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Performance Analysis of AODV, OLSR and GRP using G.729.1 Encoded Traffic

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Abstract— MANETs self network configuring property, dynamic topology and mobility of speeds make it necessary to research on the performance of routing protocols. Since mobility is involved, other workload and system factors also come in light that are the key attributes in exhibiting the variations in the routing protocols performance. This work depicts the performance of AODV, OLSR and GRP by studying the effect of node density and mobility speed using simulator OPNET Modeller 14.5. It was observed that GRP is the worst performer with the elapse of time. In case of AODV and OLSR, AODV performs well in small scale networks and OLSR works well with high density networks.

Keywords— AODV, OLSR, GRP, VoIP, G.729.1, MANETs

I. INTRODUCTION

MANET stands for Mobile Ad Hoc Networks that are capable of building a network on demand. On demand means that a network can be formed without the help of any centralized administration and base infrastructure like in emergency and defence purposes. The nodes participating in MANET can be static or mobile. Such wireless networks are in great demand because of reduced wire connections. The performance of MANETs depends on the routing protocol being used. The routing protocols in MANET decide their path from source to destination, depending on the position and topology. After years of research, MANET protocols do not have a complete formed Internet standard. There is only been an identification of experimental Request For Comments (RFCs) since 2003 [1]. At this stage, there is an indication that questions are unanswered concerning either implementation or deployment of the protocols but the proposed algorithms are identified as a trial technology and there is a high chance that they will develop into a standard [1]. The performance of a network depends on the routing protocol as well as the application traffic that flows from node to node. Different applications have different data attributes that affect the network performance quality parameters. In this work, voice services were used in the MANET to evaluate the performance of AODV, OLSR and GRP. The voice traffic was encoded with G.729.1 codec. The number of nodes and mobility speeds were varied to evaluate the effect on the performance of the routing protocols. The performance parameters jitter, delay and throughput were analysed. The rest of the paper is ordered as: Section II presents all the literature work referred. Section III holds the brief description about the routing protocols that are considered in this work. Section IV contains an introduction about VoIP, the codec considered and the effect of codec on the voice quality transmission. The simulation design and results are incorporated in Section V and section VI. The work and future scope is concluded in section VII.

II. RELATED WORK

Various literature work are reviewed and to best of the knowledge the work presented in this paper is not proposed by any other work. In [2], the performance of AODV and OLSR was investigated. QoS indicators were analyzed and evaluated. In addition, the performances of codecs were also shown. G.711, G.729, G.723.1 and GSM were the respective codecs. QoS metrics such as bandwidth, packet loss and delay were considered to carry out the final results. It was observed that G.711 is a bandwidth efficient codec. The delay increases with increase in hops number and produced OLSR with less delay while AODV being reactive produces high delay. The delay performance and packet loss rate comes out good with GSM.

In [3], TORA, OLSR, AODV, DSR and GRP were analyzed with respect to codecs G.711 and GSM-EFR. The performance metrics chosen for the comparison were jitter, delay, throughput and Mean Opinion Score (MOS). The simulation was carried out for small as well as for large scale scenarios. TORA gave good MOS value, least jitter value and voice quality in comparison to other protocols for small scale network. DSR was observed to give the worst performance. It was depicted that with increased transmission time, throughput also increases. It was concluded that TORA is one of the efficient and acceptable routing protocol for G.711 codec for small scale networks. The performance of DSR is worst.

In "Performance Evaluation of Mobility Speed over MANET Routing Protocols" [4], AODV, DSR and DSDV were compared over different mobility speeds and number of nodes. AODV and DSR gave huge routing overhead. The packet delivery ratio was good when the node movement was small. Lesser the speed, more was the packet delivery. Same result was with the delay. When the speed increased, AODV, DSR and DSDV had high delay.

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In [5], the major factors were recognized that affect the quality of the voice during the communication. Various dependencies between voice, network size, frame size, network load and voice codec were carried out through simulations. It showed that voice quality degrades with increasing network size. Increased network size leads to high packet loss rate. To increase voice quality, frame size and codec type can be changed for large scale networks. An increase in frame size leads to lesser overheads and packet loss rate. The comparison of G.711 and G.729 over H.323 and SIP was presented in [6]. It was observed that under SIP both codecs has given high delay comparative to G.729. Packet loss rate was high for the combination of SIP and G.711. The MOS values were equal for G.711/H.323 and G.711/SIP, almost can be compared with G.729/H.323. Thus, H.323 and G.729 was evaluated as better as compare to G.711/SIP.

III. ROUTING PROTOCOLS IN MANET

Routing protocols in MANET assure the routes to the destination node, forward the packet to the neighbour node and maintain those discovered routes. In MANET, the nodes movement is not predictable, so the routing protocol has to deal with dynamic topology, delivering the data efficiently retaining all the MANET desired features such as loop-free paths, distributive operations, overheads of control messages etc. 3 routing protocols AODV, OLSR and GRP are considered for simulation.

A. AODV

AODV is loop-free and one of the reactive routing protocol that maintains route only for active sessions and rest of the nodes are discarded. It can cover up to 10 to 1000 mobile nodes [7]. Both uni-casting and multi-casting are done by the protocol. The most prominent feature of AODV protocol is the use of sequence numbers. The sequence number act as a routing timestamp and guarantee the freshness of the route. It provides the latest path and avoids "count to infinity" problem. If a node receives a packet that contains the sequence number greater than that, then it updates its routing table with that sequence number of greater value. AODV has borrowed its features from DSR and DSDV. It inherits the process of discovering and maintaining routes from DSR and keeping a check on the neighbouring nodes with HELLO messages from DSDV. The route discovery and maintenance is usually done by control messages RREQ, RREP and RRER.

The Route Request Messages are issued by a source node that desires to communication with another destination node. The network is flooded with RREQ messages initially. An intermediate node that receives RREQ packet, checks the destination as well as source address and then forward the RREQ message accordingly with an increase in hop count by 1. The RREQ message is rejected if the node has already received the RREQ with same values earlier. The Route Reply Messages are sent by the node that has a route to destination. As the RREPs are propagated towards the source, each node updates the route in its table and thus a route is created. If the source node receives more than one RREP, it then chooses the path with the minimal hop count i.e. the shortest path. The Route Error Messages are generated if a node founds the connectivity between its adjacent node is lost or broken. The link is identified as failed, if there is no hearing of a HELLO message for more than ALLOWED HELLO LOSS * HELLO INTERVAL (in milliseconds) [8]

B. OLSR

OLSR is a proactive protocol and an optimized version to classical link state algorithm. The prominent feature in working of OLSR is Multipoint Relays (MPRs). MPRs are the selected set of nodes that forward the packets, generate link state information and cut down the message overhead by moderating the number of re-transmissions. OLSR is well suited for optimizing the dense networks. The sequence number in OLSR messages ensures the sequence of arrival of messages at destination. The topology of a network is discovered though packet forwarding and neighbour sensing mechanisms. These mechanisms relies on TC (Topology Control), MID (Multiple Interface Declaration) and HNA (Host and Network Association) messages [9]. The neighbour node detection and MPR nodes set selection is ensured by HELLO messages. Topology Control messages periodically broadcasts the messages for updating the MPR set if the topology changes. If a node has an empty MPR set, then no TC messages are generated. When MPR set is available and information about topology is detected, then the routes can be calculated. Routing tables do not write up the entries for the destinations with which the links are broken. HNA messages perform the task of associated host or network declaration [9].

C. GRP

GRP is a proactive protocol and periodically updates the topology information in the routing tables by exchanging hello messages. If a node does not receive any HELLO message with in specified "Neighbour Expiry Time", then the link is considered to be either lost or broken. The nodes in the network determine their own position as well as its immediate neighbours using GPS (Global Positioning System). The positions of other nodes are determined through flooding. Basically, it is a position based routing, and thus it does not require maintenance of routes. GRP thus scale the network at best.

The entire network is divided into quadrants. The entire world is divided into quadrants from Lat, Long (-90, -180) to Lat, Long (+90, +180) [3]. The exact location of the node is sensed through flooding messages. If a node A receives the messages from node B in some different quadrant then only the location of that node will be updated instead of the exact location.

The best route to the destination is chosen on the basis of shortest path. Although, the network is flooded with the messages, but only that path is considered that is closest to the destination. Sometimes flooding leads to the blocked routes, at that time backtracking mechanism is used to chose a new hop selection. The destination address is included into the header of the packet.

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IV. VOIP AND EFFECT OF CODECS

In VoIP, the analog voice is digitized and then sent to the destination in the form of packets. From years, VoIP is being preferred over traditional telephony system i.e. PSTN. Each packet in VoIP includes the following headers as shown in the Figure 1 [2].

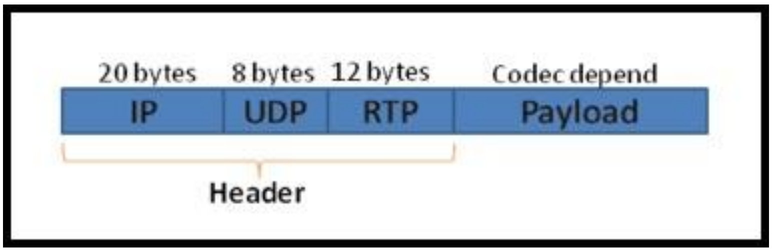

Fig. 1 VoIP Packet Header

An audio codec is responsible for encoding the voice signal and compressing to a rate that is efficient for transmission. Codecs are involved in compressing when real time data is involved in packets. There are different types of codecs that differentiate each other on the basis of their sampling rate, coding algorithm, bit rate, frame size and their capability of providing QoS to an application usage. An acceptable voice quality should have random packet loss less than 10% and packet delay less than 400ms [10]. Also, the packet size depends on the type of codec used. Higher the payload, more clarity is in voice but at the same time delay and jitter are the factors that must be considered. Moreover, if delay occurs, the quality of speech is not bothered but the quality of conversation may get affected. The delay in partner's response could be noticed if any of the delay occurs in the network. On the contrary, jitter buffers are always present at the receiver's side to correct the arrival time of the voice packets. In this work, G.729.1 was used to encode the voice data. G.729.1 is interoperable with G.729. It has the variable bit-rate varying from 8-32kbps and a frame size of 20ms. There is a significant difference between the delay that is produced at 8kbps and 32kbps. The simulations showed that increase bit-rate shows less delay.

V. SIMULATION

The simulation design carried out in the study consist of mobile nodes in the network size of 1000*1000 meters. The performance parameters on which the routing protocols AODV, OLSR and GRP were to be analysed are jitter, throughput and delay. The simulation tool used to design the model and carry the results is OPNET Modeller 14.5. The simulation environment is shown in the Figure 2.

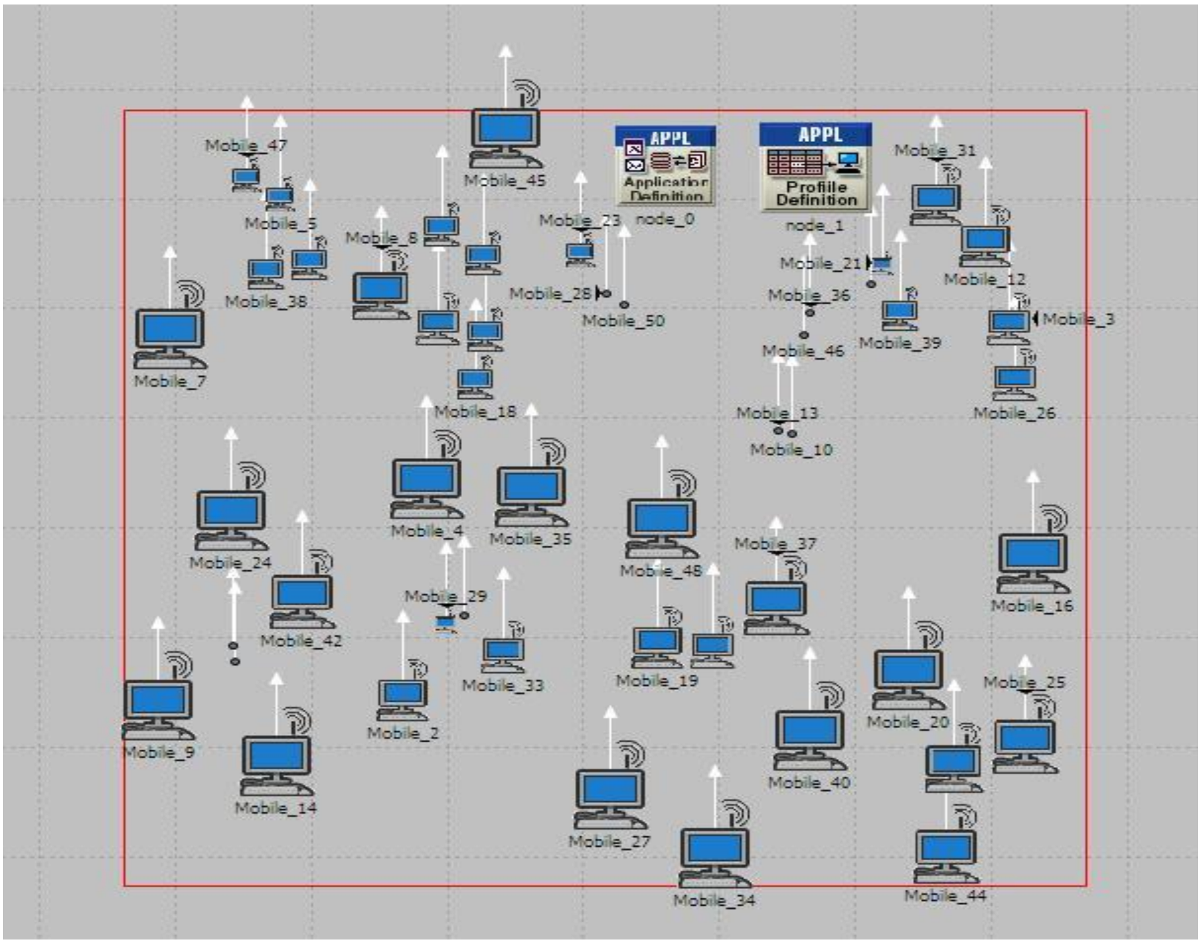

Fig. 2 Simulation Environment

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The simulation parameters are listed in the Table I.

TABLE I: SIMULATION PARAMETERS

Parameters	**Values**
Number of Nodes	50, 75 and 100
Network Size	1000 x 1000 meters
Trajectory Information	Random waypoint model with mobility speed is 5m/s and 15m/s
Type of Service	Voice
Codec Type	CS-ACELP (G729.1)
Routing Protocols	AODV, OLSR and GRP
Node Model	Manet_wkstn
Altitude	0.00 meters
Area of Movement	Within the network
Traffic Source	Discrete
Data Rate	11Mbps
Node Transmission Power	0.005 (default)
Performance Parameters	Throughput, Packet end to end delay and Jitter
Simulation Time	200 seconds

To evaluate the performances of routing protocols AODV, GRP and OLSR, six scenarios have been created by changing the node density and mobility speeds for the respective protocols. System workload parameters like VoIP packet size and number of frames per packet are same for all scenarios. The scenarios are as follows-

Scenario 1 - A base scenario with 50 nodes in the network moving at speed of 5m/s.
Scenario 2 - A base scenario with 75 nodes in the network moving at speed of 5m/s.
Scenario 3 - A base scenario with 100 nodes in the network moving at speed of 5m/s.
Scenario 4 - A base scenario with 50 nodes in the network moving at speed of 15m/s.
Scenario 5 - A base scenario with 75 nodes in the network moving at speed of 15m/s.
Scenario 6 - A base scenario with 100 nodes in the network moving at speed of 15m/s.

The simulations were carried out for all three protocols GRP, AODV and OLSR for 200 seconds. Thus in total 18 simulations were carried out.

VI. RESULTS AND DISCUSSIONS

In this section, the average values of the delay, jitter and throughput are compiled and presented for AODV, OLSR and GRP with respect to different number of nodes and mobility of nodes at 5m/s and 15m/s.

A. Effect of Network Load

It was observed from Table II that AODV performance parameters are consistently increasing with number of nodes. From node 50 to 75 there is large difference in the delay increase and significantly less jitter. This could be due to link failures. The routes are designed again if there is any broken link. At node level 100, the jitter value is large as the network grows. The jitter is large due to the long routes that are made. The packets are transferred hop-by-hop and it may encounter congestion too.

TABLE II: Average Values of AODV at different node numbers

Nodes ->	**50**	**75**	**100**
Metrics			
Delay (sec)	8.918	12.975	15.672
Throughput (bits/sec)	3,441,773.60	6,208,892.16	9,430,483.20
Jitter (sec)	0.04974	0.08364	0.13003

It was observed from Table III that the throughput of OLSR gave a significant rise in the level. It is due to its proactive nature that routes are maintained and updated periodically. With increase in number of nodes both jitter and delay level increases, due to large routing overhead.

TABLE III: Average Values of OLSR at different node numbers

Nodes ->	**50**	**75**	**100**
Metrics			
Delay (sec)	9.736	14.762	17.972
Throughput	2,219,440.00	5,521,433.92	11,708,283.20
Jitter (sec)	0.12300	0.19958	0.23199

GRP showed worst throughput. At high node level, routes could be blocked, thus the reason could be high rate in backtracking. Initially, the rise in throughput level as in Table IV is due to the initial flooding of the HELLO messages that create routes, discover topology and maintain the routing table. The jitter and delay also give a consistent high values with increase in number of nodes.

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TABLE IV: Average Values of GRP at different node numbers

Nodes -> **Metrics**	**50**	**75**	**100**
Delay (sec)	7.465	10.734	15.663
Throughput	967,199.80	1,404,667.96	1,973,071.16
Jitter (sec)	0.06701	0.11622	0.18231

B. Effect of Mobility Speed

The number of simulations were also carried out for mobile speeds 5m/s and 15m/s. The values in the Table V clearly indicates that with lesser number of nodes and high mobility speed, AODV works very well. In contrast to the performance at 5m/s speed, it gives much better performance with respect to delay, throughput and jitter at 15m/s. At high node level and at high mobility speed, throughput decreases and delay and jitter have a significant step-up.

TABLE V: Average values for AODV with respect to Mobile Speeds

Speeds	**50**		**75**		**100**	
Metrics	**5m/s**	**15m/s**	**5m/s**	**15m/s**	**5m/s**	**15m/s**
Delay (sec)	8.918	8.648	12.975	13.721	15.672	17.161
Throughput	3,441,773.60	3,488,888.32	6,208,892.16	6,277,122.72	9,430,483.20	8,902,723.68
Jitter	0.04974	0.047271	0.08364	0.08590	0.13003	0.13331

The average values in the Table VI showed up that with the increased mobility and increased nodes, OLSR performs very well. In case of delay, at 15m/s it is very less in contrast to the delay at 5m/s. The throughput of OLSR outperforms when the node density increases and mobility increases. It is due to its proactive nature of the protocol.

TABLE VI: Average values for OLSR with respect to Mobile Speeds

Speeds	**50**		**75**		**100**	
Metrics	**5m/s**	**15m/s**	**5m/s**	**15m/s**	**5m/s**	**15m/s**
Delay (sec)	9.736	9.278	14.762	14.227	17.972	17.162
Throughput	2,219,440.00	2,234,012.16	5,521,433.92	5,538,531.84	11,708,283.20	11,880,283.84
Jitter	0.12300	0.11250	0.19958	0.20463	0.23199	0.22525

From the Table VII, it can be inferred that though GRP exhibits less delay at high mobility rate but it give poor performance in throughput when the number of nodes are increased. Since the delay in arrival of GRP packets is less, then the variation in arrival will also be significantly less.

TABLE VII: Average values for GRP with respect to Mobile Speeds

Speeds	**50**		**75**		**100**	
Metrics	**5m/s**	**15m/s**	**5m/s**	**15m/s**	**5m/s**	**15m/s**
Delay (sec)	7.465	6.7134	10.734	10.157	15.663	13.560
Throughput	967,199.80	987,579.68	1,404,667.96	1,417,290.60	1,973,071.16	1,985,252.20
Jitter	0.06701	0.06518	0.11622	0.10548	0.18231	0.14056

VII. CONCLUSIONS AND FUTURE WORK

In this work, the MANET routing protocols AODV, OLSR and GRP were accessed on the basis of the network performance parameters throughput, jitter and delay. These parameters addresses the efficiency and reliability of the protocols. The voice traffic was used to send data and all nodes send data to each other. The routing protocols itself generates the UDP packets, thus no guarantee of the acknowledgements and the re-transmissions. It solely depends on the working of the protocol. By default, UDP packets were used by the routing protocols, thus due to less overhead, it results in high delivery ratio than TCP. OLSR out go than AODV in the throughput and end to end delay metrics. The delay goes low with increase in mobility rate. But at the same time, AODV exhibits less delay than OLSR. Since for high density node networks, OLSR exhibits a great throughput level than AODV, correspondingly the little delay differences between AODV and OLSR can be ignored. Hence, OLSR presents itself as an efficient protocol that can meet the network challenges efficiently. For low capacity networks, OLSR is unsuitable because of the high routing capacity.

AODV outperforms the OLSR and GRP for low capacity networks. It was found that AODV shows less delay and jitter value when the nodes are 50 and the mobility rate is 15m/s while the throughput decreases at node level 100 at 15m/s. For node level 75 and 100 delay and jitter values also rises. Thus, it was concluded that AODV works very well for low scale networks when mobility speed is high. From this study, it is concluded that no single protocol is completely efficient and reliable. One protocol will provide reliability and the other will provide efficiency. The choice of protocol solely depends on the type of traffic as well as the design of the network. It also depends on the type of application and the error rates and failures it can handle and how much sensitive it is. Whether the protocol is reactive, proactive or

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hybrid, it totally depends on the scenarios, the way the routes are discovered, maintained and the capability of handling various network failures during communication.

This study can be extended to -

- Evaluate other MANET routing protocols for the same simulation scenarios using G.729.1
- Comparing the performances for different performance metrics and considering VoIP packet size too
- Proposing an algorithm that can both give high throughput with less delay in both small and large scale networks

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