# Location and Mobility Optimized On-demand Geographical Multipath Routing Protocol for MANET

**M. Kokilamani**[1]
Research scholar, Department of Computer science,
Government Arts College, Udumalpet-642126. Tamil Nadu, India.
Email:kokilam.udt@gmail.com

**Dr. E. Karthikeyan**[2]
Head & Assistant Professor, Department of Computer Science,
Government Arts College, Udumalpet-642126. Tamil Nadu, India.
Email:e_karthi@yahoo.com

**ABSTRACT**

**The advancement of science and technology had made mobile ad hoc network an important tool to access network of next generation. Recently, numerous multipath routing protocols for mobile ad hoc network are reported in literature. Each routing methods works based on their salient feature, but failed to control congestion, energy efficiency, overhead packets, signal stability during data transmission which leads to edge effect, signal decay and bottleneck situation of the bandwidth consumption. In this paper a novel approach havely Geographical Distance based Ad Hoc On-demand Distance Vector Routing (GD-AOMDV), which selects the path based on transmission distance value to limit and control the congestion and control overheads has been proposed. The salient feature of the proposed model is that it establishes a relationship between path distance and MANET design parameters including transmission range, consumption of energy and bandwidth. The accuracy of the proposed scheme is analyzed and validated with the experimental results in respect to various flow using NS2 simulations.**

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## I. Introduction:

Recent advances in wireless communication technology pave way to significant attention to wireless ad hoc and mobile networks. The unstable nature of wireless communication and the lack of pre-defined infrastructure, the routing protocols for Mobile Ad-hoc Network (MANET)[1] [2] is a challenging issue. Dynamicity results in additional energy expenditure, increase in node failure affects the connectivity and network lifetime. Numerous routing protocols have been proposed to satisfy the demands of particular networks and real applications. These protocols have been designed for MANET to support various aspects such as purpose, energy constraints, network lifetime, degree of mobility, scalability, link reliability, node prediction, identification, cross layer design, communication, fault tolerance and maintenance needs. To design an efficient routing protocol by considering more factors implies high processing time, power consumption, overheads, congestion and latency in computing the route.

In general routing protocols are classified such as proactive, reactive, hybrid and geographic based routing etc. Pro-active routing is achieved by creating list or tables with destinations and possible paths towards the destinations. Periodically, these lists are distributed to nodes in the entire network, updating the link states. Through this mechanism, proactive routing creates a lot of traffic, and consumes excess bandwidth and a lot of power. Delay can also occur because of the slow network reaction to node mobility. Reactive routing can be a lower cost option than proactive because it does not use periodic broadcasts and initiates route discovery only when a message has to be sent, thus traffic decreases and overhead is reduced. However, using blind broadcasts (flooding and Route Request) results in energy expenditure and high latency. Scalability issues and network clogging can appear because of flooding. Hybrid techniques of routing are designed to combine the advantages in both reactive and proactive, but in general their scalability can be a problem.

Geographic routing [3] represents the algorithmic process of determining the paths in which to send traffic in a network, using position information/geographic location only about source, neighbors and destination. It is considered substantially better from an energetic point of view due to the use of solely local information in the routing process. As a result of this very little routing information being needed, no energy is spent on route discovery, queries or replies, node memory requirements are decreased and traffic overhead and computation time are considerably reduced. Also, in this sense it is different from source routing in which the sender makes some or all the routing decisions by having mapped the network and specifying in the packet header the hops that the message has to go through. In geographic routing, the process is localized and distributed so that all nodes involved in the routing process contribute in making routing decisions by using localization methods and computing the best forwarding options. However, each protocol has it strengths and weaknesses and all of the geographic location-based protocols present a novel idea or improve an old one.

In addition, routing protocols in mobile ad-hoc networks face problems to work well due to frequent varying network topology, not having predefined infrastructure like routers, peer-to peer mode of communication and restricted transmission communication range. In recent developments of routing protocols, geographic location-based routing protocols [4] exhibit better scalability, performance and robustness against frequently changing topology of the networks. Geographic protocols are currently being thoroughly studied due to their application potential in networks with demanding requirements. Their main characteristic is that they make use of location information for routing decisions. It is an elegant way to forward packets from source to destination in the demanding environments without wasting network resources or creating any impediment in the network design. Therefore it is generally considered as an attractive routing method for both wireless ad-hoc and sensor networks.

In this paper, a novel approach has been proposed by combining reactive and geographic routing to make an efficient routing. Each node updates its own position by the use of localization techniques and forwards the data to all the nodes in the network at the time of route discovery. The accuracy of nodes information results that less overheads for path prediction, maintenance, avoid congestion, queuing, and consume less energy.

The remaining of the paper is organized as follows. Followed by the simple introduction, Section II briefs the related work done in this field and Section III illustrates the proposed scheme. The results obtained from the proposed scheme are discussed in Section IV. Section V concludes the paper.

## II. Related Works

Ko and Vaidya [5] presented Location-Aided Routing (LAR) protocol which uses the location information to identify the request zone and expected zone. Request zone in this protocol is the rectangular area including both senders as well as receivers. By declining the search area, this protocol leads to the decrease in routing overheads.

Zaruba, Chaluvadi and Suleman [6] proposed Location Area Based Ad-hoc Routing (LABAR ) protocol. It requires only a subset of nodes to know their exact location forming location areas around these nodes. Nodes that are enabled with GPS equipment are referred to as G-nodes. G-nodes are interconnected into a virtual backbone structure to enable efficient exchange of information for the mapping of IP addresses to locations. This protocol is a combination of proactive and reactive protocols, because a virtual backbone structure is used to disseminate and update location information between G-nodes, while user packets are relayed using directional routing towards the direction zone of the destination.

Karp and Kung [7] proposed Greedy Perimeter Stateless Routing (GPSR) which uses the location of node to forward the packets on the basis of distance. The packets are forwarded on a greedy basis by selecting the node closest to the destination. This procedure continues until the destination is reached. In some cases the best path may be through a node which is farther in distance from the destination node. In such scenario right hand rule is applied to forward around the obstacle and resume the greedy forwarding as soon as possible.

Tzay and Hsu [8] presented a location based routing protocol called LARDAR. Firstly, it uses the location information of destination node to predict a smaller triangle or rectangle request zone that covers the position of destination in the past. The lesser route discovery space reduces the traffic of route request and the probability of collision. Secondly, in order to adapt the exactness of the estimated request zone, and reduce the searching range, it applied a dynamic adaptation of request zone technique to trigger intermediate nodes using the location information of destination node to redefine a more precise request zone. Finally, an increasing exclusive search approach is used to redo route discovery by a progressive increasing search angle basis when route discovery failed.

Mohammad A. Mikki [9] introduced an Energy Efficient Location Aided Routing (EELAR) Protocol for MANETs that is based on the Location Aided Routing (LAR). EELAR makes significant reduction in the energy consumption of the mobile nodes batteries by limiting the area of discovering a new route to a smaller zone. Thus, control packet overhead is considerably condensed. In EELAR the wireless base station is used and the network's circular area cantered at the base station is divided into six equal sub-areas. At route discovery as an alternative of flooding control packets to the whole network area, they are swamped to only the sub-area of the destination mobile node. The base station provisions locations of the mobile nodes in a position table.

Karim El Defrawy and Gene TsudikIn [10] addressed some interesting issues arising in suspicious MANETs by designing an anonymous routing framework (ALARM). It uses node’s current locations to construct a secure MANET map. Based on the recent map, every node can decide which other nodes it wants to communicate with it. ALARM takes benefit of some advanced cryptographic primitives to achieve node verification, data integrity, anonymity and intractability (tracking-resistance). It also offers opposition to certain insider attacks.

Haiying Shen and Lianyu Zhao [11] proposed an Anonymous Location-based Efficient Routing protocol (ALERT) to offer high anonymity protection at a low cost. ALERT dynamically partitions the network field into zones and randomly chooses nodes in zones as intermediate relay nodes, which structured a non-traceable anonymous route. Furthermore, it hides the data initiator/receiver among many initiators/receivers to reinforce source and destination anonymity protection. ALERT achieves better route anonymity protection and lower cost compared to other anonymous routing protocols. Also, ALERT achieves analogous routing effectiveness to the GPSR geographical routing protocol.

Mohammad Al-Rabayah and Robert Malaney [12] introduced a new hybrid wireless routing protocol specifically designed to address this issue. This protocol combines features of reactive routing with location-based geographic routing, in such a manner so as to efficiently use all the location information available. The protocol is designed to gracefully exit to reactive routing as the location information degrades. Another aspect of this protocol is that it can be spatially dependent and different physical areas of the network can be using quite different routing procedures at the same epoch. This protocol can dramatically increase scalability can be measured via the routing control overhead.

Dan Luo and Jipeng Jhou [13] proposed an improved Hybrid Location based routing protocol approach combines geographic routing with topology based routing protocol. It over comes the major problems of reactive routing and the end-to-end delay is reduced by this algorithm. In addition, the path length performance of geographic routing is also improved. This routing protocol outperforms the pure reactive routing in terms of average delay and packet delivery rate.

Lee, Yoo and Kim [14] proposed a mechanism that considers not only the location of nodes but energy consumption to solve the several problems in wireless networks by improving LAR algorithm. This protocol provides efficient routing by minimizing the flooding of unnecessary control message, considering the limited energy of a mobile node and using appropriate transfer power to communicate. Proposed scheme can reduce energy consumption and the average lifetime increases 12 percent than Location Aided Routing Protocol.

Shanshan, Yanliang, Yonghe, Mohan [15] proposed LOOP (A Location Based Routing Scheme for Opportunistic Networks), a new location based routing scheme for opportunistic networks. By forwarding messages to specified location instead of a targeted node, LOOP can serve as the underlying routing protocol for a plethora of pervasive applications. This protocol effectively employs node's movement patterns that are learnt from mobility trace in message forwarding. They evaluate the performance of LOOP and compare with well known protocols including Epidemic, Prophet and Bubble Rap. The Proposed scheme is able to deliver messages at a high ratio; drastically reduce network load and nodes' buffer occupation, especially when more messages are involved in the network.

Prakash Raj, Selva Kumar, Lekha [16] proposed protocol LBRP (Location-Based Routing Protocol) for ad hoc networks based on location system .The aim is extracting an optimum topology from the dynamic and irregular topology of a mobile ad hoc network to reach more quickly the destination applying for routing. The method operates in a loop free manner.

Kim, Young-Song, Hwang [17] proposed the location-based routing algorithm that is possible to have a stable data transmission with less energy consumption. The proposed technique does not ask for the BS to be aware of locations of nodes and tries to consume balanced distributed energy of all nodes through the lifecycle of the network. It also operates location-based routing algorithm which transmits location information of node with cluster based to widen extension and mobility and makes itself possible to apply to the distributed environment network.

Haidar Safa, Hassan Artail and Diana Tabet [18] proposed a novel cluster based trust-aware routing protocol (CBTRP) for MANETs to protect forwarded packets from intermediary malicious nodes. The anticipated protocol organizes the network into one-hop disjoint clusters then elect the most qualified and trustworthy nodes to play the role of cluster-heads that are responsible for handling all the routing activities. The anticipated CBTRP continuously ensures the trustworthiness of cluster-heads by replacing them as soon as they become malicious and can dynamically update the packet path to avoid malicious routes.

Putthiphong Kirdpipat and Sakchai Thipchaksurat [19] presented the impact of mobility on a scheme called Location-based Routing with Adaptive Request Zone (LoRAReZ). In LoRAReZ, the size of expected zone and request zone is set adaptively based on the distance between the source node and destination node. Proposed protocol evaluates the impact of mobility on the performance of LoRAReZ in terms of packet delivery fraction, routing overhead, end-to-end delay, and throughput and power consumption by comparing with those of the traditional Ad Hoc On-Demand Distance Vector (AODV) and Modified Ad Hoc On-Demand Distance Vector (M-AODV).

Juanfei Shi and Kai Liu [20] proposed A power efficient location-based cooperative routing algorithm (PLCR) to reduce the overall power for routing in wireless networks. With hypothetical analysis, by means of a cooperative relay, the likelihood of successful packet reception can be enlarged, and the overall power for routing can be condensed, given the outage probability of the link controlled at a definite objective level. The PLCR algorithm uses the location information of nodes to select the finest next-hop node and supportive node hop by hop with minimum power so that the cooperative route with minimum overall power from source to destination can be set up. PLCR routing algorithm considerably reduces the overall power in comparing to non-cooperative routing algorithm.

S. Basagni et al. [21] proposes DREAM (A Distance Routing Effect Algorithm for Mobility) which maintains each node's location information in routing tables. Data packet is send by using this location information. To maintain the location table accurately, each node periodically broadcasts a control packet containing its own coordinates maintain the location table accurately; each node periodically broadcasts a control packet containing its own co-ordinates.

## III. Geographical Distance Based Ad Hoc On-demand Multipath Distance Vector Routing Protocol:

The path selection process for distribution of packets along network path basically depends on the number of hops from the source to destination. In this paper, we present the concept of choosing the path which is based on the geographical distance based routing scheme called **Geographical Distance Based Ad Hoc On-demand Multipath distance Vector Routing Protocol (GD-AOMDV)** from the source to destination. The proposed approach selects multiple paths based on the transmission distance and choose minimum transmission distance path for communication. In Route Discovery phase, the RREQ packet collect the distance information of all intermediate nodes till it reaches the destination. Then destination sorts all available paths with the consideration of transmission distance value. The reason for choosing the paths based on the geographical distance is that to reduce end-to-end delay, congestion and to reduce large queue of packets to move along the shortest path traffic. Although this distance based path selection scheme relate the concepts of energy consumption and success ratio of packet transmission in analysis part.

In general path selection is basically done by selecting minimum number hops on the path (Shortest path). Some times the selection of hops may be few but the transmission distance is high. While selecting shortest path the center of the network become more congestion compared to the perimeter of the network and leads to path breakage, packet loss, node over usage. Another thing to be considered is that when choosing shortest path, the hop is usually present at the transmission edge because of which earlier outcome of the hop from the transmission edge happens. So that topology of the network changes dynamically. Even though by using distance metric for path selection in the proposed GD-AOMDV scheme, the number of hops may increase the delivery of packet to the destination, reduces delay and decrease energy consumption.

If paths are chosen based on the distance then the number of hops within the network coverage is high, so that if any moves out of the coverage an alternate nearby hop takes the path and energy required for transmission is also optimally maintained. Besides the traffic outcome of the hop from the network coverage is the most important thing to be considered for selecting paths because the waiting time for the packets along the path reduces considerably.

The distance between two nodes can be determined by the Euclidean distance is as follows:

$$D_{P_i} = \sqrt{\left(S_{xi} - S_{xj}\right)^2 + \left(S_{yi} - S_{yj}\right)^2} \quad - \ 3.1$$

where $S_i$ and $S_j$ are nodes to find the distance D of the path $P_i$. To find distance of multiple path on the network $P_n$ is as follows:

$$D_{P_n} = \sum_{P_i}^{p^n}\left(D_p\right) \quad - \ 3.2$$

From the above discovered paths our approach selects the path that has the minimum transmission distance, that is

$$GD - AOMDV = \min\left(D_{P_n}\right) \quad - \ 3.3$$

While using this approach the power consumption, signal strength and mobility are intently achieved. We analyzed and evaluated the occasions when a sender can use this mechanism to improve the packet delivery and transmission bandwidth.

**Analysis of signal strength, power consumption, distance and mobility**

Mobile nodes usually communicate with each other using radio signals. If the transmission distance of the routing path increased, the increased distance may cause topology changes, signal problem and more energy consumption to make difficult for routing decision. To prevent this, the proposed novel route selection policy Geographical Distance based Ad Hoc On-demand Distance Vector Routing (GD-AOMDV) selects the path based on transmission distance value to consume less power, bandwidth and overheads. So we analyze the relationship between power signal strength, distance and power consumption. From Stojmenovic and Lin [22], the relationship between power signal strength and distance is shown as:

$$S_r = S_t\left(\frac{\lambda}{4\pi d}\right)^n g_t g_r \quad - \ 3.4$$

Where λ is the wavelength, d is the distance from the sending node to the receiving node, $S_r$ is the receiving power signal strength, $S_t$ is the transmitting power, n is the co-efficient of the power delay and is bigger than 2 and $g_t$ , $g_r$ are the antenna parameter of the sending/receiving node. So receiving signal strength is as follows:

$$S_r = S_t\left(\frac{1}{d}\right)^n * \alpha, \text{ where } \alpha = \left(\frac{\lambda}{4\pi d}\right) g_t g_r \quad - \ 3.5$$

Based on the above equations, we can see that when a signal received by a node decreases due to mobility and transmission distance, the successful ratio of the data transmission also decreases. In the following, to obtain the relationships among the transmission distance, received signal strength and power consumption, we take into account the successful ratio of data transmissions between nodes. To compute the success ratio of data transmissions between two nodes, we obtain its SNR (signal-to-noise ratio) from the receiving power signal strength and environmental noise $N_o$.

$$\mathbf{SNR_r = \frac{S_r}{N_o} = \frac{S_t}{N_o\, d^n} * \alpha} \qquad \text{- 3.6}$$

Also each packet has its BER (Bit Error Rate) from the SNR. So

$$\mathbf{BER = Q\sqrt{2\, SNR_r} = Q\left(\sqrt{2\frac{S_r}{N_o}}\right)} \qquad \text{- 3.7}$$

When we obtain a BER of the received data signal, from Proakis[23] we obtain the successful ratio SR (Success Ratio) of data transmission as

$$\mathbf{SR = 1 - P, where\ p = Packet\ Size * BER} \qquad \text{- 3.8}$$

Where packet size is the size of a packet and p is the error ratio of the received packets. This results that the equation (3-1) and (3-3) shows when transmission distance increases the success ratio of data transmission decreases. We also analyze the power consumption of transmitting data using a relay model. Therefore the power consumption required to transmit a packet from a sending node to a receiving node is in direct ratio to n to the power of the distance. The relationship between the power consumption and the successful ratio for data transmission is shown here

$$\mathbf{PC = (PC_{tx} + PC_{rx}) * \frac{1}{SNR}} \qquad \text{- 3.9}$$

Where $PC_{tx}$ and $PC_{rx}$ are the power consumed in transmitting a packet and receiving a packet respectively. SNR is the successful ratio for transmitting a packet.

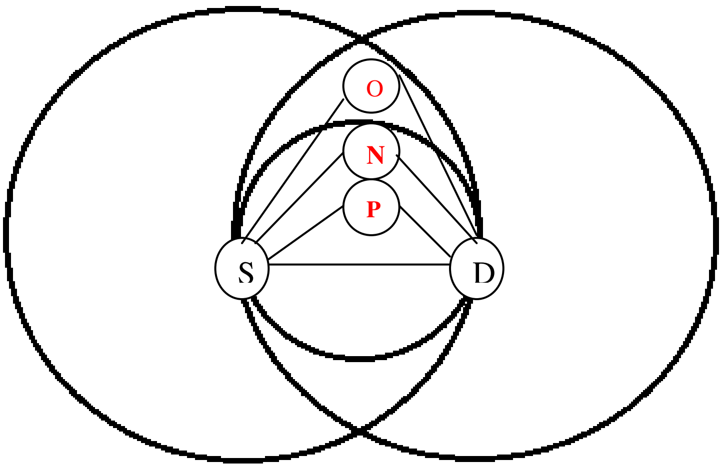



**Figure-1. Three possible locations, P, N, and O of a neighbor for nodes S and D.**

Figure 1 shows three ranges for a neighbouring node. A neighbouring node can be inside the circle, outside the circle or on the edge of the circle. The circle is formed from the diameter of the line segment SD this is called as transmission edge, where S is the sending node and D is the receiving node. From the three ranges mentioned above node S, node D, and a neighbouring nodes P,N and O may form a right triangle, an obtuse triangle, or an acute triangle. Based on Power Consumption, if a neighbouring node is inside the circle formed by the line segment SD, the power consumed in transmitting data from node S to node D via the neighbouring node is less than the power consumed in transmitting data from node S to node D directly.

Finally, if a neighbouring node is outside the circle, the power consumed in transmitting data from node S to node D directly is more than the power consumed in transmitting data with the help of the neighbouring node. As a result, if a neighbouring node is inside the circle, the power consumed in transmitting a packet via the neighbouring node is less than the power consumed in transmitting a packet directly. This results that the nodes inside the transmission edge consume less power than nodes on the transmission edge. So to select minimum transmission distance path between intermediate nodes consume less energy than selecting shortest path (minimum no of hops) for data transmission. It also prolong node, network lifetime and cope up with topological changes.

## IV. Illustration of the proposed scheme

Let us consider the following Figure-2 the circles represents the wireless nodes and lines represents the paths from source S to destination D. The source node deliver the packets along the path based on the transmission distance metric to destination. The number of paths for the packets to travel from the S to D are P1,P2,P3, P4, P5, P6 ,P7,P8,P9. The transmission distance for all paths can be obtained by using the equation (3.1) and (3.2). The proposed scheme selects the minimum transmission distance path by using equation (3-3).

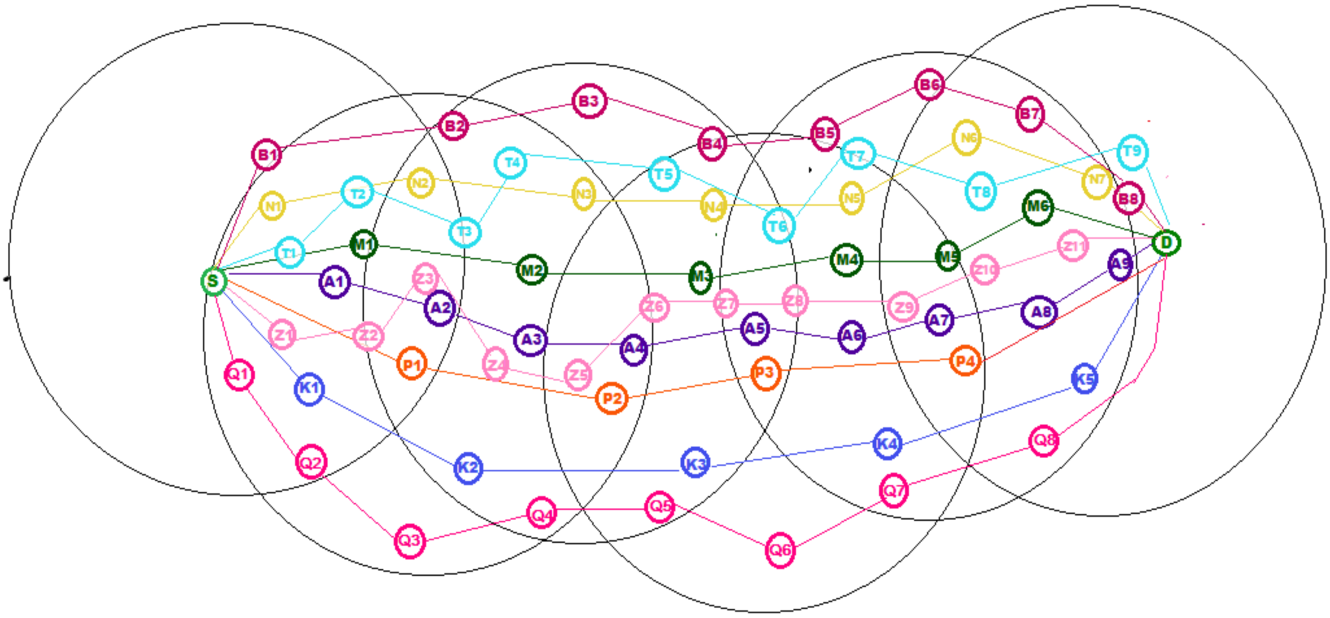



**Figure-2: GD-AOMDV Route discovery process**

The Table-1 shows each path with its hop count, nodes position and total length of the path. Based on the total length the paths are ordered by using equation (3.3). The proposed scheme choose minimum distance path P1 (20.86 m) with 6 hops as primary path for the data transmission to control congestion and overheads. By using general approach the shortest path is based on number of hops, so P4(22.91 m) is primary path with 4 hops. While using the general approach the transmission distance is increase, so it consume additional energy power to transmit the data, also the hops (P1,P2,P3,P4) are positioned near by the transmission edge which moves out of the transmission range due to mobility. It initiates route re-discovery and additional overheads and processing cost, the signal strength is also weak .It leads to congestion , energy depletion and re-route discovery problem.

| **Paths & no of hop** | **Nodes and their distance value (in meter)** | **Total length of the path** |
|---|---|---|
| P1- (6) | M1(12,16.5),M2(15,17),M3(18,16),M4(21,14),M5(23.5,13.5),M6(26,14) | 20.86 |
| P2 - (11) | Z1(10,17.5),Z2(11.5,17.5),Z3(13,17.5),Z4(14.5,16.5),Z5(16,16), Z6(18,15.5),Z7(19.5,15.5),Z8(21,13),Z9(23,14.5),Z10(25,14.5),Z11(27,14.3) | 21.39 |
| P3- (8) | T1(11,19),T2(13,19),T3(14.5,18),T4(17,18),T5(19,17),T6(21,16), T7(23,15), T8(25,15),T9(27,14.5) | 22.06 |
| P4 - (9) | A1(11,18),A2(13,17),A3(15,16),A4(17,15.5),A5(19,14),A6(21,13), A7(23,12.5),A8(25,13),A9(27,13.5) | 22.91 |
| P5 – (4) | P1(12.5,16),P2(17,14.5),P3(20.5,11.5),P4(25,12) | 22.96 |
| P6 – (8) | B1(11.5,21.5),B2(15,21),B3(18,20.5),B4(19,20),B5(21,20),B6(23,19.5) B7(25,18),B8(27,16) | 23.46 |
| P7- (7) | N1(11,20),N2(13.5,20),N3(16,20),N4(18,18),N5(22,18),N6(24,16), N7(27,15) | 23.46 |
| P8- (5) | K1(10,16),K2(14,13.5),K3(18,11),K4(22,12),K5(26.5,10.5) | 25.76 |
| P9 – (8) | Q1(8.5,17),Q2(10,14.5),Q3(11.5,12.5),Q4(14,12),Q5(16,10),Q6(19,9), Q7(22,9),Q8(25.5,8.5) | 29.26 |

**Table-1: Paths and Total length obtained by GD-AOMDV approach.**

But the proposed approach reduces the transmission distance, less energy consumption for transmitting a packet, the successful ratio of data is high due to the mobility and topological changed, the signal strength is also optimally managed and produce less overheads for path selection process.

## V. Simulation of the Proposed Scheme

We consider the AOMDV [24] protocol to compare with the proposed GD-AOMDV and NS2 is used to simulate the results. The performance metrics such as Average End-to-End Delay, Minimum Energy consumption, Packet delivery fraction, Packet loss Ratio, Routing Overheads and Throughput are taken into account. The considered simulation parameters are given in Table-2:

| Parameter | Value |
|---|---|
| **Simulator** | NS-2.34 |
| **Simulation time** | 100 seconds |
| **Simulation Area** | 1520x1520 $m^2$ |
| **Transmission Range** | 250 m |
| **Packet Size** | 512 bytes |
| **Traffic & Mobility model** | CBR/TCP |
| **Traffic Rate** | 10 packets/second |
| **Simulation Model** | Random Way Point |
| **Pass Time** | 5 seconds |
| **Number of nodes** | 100 |
| **Mobility Pattern** | 20,40,60,80,100 |
| **MAC Type** | 802.11 DCF |
| **Channel Type** | Wireless Channel |
| **Routing Protocols** | AOMDV, GD-AOMDV |
| **Antenna Model** | Omni |
| **Network Load** | 4 packets/sec. |
| **Number of Connections** | 1, 5, 10, 20, 30, 40 |
| **Radio Propagation Model** | TwoWayGround |
| **Idle Power** | 0.0001 W |
| **Transmission Power** | 1.0 W |
| **Receiving Power** | 1.0 W |
| **Transition Power** | 0.002 W |
| **Transition Time** | 0.005 Sec. |
| **Initial Energy** | 100 Joules0 |
| **Interface Queue Length** | 50 |
| **Interface Queue Type** | DropTail/PriQueue |
| **Speed** | 5 m/sec. |
| **Frequency** | 2.4 GHz |
| **Data Rate** | 11.4 Mbps |
| **Carrier sensing range** | 500 m |
| **Carrier receiving range** | 250 m |

**Table-2: Simulation Parameters for GD-AOMDV**

**1) Average End-to-End Delay Analysis with Normal AOMDV and GD-AOMDV**

Average End-to-End Delay is represented by the time it takes for successful packet transmission. It includes all possible delays such as buffering during the route discovery latency, queuing at the interface queue, retransmission delay at the MAC, the propagation and the transfer time is calculated as follows:

$$\text{Average E} - 2 - \text{E Delay} = \frac{\sum_{i=1}^{n} R_I - S_I}{n}$$

Where n is the number of data packets successfully transmitted over the MANET, ' i ' is the unique packet identifier, Ri is the time at which a packet with unique identifier ' i ' is received and Si is the time at which a packer with unique identifier ' i ' is sent

**Table-3: Average End-to-End Delay**

| No of connections | AOMDV (in econds) | GD-AOMDV (in seconds) |
|---|---|---|
| 1 | 1.138 | 1.174 |
| 5 | 1.499 | 1.545 |
| 10 | 1.894 | 1.895 |
| 20 | 3.074 | 2.902 |
| 30 | 5.722 | 5.958 |
| 40 | 13.724 | 11.864 |

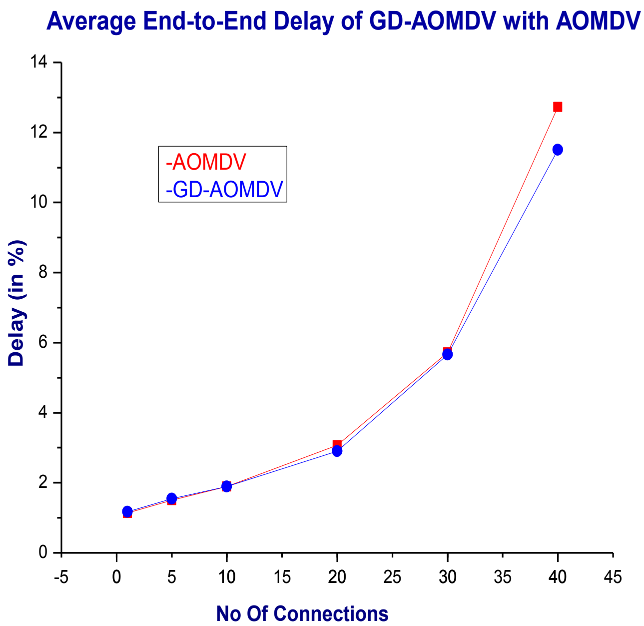



**Figure-3: Average End-to-End Delay of GD-AOMDV with AOMDV**

Here the average end-to-end delay for tested AOMDV protocol increases when increasing the network flow with various load, but in GD-AOMDV delay is decreases with significant value in Table-2. Also AOMDV selects shortest hop based path instead of GD-AOMDV selects distance based path for data transmission, so congestion and packet queue waiting time are low. The proposed scheme show significant improvements with mobility increases. In AOMDV routing the performance of network degrades but proposed GD-AOMDV scheme gives better performance than previous approach. The Table-3 and figure-3 illustrate an average delay time by each protocol.

**2) Minimum Energy consumption Analysis with Normal AOMDV and GD-AOMDV:**

In this analysis the energy consumption for packet transmission (transmitting and receiving) is taking into account. The Total energy consumption is calculated as follows:

$$\text{Total Energy Consumed} = \sum_{i=1}^{n} (\text{Initial Energy}_i - \text{Residual Energy}_i)$$

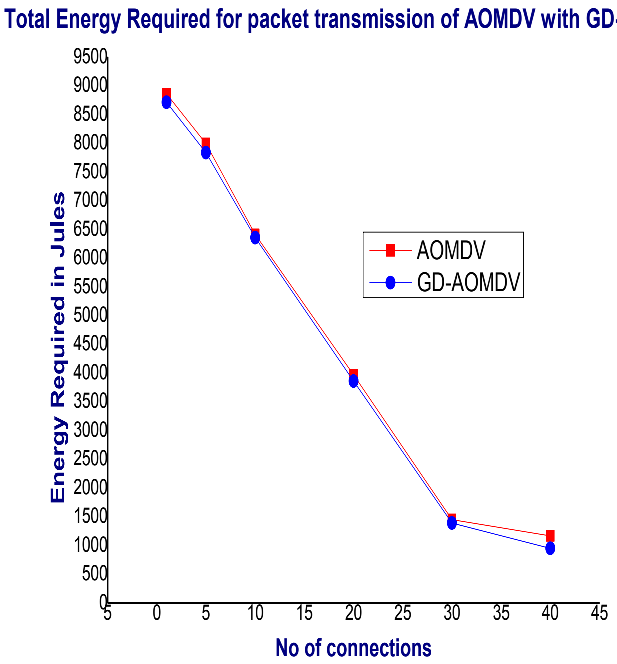



**Figure-4: Energy consumption of GD-AOMDV with AOMDV**

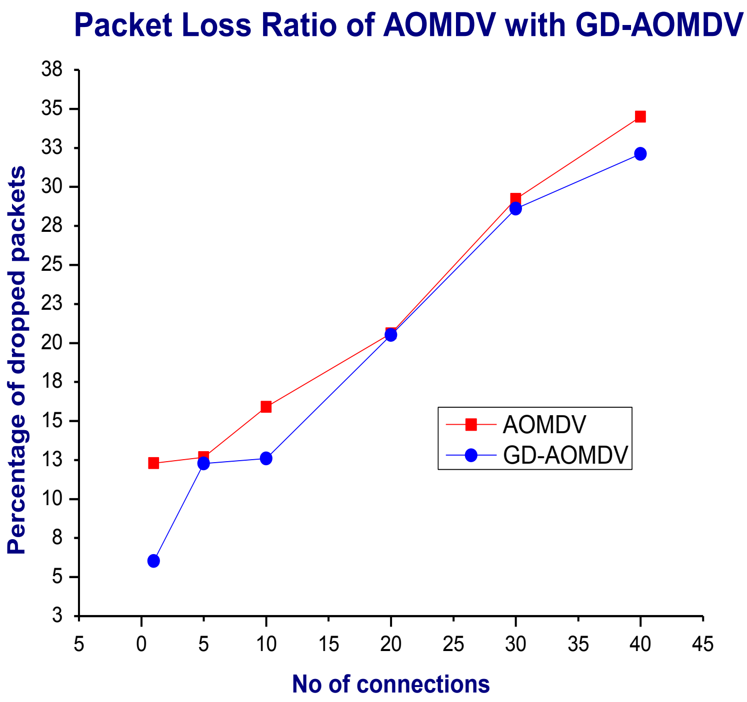
| Table-4: Minimum Energy consumption | | |
|---|---|---|
| **No of connections** | **AOMDV (in Jules)** | **GD-AOMDV (In Jules)** |
| 1 | 8860.36 | 8712.16 |
| 5 | 7995.51 | 7835.26 |
| 10 | 6411.57 | 6358.88 |
| 20 | 3971.42 | 3858.41 |
| 30 | 1452.64 | 1391.60 |
| 40 | 1168.67 | 1153.01 |

Here we consider node selection based on its location information for route selection. Thus GD-AOMDV balances the energy among all the nodes and prolongs the individual node lifetime and hence the entire network lifetime. Without considering the transmission distance and energy cost for transmitting a packet to that distance the AOMDV required more energy for packet transmission during communication shown in Table-4. Our scheme finds location aware path and prolong energy of node shown with figure-4:

**3) Packet Loss Ratio Delay Analysis with Normal AOMDV and GD-AOMDV**

The ratio of data packets not delivered to the destination to those generated by the sources are calculated by

$$\text{Packet Loss Ratio} = \frac{\text{No of Data Packets Sent} - \text{No of Data Packets Received}}{\text{No of Data Packets Sent}} * 100$$




| Table-5: Packet Loss Ratio | | |
|---|---|---|
| **No of connections** | **AOMDV (in %)** | **GD-AOMDV (in %)** |
| 1 | 12.290 | 6.017 |
| 5 | 12.684 | 12.267 |
| 10 | 15.899 | 12.600 |
| 20 | 20.604 | 20.516 |
| 30 | 29.233 | 28.604 |
| 40 | 34.489 | 33.112 |

**Figure-5: Packet losses of EA-AOMDV with AOMDV**

The reasons for packet drops can be incorrect routing information, mobility & power management. AOMDV cannot maintain precise routes and drops, when connections increased often. The usage of state routes from its caches is the major reason for AOMDV packet drops. In this graph the packet loss analysis has been done in both the cases, normal AOMDV and GD-AOMDV scheme. Here the packet loss is more in case of normal AOMDV and it means that only the concept of multipath routing does not provide the reliable packet delivery but if we enhance the performance of AOMDV by including the concept of transmission, it extends network lifetime. In this technique the packet loss has minimized. It means that there is a significant difference in packet loss between normal AOMDV and GD-AOMDV technique. The Table-5 and figure-5 illustrate that the number of packets dropped by each protocol.

**4) Packet Delivery Ratio Delay Analysis with Normal AOMDV and GD-AOMDV**

The ratio of data packets delivered to the destination to those generated by the sources and is calculated as follows:

$$\text{Packet Delivery Ratio} = \frac{\text{Number of Data Packets Received}}{\text{Number of Data Packets Sent}} * 100$$

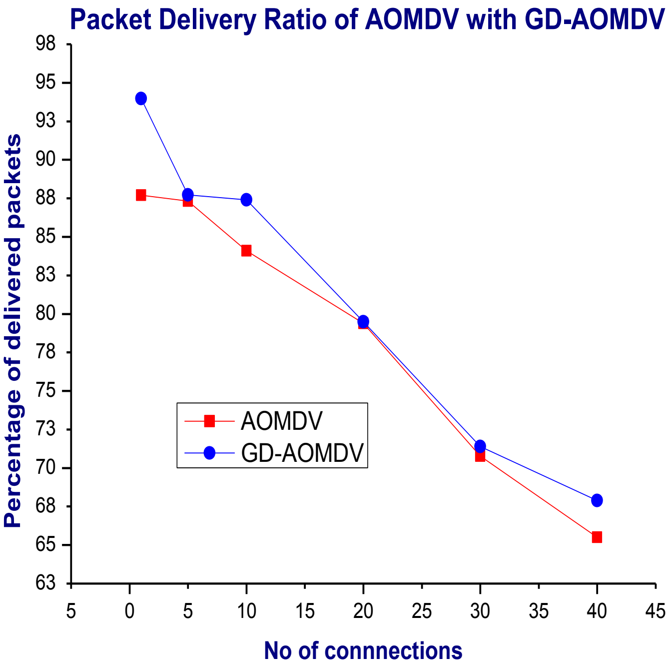



**Figure-6: Packet Delivery Ratio of GD-AOMDV with AOMDV**

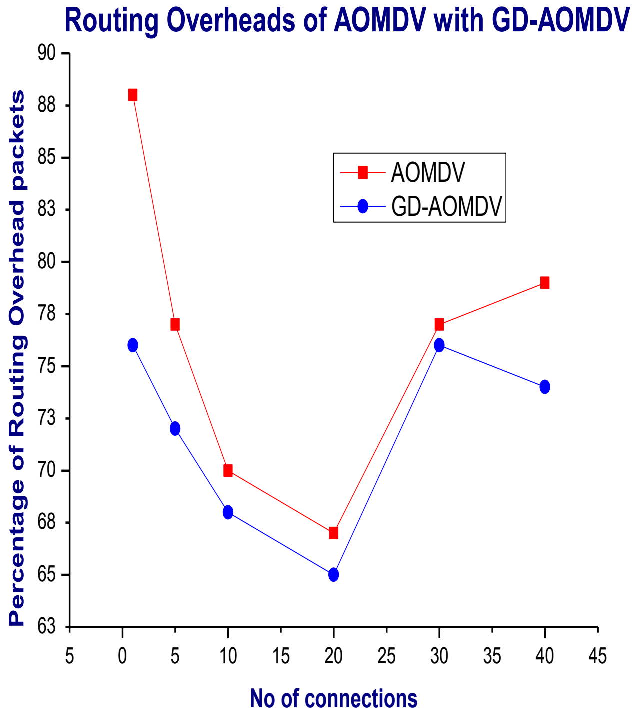
| Table-6 Packet Delivery Ratio | | |
|---|---|---|
| **No of connections** | **AOMDV (in %)** | **GD-AOMDV (in %)** |
| 1 | 87.710 | 93.983 |
| 5 | 87.316 | 87.733 |
| 10 | 84.101 | 87.400 |
| 20 | 79.396 | 79.484 |
| 30 | 70.767 | 71.396 |
| 40 | 65.511 | 69.888 |

This is the performance analysis depending on the ratio of packets in case of previous AOMDV and proposed GD-AOMDV scheme. Here the packet delivery ratio of proposed scheme is about 69% but in case of previous normal AOMDV is about 65% that is lesser than previous. In case of normal AOMDV the transmission distance concept are not added it means the nodes notify maximum packet drops, delay and degrade the performance of the network. But in case of proposed scheme each node that handles transmission distance in good way and minimize energy consumption for packet transmission, routing overhead and Delay. The Table-6 and figure-6 shows packet delivery fraction of GD-AOMDV and AOMDV.

**5) Routing Overheads Delay Analysis with Normal AOMDV and GD-AOMDV**

The total number of control or routing packets generated by routing protocol during simulation and is obtained as follows:

$$\text{Routing Overhead} = \text{Number od RTR packets}$$




| Table-7: Routing Overheads | | |
|---|---|---|
| No of connections | AOMDV (no of packets) | GD-AOMDV (no of packets) |
| 1 | 88 | 76 |
| 5 | 77 | 72 |
| 10 | 70 | 68 |
| 20 | 67 | 65 |
| 30 | 77 | 76 |
| 40 | 79 | 74 |

**Figure-7: Routing Overheads of GD-AOMDV with AOMDV**

The routing packets in network are required to establish connection between sender and receiver and the less number of routing packets shows the better network performance. In this graph the performance of proposed GD-AOMDV protocol is better as compared to previous normal AOMDV routing protocol. Here in case of proposed scheme about only 74 routing packets are delivered in network but in case of previous normal routing about 79 packets are delivered in network. In AOMDV routing overheads are increased, due to the signal decay or congestion of node and p1ath life time. AOMDV path selection doesn't care of transmission distance metric for path selection. So it causes more congestion and route rediscovery packets. The Table-7 and figure-7 compares the routing overhead of AOMDV and GD-AOMDV. GD-AOMDV reduces Routing Overhead in the way of selecting minimum distance with increase in number of hops at the time of Route Discovery.

**6) Throughput Analysis with Normal AOMDV and GD-AOMDV**

Throughput is obtained by calculating how many packets are received at the destination from the source at a specified time interval (kbps).

$$\text{Throughput} = \frac{\text{Number of Bytes Received} * 8}{\text{Simulation Time} * 1000} \text{ kbps}$$

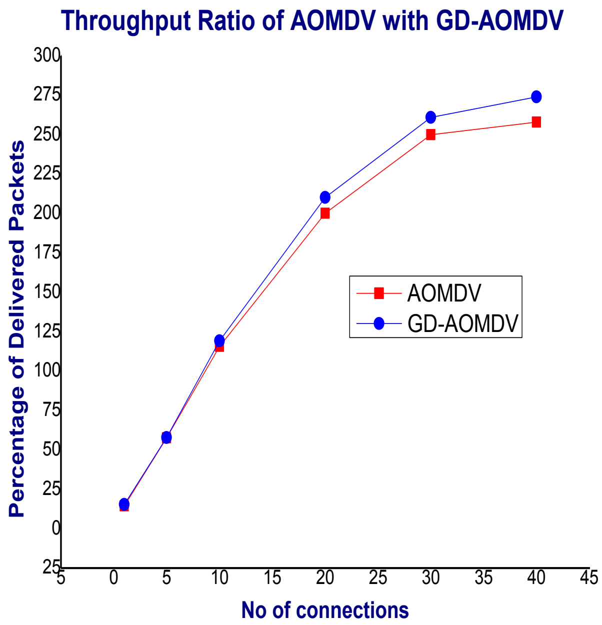



**Figure-8: Throughput of GD-AOMDV with AOMDV**

The Table-8 and figure-8 show throughput of each protocol in packet delivery fraction. GD-AOMDV protocol throughput becomes high when number of connections increased. But AOMDV protocols throughput becomes less when network flow increased and selecting shortest paths, which leads congestion and queue problem.

## V. Conclusion

Even though many factors are to be considered to improve the QoS aspect of MANET, routing is standing front of all. Among the routing protocols, recently geographical multipath routing protocols attained very big attention among the research communities. In this paper we proposed a novel scheme called GD-AOMDV to improve the performance of the AOMDV routing protocol. By considering transmission distance metric for path selection to extend nodes lifetime. From the simulated result it is found that the proposed scheme give a better result than the existing AOMDV with respect to Average End-to-End Delay Minimum Energy Consumption, Packet delivery fraction, Packet loss Ratio, Routing Overheads and Throughput.

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**Table 8: Throughput**

| No of connections | AOMDV ( in %) | GD –AOMDV ( in %) |
|---|---|---|
| 1 | 14.434 | 15.348 |
| 5 | 57.636 | 57.821 |
| 10 | 115.641 | 119.086 |
| 20 | 200.092 | 200.113 |
| 30 | 249.998 | 250.988 |
| 40 | 267.917 | 273.980 |

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