Performance Analysis of Reactive and Hybrid Routing Protocols in Mobile Ad hoc Network

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***Abstract*— Mobile ad hoc network (MANET) is a collection of mobile nodes possessing the capability to establish temporary wireless communication. MANET neither supports a centralized coordinator system nor any type of the fixed infrastructure environment. MANET employs broadly three types of routing protocols namely table driven/proactive, on-demand/reactive and hybrid. In MANET the nodes are mobile, hence the topology changes randomly thus causing numerous complication in the working of network, for example how to find a path between mobile devices, mobility of nodes, energy consumption, security, quality of service requirements, velocity of nodes and traffic load etc. In this paper the effect of velocity of nodes on the performance of on-demand driven/reactive and hybrid routing protocols have been analyzed based on qualitative metrics like, average jitter, throughput, average delay and TTL-based average hop count.**

Keywords*— *MANET; Routing Protocols; Velocity; Delay; Throughput; Jitter; TTL-based average hop count

I. INTRODUCTION

In Mobile Ad Hoc Network (MANET) nodes change their positions arbitrary thus causing the topology of network to be highly dynamic [1]. Now a days there is a need of rapid deployment of individual mobile nodes in wireless communication. In MANET mobile nodes can communicate with other mobile nodes directly, which falls in their radio range. Each node acts as a router in the network. MANET connects not only two or three mobile devices but also it can interconnect thousands of devices very easily [2]. High speed movements of mobile nodes directly impact the performance of the network. Some real life applications of MANET's are military battlefields, search and rescue operations, meeting and conferences, taxi cab network, policing and fire fighting etc. In MANET all the mobile nodes are cooperative and share information among themselves. This process is known as routing in MANET.

The dynamic behavior of MANET gives rise to various complex issues which need to be addressed for successful communication. Some of important issues in MANET are listed below.

- **Topology**: In MANET the mobile nodes are dynamic, thus the topology of the network changes rapidly and is not predictable.
- **Routing**: As topology in MANET is unpredictable, routing is a big issue in multi-hop ad hoc network to find up to date routing path between the mobile nodes [3]. It is more complex for communication than any pre-existing infrastructure.
- **Node discovery**: Movement of mobile nodes is dynamic in MANET, so the process of identifying the location of a particular node is very challenging task in order to establish routes between nodes [4].
- **Energy consumption**: Mobile nodes are dependent on the battery power for their energy. Consumption of nodes energy should be optimized for increasing the life time of the network environment [5].
- **Security and threats**: There is no centralized administration to handle routing in MANET, thus attack on ad hoc network is easier than fixed cable network [6].
- **Service quality**: It is a big challenge to provide constant efficient quality of service in the rapidly changing topology of MANET.

In recent years MANET has become an important research area. Lot of work has already been done on the comparative analysis between routing protocols where different parameter's values are kept fixed. The work in this paper is based on variable velocity of nodes. In this paper performance comparison of two reactive routing protocols and a hybrid routing protocol have been carried out. Qualnet 5.02 simulator is used for evaluating the performance results of Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Zone Routing Protocol (ZRP) routing protocols. Four performance metrics, average end to end delay, average jitter, throughput and average number of hop count is considered for analyzation of results.

The rest of paper is structured as follows: Different MANET routing protocols are described in Section II, Section III contains discussion on factors which effect performance of MANET's. In Section IV network simulation environment, results and performance metrics are elaborated. Section V finally concludes the paper.

II. ROUTING PROTOCOLS DESCRIPTION

The routing protocols used in MANET are broadly categorized as table driven/proactive, on-demand/ reactive and hybrid (Figure 1).

- **Table driven**/proactive **routing protocols:** Table driven routing protocols are proactive in nature, and each node knows complete routing information of the network [7]. Every node in the network consistently updates the routing information in their routing tables.

Forwarding of data packets in proactive protocols is faster because the routing information is already specified in routing table. Defining the route before sending the packet to destination node is extra overhead in table driven routing protocol. Destination Sequenced Distance Vector Routing (DSDV), Optimized Link State Routing Protocol (OLSR), Cluster head gateway Switch Routing protocol (CGSR), Wireless Routing Protocol (WRP) are various available proactive routing protocols being used in MANET [8].

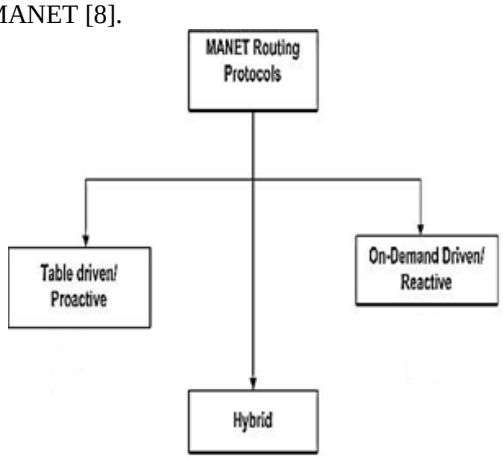

Fig.1: Categories of routing protocols used in MANET

- **On-demand driven/reactive routing protocols:** On-demand driven/reactive routing protocols do not have any kind of routing information in a particular network. When any node wants to communicate to other node then they apply on-demand route discovery mechanism for creating connections [9]. Dynamic Source Routing (DSR), Ad-hoc on-demand Distance Vector (AODV), Temporary Ordered Routing Algorithm (TORA), Associativity Based Routing (ABR), Signal Stability Routing (SSR) are various reactive routing protocols.
- **Hybrid routing protocols:** The hybrid routing protocol [10] utilizes reactive as well as proactive concepts for route discovery between source and destination nodes. In a particular geographical area nodes communicate with each other in proactive protocols manner otherwise they use reactive protocols. Proactive routing protocols maintain the Intrazone information in hybrid whereas Interzone information is maintained by on-demand protocols. It reduces the table-driven routing protocols control overhead as well as decrease the route discovery latency of reactive routing protocols.

In this paper in order to perform comprehensive analysis two on-demand driven routing protocols namely Ad hoc On-demand Distance Vector (AODV)**,** Dynamic Source Routing (DSR) and one hybrid routing protocol namely Zone Routing Protocol (ZRP) are deployed. The details of these routing protocols are given below.

A. Ad hoc On-demand Distance Vector(AODV)

As per naming convention AODV protocol uses on-demand approach to search routes in a network. Destination sequence number (DSN) in AODV determines recently updated routing path between the mobile devices and it also helps to establish a connection between them. Any one of the node in a network starts sending a DSN when they wants to deliver data packets to other nodes [11]. The most recently updated routing path is used for flooding the route request (RREQ) packet to their neighboring nodes. They rebroadcast again to their intermediate nodes until the RREQ packet reaches the destination node. As shown in Figure 2 source node A broadcast a RREQ packet to the destination node G with the help of intermediate nodes.

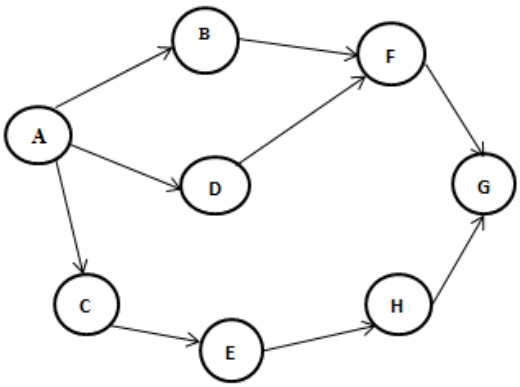

Fig.2: RREQ Packets in AODV

In Figure 3 destination node G is unicasting the route reply message with the help of intermediate nodes for establishing the routing path to the source node A.

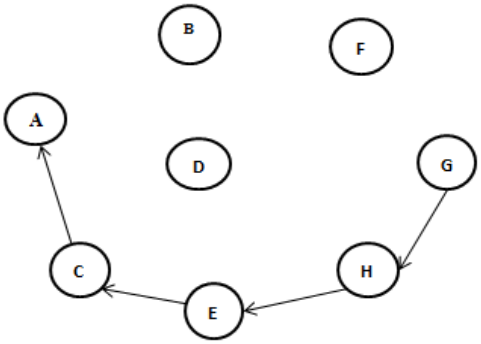

Fig.3: RREP packets in AODV

The communication between mobile nodes in MANET is link based. If any link is broken in the network then a route error message generated and broadcasts to other nodes.

B. Dynamic Source Routing Protocol (DSR)

DSR is a reactive routing protocols mainly used for multi-hop communication in MANET. It allows each node in MANET to search a route from source to destination dynamically by source routing mechanism. At the time of route discovery all the details of path information is placed in the data packet [12]. DSR is the only routing protocol which uses cache to store the routing information. To find route between the mobile devices, and maintain up-to-date routing information are main two functions of DSR protocol. Maintenance of routes is required only for those nodes which are active. Route discovery process applies only when any device does not know the route to other device. Unidirectional links are supported by DSR. Link breaks between mobile devices is a big issue in MANET. In DSR damage of link information is broadcasted to each node to update their cache table.

C. Zone Routing Protocol (ZRP)

ZRP is the combination of proactive and reactive protocols specifications [13]. Routing zone in ZRP has a fixed amount of radius where the nodes can communicate within a specified area. To interact with devices which are outside of routing zone, ZRP uses reactive approach for searching routes between those devices. Routing zones can overlap each other. Intrazone Routing Protocol and Interzone Routing Protocol are the two components of ZRP. If destination node is present inside of the routing zone then proactive approach applied for route discovery. In Figure 4 nodes A, B, C, D, and E lie inside routing zone whereas F and G nodes are outside routing zone.

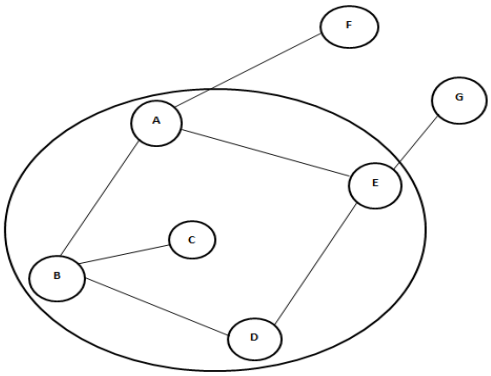

Fig.4: Zone routing protocol

An Intra zone allows for communication between the mobile nodes which are inside of the routing zone [14]. For communicating with the nodes which are outside of the routing zones the global reactive Interzone routing protocol is used.

III. FACTORS EFFECTING THE WORKING OF ROUTING PROTOCOLS IN MANET

Performance of routing protocols is affected by several factors in MANET. Some of important factors are velocity of nodes, mobility, offered load, network size and placement model [15]. Velocity of individual mobile devices has great influence on the performance of network it may causes high packet drop. Mobility of mobile nodes also results in unpredictable impact and it can cause link failure between mobile devices.

- **Velocity**: Place and time of mobile devices are not fixed due to their dynamic behavior [16]. Nodes are moving with different velocity in the network. Variation on velocity of these nodes can give unpredictable results. It may also affect the performance metrics of various MANET routing protocols.
- **Mobility model:** Generally nodes are placed randomly on the canvas area by random waypoint mobility model but using pedestrian and file based mobility model may affect the performances of the MANET routing protocols [17].
- **Offered load:** Bandwidth of a particular channel is limited in MANET. Transmission of large data size packets from single channel may cause low utilization of channel's capacity [19].Dropped data packets also consume the bandwidth of channel.
- **Network size:** Nodes have specific radio ranges for sending packets in MANET [20]. With large area of network the performance of various protocols may decrease due to limited radio range of devices.
- **Node placement model:** MANET uses various placement model techniques. These can be random, uniform, grid, file and pedestrian that can affect the performance of application layer, network layer and other layer metrics.

After going through critical analyzation of above factors, velocity of mobile nodes is kept in variable mode in this paper for the purpose of comprehensive analysis.

IV. SIMULATION ENVIRONMENT AND RESULTS

In most of the previous research work the velocity of nodes has been kept fixed. In this paper an attempt has been made to keep the velocity of nodes in variable mode. Our aim is to analyze performance of AODV, DSR, and ZRP protocols under the variation on maximum velocity of mobile nodes using Qualnet simulator. Qualnet is an event based simulation tool that simulates and shows the real time communication because it uses scalable networking technology. In this scenario the square field canvas area of 1500*1500 meter^2 with 50 nodes is used. The constant bit ratio (CBR) application traffic and 802.11b radio propagation model is applied. The Omni directional antenna model is used for high transmission power gain.

All the detail of various parameters used in simulation are represented in the Table-1.

TABLE-1: Parameters used for simulation setup

Parameters	Values
Simulator	Qualnet 5.0.2
No. of mobile nodes	50
Routing protocols	AODV, ZRP, DSR
Simulation area (m^2)	1500×1500
Mobility model	Random waypoint
Pause time (seconds)	15
Application traffic	CBR (constant bit rate)
Maximum speed (m/s)	15, 25, 35, 45
Simulation time (s)	60
Packet size (bytes)	512
Radio propagation model	Two Ray ground
Antenna type	Omni-directional

A. Measured Performance Metrics

The four performance metrics used for evaluation of results pertaining to our scenario are average end to end delay, throughput, average jitter and TTL-based average hop count.

- **Average delay:** It is the travel time of a data packet to reach destination node that was originated by source node [17]. Average Delay includes its transmission delay, processing, queuing delay and propagation delay. Time unit of delay is represented in seconds. During simulation implementation it is observed that average end to end delay is minimum in case of AODV whereas in case of ZRP average end to end delay is maximum. ZRP shows improvement as velocity rate of nodes is increased but it high in comparison to AODV. DSR matches the performance of AODV initially but as velocity of

nodes is increased finally AODV out performs DSR. The results obtained are represented in Figure 5.

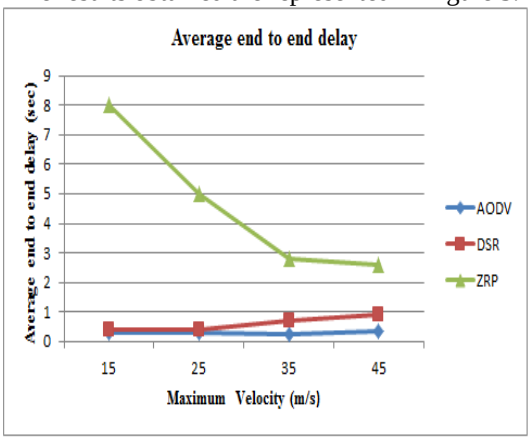

Fig.5: Average end to end delay for 50 nodes

- **Throughput:** The ratio between total data packets received at destination node to per unit time taken [10]. It's a particular channel's transmitting rate of successfully delivered packets at the destination. In simulation with variation in velocity of nodes throughput of AODV changes but it performs better as compared to DSR protocol. The throughput of DSR protocol continuously degrades as velocity of nodes increased. ZRP protocols throughput is high initially but degrades with increases velocity of nodes. The results obtained are represented in Figure 6.
- **Average Jitter:** It is time variation of each data packets received at the destination node [19]. Simulation result at Initial level shows average jitter of AODV and DSR protocols is approximately same. As velocity of nodes increases DSR protocols performance degrades whereas AODV protocol gives steady performance. Jitter of ZRP protocol is initially very high in comparison to AODV and DSR. But with increase in velocity of nodes it shows better results than DSR.

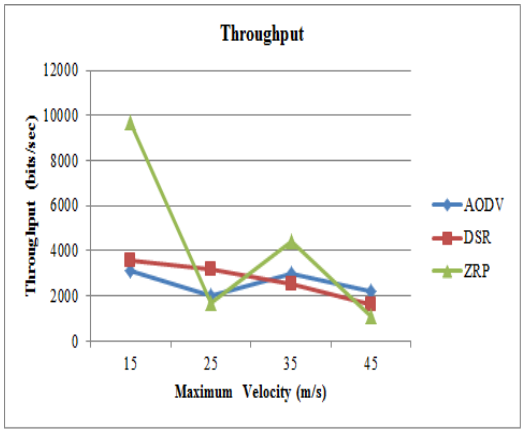

Fig.6: Throughput for 50 nodes

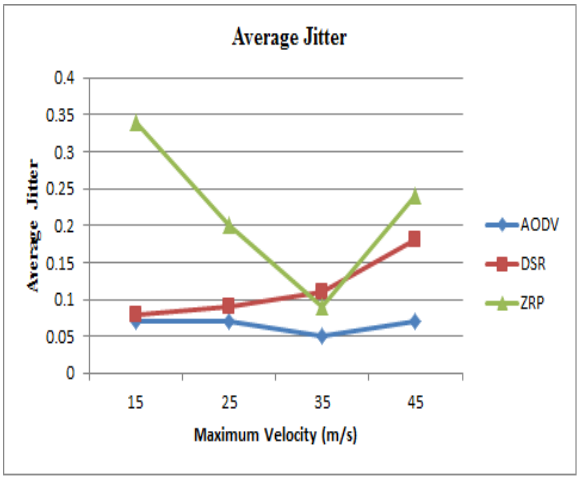

Fig.7: Average jitter for 50 nodes

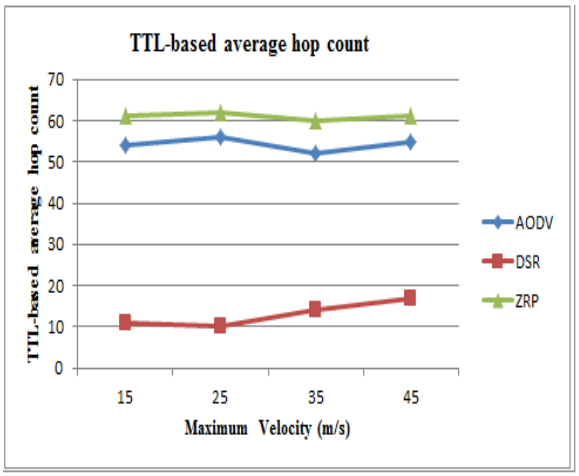

Fig.8: TTL-based average hop count for 50 nodes

After certain point of time performance of ZRP again degrades thus resulting in unstable behavior. The results obtained are shown in Figure 7.

- **TTL- based average hope count:** It is defined as total number of hops (nodes) required to transmit the data packets from one CBR source to another CBR destination [8]. As represented in Figure 8 DSR protocol takes minimum number of hops to transmit data packets, whereas ZRP takes maximum number of hops.

V. CONCLUSION

In this paper the comprehensive analysis between AODV, DSR, and ZRP protocols is carried out by varying velocity of mobile nodes. The performance of these routing protocols is application specific and under different network environment they have shown different results. In simulation four performance metrics namely throughput, average jitter, TTL - based average hop count and average end to end delay are considered. The average jitter and average end to end delay of the AODV protocol are better comparison to DSR and ZRP routing protocols. The throughput of ZRP is initially high but degrades when velocity of nodes is increased. DSR takes minimum number of hop to transmit the packets while ZRP takes maximum. Concluding it is recommended that in scenarios like military battlefield, vehicular communication

etc. where velocity of nodes vary continuously, AODV routing protocol may be preferred as it takes less end to end delivery and jitter in comparison to other routing protocols.

REFERENCES

[1] A.O. Bang and P. L. Ramteke, "MANET : History , Challenges And Applications," Int. J. Appl. or Innov. Eng. Manag., vol. 2, no. 9, pp. 249–251, 2013.
[2] S. Denakaran and A. Parvithavarthini, "An Overview of Routing Protocols in Mobile Ad-Hoc Network," Int. J. Adv. Res. Comput. Sci. Softw. Eng., vol. 3, no. 2, pp. 251–259, 2013.
[3] J. Kumar, "Comparative Performance Analysis of AODV , DSR , DYMO , OLSR and ZRP Routing Protocols in MANET using Random Waypoint Mobility Model," Int. J. Comput. Intell. Inf., vol. 2, no. 1, pp. 7–13, 2012.
[4] A. Ramesh, P. Sumithabhashini and P.K.J. Bharathi, "Performance Comparison and Evaluation of Proactive , Reactive and Hybrid Routing," Int. J. Adv. Res. Electr. Electron. Instrum. Eng., vol. 3, no. 6, pp. 10279–10285, 2014.
[5] A. Kumar and D. Singh, "Importance of Energy In Wireless Sensor Networks : A Survey," Int. J. Eng. Sci., vol. 17, no. January 2016, pp. 500–505, 2016.
[6] M. Kaur, "Comparison and Analysis between Reactive Routing Protocols in MANET using Opnet17.5v," Int. J. Innov. Technol., vol. 6, no. 1, pp. 240–247, 2015.
[7] A. Rahman and F. Anwar, "A Simulation Based Performance Comparison of Routing Protocol on Mobile Ad-hoc Network (Proactive, Reactive and Hybrid)," International Conference on Computer and Communication Engineering, 2010, May, pp. 11–13.
[8] R..K. Jha and P. Kharga, "A Comparative Performance Analysis of Routing Protocols in MANET using NS3 Simulator," I. J. Comput. Netw. Inf. Secur., no. 4, March, pp. 62–68, 2015.
[9] S.R. Das and E.M. Roycr, "Performance Comparison of Two On-demand Routing Protocols for Ad Hoc Networks," Inf. Commun., vol. 1, pp. 3–12, 2000.
[10] L. Layuan, L. Chunlin, and Y. Peiyan, "Performance evaluation and simulations of routing protocols in ad hoc networks," Comput. Commun., vol. 30, pp. 1890–1898, 2007.
[11] K. Pandey and A. Swaroop, "A Comprehensive Performance Analysis of Proactive , Reactive and Hybrid MANETs Routing Protocols," Int. J. Comput. Sci., vol. 8, no. 6, pp. 432–441, 2011.
[12] S. Kaur and M. Mohali, "Analysis of zone routing protocol in manet," Int. J. Res. Eng. Technol., vol. 02, no. 09, pp. 520–524, 2013.
[13] D. Kampitaki and A. Economides, "Simulation study of MANET routing protocols under FTP traffic," Procedia Technol., vol. 17, pp. 231–238, 2014.
[14] L. Dev and N. Roberts, "Effects of Velocity on Performance of DYMO, AODV and DSR Routing Protocols in Mobile Ad-hoc Networks," Procedia Technol., vol. 4, pp. 727–731, 2012.
[15] N.K. Ray and A.K. Turuk, "Performance Evaluation of Different Wireless ad hoc Routing Protocols," Int. J. Wirel. Mob. Netw., vol. 4, no. 2, pp. 203–215, 2012.
[16] A. Kaur and H. Singh, "A Study of Secure Routing protocols," Int. J. Appl. or Innov. Eng. Manag., vol. 2, no. 2, pp. 176–179, 2013.
[17] S.R. Raju, "ZRP versus AODV and DSR : A Comprehensive Study on ZRP Performance," Int. J. Comput. Appl., vol. 1, no. 12, pp. 35–40, 2010.
[18] S. Mohapatra and P. Kanungo, "Performance analysis of AODV , DSR , OLSR and DSDV Routing Protocols using NS2 Simulator," Procedia Technol., vol. 30, no. 2011, pp. 69–76, 2012.
[19] S.A. Hosseini and H. Farrokhi, "The Impacts of Network Size on the Performance of Routing Protocols in Mobile Ad-Hoc Networks," in Second Pacific-Asia Conference on Circuits, Communications and System (PACCS), 2010, pp. 18–22.
[20] P. Singh, "Node Mobility Based Route Selection in AODV for use in MANETs," in International Conference on Computing Control and Automation, 2015, pp. 7–11.