Performance Analysis of ZRP over AODV, DSR and DYMO for MANET under Various Network Conditions using QualNet Simulator

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ABSTRACT
A network which does not require any fixed pre-existing infrastructure and can be defined as a set of mobile nodes is called MANET. In MANET mobile nodes are communicating through wireless medium. In MANET all mobile nodes behaves as router and when required they takes part in discovery and maintenance of the route to the other node. One of the major challenges in designing a routing protocol for the MANET is to determine a packet route; a node needs to know at least about its neighbors. On the other hand in MANET wireless networks conditions changes frequently with time due to the mobile nodes thus routing becomes a challenging task. To serve this purposes various proactive, reactive and hybrid routing protocols are developed by researchers. Among all AODV, DSR, DYMO and ZRP are well known popular routing protocols and have been standardized by the IETF MANET WG. ZRP is a well known hybrid routing protocol. To understand its suitability we must understand its behavior under various real time conditions. This paper presents performance analysis of ZRP routing protocol over AODV, DSR, and DYMO routing protocols using QualNet version 5.2. This experiment uses different network conditions, close to real time condition, for the performance analysis of ZRP using AODV, DSR and DYMO as a reference protocol. Simulations are carried out to analyze the different network parameters such as throughput, average jitter, average end-to-end delay and packet delivery ratio.

KEYWORDS
MANET, AODV, DSR, DYMO, ZRP, QualNet version 5.2.

1. INTRODUCTION
MANET is a collection of wireless nodes that can dynamically form a network to exchange information without using any pre-existing fixed network infrastructure with rapid configuration of wireless connections on-the-fly [1, 2]. In MANET mobile nodes are communicating through wireless medium. In MANET all mobile nodes behaves as router and when required they takes part in discovery and maintenance of the route to the other node. MANET's application areas are very wide some of them are: military operations, disaster managements, rescue operations, meetings and conferences, educational purposes etc. One of the major challenges in designing a routing protocol for the MANET is to determine a packet route; a node needs to know at least about its neighbors [1]. On the other hand in MANET network conditions changes frequently with time due to the mobile nodes thus routing becomes a challenging task. To serve this purposes various proactive, reactive and hybrid routing protocols are developed by researchers. Different types of routing protocols are proposed, for different network conditions, for MANETs some of them are: AODV [3, 4], DYMO [5], OLSR [7], TORA [6], DSR [9], ZRP [8] etc. Among all AODV, DSR, DYMO and ZRP are well known popular routing protocols and have been standardized by the IETF MANET WG. The three most popular reactive routing protocols for MANETs namely Ad-Hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Dynamic MANET On-demand (DYMO), find route only when node have data to send. It avoids the need of frequent link and route updates therefore substantially reduces energy consumption when the traffic load is light or the network mobility is high [2].
Zone Routing Protocol (ZRP) is a Hybrid Routing protocol which contains both the properties of Reactive Routing Protocols and Proactive Routing Protocols. All above discussed protocols are operating only in Network layer.
This paper evaluates the performance comparative study of ZRP by taking AODV, DSR and DYMO as reference protocols under different network conditions.
The rest of the paper is organized as follows: Section–2 gives a brief description about Related Works which help in performance evaluation of the ZRP, Section-3 introduces Overview of Routing Protocols; Section-4 gives the Simulation Environment, Section-5 presents Simulation Results and Discussion and performance comparison graphs. Finally, Conclusion is presented in Section-6.

2. RELATED WORK
S. R. Raju and J. Mungara [2] proposed an algorithm to provide improved quality of service via hybrid routing protocol ZRP. They considered AODV and DSR as reference protocols for evaluating ZRP performance, and used QualNet version 4.5 to compare QoS parameters viz., throughput, number of bytes received, number of packets received, average end-to-end delay and the time at which first packet is been received for DSR, AODV and ZRP. Their simulation result shows that ZRP was not up to the task and it performed poorly throughout all the simulation sequences. Their work did not include DYMO protocol, uses fixed mobility speed 1-8 mps and pause time but they use different network sizes with different nodes.
K. Suresh and K. Jogendra [14] proposed the performance analysis of ZRP, AODV and DSR, they used QualNet simulator for simulation and taken First Packet sent, Last Packet sent, Total Bytes sent, Total Packet sent, Throughput client, First Packet Received, Last Packet Received, Total Bytes Received, Throughput server as performance metrics.

Their work did not include DYMO and used constant mobility speed but they vary CBR application.

S. R. Raju, et al [15] used QualNet 4.5.1 Network simulator to study the behavior of ZRP versus AODV and DSR and find out that ZRP performed poorly throughout all the simulation sequences, hence putting itself out of competition. ZRP has low packet delivery ratio when compared to DSR and AODV. Their work did not include DYMO protocol, uses constant mobility speed and pause time but they use different network sizes with different nodes.

S. R. Raju, et al [16] used well known network simulator QualNet version 4.5 to compare QoS parameters viz., throughput, number of bytes received, average end-to-end delay for DSR, AODV and ZRP. They considered two reactive routing protocols DSR, AODV as reference for analyzing ZRP. They had taken their simulation in two phases with different network parameters and with varying network size and nodes. They observed that ZRP was not up to the task and performed poorly throughout all the simulation sequences. To improve the efficiency of ZRP they proposed an algorithm.

D.W. Kum et al [17] compared AODV and DYMO using ns-2 simulator. Simulations are run to analyze the total throughput, routing overhead, and average packet size of the routing control packets. Their work shows that the path accumulation of DYMO reduced the routing overhead; the size of the routing packet was increased. At moving speeds between 1m/s and 9m/s, throughput of DYMO could outperform that of AODV. However, at moving speeds between 11m/s and 15m/s, AODV could achieve a higher throughput than DYMO. Their work did not include DYMO and ZRP protocols and did not include propagation models, Pathloss models, battery models energy models and varying pause time.

3. OVERVIEW OF ROUTING PROTOCOLS

3.1 Ad-hoc On Demand distance Vector routing protocol (AODV)

AODV [3, 4] is a reactive routing protocol.The AODV Routing protocol [2, 4] uses an on-demand approach for finding routes, that is, a route is established only when it is required by a source node for transmitting data packets. AODV enables dynamic, self-starting, multihop routing between mobile nodes wishing to establish and maintain an ad-hoc network. AODV allows mobile nodes to find out routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. It allows nodes to respond to link breakages and a change in network topology in a timely manner.The operation of AODV is loop-free. When a route to a new destination is required, the source broadcasts a RREQ message to find a route to the required destination. A route can be determined when the RREQ message reaches either the destination itself, or an intermediate node with a 'fresh enough' route to the destination [4]. A 'fresh enough' route is a valid route entry for the destination whose associated sequence number is at least as great as that contained in the RREQ. The route is made available by unicasting a RREP message back to the origination of the RREQ message. Each node receiving the request caches a route back to the originator of the request, so that the RREP can be unicast from the destination along a path to that originator, or likewise from any intermediate node that is able to satisfy the request [4].

In AODV route maintenance is done by HELLO messages and route error (RERR) messages. Nodes monitor the link status of next hops in active routes. When a link break is detected, a RERR message is used to notify other nodes that the loss of that link has occurred. After receiving RERR message the source node initiates the new procedure for route discovery [4].

AODV, one of the most famous protocols of MANET among all but AODV has a heavy routing overhead and also have complexity problem.

3.2 Dynamic Source Routing (DSR)

The DSR protocol [2, 9] is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad-hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any pre-existing network infrastructure. In designing DSR, we sought to create a routing protocol that had very low overhead yet was able to react very quickly to changes in the network. The DSR protocol provides highly reactive service in order to ensure successful delivery of data packets in spite of node movement or other changes in network conditions.

The Dynamic Source Routing protocol is composed of two main mechanisms route discovery and route maintenance. In the Route Discovery mechanism a source node wishing to send apacket to a destination node, discover a source route to the destination. In Route Maintenance mechanism a node wishing to send a packet to a destination is able to detect, while using a source route to the destination, if the network topology has changed such that it can no longer use its route to destination because a link along the route no longer works. When Route Maintenance indicates a source route is broken, source can attempt to use any other route, it happens to know to destination, or it can invoke Route Discovery again to find a new route for subsequent packets to destination.

3.3 Dynamic MANET On-demand routing protocol (DYMO)

The DYMO routing protocol [5] is designed for stub (i.e., non-transit) or disconnected (i.e., from the Internet) mobile ad-hoc networks (MANETs). DYMO handles a wide variety of mobility patterns by dynamically determining routes on-demand. It also handles a wide variety of traffic patterns. The basic operations of the DYMO routing protocol are route discovery and route maintenance.

During route discovery, a DYMO router initiates flooding of a Route Request message (RREQ) throughout the network to find a route to a particular destination, via the DYMO router responsible for this destination. During this hop-by-hop flooding process, each intermediate DYMO router receiving the RREQ message records a route to the originator. When the target's DYMO router receives the RREQ, it records a route to the originator and responds with a Route Reply (RREP) unicast hop-by-hop toward the originating DYMO router. Each intermediate DYMO router that receives the RREP creates a route to the target, and then the RREP is unicast hop-by-hop toward the originator. When the originator's DYMO router receives the RREP, routes have been established between the originating DYMO router and the target DYMO router in both directions.

Route maintenance consists of two operations. In order to preserve routes in use, DYMO routers extend route lifetimes upon successfully forwarding a packet. In order to react to changes in the network topology, DYMO routers monitor traffic being forwarded. When a data packet is received for forwarding and a route for the destination is not known or the route is broken, then the DYMO router of the source of the packet is notified. A Route Error (RERR) is transmitted to indicate the route to one or more affected destination addresses is Broken or missing. When the source's DYMO router receives the RERR, it marks the route as broken. Before the DYMO router can forward a packet to the same destination, it has to perform route discovery again for that destination. Similarly to AODV, DYMO uses sequence numbers to ensure loop free operation.

3.4 Zone Routing Protocol (ZRP)

ZRP [8] is designed to provide an optimal balance between purely proactive and reactive routing. This applies equally well to routing between nodes at the intra-cluster level and between clusters at the inter-cluster level. In the Zone Routing framework, a proactive routing protocol provides a detailed and fresh view of each node's surrounding local topology (routing zone) at the local level. The knowledge of local topology is used to support services such as proactive route maintenance, unidirectional link discovery and guided message distribution. One particular message distribution service, called bordercasting, directs queries throughout the network across overlapping routing zones. Bordercasting is used in place of traditional broadcasting to improve the efficiency of a global reactive routing protocol. The benefits provided by routing zones, compared with the overhead of proactively tracking routing zone topology, determine the optimal framework configuration. As network conditions change, the framework can be dynamically reconfigured through adjustment of each node's routing zone.

ZRP is formed by two sub-protocols, a proactive routing protocol: Intra-zone Routing Protocol (IARP) [8, 11] is used inside routing zones and a reactive routing protocol: Inter-zone Routing Protocol (IERP) [8, 12] is used between routing zones, respectively [2]. The IARP protocol is used by a node to communicate with the other interior nodes of its zone. Existing proactive routing algorithms can be used as the IARP protocol for ZRP.

The Inter-zone Routing Protocol (IERP) [8, 12] is used to communicate between nodes of different routing zones. It is a reactive routing protocol and the route discovery process is only initiated when needed or on demand. This makes route finding slower, but the delay can be minimized by use of the Bordercast Resolution Protocol (BRP) [8, 13]. BRP is rather a packet delivery service than a full featured routing protocol. It is used to send routing requests generated by IERP directly to peripheral nodes to increase efficiency. BRP takes advantage of the local map from IARP and creates a Bordercast tree of it. The BRP employs special query control mechanisms to steer route requests away from areas of the network. The use of this concept makes it much faster than flooding packets from node to node.

4. SIMULATION ENVIRONMENTS

Simulations had carried out on QualNet version 5.2 [10] platforms and defined the parameters for the performance evaluation of ZRP by taking AODV, DSR and DYMO as reference protocols. Many authors [2, 14, 15, 16, 17] have been worked with AODV, DSR, DYMO, ZRP and other routing protocols with different network conditions for evaluating performance. We had done simulations with two network conditions [table 1 & 2], we have taken different routing protocols, path-loss models, shadowing models, energy models, battery models, varying mobility speed and varying pause time. We have taken same 1500X1500 m^2 network size for both the network conditions and placed 75 nodes and apply four CBR applications.

Simulation parameters are shown in table 1 & 2 and simulation results are shown in figures from 1 to 8. With the help of simulation results we had analyzed Average Jitter, Packet delivery ratio, Throughput, and End-to-End delay for the given protocol.

4.1 Performance metrics

A. Throughput: Throughput is defined as the total amount of data received by destination node from the source node divided by the total time it takes from the destination to get the last packet and it measures is bits per second (bit/s or bps).
B. Average Jitter: Jitter is the time variation between subsequent packet arrivals; it is caused by network congestion, timing drift, or route changes. It must be as low as possible for an efficient protocol.
C. Average End-to-End delay: Average end-to-end delay is the time interval when a data packet generated from source node is completely received to the destination node.
D. Packet delivery ratio: Packet delivery ratio is the ratio of total packets sent by the source node to the successfully received packets by the destination node.

Table 1: Network Condition-I

Simulation Parameters	Value
Area	1500X1500 m^2
No. of nodes	75
Simulation Time	90sec
Routing Protocols	AODV, DSR, DYMO, ZRP
Channel frequency	2.4 GHz
Seed	1
Shadowing Model	Log Normal
Pathloss Model	Free-Space
Energy Model	MicaZ
Battery Model	Service Life Estimator
Mobility Model	Random way point
Mobility	Restricted to selected nodes
Mobility Speed	0-10 mps
Pause Time	10, 20, 30, 40 sec
Item size	512 bytes

Table 2: Network Condition-II

Simulation Parameters	Value
Area	1500X1500 m^2
No. of nodes	75
Simulation Time	90sec
Routing Protocols	AODV, DSR, DYMO, ZRP
Channel frequency	2.4 GHz
Seed	1
Shadowing Model	Constant
Pathloss Model	Two Ray
Energy Model	Mica Motes
Battery Model	Simple Linear
Mobility Model	Random way point
Mobility	Restricted to selected nodes
Maximum Speed	10, 20, 30, 40 mps
Pause Time	10 sec
Item size	512 bytes

5. SIMULATION RESULTS AND DISSCUSSION

Fig 1 shows Average jitter against Pause time, it can be observed that for ZRP jitter variation is very small but ZRP performs well than DSR and DYMO. Among all AODV performs very well but when pause time increases above 40 seconds the value of jitter for AODV decreases.

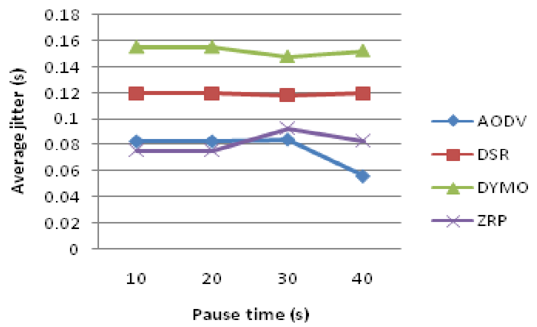

Fig 1: Average jitter Vs Pause Time

From Fig 2, it can be observed that ZRP has lowest throughput with increasing pause time and DSR working best among all with almost constant throughput. AODV has almost constant throughput during the experiment and DYMO has increasing throughput with pause time.

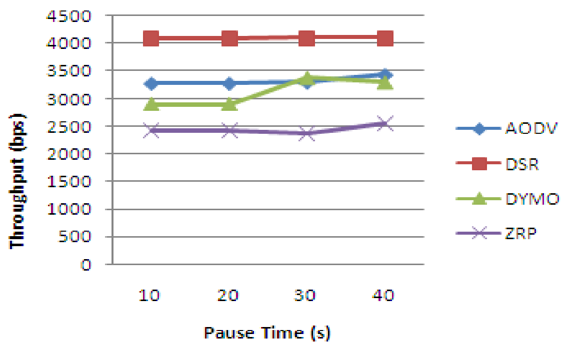

Fig 2: Throughput Vs Pause Time

Fig 3 shows ZRP has lowest Average End-to-End Delay but DYMO performs worst with varying pause time. In the case of AODV when pause time is less than 30 seconds Average End-to-End Delay is almost constant but after 30 seconds it decreases. DSR has lesser Average End-to-End Delay than AODV and DYMO.

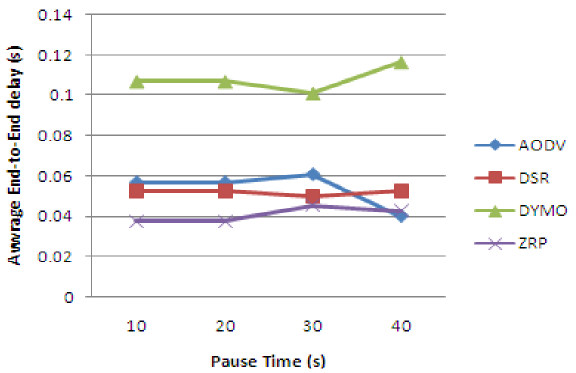

Fig 3: Average End-to-End Delay Vs Pause Time

From Fig 4, it is observed that ZRP has lowest packet delivery ratio, performs worst, but DSR performs well among all. AODV and DSR have PDR value between ZRP and DYMO. DYMO shows increase in PDR with increase in pause time.

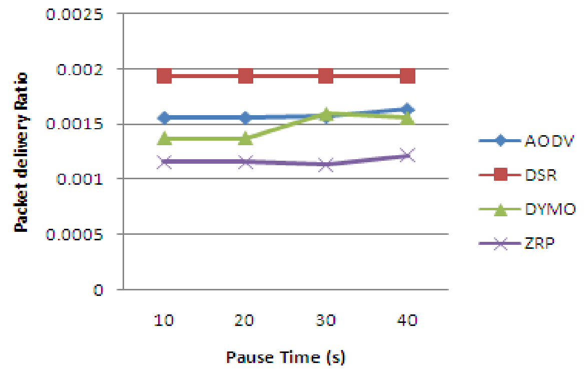

Fig 4: Packet Delivery Ratio (PDR) Vs Pause Time

Fig 5, it is observed that as maximum speed of nodes increases above 30 mps average jitter for ZRP increases sharply. AODV have lowest jitter among all above 30 mps. For DYMO and DSR jitter value is also increases.

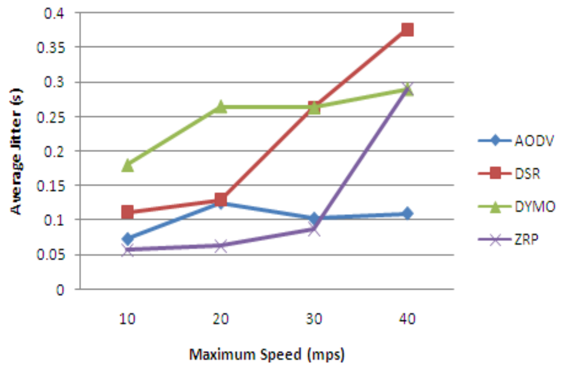

Fig 5: Average jitter Vs Maximum Speed

Fig 6, AODV has best throughput at all maximum speeds while ZRP performs worst. In case of DSR throughput is decreasing gradually while maximum speed is increasing. DYMO performs better than ZRP and DSR

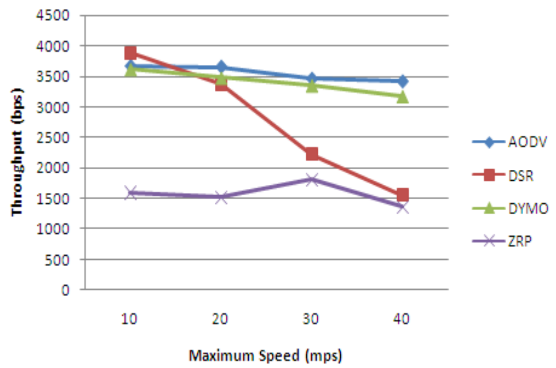

Fig 6: Throughput Vs Maximum Speed

Fig 7, DSR performs worst, while ZRP and AODV have lowest end-to-end delay with almost constant value. DYMO has less increase in end-to-end delay with maximum speed.

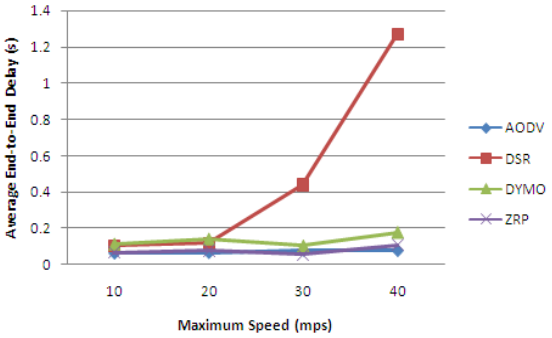

Fig 7: Average End-to-End Delay Vs Maximum Speed

From Fig 8, ZRP has lowest PDR with maximum speed while DSR shows gradual decay in PDR with maximum speed. AODV and DYMO perform better but AODV shows highest PDR than all with maximum speed.

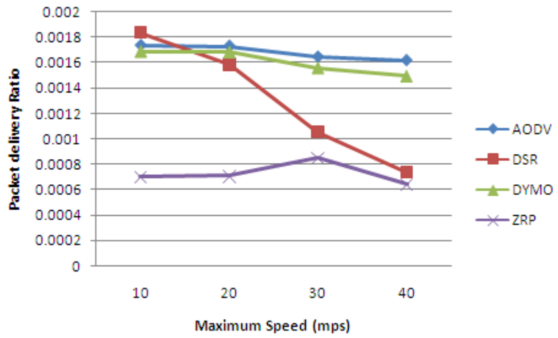

Fig 8: Packet Delivery Ratio (PDR) Vs Maximum Speed

6. CONCLUSION

In this paper the performance of ZRP protocol is evaluated against AODV, DSR and DYMO protocols. With the help of simulation results we compared ZRP protocol with three important standard routing protocols AODV, DSR and DYMO, under two different network conditions. We measure the average jitter, average end-to-end delay, packet delivery ratio and throughput as performance metrics. Our simulation results show that ZRP has lower throughput, lower PDR than AODV, DSR and DYMO and makes himself out of the race. On the other hand the performance of AODV is better than others in the second network conditions (with Constant shadowing model, Two Ray, Simple Linear battery model and with varying maximum speed) but average in first (better than DYMO and ZRP but lower than DSR). While DSR performs well in first condition (with Log Normal shadowing model, free space Pathloss model, Service Life Estimator battery model and with varying Pause time) but worst in second (with Constant shadowing model, Two Ray, Simple Linear battery model and with varying Maximum speed). DYMO shows average performance in both the cases (better than ZRP). Over all we can say that AODV performs better under different network conditions.

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