A Comparative Study of Channel Fading Effect on Ad Hoc Routing Protocols

Khushboo Tripathi & S. D. Dixit
Department of Electronics & Communication
University of Allahabad, India

Abstract: **Ad hoc networking is a technology still under development and there are several proposals for defining the most suitable routing protocol. The topology of an ad hoc network may change dynamically, which makes it difficult to design an efficient routing protocol. This paper presents a comprehensive study on the performance of ad hoc network routing protocols under realistic network scenarios with the effect of channel fading models. The routing protocols used in this study include DSR, AODV, & ZRP which comprise a good mix of reactive, proactive & hybrid protocols. Their performance is analyzed on throughput, jitter and end-to end delay, energy consideration (transmitting and receiving mode) measuring metrics by varying CBR data traffic load using QualNet 5.0 network simulator.**

Keywords: **Ad hoc network, AODV, DSR and ZRP.**

1. INTRODUCTION

Since a few years research interest in ad hoc networks has been growing, and especially the design of ad hoc routing protocols has received a lot of attention [2]. One of the reasons is that routing in ad hoc network is a particularly challenging task due to the fact that the topology of the network changes constantly and paths which were initially efficient can quickly become inefficient or even infeasible. Factors such as variable wireless link quality, propagation path loss, fading, energy consumption and quality of services, multi-user interference, power expanded and topological changes become important issues[9][10]. The network must be able to adaptively alter the routing paths to alleviate any of these effects. Many routing algorithms for ad hoc wireless networks today promise rapid network convergence, multi-hop routing capabilities and soft real-time performance. Routing metrics are important as they contribute to the success of the ad hoc protocols. Selecting the right routing metrics to be incorporated in a protocol would determine the efficiency and the reliability of the protocols. Several routing protocols have been proposed in the past both of proactive and reactive nature as well as and some that take a hybrid approach. An analytical performance comparison of some of the most important algorithms is presented, like Dynamic Source Routing (DSR), Ad hoc On demand Distance Vector Routing Protocol (AODV) and ZRP.

Fading is a serious impairing effect introduced by the radio wave's propagation through the channel and causes a big problem to the signal detection process at the receiver. When the signal experiences fading in the channel, both its envelope and phase will fluctuate over time. Where a coherent modulation scheme is concerned, the fading effects on the signal phase can seriously impair performance, unless some necessary receiving end even at the cost of complexity of the receiver. With two different fading models we have simulated the experiments. The methodology is used in order to isolate the impact on network performance. In this paper the comparison of DSR, AODV and ZRP routing protocol based on IEEE 802.11 is analyzed, compared and presented.

II.ROUTING PROTOCOLS: CLASSIFICATION IN BRIEF

Routing is the process of finding a path from a source to some arbitrary destination on the network. The routing protocols are classified as follows on the basis of the way the network information is obtained:

A. Proactive or Table-driven routing protocol

B. Reactive or On-demand routing protocol

C. Hybrid Protocols

These classes of routing protocols are reported but choosing best out of among them is very difficult as one may be performing well in one type of scenario the other may work in other type of scenario[3][8][11]. In this paper it is observed with the simulation of DSR, AODV and ZRP routing protocol.

III. RELATED WORK

A. Dynamic Source Routing (DSR) Protocol: DSR is based on the concept of source routing protocol wherein the sender node knows the complete hop by hop route to the destination and every generated data packet carries this information in its packet header. DSR is composed of two main mechanisms: Route Discovery and Route Maintenance [3] [4]. For route discovery the source node floods the route request (RREQ) packets in the network. The nodes receiving RREQ rebroadcast it and the process repeats until the destination node or an intermediate node having a route to the destination is found. Such a node replies back to the source with a RREP packet Route request (RREQ) and route reply (RREP) packets accumulate source route so that once a route is discovered, the source learns the entire source route and can place that route into subsequent data packets. The source node places the destination IP address, into the RREQ and broadcasts the message to its neighbor's node. When a node with a route to the destination receives the RREQ, it responds by creating a RREP to the source. Intermediate nodes have only to transmit the packet according to the source route. These routes are maintained in a route cache and are continually updated as new routes are learned (route cache entries need not have lifetimes). When a link break in an established path occurs, the node upstream of the break creates a route error (RERR) message and sends it to the source node. On receiving RERR the source node utilizes alternate routes from the route cache, if they are available, to prevent another route discovery [4]. The drawback with DSR is that it needs to place entire route in both the route replies and the data packets and thus requires greater control overhead. An advantage of DSR is that it does not make use of periodic routing advertisements so that there is saving in bandwidth and power consumption.

B. Ad Hoc on demand Distance Vector Routing (AODV) Protocol: There are different approaches for discovering routes in on demand algorithms AODV is amongst them. AODV relies on per-node sequence numbers for loop freedom and for ensuring selection of the most recent routing path. AODV nodes maintain a route table in which next-hop routing information for destination node is stored. To start route discovery, the source node creates a route request (RREQ) packet [1] [3]. This packet contains the destination node's IP address, the last known sequence number for that destination, the source's IP address and current sequence number. After creating this message, the source broadcasts the RREQ to its neighbors [5]. When a neighboring node receives a RREQ, it first creates a reverse route to the source node. The node from which it received the RREQ is incremented by one to get the hop distance from the source. In this manner, the RREQ floods the network in search of a route to the destination. Fig. 1(a) illustrates this flooding procedure. The reverse route as created above is utilized to send RREP hop by hop back to the source node as in Fig 1(b). Once the source receives the RREP, it can utilize the path for the transmission of data packets. AODV contains a number of optimizations and optional features. When a link break along an active path occurs, the node upstream of the break invalidates the routes to each of those destinations in its route table. It then creates a route error (RERR) message and also broadcasts the data packet to its neighbors. The propagation of RREQ is controlled by modifying the time to live (TTL) value of the packet as given in Fig 1(c). AODV doesn't broadcast update information of network topology in entire network periodically. Only when a data arrives from upper layer and it needs a route to the destination. AODV searches a route for the data and maintains the route.

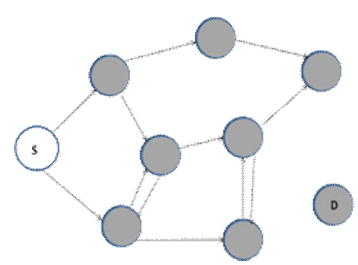


Fig. 1(a): RREQ Broadcast

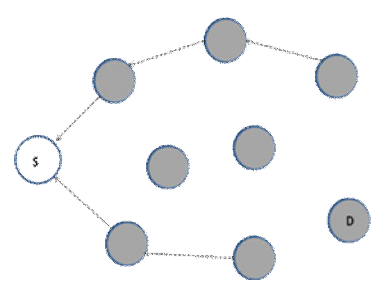


Fig. 1(b): RREP Propagation

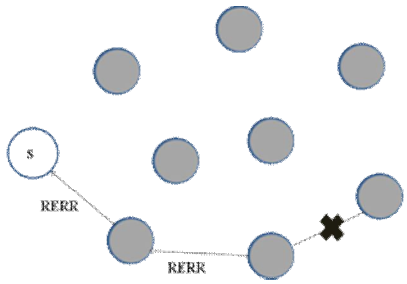


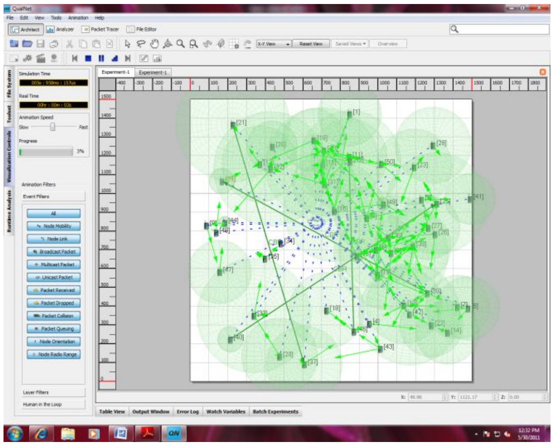
Fig. 1(c): RERR Message

Fig. 1: AODV route discovery and maintenance

C. Zone Routing Protocol (ZRP): ZRP is a hybrid routing protocol that combines proactive and reactive both strategies. ZRP was proposed to reduce the control overhead of proactive routing protocols and decrease the latency caused by routing discover in reactive routing protocols [3]. The basic Idea of ZRP defines a zone around each node consisting of its k-neighborhood (e. g. k=3). In ZRP, the distance and a node, all nodes within –hop distance from node belongs to the routing zone of node. ZRP is formed by two sub-protocols, a proactive routing protocol: Intra-zone Routing Protocol (IARP) is used inside routing zones to maintain routing information and a reactive routing protocol: Inter-zone Routing Protocol (IERP) is used between routing zones, respectively. IARP can be any type of routing: LS routing or distance vector routing depending on the implementation. If the source and destination is in the same zone, the packet can be delivered immediately [6]. Most of the existing proactive routing algorithms can be used as the IARP for ZRP. For routes beyond the local zone, reactive IERP is performed. IERP uses the RREQ/RREP packets to discover a route similar to the reactive routing protocol. When the intended destination is not known at a node that node must be outside of its zone. Therefore, a RREQ packet is broadcast via the nodes on the border of the zone. Hence the source node sends a route requests to its border nodes, containing its own address, the destination address and a unique sequence number. Border nodes are nodes which are exactly the maximum number of hops to the defined local zone away from the source. The border nodes check their local zone for the destination. If the requested node is not a member of this local zone, the node adds its own address to the route request packet and forwards the packet to its border nodes [8]. If the destination is a member of the local zone of the node, it sends a route reply on the reverse path back to the source. The source node uses the path saved in the route reply packet to send data packets to the destination. The hybrid schemes limits the proactive overhead to only the size of the zone and reactive search is to only selected border node.

IV. SIMULATION SETUP AND RESULTS

The Qualnet 5.0 network simulator is used to analyze the parametric performance of Dynamic Source Routing (DSR), Ad Hoc On-Demand Distance-Vector Protocol (AODV) and ZRP routing protocols. We have also used the wireless module to enable mobility of the wireless nodes and support more accurate wireless models for propagation, path loss, multipath fading and reception on wireless networks. The simulations were carried out for Rayleigh fading and Rician fading with network size 50 respectively. The image of the network as it appears in QualNet 5.0[7] is presented in Figure.



Experiment 1-

The simulation was configured with the following parameters:

Routing Protocols: DSR, AODV and ZRP
Fading Model: Rayleigh
Shadowing Model: Constant
Pathloss Model: 2Ray
Energy Model: user specified:
- Noise factor: 10db
- Temp: 290K
- Transmission Control Load: 280mamp
- Reception load: 204mamp
- Ideal current load: 178mamp
- Sleep current load: 140mamp
- Supply voltage of the interface: 3.0v
- Radio type: 802.11bradio

Battery Model: Simple linear
Mobility: Random Way Point
Mobility Speeds: 0 to 30 mps

Simulation time: 90 sec
Area: 1500x1500 meters

Case 1: With Rayleigh fading

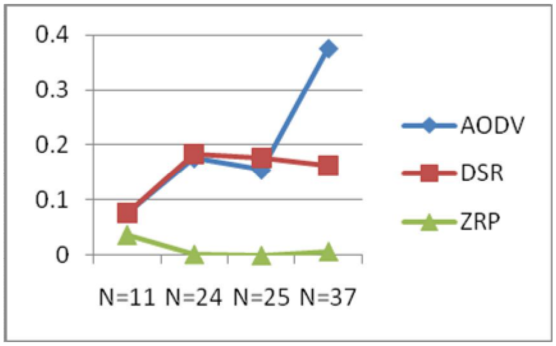


Fig. 2(a) Jitter(s)

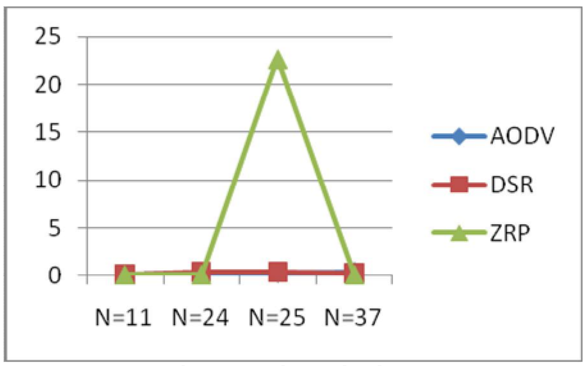


Fig. 2(b) Avg. End to End Delay (sec.)

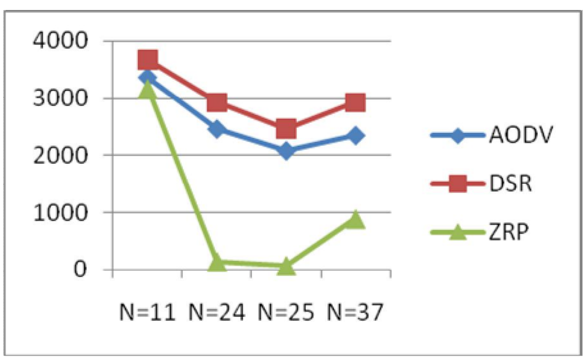


Fig. 2(c) Throughput (bits/sec)

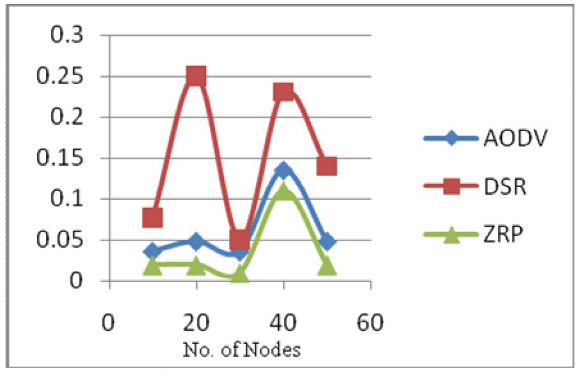


Fig. 2(d) Energy in transmitting mode (mJoule)

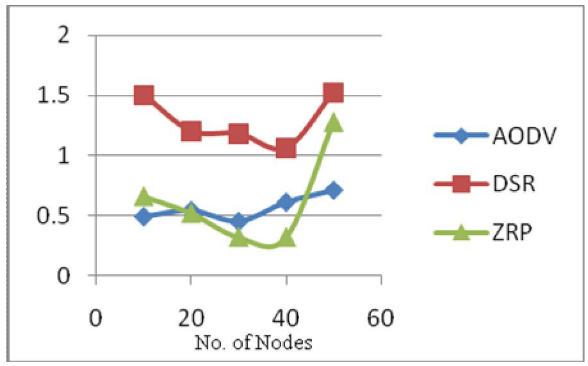


Fig. 2(e) Energy in receiving mode (mJoule)

Experiment 2-

The simulation was configured with the following parameters:

Routing Protocols: DSR, AODV and ZRP
Fading Model: Rician
Shadowing Model: Long Normal
Pathloss Model: Free space
Energy Model: MICAZ
Battery Model: Service Life Estimator
Mobility: Random Way Point
Mobility Speeds: 0 to 30 mps
Simulation time: 90 sec
Area: 1500x1500 meters

Case 2: With Rician Fading

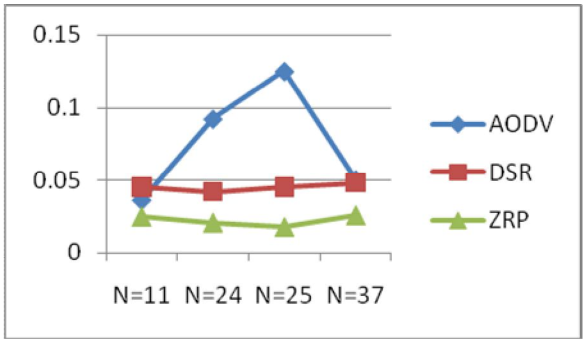


Fig. 3(a) Jitter(s)

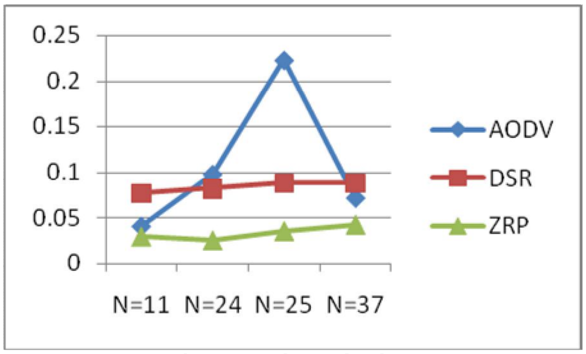


Fig. 3(b) Avg. End to End Delay (sec)

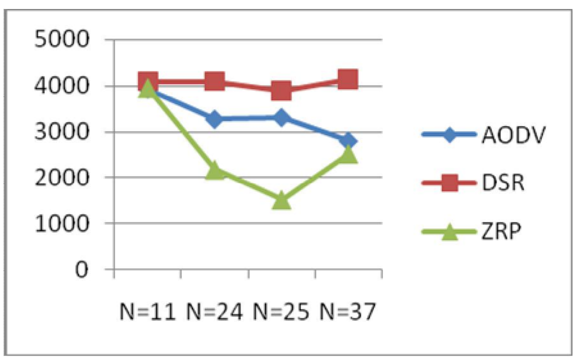


Fig. 3(c) Throughput (bits/sec)

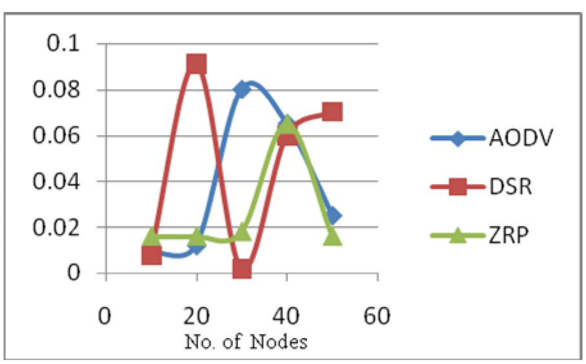


Fig. 3(d) Energy in transmitting mode (mJoule)

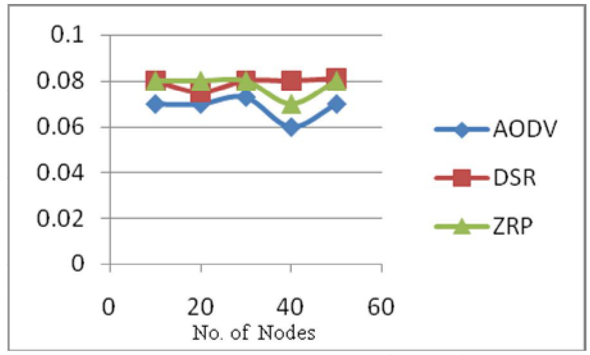


Fig. 3(e) Energy in receiving mode (mJoule)

V. CONCLUSION

In conclusion, a more reliable and efficient routing protocol is necessary in a mobile ad hoc network which considers mobility and longevity of a route as its main concern. Two reactive and one hybrid routing protocols have been simulated and evaluated using Qualnet tool. The main characteristic of ZRP has presented against DSR and AODV.ZRP protocol performed poorly throughout the simulation experiments. It has also observed the variation in packets i.e. jitter is maximum in case of Rayleigh fading as compare to the case of Rician fading. Delay is too long in the case of Rayleigh fading while in case of Rician it varies upto only 0.24sec. In both the cases DSR achieved high throughput in comparison to AODV and ZRP. Minmum throughput is achieved by ZRP. As for as energy parameter is considered, in case of Rayleigh fading the energy consumed in transmitting mode is maximum .25mjoule while in receiving mode it varies upto 1.5mjoule. Maximum energy is consumed by DSR on demand protocol and lesser by ZRP. On the other hand, when Rician fading is used, energy in transmitting mode varies maximum .09mjoule while in receiving mode it reaches upto .08mjoule.It is observed that maximum energy is consumed by DSR in transmitting mode but in receiving mode the energy consumption pattern is different as DSR, AODV and ZRP consume nearly same amount of energy. A comparative study between the Rayleigh fading and Rician fading considering energy metric it can be seen that the energy consumption is high in both the transmitting and receiving mode as comparison to the case of Rician fading.

Further research is needed to find most suitable protocol for each and every scenario condition so that an optimized routing protocol could be suggested for various real life applications of the simulated wireless network environment.

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Authors Profile

Khushboo Tripathi is a D.Phil. student in the Department of Electronics and Communication of J. K. Institute of Applied Physics and Technology, University of Allahabad, Allahabad. She obtained her master's degree in mathematics in 2005 from University of Allahabad. Also she received the MCA degree from Allahabad. Her research is in the area of Wireless Communication & networks, particularly in MANETs & WSN.

S. D. Dixit is a professor in the Department of Electronics and Communication Engineering, University of Allahabad at Allahabad. Presently he is Dean Faculty of science at University of Allahabad. He has teaching experience of 35 years in the field of Electronics and Communication Engineering at J.K. Institute of Applied Physics and Technology, University of Allahabad, Allahabad. He obtained M. Tech. and D.Phil. degrees in 1975 and 1981 respectively. He has published a number of research papers in National and International Journals. He is the fellow of IETE, India. His current interests are in the field of Wireless Communications, Coding and Cryptography.