes are available in advance, resulting lesser end-to-end packet delay when the data information packet exchange is needed. While the DSR protocol maintains the highest delay on average, due to the source routing mechanism that is follow, where the information of the complete route is included in the header of the data packet, causing an increase in the length of the data packet, and resulting also an increase in the delay experienced by the network data packets.



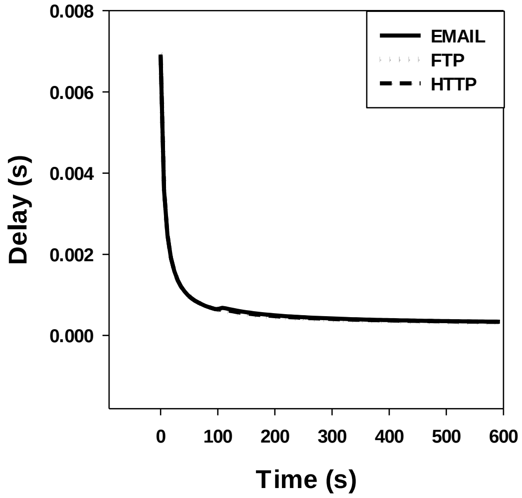
(a) AODV



(b) DSR



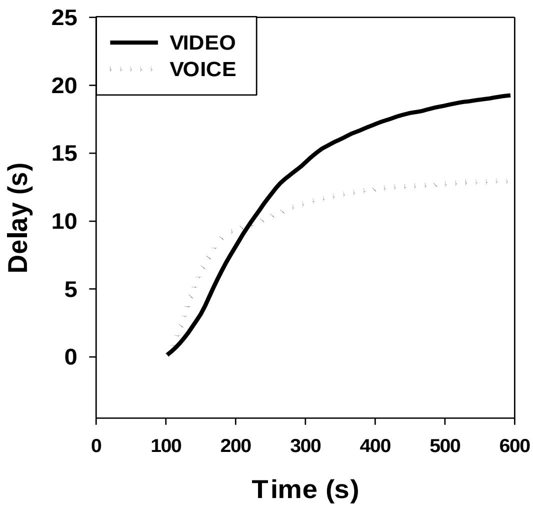
(c) OLSR



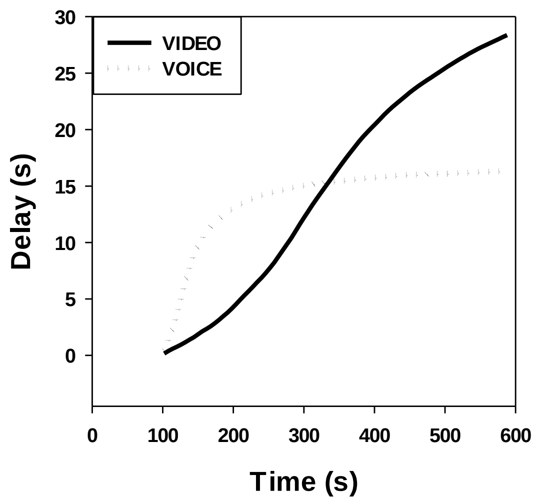
(d) GRP

Figure 1: Average delay of (a) AODV, (b) DSR, (c) OLSR and (d) GRP protocols for non-real time traffic

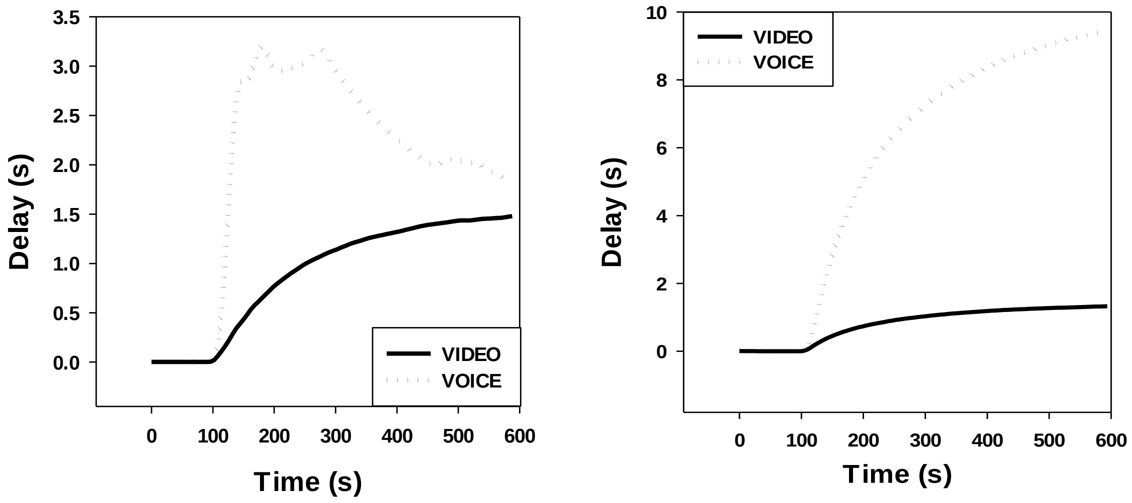
The real time traffic delays shown in Figure 2 are higher, where the DSR and AODV protocols have higher delays, because there is no appropriate flow control mechanism for such data. Each network node transmits real time data packets without knowing the acknowledgment of the buffer for the receiving node. Therefore the packets in the queue of the buffer wait for a long time [11].



(a) AODV



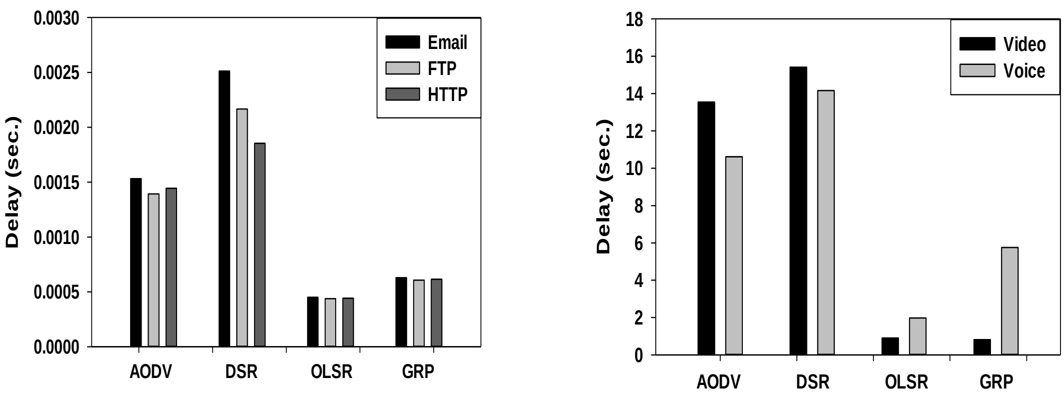
(b) DSR



(c) OLSR (d) GRP

Figure 2: Average delay of (a) AODV, (b) DSR, (c) OLSR and (d) GRP protocols for real time traffic

By analyzing the end-to-end average packet delay with respect to different traffic types as in Figure 3, it is shown that the OLSR and GRP as proactive protocols set up quick connections between network nodes without creating major delays for both real and non-real time traffic. This is because that the OLSR and GRP protocols do not need much time in a route discovery mechanism. The routes are always available in advance at the routing tables resulting lesser end-to-end packet delays. Mainly this advantage in OLSR is due to the utilization of the MPR nodes, to permit the control messages to be forwarded to other nodes, while in GRP the information is gathered rapidly at a source node without spending a large amount of overheads. The source node still has to wait until a route to the destination node can be discovered increasing the response time, but it depends on the closest node to the destination. Eventually this helps to minimize the overhead and maximize the throughput of the network for non-real time traffic as shown later in Figure 4. On the other hand, both AODV and DSR protocols cannot set up the node connection quickly and create larger delays in the network. Due to the reactive approach nature of the AODV and DSR protocol, it is highly possible that the data packets wait in the buffers, till it discovers a route on its way to the destination node. In time a RREQ packet is transmitted for the purpose of route discovery, the destination node replies back to all nodes for the same route request packet that it receives, thus, they need larger time to determine the lowest congested route. The DSR protocol follows a source routing mechanism where the information of the complete route is included in the header of the data packet, causing an increase in the length of the data packet, and resulting also an increase in the delay experienced by the network data packets. For the real-time traffic due to the larger size of video and voice packets, it needs more time to be transmitted through the route comparing to the non-real time traffic. The video traffic delay increases steadily with increasing congestion in the network since nodes are only allowed to transmit when the available bandwidth is enough [12]. Audio latency is more intolerable than video latency because it causes choppiness and breakup in the audio playback at the receiver end [5]. Therefore audio stream is given higher priority than video stream [13]. And so the end-to-end delay for voice traffic curves down during the simulation. As network congestion increases, the video delay increases, contrarily to voice traffic. This is due to the fact that video streams require a much larger bandwidth share, resulting more time needed to stream. On the other hand, the non-real time traffic has lower delay and it is relatively tolerable to its delay time.



(a) Non-real time traffic (b) Real time traffic

Figure 3: Average delay of AODV, DSR, OLSR and GRP protocols for (a) non-real time traffic and (b) real time traffic

The average throughput of the routing protocols is analyzed as the second metric. The Figures 4 and 5 show the average throughput of the AODV, DSR, OLSR and GRP protocols for non-real and real time traffic respectively. For the non-real time traffic shown in Figure 4, it is obvious that the OLSR protocol overtakes other three routing protocols by achieving the highest throughput. The higher performance achieved by the OLSR protocol is due to the proactive characteristics of this protocol. It constantly sets up, maintains and updates the routing information with the assist of MPR in the network, which leads to the reduction of routing overhead [14]. In order to maintain good network performance, congestion control mechanism must be provided to prevent the network from being congested for any significant period of time.

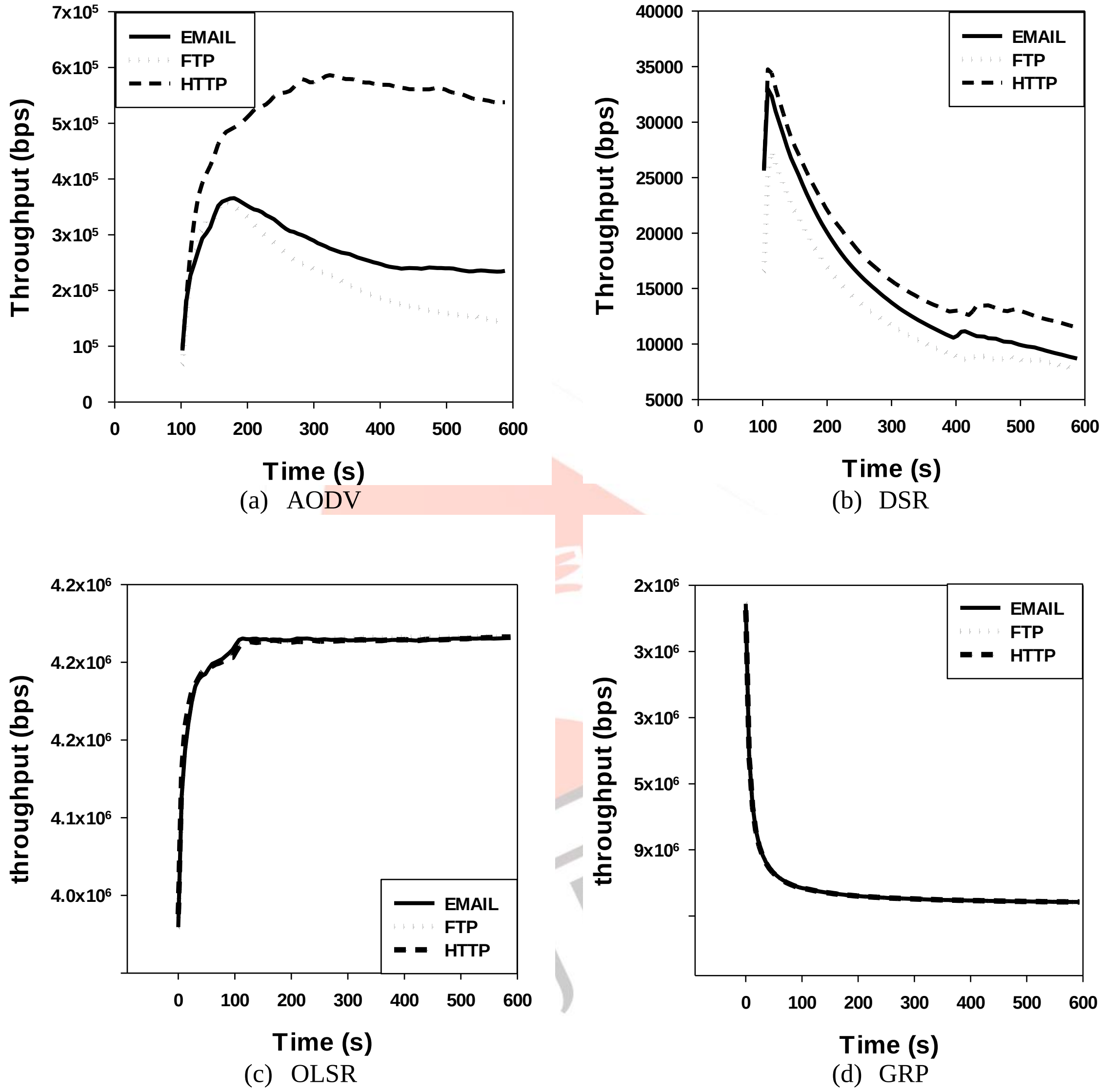


Figure 4: Average throughput of (a) AODV, (b) DSR, (c) OLSR and (d) GRP protocols for non-real time traffic

In figure 5 For real time traffic transmission such as video and voice, the throughput rate is not controlled by congestion mechanism and the size of the packet are much larger; therefore the throughput is higher than non-real time traffic applications [11]. Also GRP protocol graph lines start before the warm up period finishes since it need to transmit the control messages in the network for making the routes available before the data transmission starts during the warm up period.

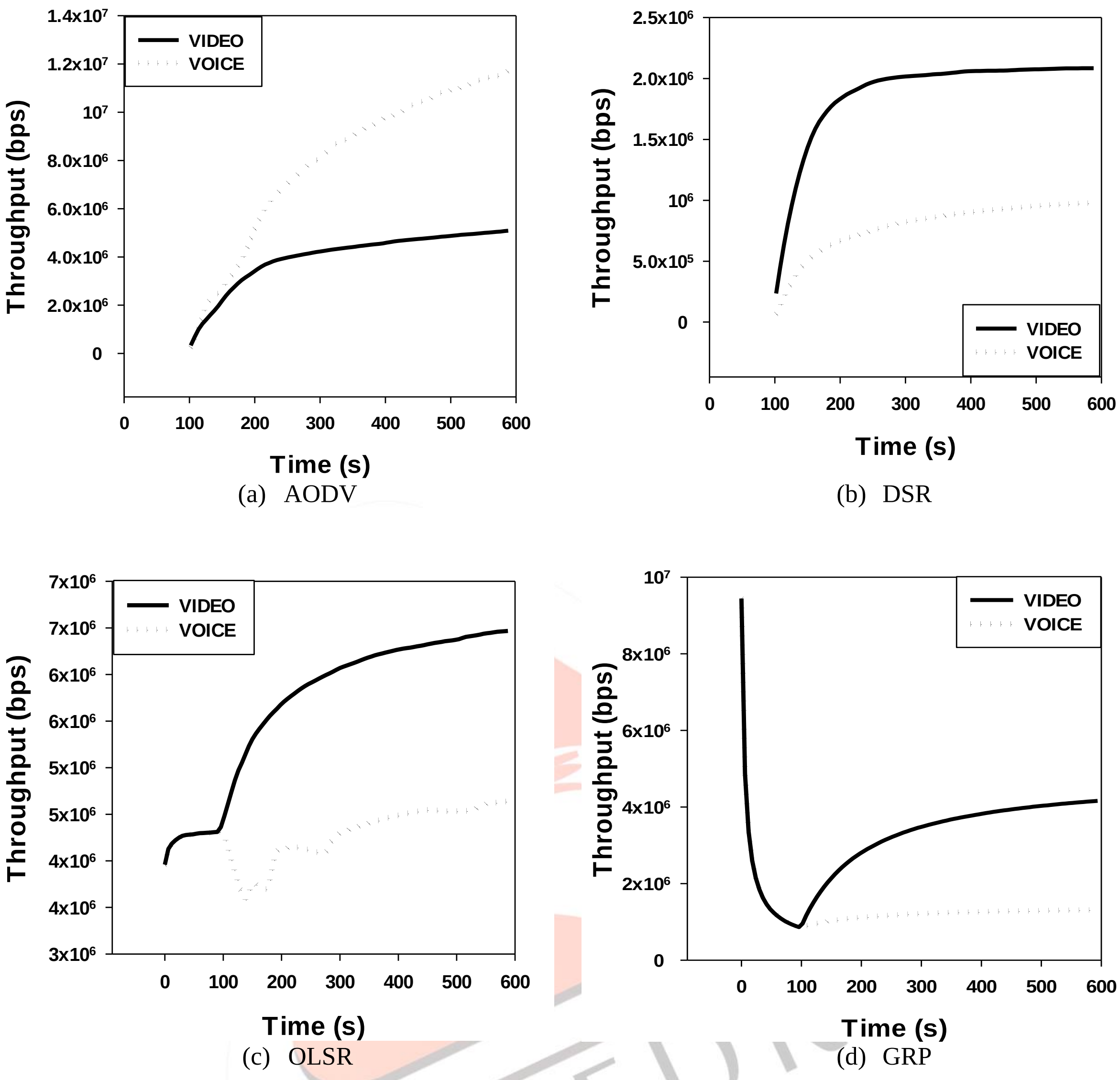
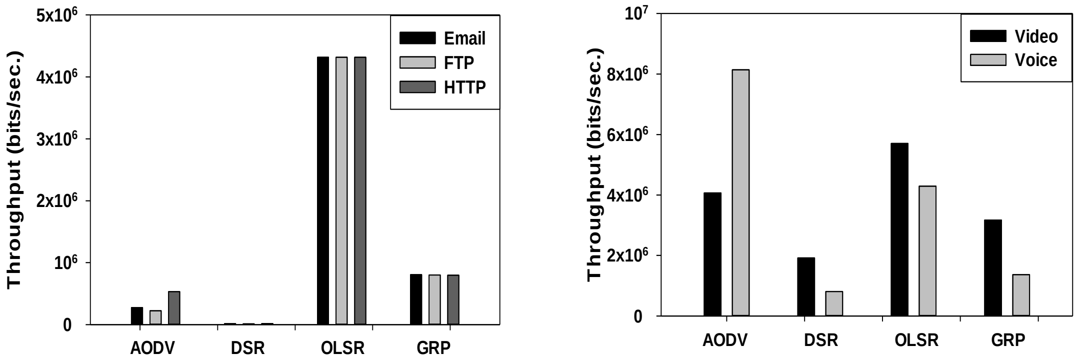


Figure 5: Average throughput of (a) AODV, (b) DSR, (c) OLSR and (d) GRP protocols for real time traffic

However, it can be noticed from Figure 6 that the AODV outperforms the OLSR, GRP and the DSR protocols for real time voice traffic. The amount of transmitted HELLO messages becomes larger, due to a neighbor lists included in the messages for the OLSR protocol. Therefore when increasing the HELLO interval, packets with large sample size (as video and voice) achieve good delay. This can be explained by lower control overhead releases the bandwidth which is requested by real time traffic application [15]. Likewise, the GRP and AODV protocols are also desirable when the network aims for achieving higher throughputs, despite of the different traffic types in the network. The GRP protocol gathering the information rapidly at a source node without spending a large amount of overheads, also AODV protocol follows a routing mechanism known as hop by hop and removes the overhead of the sender/source routing within the network [7]. Related to above, the availability of multiple route information in the AODV assists in producing the higher amount of throughput in the network. DSR protocol follows a source routing mechanism and the byte overhead in each packet extremely affects the total byte overhead when the network traffic increases. Resulting, the DSR protocol tends to achieve lower amount of data packets in more stressful network.



(a) Non-real time traffic (b) Real time traffic

Figure 6: Average throughput of AODV, DSR, OLSR and GRP protocols for (a) non-real time traffic and (b) real time traffic

V. CONCLUSIONS

In this paper, the performances of four routing protocols, namely AODV, DSR, OLSR and GRP are analyzed and compared for non-real time traffic (HTTP, FTP, e-mail) and real time traffic (video, voice) in terms of end-to-end average delay and throughput. The lowest end-to-end average packet delay performance is achieved by the use of OLSR protocol for both real and non-real time traffics. On the other hand the highest throughput is achieved by the use of OLSR protocol for the non-real time and real time video traffic and AODV protocol for the real time voice traffic. Although AODV protocol gives the highest throughput for real time voice traffic, the delay produced by AODV is above the acceptable level for a real time data transmission. DSR protocol shows an extremely low average throughput as a means of dropping more data packets, and high end-to-end average packet delay for all traffic types. In summary, the proactive protocol OLSR is verified to be very efficient and effective routing protocol for MANETs for real and non-real time data.

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