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# Energy Efficient DHT Based Multipath Routing in Wireless Sensor Networks

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***Abstract— The popularity of Wireless Sensor Networks (WSNs) has increased tremendously in recent time. WSNs have the potentiality to connect the physical world with the virtual world by forming a network of sensor nodes. Here, sensor nodes are usually battery-operated devices, and hence energy saving of sensor nodes is a major design issue. To prolong the network's lifetime, energy consumption should be reduced in the sensor nodes. In this paper, Distributed hash table based multipath routing protocol, namely Multipath Dynamic Address Routing (MDART) for WSNs has been evaluated. The main concept of Dynamic Hash Table based routing is to keep, at any node complete routing information about nodes which are close to it and partial information about nodes located further away. This Protocol also guarantees multi-path forwarding without introducing any additional communication or coordination overhead with respect to Ad-hoc On Demand Multipath Routing Protocol (AOMDV), Ad-hoc On demand Routing Protocol (AODV) which are Reactive Protocols and Dynamic Source Routing Protocol (DSR) which is Proactive protocol. The performance of MDART, AOMDV, AODV and DSR routing protocols has been evaluated by using Network Simulator (ns 2.35).***

***Keywords— Dynamic Hash Table, Wireless sensor networks (WSNs), Energy, MDART, ad-hoc routing***

## I. INTRODUCTION

Recent advances in wireless communication technologies and the manufacture of inexpensive wireless devices have led to the introduction of low-power wireless sensor networks. Due to their ease of deployment and the multi-functionality of the sensor nodes, WSNs have been utilized for a variety of applications such as healthcare, target tracking, and environment monitoring [3]. It is composed of a large number of sensor nodes that are randomly and densely deployed in an area for the purpose of monitoring certain phenomena of interest. The nodes sense information, process the sensed data and transmit the processed data to the base station over a wireless channel. The advancement in sensor technology has made it possible to have extremely small, low powered sensing devices equipped with programmable computing, multiple parameter sensing and wireless communication capability. Also, the low cost makes it possible to have a network of hundreds or thousands of these sensors, thereby enhancing the reliability and accuracy of data and the area coverage.

In this perspective, researchers have proposed numerous routing protocols to improve performance of different routing protocols in WSNs [4][5][6]. Most of the existing routing protocols in WSNs are designed based on the single-path routing strategy without considering the effects of various traffic load intensities and energy efficiency of the sensor nodes. Due to the resource constraints of sensor nodes and the unreliability of wireless links, single-path routing approaches cannot be considered effective techniques to meet the performance demands of various applications. In order to cope with the limitations of single-path routing techniques, another type of routing strategy, which is called the multipath routing approach has become as a promising technique in wireless sensor as well as ad hoc networks. Dense deployment of the sensor nodes enables a multipath routing approach to construct several paths from individual sensor nodes towards the destination. Discovered paths can be utilized concurrently to provide adequate network resources in intensive traffic conditions. There are many limitations of wireless sensor networks in practical implementation of large networks because maintenance in big network infrastructures is very high. Although WSNs have huge advantages over wired ones, in any critical scenarios like disaster, military attacks, flood and cyclone, earthquake etc, the sensor network infrastructure may breaks down. To overcome these limitations researchers are working on ad-hoc and WSNs.

Energy of Sensor nodes is an important parameter in WSNs; many routing strategies are applied in WSNs to overcome the Energy issue. Many routing protocols for WSNs are already tested in different simulators. But still it has some limitations due to its complexity. To realize the importance of ad-hoc routing in WSN, in this paper we are focusing especially on ad-hoc routing protocols in WSNs. Various multipath routing protocols for WSNs use the static addressing so they are not scalable to networks with more than 100 nodes. As the network grows to more than 100 nodes, in static addressing routing becomes very complex. Dynamic Hash Table (DHT) based protocols were proposed in [2][7] to solve the Energy and Scalability problem. DHT based multipath routing protocols requires a lot of work to be done in

 

WSNs. A DHT based protocol MDART [1] has shown satisfactory results for ad-hoc networks, this protocol was not evaluated on the basis of Energy constraint with respect to multipath protocols. In this paper we have evaluated MDART protocol on the basis of Residual Energy. Routing protocols have been discussed in the next section.

## II. ROUTING PROTOCOLS

### A. *Ad Hoc On-Demand Distance Vector Routing: AODV*

AODV routing protocol is an on demand routing protocol proposed in [8]. To find the route to the destination, source node floods whole network with the Route Request packets. These Route Request packets create the temporary route entries for the reverse path from every node it passes in the network. As soon as it reaches the destination a Route Reply is sent back from the same path the Route Request was transmitted. A route table entry is maintained by each node which updates the route expiry time. Route is valid for the given expiry time, after that the route entry is deleted from the routing table. To forward the data packet whenever a route is used, the route expiry time is updated to the present time plus the Active Route Timeout. AODV uses an active neighbour node list at every node as a route entry as to keep track of the neighbouring nodes that are using entry to route data packets. When the link to the next hop node is wrecked these nodes are notified with Route Error packets. Each such neighbour node then forwards the Route Error to its own active neighbours, thus cancelling all the routes using that broken link.

### B. *Dynamic Source Routing: DSR*

DSR [11] is an reactive protocol based on the source routing approach each packet stores the whole path in the header allowing so a simpler forwarding process with respect to the hop-by-hop forwarding exploited by AODV. Both the Route Request and the Route Reply packets accumulate the forwarders' IP addresses at each hop so that, once a route has been discovered, the source knows the entire route. DSR shares with AODV some common mechanisms: the Route Request packets are broadcasted by each receiving node until a route have been discovered, while the Route Reply packets are forwarded resorting to the reverse route information collected by the Route Request. Moreover, both maintain the routes resorting to Route Reply packets. However, unlike AODV, each node maintains several routes toward the same destination which can be used in the case of link failures. In other words, DSR exploits a multi-path routing strategy. Moreover, the routes have no lifetime: once a route has been discovered, it remains valid until it breaks. Finally, DSR enables nodes to promiscuously listen to control packets not addressed to them. In such a way, nodes can utilize the source routes carried in both DSR control messages and data packets to gratuitously learn routing information for other network destinations.

### C. *Ad hoc on-demand multipath distance vector routing: AOMDV*

Adhoc On Demand Multipath Distance Vector Routing Algorithm (AOMDV) [12] employs the "Multiple Loop-Free and Link-Disjoint path" method. In this protocol only disjoint nodes are considered in all the paths, thus achieving path disjointness. Route Request packets are propagated all over the network for route discovery thereby establishing multiple paths at destination node and at the intermediate nodes. Multiples Loop-Free paths are found using the advertised hop count technique at each node. At every node in the route table entry this advertised hop count is required to be maintained. The route entry table at every node in addition contains a list of next hop along with the related hop counts. An advertised hop count is maintained at each for the destination. Advertised hop count is defined as "maximum hop count for all the paths". This hop count is used to send route advertisements of the destination. If the hop count is less than the advertised hop count for the destination alternate path to the destination is established by a node.

### D. *Multipath Dynamic Address Routing: MDART*

MDART [1], a multi path based improvement of a recently proposed Dynamic Hash Table-based shortest-path routing protocol, namely the Dynamic Address Routing protocol (DART) [9]. MDART is able to exploit all the available paths without introducing any communication or coordination overhead with respect to the original protocol. Simulation results and performance comparisons with existing protocols substantiate the effectiveness of MDART for scalable networks with different workloads and environmental conditions in presence of moderate mobility. In particular, MDART is able to perform best or comparable with the best protocol for each considered scenario.

## III. RESULT ANALYSIS

Residual Energy of Dynamic Hash Table based proactive multipath routing protocol i.e. MDART has been compared with reactive multipath routing protocol i.e. AOMDV and single path routing protocols i.e. AODV and DSR by varying Traffic load, Number of nodes, Simulation time, Shadow Deviation using ns-2.35. Each simulation ran ten times, and for each metric we have calculated both average value and the standard deviation.

### A. *Residual Energy vs. Traffic Load*

In network scenario given in Table 1, we have varied the Traffic Load from 0.001 kbps to 5 kbps for different simulation results. Number of Nodes is set to 25. In this scenario maximum simulation time taken was 1000 seconds. Node-UDP type of Data Pattern was used for wireless environment. Speed of mobile nodes is varied from 0.5 m/s to 1.5 m/s. For all type of simulation Omni directional antennas were used.

 

Table 1: Scenario for Varying Traffic load

| S. No | Parameter | Value |
|---|---|---|
| 1. | Traffic Load (kbps) | 0.001 - 5 |
| 2. | Number of Nodes | 25- Fixed |
| 3. | Simulation time | 1000 seconds |
| 4. | Data Pattern | Node-UDP |
| 5. | Routing Protocols | MDART,AOMDV, AODV and DSR |
| 6. | MAC type | MAC/802.11 |
| 7. | Simulator | NS-2.35 |
| 8. | Speed | 0.5 m/s to 1.5 m/s |
| 9. | Antenna Type | Omni Directional |

Figure 1 shows the analytical graph of Residual Energy vs. Traffic Load when the Traffic Load is increased from 0.001 kbps to 5 kbps for MDART, AOMDV, AODV and DSR.

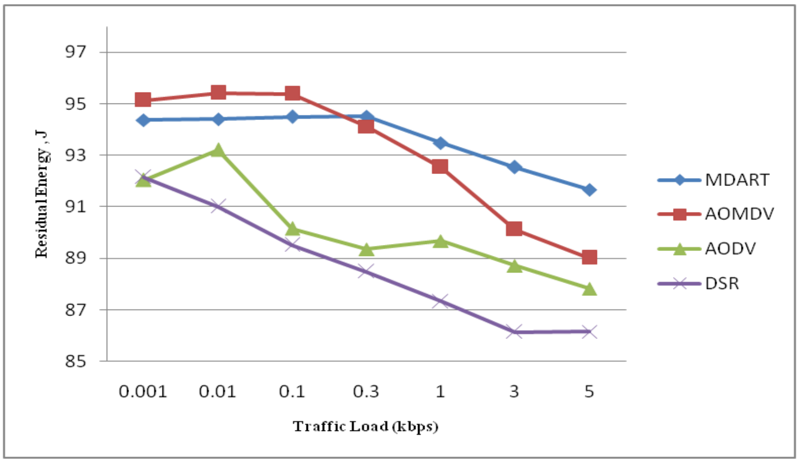


Fig. 1 Residual Energy verses Traffic load

For small traffic load ≤ 0.3 kbps value of Residual Energy for MDART and AOMDV is almost close. But for high traffic load ≥ 0.3 kbps value of Residual Energy for MDART is higher than all the other protocols. It seems that such behaviour of MDART is because of its proactive nature. Residual Energy of AODV is lower as it is single path routing protocol and residual energy of DSR is lowest as it is single path as well as proactive routing protocol.

### *B. **Residual Energy vs. Number of Nodes***

In network scenario given in Table 2 we have varied the number of nodes from 25 to 300 for different simulation results. Traffic Load is kept constant i.e. 5 kbps. In this scenario maximum simulation time taken was 1000 seconds. Node-UDP type of Data Pattern was used for wireless environment. Speed of mobile nodes is varied from 0.5 m/s to 1.5 m/s. For all type of simulation Omni directional antennas were used.

Table 2: Scenario for Varying Number of nodes

| S. No | Parameter | Value |
|---|---|---|
| 1. | Number of Nodes | 25 - 300 |
| 2. | Traffic Load (kbps) | 5 |
| 3. | Simulation time | 1000 seconds |
| 4. | Data Pattern | Node-UDP |
| 5. | Routing Protocols | MDART,AOMDV, AODV and DSR |
| 6. | MAC type | MAC/802.11 |
| 7. | Simulator | Ns-2.35 |
| 8. | Speed | 0.5 m/s to 1.5 m/s |
| 9. | Antenna Type | Omni Directional |

 

Figure 2 shows the graph of Residual Energy vs. Number of Nodes for MDART, AOMDV, AODV and DSR

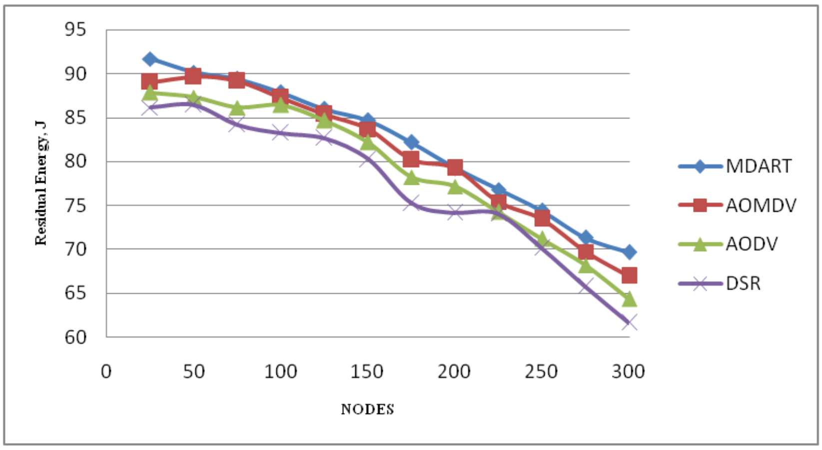


Fig. 2 Residual Energy over Number of Nodes

In figure 2 Residual Energy of all the four protocols have been checked with respect to scalability. It is clearly observed that MDART is more energy efficient than other protocols in case of higher number of nodes. This is because of proactive nature of MDART all the roots are available in MDART as it is using DHT paradigm and because of that overall processing or computation to find and reach next hop is comparatively low, so energy consumed in MDART is slightly lower than AOMDV, Also, simulation results shows that AODV is consuming more energy than MDART and AOMDV, while DSR consumes more energy than all the other.

### *C. Residual Energy vs. Simulation time*

In network scenario given in Table 3, we have varied simulation time from 200 seconds to 1000 seconds for different simulation results. In this scenario number of nodes are set to 25 and Traffic load is kept constant i.e. 5 kbps. Node-UDP type of Data Pattern was used for wireless environment. Speed of mobile nodes is varied from 0.5 m/s to 1.5 m/s. For all type of simulation Omni directional antennas were used.

Table 3: Network Scenario for varying Simulation time

| S. No | Parameter | Value |
|---|---|---|
| 1. | Number of Nodes | 25 |
| 2. | Traffic Load (kbps) | 5 |
| 3. | Simulation time | 200 to 1000 seconds |
| 4. | Data Pattern | Node-UDP |
| 5. | Routing Protocols | MDART,AOMDV, AODV and DSR |
| 6. | MAC type | MAC/802.11 |
| 7. | Simulator | Ns-2.35 |
| 8. | Speed | 0.5 m/s to 1.5 m/s |
| 9. | Antenna Type | Omni Directional |

Figure 3 shows the graph for Residual energy vs. Simulation time for MDART, AOMDV, AODV and DSR

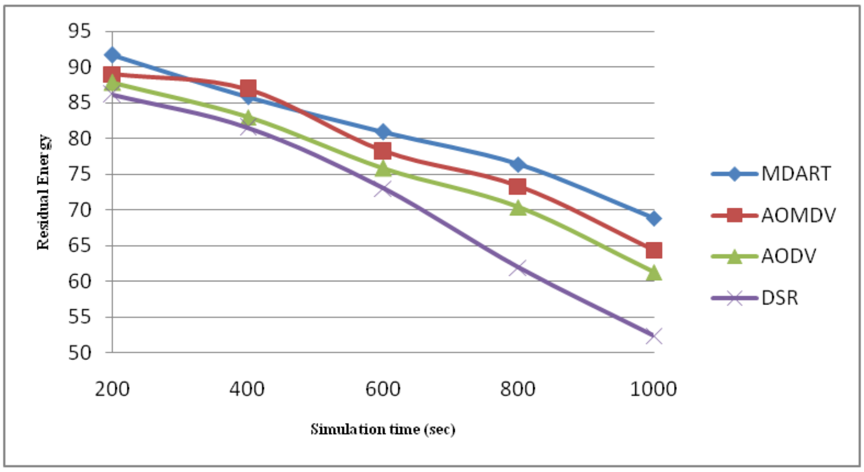


Fig. 3 Residual Energy verses Simulation time

 

Residual Energy in MDART is more as compared to other protocols when the simulation time is increased as shown in figure. Initially energy consumption of MDART is more as it needs to built routing Tables at start-up whereas AOMDV, AODV and DSR do not need to built routing Table at start up. Residual Energy is more in MDART as compared to other protocols because of Efficiency of DHT paradigm; other protocols are based on On-Demand paradigm. For 1000 seconds MDART has 1.07 times more Residual Energy than AOMDV, 1.12 times more Residual Energy than AODV and 1.31 times more Residual Energy than DSR.

### *D. **Residual Energy vs. Shadow deviation***

In network scenario given in Table 4, we have varied the shadow deviation from 1 to 5 for different simulation results. Number of nodes are kept constant i.e. 300 nodes. Traffic load is kept constant i.e. 5 kbps. In this scenario maximum simulation time taken was 200 seconds. Node-UDP type Data Pattern was used for wireless environment. Speed of mobile nodes is varied from 0.5 m/s to 1.5 m/s. For all type of simulation Omni directional antennas were used.

Table 4: Network Scenario for varying Shadow Deviation

| S. No | Parameter | Value |
|---|---|---|
| 1. | Number of Nodes | 300 |
| 2. | Shadow Deviation(db) | 1-5 |
| 3. | Traffic Load (kbps) | 5 |
| 4. | Simulation time | 200 |
| 5. | Data Pattern | Node-UDP |
| 6. | Routing Protocols | MDART, AOMDV, AODV and DSR |
| 7. | MAC type | MAC/802.11 |
| 8. | Simulator | Ns-2.35 |
| 9. | Speed | 0.5 m/s to 1.5 m/s |
| 10. | Antenna Type | Omni Directional |

Figure 4 shows the graph of Residual Energy vs. Shadow Deviation for MDART, AOMDV, AODV and DSR, based on the scenario mentioned in Table 4

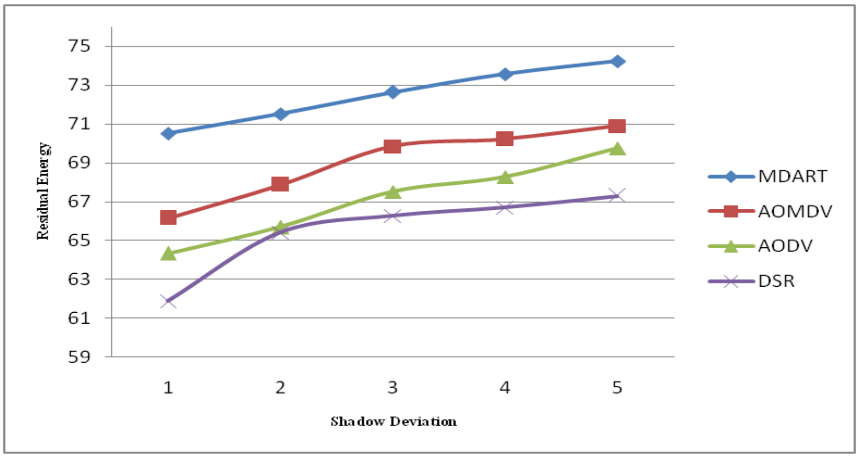


Fig. 4 Residual Energy over Shadow Deviation

As shown in Figure 4 the hostility of the channel, namely the Shadow deviation affects the Residual Energy of all the protocols. Residual Energy of all the mentioned protocols increases with increase in shadow deviation; Experimental results show that MDARTs Residual Energy is higher as compared to that of AOMDV, AODV and DSR.

## IV. CONCLUSION

The paper evaluates the Residual Energy of MDART protocol; a multipath improvement over DHT based routing protocol, namely the DART. Simulation results and comparisons with existing protocols namely AOMDV, AODV and DSR validate the effectiveness of MDART protocol for greater number of nodes, at different traffic load, shadow deviation and also simulation time in presence of temperate mobility. Particularly MDART's performance is best or equivalent with the best protocol for the considered scenario. There are several additional issues related to the design of multipath dynamic addressing routing based protocols which are required for further investigation. The protocol can be enhanced by resorting to more effective multipath routing strategies. And there is a need to validate the obtained results with real experimental results.

 

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