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Improving Multi-path AODV by Utilizing All Available Paths for a Small Tactical Network

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***Abstract*—Nowadays, Most of the routing protocols support QoS provisioning using constraints like bandwidth, delay, packet delivery ratio, jitter etc, to achieve more deterministic behavior of the Networks. But very few routing protocols perform well in military applications for tactical scenarios like battlefield, disaster relief & rescue operations. In this paper we propose a variant to AODV for small military networks where packet delivery ratio is a vital QoS constraint. We have modified standard AODV protocol to improve QoS, specifically the Performance Delivery Ratio (PDR) for low mobility military applications. For simulation we have used radio's specifications for two types of military radios. Simulations were carried out by using QualNet network simulator and group mobility model & realistic tactical mobility are used. Comparison between AODV and proposed variant of AODV is done on the basis of Packet Delivery Ratio, Average end to end delay and Normalized routing load.**

Index Terms— ***AODV, MANET, Military Radio, QualNet, Routing, QoS.***

I. INTRODUCTION

Mobile Ad Hoc Networks (MANETs) are highly dynamic networks and formed by independent mobile nodes. They are highly responsive and a key enabling technology for quickly deployable tactical forces. MANETs are considered by many as fundamental to Global Information Grid [1].

Quality of Service (QoS) is a generic term defined as a set of service that needs to be met by network while transporting in packet stream from source to destination [2]. The service requirements often include performance metrics such as throughput, delay, packet delivery ratio, jitter (delay variance), bandwidth, reliability, etc., and different There are many issues and challenges in providing QoS like dynamically varying network topology, imprecise state information, lack of central coordination, error prone shared radio channel, hidden terminal problem, limited resource availability and insecure medium [3].

There are several major approaches for QoS routing and multipath routing in ad hoc networks. Ad hoc on-demand multipath distance vector routing (AOMDV) [4] and M-AODV [5] a variant to standard AODV [6] protocol, they have used multipath concept for increasing packet delivery ratio. AOMDV reduces the packet loss by up to 40% and has also improved end to end delay. M-AODV suggested that the discovering operations for reconstruction of paths should be done from the source [5]. In AODV-BR [12] proposes a scheme for alternate path when a link is broken and intermediate node search for the alternate path. [14] proposed the two variants of protocol Node-Disjoint MP-AOMDV & Link-Disjoint MP-AOMDV and investigated that node disjoint is more strict than the link disjoint protocol and thus produces less alternate routes. [13] proposed a node disjoint minimum interference multi-path (ND-MIM) routing protocol that finds the main route based on AODV, then backup route is searched when data transmission is in progress.

Many other solutions to multipath routing have been proposed [15] - [19]. In this work we have also used multipath mechanism for determining multiple routes but we have kept the number of routes to be used for data transfer as configurable parameter. The data to be transmitted is sent on all available routes. For simulation work we have considered two types of tactical radio with different physical layer characteristics and antenna specifications. Simulation is done in in two separate scenarios using group mobility & realistic tactical mobility and the actual specifications of the two military radios.

II. BACKGROUND

AD-HOC ON DEMAND DISTANCE VECTOR (AODV)

AODV routing protocol is a reactive protocol or demand driven protocol. AODV [6] uses a broadcast route discovery mechanism, and it relies on the dynamically established routing table entries at intermediate nodes. The path discovery process is initiated whenever a source node needs to communicate with another node for which it has no routing information in its table. The source node initiates path discovery by broadcasting a RREQ packet to its neighbors. When a node receives RREQ, and has routing information, it generates the RREP packet; otherwise it rebroadcasts the RREQ packet further to its neighbors. As RREQ packet travels from the source to destination it automatically sets up the reverse path form all nodes back to source. As the RREP travels back to the source, each node along the path sets up a forward pointer to the node from which the RREP came and updates its timeout information for the route entries to source and destination.

III. PROPOSED MODIFICATION IN AODV

In existing AODV, if a source node is going to transmit data to destination, the source node broadcast RREQ packets to all neighbors for having a route from source to destination with least hop count. On reception of a RREQ packet an intermediate node initiates RREP if it has route to destination otherwise it forwards the RREQ. If RREQ reaches the destination node then the RREP is initiated by destination node.

In tactical scenarios packet delivery is quite important and as there is not much traffic so we can transmit the same data on more than one route so we modified the standard AODV protocol to have multiple routes. When RREQ packet is received by a node, it checks that current node is destination node, generates the RREP packet respective of RREQ packet received and broadcast it on all interfaces running protocol. When this RREP packet is received by source node, checks for any route existence, check whether destination sequence number is greater than the one in the routing table and next hop is different from the address from the RREP came from. When source node is going to transmit data from source to destination it can select number of routes to be used for transmission and send the data on all selected paths and rest of the protocol behaves same as standard AODV does. We name the modified AODV protocol as Enhanced Packet Delivery Ratio AODV (EN-PDR-AODV).

IV. SIMULATION ENVIRONMENT & PARAMETERS

We have used QualNet [7] for carrying out the simulations. QualNet is a discrete event simulator which provides a scalable simulation environment for mobile ad hoc networks [7]. We have considered two different scenarios for tactical radios with group mobility and realistic model [11].

Tactical scenario with realistic mobility:

TABLE I. SIMULATION PARAMETERS

Parameter	Value
Simulation Area	1500 x 1500 m^2
Simulation Time	250 seconds
Node Density	10
Node Placement Model	Uniform
Packet Size	512 bytes
Traffic Type	Constant Bit rate(CBR)
Items to send	100
Mobility Model	Realistic Mobility
Frequency	512Mhz
Data rate	1Mbps
Antenna Model	Omni-directional

Tactical scenario with group mobility:

We modified the physical layer properties [10] of the nodes as per the specification of handheld & man-pack tactical radios. We have used a mix of both types of radios in our simulations. The handheld radios are assumed to be carried by as soldiers and man-packs mounted on military vehicles. So the maximum speeds have been set accordingly. In simulation there are 10 node and divided into two groups viz. 5 nodes (soldiers) and other as military vehicles. We have used group mobility with 100s pause time and network simulation area is 1km^2. Also in our simulation CBR traffic is used, data rate is 1Mbps and packet size is 512 bytes, simulation time is 900 sec. Other detailed physical layer parameter listing of simulation is provided in TABLE 2.

TABLE II. PHYSICAL LAYER SIMULATION PARAMETERS FOR TACTICAL SCENARIO

Parameter	Value
Maximum Speed (Hand-held & Man-pack) Man-pack assumed to be vehicle mounted	5km/h & 20km/h
Frequency	300Mhz
Transmission power (Hand-held & Man-pack)	33 dBm & 37 dB
Receive sensitivity (Hand-held & Man-pack)	-95 dBm & -100 dBm
Antenna Height (Hand-held & Man-pack)	20 cm & 1m
Efficiency	1 dB
Antenna Loss	2 dB

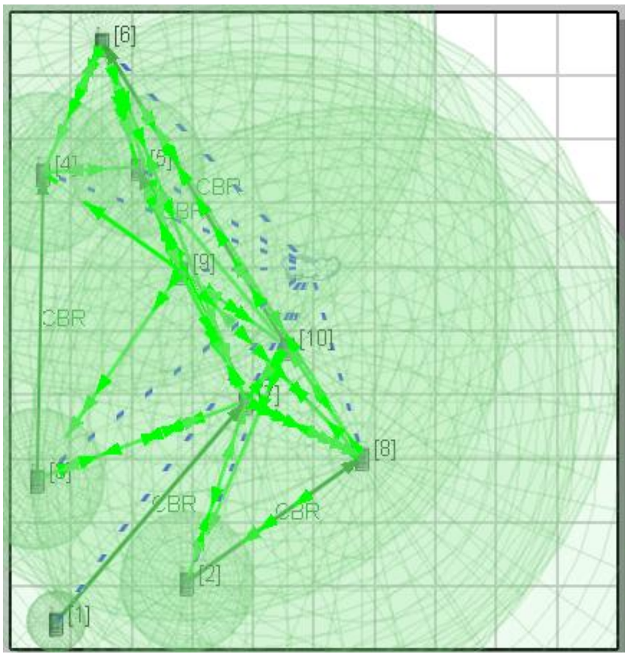

Fig 1. Snapshot of 10 nodes during simulation

The following metrics have been used for comparing the performance of routing protocols [8].

- **Packet Delivery Ratio (PDR)**: This is defined as the ratio of total number of data packets received by the destination nodes to the number of data packets sent by source node throughout the simulation.
- **Normalized Routing Load (NRL)**: Normalized routing load is ratio of total number of routing packets exchanged to the total data packets received by destination nodes.
- **Average End-to-End Delay (AED):** This is defined as average delay in transmission of a packet between two nodes.

V. Simulation Results

Simulation Results for Realistic Mobility:

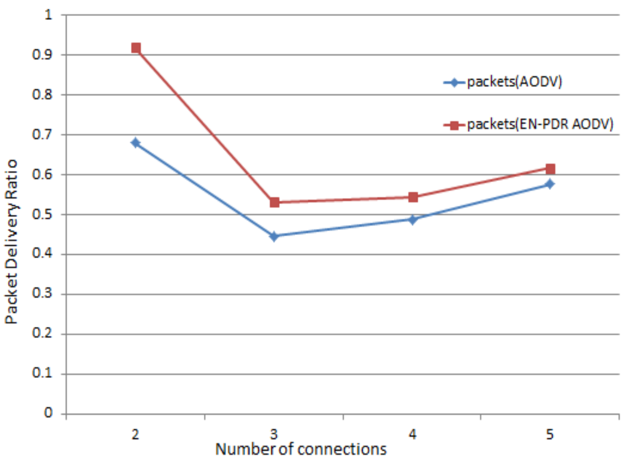

Fig 2. Packet Delivery Ratio Comparison in Realistic Mobility

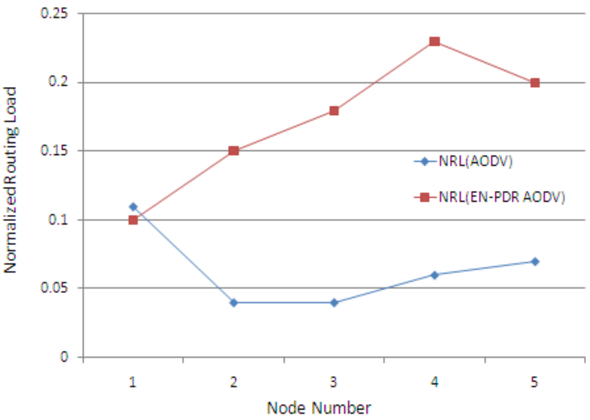

Fig 3. NRL Comparison

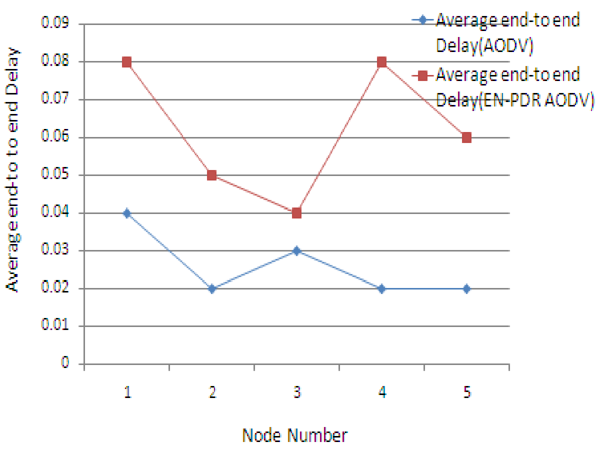

Fig 4. Average end to end delay Comparison

Results for Group Mobility:

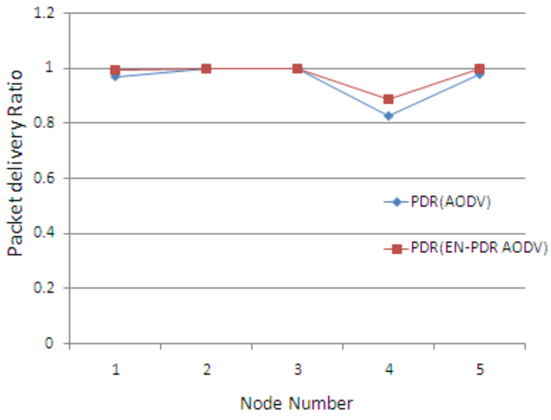

Fig 5. Packet Delivery Ratio Comparison in Group Mobility

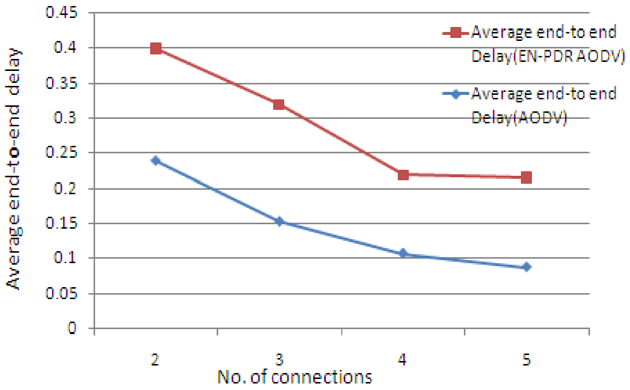

Fig 6. . Average end to end delay Comparison in Group Mobility

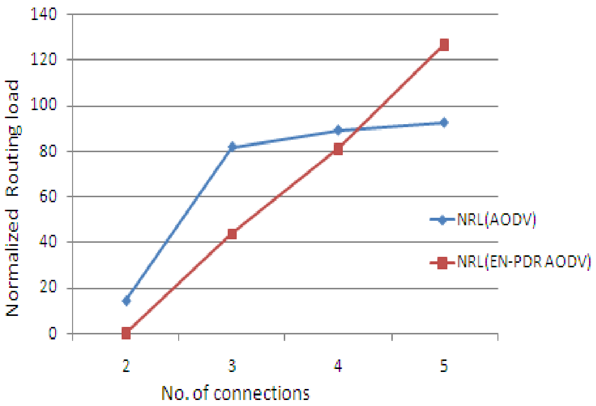

Fig 7. NRL Comparison in Group Mobility

CONCLUSION

The simulation results show that in both scenarios packet delivery ratio increases significantly as compared to Standard AODV protocol. But normalized routing load and average end-to-end delay also increase respectively. For small tactical networks with low traffic load the increase in routing overhead and delay can be traded off for increase in packet delivery ratio.

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