Performance Analysis of Multipath Routing in WSN

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Abstract— Wireless Sensor Network is a collection of sensor nodes which are randomly distributed over the network. Some of the conventional single path routing schemes may not be optimal to maximize the network lifetime and connectivity. This results in unfair utilization of nodes with respect to energy and traffic. Multipath routing provides multiple paths towards destination instead of single path routing thus enhancing network lifetime and minimizing routing overheads. This paper describes comparative performance analysis of AODV and AOMDV routing protocols for traffic variation in WSN. Simulation result shows the suitability protocol for grid topology in terms of packet delivery ratio, throughput, average energy consumption, control overheads and routing overheads.

Keywords—Congestion, Energy, Packet delivery ratio, Multipath Routing, Throughput, Wireless Sensor Network.

I. INTRODUCTION

Wireless Sensor Network (WSN) consists of densely distributed nodes that support sensing, signal processing, computing and connectivity. These nodes which are randomly distributed over wide area transmit gathered data to one or many central nodes called as sink [1]. WSN is one of the emerging research areas that provide applications with services such as environment monitoring, disaster prevention, medical monitoring, habitat monitoring, military surveillance, health monitoring, inventory management, and intelligent logistics [2]. In WSN each sensor node consists of various processing capabilities such as micro controllers, central processing unit and digital signal processing chips, memory and also the power batteries. These sensor nodes communicate with each other wirelessly and often self-organize themselves after being deployed in an ad hoc fashion over the network [3].

In Figure 1 nodes are placed in remote area which is termed as sensor field. These sensor nodes sense the information from sensor and this information is forwarded through the routing path towards sink. The intermediate nodes are forwarding nodes which forward packets hop by hop towards sink. Sink does processing of the packets and takes appropriate action accordingly. WSN can be signified by measuring various Quality of Service (QOS) parameters like Reliability, Energy, Throughput, Congestion Control, Fairness and Delay.

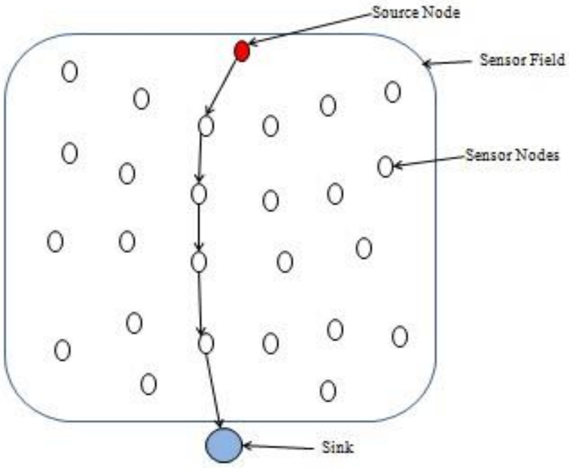

Figure 1: **Wireless Sensor Network**

Reliability in WSN means data delivery of whole data sensed by the sensor node to the destination. Energy is considered as the most important QOS parameter as WSN is having very less amount of energy. As it is not possible frequently to change the batteries it is necessary to efficiently use the energy for computation and data transmission in WSN. Throughput is defined as the total number of packets processed per unit time. For any system if throughput is high then that system is considered as more reliable, as more number of packets are processed per unit time [4]. Congestion in the network causes due to transmission of heavy traffic than normal [5]. Congestion causes unnecessary packet retransmissions and wastage of energy. Hence it is very essential to control congestion over the network. Fairness means equally distributed resources. Fairness maintains the network with respect to energy and traffic. By fair rate allocation we can avoid congestion in the network [6]. Delay is nothing but the time required to reach the packet to the destination node.

Multipath routing approach recently is widely used in WSN to improve network lifetime and performance by efficient utilization of available network resources. The main aim for proposing multipath routing was to provide path resilience against node or link failures and for reliable data transmission [7]. If alternative paths are available towards destination, data forwarding can be continued without any interruption even in the case of path failure. Multipath routing also controls congestion by dividing network traffic over several paths. Multipath routing also enhances packet delivery ratio, throughput and reduces end to end delay over single path routing.

The rest of paper is prepared as follows. Section I includes the survey and Section II includes related work. Section III includes the performance analysis. Section IV concludes the paper.

II. RELATED WORK:

Quality of Service (QOS) parameters of the network are used to measure performance of sensor network. Packet delivery ratio, packet loss ratio, throughput, congestion, energy consumption, fairness, reliability and delay are the QOS parameters of the network. The papers discussing multipath routing and its effect on QOS parameters are discussed here.

Omar Banimelhem et. al [8] has proposed a Grid-based Multipath with Congestion Avoidance Routing protocol (GMCAR). The sensor network field is divided into grids. In grid formation phase nodes are uniformly or randomly distributed in grid structure from which a master node is selected with highest ID. In routing table phase, sink initiates a flooding message to enable the master nodes to discover the available paths from each grid to the sink. After establishing the routing tables, nodes can start transmitting their data to the sink. All nodes within the grid send their data to master node and master node then forwards that data towards sink. In GMCAR, as data is sent through multiple paths, high packet delivery ratio is observed over the network. Through buffer occupancy congestion is detected and route invalidate message is broadcasted. Hence the path towards destination is chosen from neighboring master node. This reduces the congestion in the network. In grid formation phase, there is uneven distribution of nodes within grid which is one of the disadvantages of GMCAR.

Distributed Scheduling in Multihop Wireless Network [9] uses multipath routing for data transmission. A set is maintained for routing paths for different flows. Link-dependent channel code rates are used to counter channel variations and improve network reliability. Online flow control and scheduling is done in decentralized manner. The stability of queue is maintained by having input rate less than or equal to service rate. Through distributed scheduling traffic fairness is highly achieved. Online flow control and scheduling over multiple paths achieves high aggregate throughput. Reliability is achieved using channel coding in which redundant bits are added to channel to control channel variations. Fairness and aggregate throughput are inversely proportional to each other. Achieving high fairness may lead to degradation of aggregate throughput.

Secure and Energy Efficient Disjoint Multipath Routing (SEDR) [10] uses multipath routing to send a packet through disjoint routes from source to destination assuring security. The line from source node to sink node is considered as X axis and the line orthogonal to the X-axis at the source node as the Y -axis. Hop length and hop coordinate are taken into consideration. Initially each packet is broken into M shares. Each share has unique set f information such as ID, hop lengths along X and Y axis and hop coordinate. Each share is then transmitted hop by hop until it reaches the destination. In SEDR scheme disjoint multipath enhances network security and thus prevents from single and multiple black hole attacks. It also enhances network lifetime by maintaining energy constraints. Identification of sink node by an adversary may affect the network security and network lifetime.

III. PERFORMANCE ANALYSIS:

Simulation scenario contains 30 nodes. One of them is destination node while five nodes are connected with UDP agents which generates traffic, and remaining nodes are common nodes. Packet Size is of 50 Bytes and reporting rate varies from 10 to 100 packets/sec. All the nodes are static. Routing protocols used are and Ad-hoc On Demand Distance Vector (AODV) Ad-hoc On Demand Multipath Distance Vector (AOMDV) and with 802.11 MAC. Grid topology is used in this scenario.

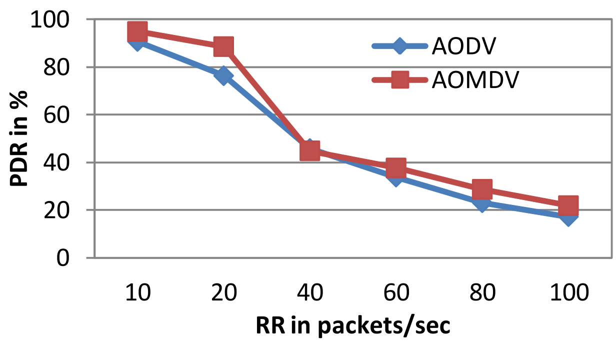

Figure 2: **PDR as a function of Reporting Rate**

Figure 2 depicts Packet Delivery Ratio (PDR) as a function of Reporting Rate. For lower reporting rate the PDR is high for both AODV and AOMDV. As reporting rate goes on increasing PDR for both the protocol decreases. As reporting rate increases, the number of packets thumped into the network will be very large and it creates congestion in the network. The drop packets will be increased and hence packets reached up to the destination will be less. This results in decreasing PDR for both AODV and AOMDV for increasing reporting rate. AOMDV maintains all the alternate routes towards destination. PDR for AOMDV is better as compared to AODV for varying reporting rate. This is because AOMDV can find an alternate route if there is link failure or congestion due to which more packets are delivered, whereas AODV is rendered useless at that point.

Figure 3 shows Throughput as a function of Reporting Rate. As reporting rate goes on increasing throughput in the network goes on increasing up to certain threshold and after that due to congestion it decreases. Throughput for AODV goes on increasing till 60 packets per second and then it becomes constant whereas for AOMDV throughput goes on increasing till 80 packets per second and then decreases due to congestion. As packet delivery ratio over specified time is more for AOMDV than AODV, throughput for AOMDV is better than AODV.

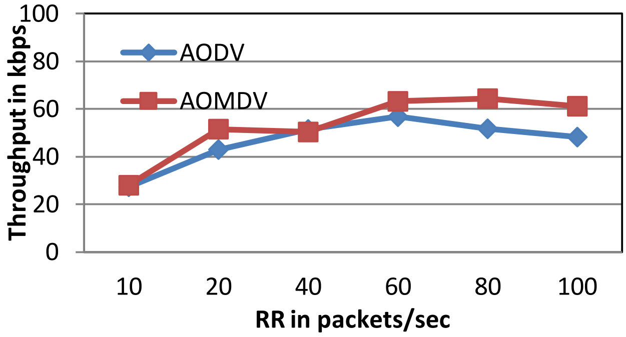

Figure 3: **Throughput as a function of Reporting Rate**

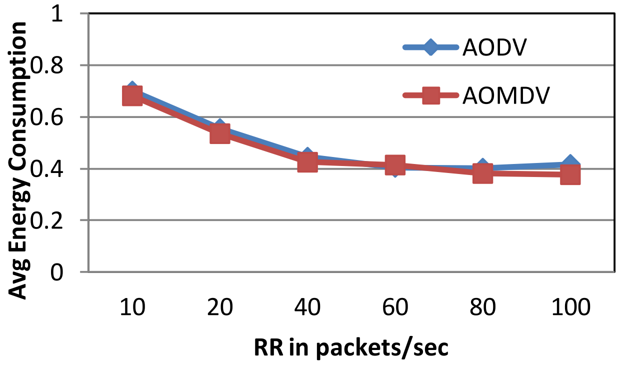

Figure 4**: Average energy consumption as a function of reporting rate**

Figure 4 shows Average energy consumption as a function of reporting rate. Average energy consumption for AODV and AOMDV for varying reporting rate decrease till 40 packets per second and then it remain constant. Average energy consumption for AODV and AOMDV is almost same but still it is slightly less for AOMDV. In AODV there is very high control and routing overhead as compared to AOMDV which results in more energy consumption. As control overheads and routing overheads required for AOMDV is less, average energy consumption for varying reporting rate is also less as compared to AODV.

Figure 5 portrays Delay as a function of reporting rate. As reporting rate goes on increasing, delay in the network goes on increasing for both AODV and AOMDV. Delay for AOMDV is less as compare to AODV. For AOMDV delay increases till 60 packets per second and after that it decreases whereas for AODV it goes on increasing. This is because in case of congestion or path failure packets are sent through alternate routes which minimize delay for AOMDV.

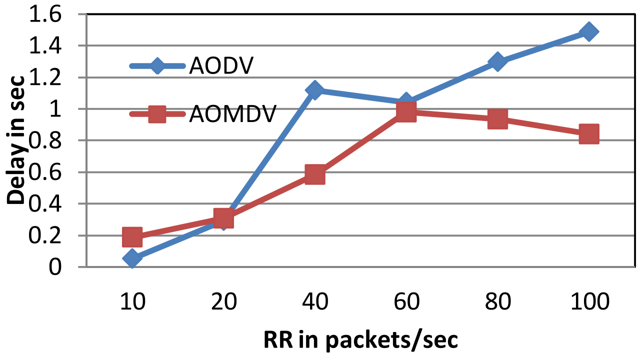

Figure 5: **Delay as a function of reporting rate**

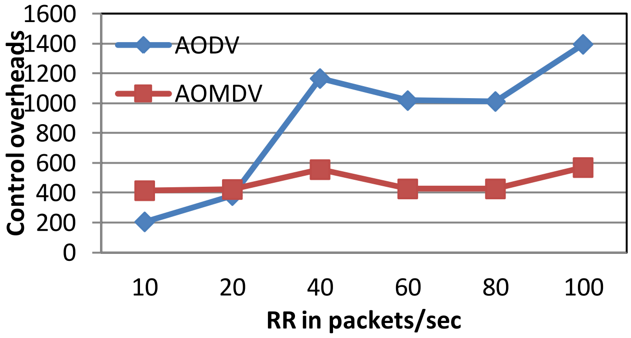

Figure 6: **Control overheads as function of reporting rate**

Figure 6 depicts Control overheads as function of reporting rate. As reporting rate goes on increasing, control overheads in the network increases. Control overheads for AODV as compared to AOMDV are more. In AODV large number of control messages occurs at the time of route failure which results into increase of control overheads. In AOMDV as alternate routes are maintained at the time of route discovery less control overheads are observed at the time of route failure.

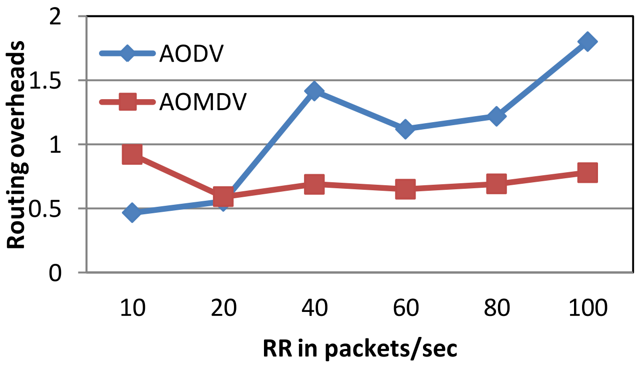

Figure 7: **Routing overheads as function of reporting rate**

Figure 7 shows Routing overheads as function of reporting rate. As reporting rate goes on increasing, routing overhead for AOMDV almost remains constant whereas for AODV it increases gradually. AODV has more routing overheads as compared to AOMDV. In AODV, at the time of route establishment after route failure, every node searches for the shortest path which leads to high routing overheads, whereas in AOMDV nodes utilize the already maintained alternate routes to establish the route, which minimizes routing overheads.

IV. CONCLUSION AND FUTURE WORK

This paper presents the comparative study and performance analysis of routing protocols (AODV and AOMDV) on the basis of packet delivery ratio, throughput, average energy consumption, delay, control overheads and routing overheads. The study of these routing protocols shows that AOMDV is more efficient in the networks with high traffic. AOMDV outperforms AODV with respect to packet delivery ratio and throughput. Control overheads and Routing overheads of AODV are 50% more than AOMDV. The light weight protocol will be developed to improve packet delivery ratio, network lifetime, throughput, and to minimize delay and routing overheads for AODV.

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