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Analysis of AOMDV Routing Protocol in Square and Triangle Based Topologies of Wireless Mesh Network

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***Abstract*— Wireless mesh networks are a potentially valuable type of a wireless network that has the capacity to provide everywhere internet access as well as broadband wireless coverage to large area. Wireless Mesh Topology is a key network design in which devices are connected with many redundant interconnections between network nodes. Routing plays a vital role in Wireless Mesh Network for providing better connectivity among the network. The routing protocols are categorized into unipath and multipath protocols. The multipath routing protocols have the features of fault-tolerance, increased bandwidth and improved security. Hence, in this paper the multipath routing protocol AOMDV (Ad hoc On-Demand Multipath Distance Vector) is analyzed in square and triangle based topologies of wireless mesh network by considering the various performance metrics (PDR, Dropped Packets, Average End to End Delay and Routing Overhead) by varying the Transmission Rate and Pause Time.**

***Keywords*— Wireless Mesh Network, AOMDV protocol, Square based topology and Triangle based topology.**

I. INDRODUCTION

Wireless Mesh Networks (WMNs) are highly promising technology and plays an important role in wireless networks. WMN is characterized by dynamic self-organization, self-configuration and self-healing to enable quick deployment, easy maintenance, low cost, high scalability and reliable services, as well as enhancing network capacity, connectivity and resilience. WMNs are undergoing rapid commercialization in many other application scenarios such as broadband home networking, community networking, building automation, high speed metropolitan area networks, and enterprise networking [1]. The architecture of WMN are comprised of three types of nodes: mesh routers, mesh clients and gateway.

Mesh Routers maintain connectivity, perform routing and act as the wireless backbone of the network. They are similar to the conventional routers in that they have the gateway/bridging functionality but they also have the added functionality to handle the mesh infrastructure.

Mesh clients route data among themselves. They are however, much simpler than the mesh routers and usually carry only a single radio interface.

For example, communication protocols for mesh clients can be light-weight and gateway or bridge functions do not exist in mesh clients [1].The mesh clients connect to the network either directly through the network gateways, or through the mesh routers.

Gateways act as the bridge between the wireless mesh domain and the wired Internet domain. Some approaches consider only mesh routers and mesh clients as part of the mesh network [2]. Figure 1 Shows the Architecture of Wireless Mesh Network[3]

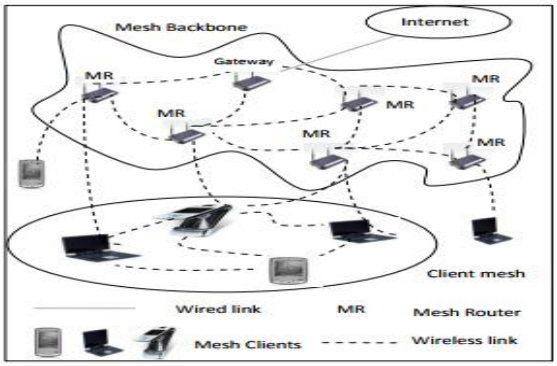

Figure 1 Architecture of Wireless Mesh Network

Routing is an important research issue in WMN. The routing protocols are divided into three different categories proactive, reactive and hybrid based on their route construction process. They can also be further divided into two different categories based on the paths choosen for transmission of data. They are unipath and multipath routing protocols. The unipath routing protocols use only one path at a time to reach a destination. Most routing protocols are unipath or have a unipath mode of operation. Multipath routing is a routing technique which uses multiple alternative paths through a network, which can yield a variety of benefits such as fault tolerance, increased bandwidth and improved security. The multiple paths computed might be overlapped, edge disjointed or node-disjointed with each other. Multipath routing protocols is the extension of the unipath routing protocols. [4].

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The Multipath routing protocols are also belonging to three categories: Proactive, Reactive and Hybrid routing protocols.

In proactive multipath routing protocols, each node maintains up-to-date routing information to each and every node in the network. The example of the proactive routing protocol is OSPF (Open Shortest Path First) In OSPF, the existence of several equal-cost routes to a destination and the traffic is distributed equally among them[5].

Reactive routing protocols can be split into three components: route establishment, route maintenance, and traffic allocation. AOMDV is an example of reactive routing protocol. AOMDV protocol is an extension of AODV. AOMDV is designed to provide efficient recovery from route failures and efficient fault tolerance. To achieve these goals, AOMDV computes multiple loop-free and link-disjoint paths[6].

Both proactive and reactive protocols are combined together to form a new generation of protocols called Hybrid multipath routing protocols[7]. The On-demand Hybrid Multipath Routing (OHMR) protocol is an example of hybrid multipath routing protocol. Thus this paper mainly focuses the multipath routing protocol AOMDV and the topologies such as Square and Triangle which are considered in the proposed work.

The rest of the paper is organized as follows. Section II deals with Literature survey, sectionIII deals with Overview of AOMDV protocol, section IV deals with square and triangle based topologies, Section V deals with Analysis of AOMDV protocol in Square and Triangle based topologies, Section VI concluded this paper.

II. Literature Survey

Many researchers have analyzed various topologies and routing protocol of AOMDV.

Yoursef Iraqi et al[8] investigated the effect of topology of WMNs on their capacity. Networks with different topologies, both in terms of type and size were studied and compared. Three different topology types are considered: square, triangle and hexagon. The results of the performance evaluation suggest that using a triangle based topology it provides higher network capacity.

Kou ke-hao et al [9**]** studied the quantitative result of the per node average throughput capacity of CWMN with power control for the first time. Under the large-scale channel fading model and protocol interference model, a closed form expression for the channel capacity with power control is presented. Based on two regular topologies i.e. square topology and triangle topology, the per node average throughput capacity of CWMN was derived.

The proposed variation of the per node average throughput capacity with power control and the capacity of triangle topology is higher than that of square topology. Moreover, the capacity increases with higher tolerated interference threshold Q and permissible transmit power P, with lower number of Cognitive Users and Primary Users.

Tanya Koohpayeh Araghi et.al[10] analyzed the performance metrics such as throughput, end to end delay and packet delivery ratio in order to find the best routing protocol based on the enforced conditions in the network. It is observed that, in a network with increased number of nodes with the maximum of 20 nodes, packet delivery ratio and throughput in DSR and AOMDV routing protocols are better than AODV while in checking end to end delay AOMDV shows less delay than DSR and AOMDV.

Djellouli Ahmed Amine et.al[11] discussed an enhancement versions of the AOMDV routing protocol. It mainly focuses to reduce the number of packets transmitted while minimizing the number of conditions and tests when compared to the old version. It proposed a formal verification using a powerful model checking approach.

Geetha S et.al [12] had taken random way point mobility model in order to analyze the performance enhancement of AOMDV with energy efficient routing. Each node in MANET will maintain the information required for proper route traffic. In order to improve the performance of AOMDV in selecting main path, a new concept is proposed which is called Node State with mobility model (NS-AOMDV). The simulation results showed that the proposed method (NS-AOMDV) had significant reliability improvement as compared to AOMDV.

III. Overview Of AOMDV Routing Protocol

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) protocol is an extension of AODV protocol for computing multiple loop-free and link-disjoint paths. It consists of two procedures: Route Discovery Process and Route Maintenance Process.

Route Discovery Process: The source broadcasts the RREQ packet and waits the reception of RREP packet. When a node receives RREQ, it first checks if it is not a RREQ that has received earlier or an old one, in case if it's a new one, a reverse route is built to the previous node, update the fields in the RREQ and forward it, otherwise it rejects the RREQ packet. The RREP packet is sent to the source either by an intermediate node who knows the route to the destination, or by the destination node itself.

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AOMDV has two main components a) A route update rule to establish and maintain multiple loop-free paths at each node. b) A distributed protocol to find link-disjoint paths. To find multiple link-disjoint paths, AOMDV add a new field in the RREP-packets named "First Hop", which indicate the first neighbor of the source who has received the packet. Also, each node maintain a list called "first hop-list" so that to keep a trace of the neighbors of the source which transmitted the RREQ-packet. Only one version of the packet is rebroadcasted, but keeps in memory the neighbors who send the RREQ-packets in case where the First Hop is different. This allows an intermediate node to know multiple node-disjoint paths to return to the source.

The destination responds to k copies of RREQ-packets arriving via the same neighbor (independent from the First Hop) with RREP-packets in the corresponding reverse path. Each intermediate node receiving this packet, choose one neighbor from its routing table and transmit the RREP-packet to it. In a case, where multiple RREP-packets are received by the same node, this node is an in-charge to transmit each one of them to a different neighbor so that the RREP-packets follows path which are link-disjoint [13]. Figure 2 shows the Route Discovery Process of AOMDV.

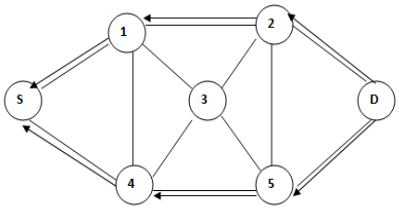

Figure 2 Route Discovery Process

Route Maintenance Process: This procedure allows a rollback to the source in case the route is broken in order to update it or to discover another. A node reports its status to the neighbors by sending a message called HELLO. In case where no HELLO message is received from a node, then a local route discovery is performed to discover an alternative path. If no route is found, an error message is diffused called RERR. All nodes receiving this packet invalid the route and the source node starts a new route discovery[14].

IV. Wireless Mesh Network Topology

The arrangement of nodes in the network to communicate with each other is called network topology. The nodes in the WMNs automatically establish and maintain the mesh connectivity between them.

The formation of the WMN topology is influenced by many factors like link quality, the mobility of the nodes, the accessibility of the nodes, network consumption and so on. The topology discovery process provides the network topology and other related information to the routing protocol [15]. The topologies such as Square based topology and Triangle based topology are considered in the proposed work.

A. Square Based Topology

In this type of topology, the mesh routers form a square shape with their immediate neighbors. The square grid topology is formed based on N x N matrix format[15]. Note that the important thing that the topology is in terms of links between the mesh routers and not the actual position of each mesh router. In the proposed work, the square based topology is created by placing mesh routers in fixed position which means static. The routers are set in square shape as 5x5 matrix formats, totally it contains 25 mesh routers and the mesh clients are created as mobile nodes with a total of 50. Figure 3 shows the square based topology.

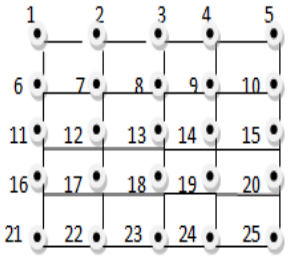

Figure 3 Square Based Topology

B. Triangle Based Topology

The second type of topology is the triangle-based topology. Here, the mesh routers form a triangle shape with their immediate neighbors[15]. The mesh routers from triangle shape, totally it contains 24 mesh routers and the mesh clients are created as mobile nodes with a total of 50. Figure 4 shows the triangle based topology.

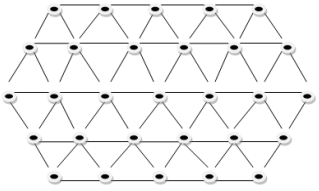

Figure 4 Triangle Based Topology

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V. Analysis Of AOMDV Protocol In Square And Triangular Based Topologies

The performance of the AODMV routing protocol using square and triangle based topologies is analyzed using Network Simulator 2(NS-2) tool. NS-2 is widely used open source network simulation software designed mainly for research in computer networks. The analysis is carried out by considering the performance metrics Packet Delivery Ratio (PDR), Dropped Packets, Delay and Routing Overhead by varying the pause time and transmission rate. The simulation results are shown in the form of line graphs. The transmission rates are varied from 0.016 Mbps to 1.0 Mbps for each pause time such as 10, 20 and 30. The simulation parameters used for the analysis in the proposed work is shown in Table 1

TABLE 1
Simulation Parameters

Parameters	Value
Simulation Time	300 sec
Simulation Area	700 x 700 m
Packet Size	512 bytes
Max speed	10 m/s
Transmission Rate	0.016, 0.032, 0.064, 0.128, 0.256, 0.512, 1.0 Mbps
Routing protocol	AOMDV
Bandwidth	10 Mbps
No of Mesh Routers	25
No of Mesh Clients	50
Traffic Type	CBR (UDP)

A. *Square Based Topology*

The performance analysis of AOMDV protocol in Square based topology of WMN for the considered metrics are shown in Figure 5

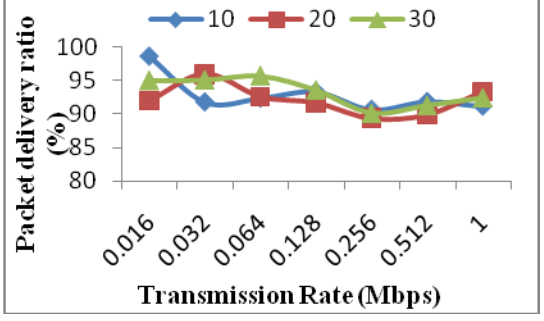

Figure 5(a) Transmission Rate vs PDR

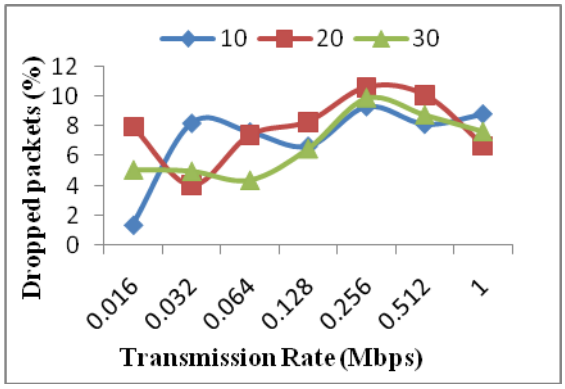

Figure 5(b) Transmission Rate vs Dropped Packets

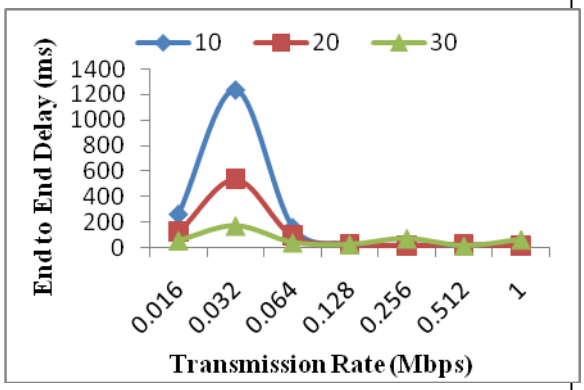

Figure 5(c) Transmission Rate vs Delay

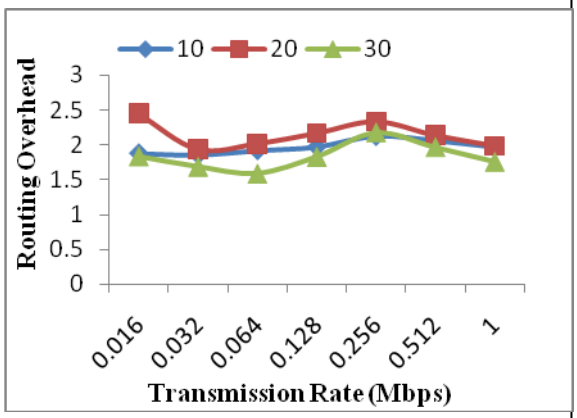

Figure 5(d) Transmission Rate vs Routing Overhead

Figure 5 Analysis of Square based Topology

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In square based analysis, from Figure 5(a), it is clear that the PDR is above 90% from transmission rate 0.016 Mbps to 0.128 Mbps for all the considered pause time 10, 20 and 30. The PDR is high at transmission rate of 0.016 Mbps with the pause time of 10. From the transmission rate of 0.256 Mbps the PDR deteriorates. Thus the ideal range of transferring data for the considered scenario from the pause time 10 to 30 ms with the transmission rate not greater than 0.128 Mbps. Figure 5(b) shows the ideal range for reducing dropped packets is from the transmission rate of 0.016 Mbps to 0.128 Mbps for the pause time varying from 10 to 30. Figure 5(c) shows that the minimum delay is occurred from the transmission rate 0.064 Mbps to 1 Mbps in all the considered pause time 10, 20 and 30. Figure 5(d) shows that the minimum difference of routing overhead exists in all the considered pause times and transmission rates. Among these the best results is at the pause time 30 in all the considered transmission rates. Thus ideal range for better routing overhead is from transmission rate 0.016 Mbps to 1 Mbps at pause time 30.

B. Triangle Based Topology

The performance analysis of AOMDV protocol in Triangle based topology of WMN for the considered metrics are shown in Figure 6.

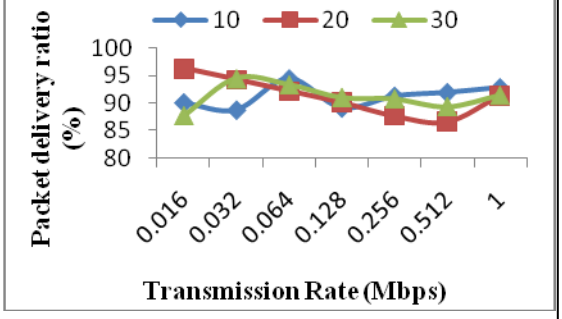

Figure 6 (a) Transmission Rate Vs PDR

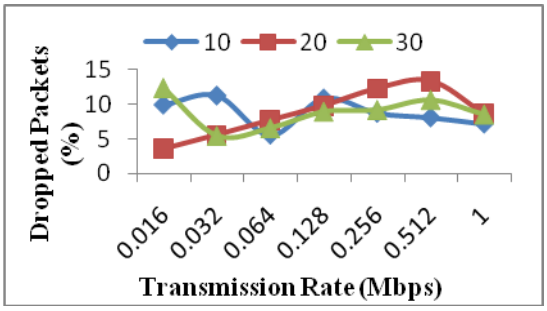

Figure 6 (b) Transmission Rate vs Dropped Packets

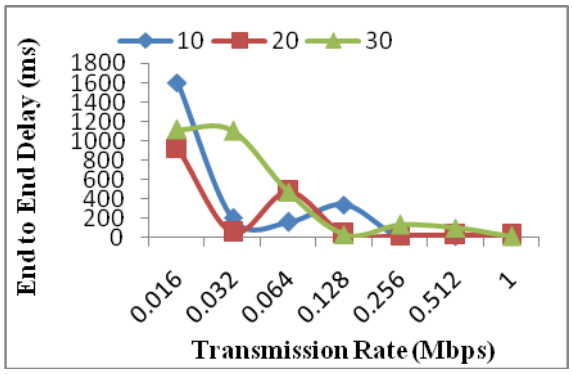

Figure 6 (c) Transmission Rate Vs Delay

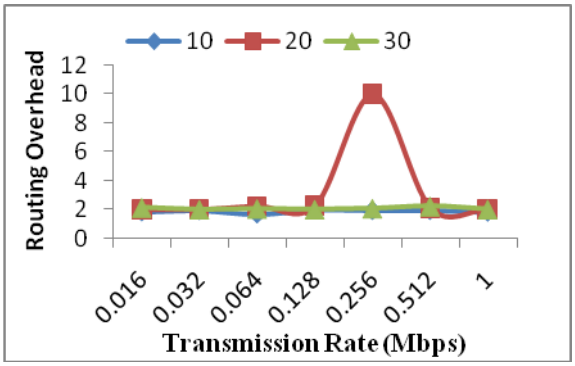

Figure 6 (d) Transmission Rate Vs Routing Overhead

Figure 6 Analysis of Triangle based topology

In triangle based topology analysis, from Figure 6(a), it is clear that the PDR is above 85% from transmission rate 0.016 Mbps to 0.064 Mbps for all the considered pause time 10, 20 and 30. The PDR is high at transmission rate of 0.016 Mbps with the pause time of 20. From the transmission rate of 0.128 Mbps the PDR deteriorates. The ideal range of transferring data for the considered scenario is at the pause time of 10 to 30 with the transmission rate not greater than 0.128 Mbps. Figure 6 (b) shows the ideal range of dropped packet is from the transmission rate of 0.016 Mbps to 0.128 Mbps for the pause time varying from 10 to 30. Figure 6 (c) shows that the minimum delay occurred in transmission rates from 0.128 Mbps to 1 Mbps in pause time 10, 20 and 30. Figure 6(d) shows the minimum difference of routing overhead exists in all the considered pause times and transmission rates. Among these the best results is at the pause time 30 in transmission rates from 0.016 Mbps to 1 Mbps.

Thus the ideal range for better routing overhead is from transmission rate 0.016 Mbps to 1 Mbps at pause time 30.

VI. Conclusion

This paper focused the analysis of multipath routing protocol AOMDV in square and triangle based topologies of WMN. The analysis is carried out by varying transmission rate and pause time. From this evaluation, it revealed that, in square and triangle based topologies the PDR, Dropped Packets and Routing Overhead provides better results in all the considered pause time 10, 20 and 30. The End-to-End delay has minimum values at pause time 30. When considering the analysis of both topologies the PDR and Dropped Packets provide better results at transmission rates from 0.016 Mbps to 0.128 Mbps, Delay metric provide better results at transmission rate from 0.128 Mbps to 1 Mbps and Routing Overhead has best results in all the considered transmission rates.

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