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# Performance Evaluation of Reactive Protocols for Ad Hoc Wireless Sensor Network

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***Abstract* — The requirement for good Quality of Service in Mobile Ad Hoc Network is that, better protocols should be used. To improve protocol efficiency, the two key issues to be considered are, low control overhead and low energy consumption. For reducing energy consumption and routing overhead, an enhanced routing algorithm, EEDSR (Energy Efficient Dynamic Source Routing) with local route enhancement model for DSR (Dynamic Source Routing) is implemented. Comparisons based on routing overhead, energy and throughput is done between EEDSR and EEAODV (Energy Efficient Ad Hoc on Demand Distance Vector) and AODV (Ad Hoc on Demand Distance Vector) protocols. For all protocols, NS-2.34 Simulator is used. This paper presents the simulation results in order to choose the best routing protocol to give highest performance. The simulations have shown that EEDSR protocol performs well as it consumes 12% less energy than EEAODV and AODV.**

***Keywords* — MANETs, Mobility Model, Quality of Service, Routing overhead.**

## I. INTRODUCTION

The wireless technologies have penetrated everyone's life in various ways in the recent past. Besides the wireless and mobile technologies such as GSM and WLAN unattended and self organizing wireless networks are envisaged. One such network is called the wireless ad-hoc sensor network. Such networks open a plethora of new applications such as disaster relief, community mesh networks, data gathering, monitoring and surveillance. As the importance of computers in our daily life increases it also sets new demands for connectivity. Wired solutions have been around for a long time but there is increasing demand on working wireless solutions for connecting to the Internet, reading and sending E-mail messages, changing information in a meeting and so on. There are solutions to these needs, one being wireless local area network that is based on IEEE 802.11 standard [1]. However, there is increasing need for connectivity in situations where there is no base station (i.e. backbone connection) available (for example two or more PDAs need to be connected). This is where ad hoc networks step in.

A "mobile ad hoc network" (MANET) is an autonomous system of mobile routers (and associated hosts) connected by wireless links - the union of which forms an arbitrary graph. The routers are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably [3]. Due to the mobility of nodes, some pairs of nodes may not be able to communicate directly with each other. This has triggered the research on the research on the routing protocols for WASN.

There have been many proposals for routing protocols for ad hoc networks, and several protocols have emerged. They can be classified into three main categories: the *proactive*, *reactive*, and *hybrid* protocols. In proactive routing, each node has one or more tables that contain the latest information of the routes to any node in the network. Example of proactive routing protocol is, Destination Sequenced Distance Vector (DSDV). Reactive routing is also known as on-demand routing protocol since they don't maintain routing information or routing activity at the network nodes if there is no communication. Examples of reactive routing protocols are the dynamic source Routing (DSR), ad hoc on-demand distance vector routing (AODV). A set of sensor node is the basic component of the sensor network. It has mainly four components, namely sensing unit, processing unit, communication unit and power unit. The sensor network protocols and algorithms must possess self-organizing capabilities. Some of the application areas are health, military, and security.

## II. RELATED WORK ON ROUTING PROTOCOLS

The basic feature of an Ad-Hoc network is that it is a dynamically reconfigurable wireless network with no fixed wired infrastructure. Due to the limited transmission range of wireless network nodes, multiple hops are usually needed for a node to exchange information with any other node in the network. Thus routing protocols play an important role in ad hoc network communications. Multipath routing allows the establishment of multiple paths between a single source and single destination node. It is typically proposed in order to increase the reliability of data transmission (i.e., fault tolerance) or to provide load balancing.

Recently, some adaptive ad hoc routing protocols have been reported. For example, Associatively Based Routing (ABR) which according to this algorithm, each node periodically transmits beaconing ticks to identify itself, and a stable link exists if a large amount of the ticks are received and accumulated at the receiving node. Another protocol that uses stability is Signal Stability based Adaptive routing (SSA), chooses the route if the receiving signal strengths of radio links along this route are larger than a threshold value; otherwise, the shortest path routing algorithm applies to find another route [5]. The Ad Hoc On-Demand Distance-Vector Protocol (AODV) is a distance vector routing for mobile ad-hoc networks. AODV is an on-demand routing approach, i.e. there are no periodical exchanges of routing information. It consists of two phases namely route discovery and route maintenance The route discovery process of AODV was improved by using the Improved AODV (IMAODV) protocol which has less average end to end delay than AODV [6]. The IMAODV protocol uses the new packet structure to add new fields to the existing packets in route discovery phase so that the routing table is updated for every hop count.

For avoiding the ping-pong effect a techniques was employed, known as Split-horizon and Poison-Reverse technique by the RIP (Routing Information Protocol). For the conventional protocols of direct transmission, minimum-transmission-energy, multihop routing, and static clustering may not be optimal for sensor networks. So an energy efficient optimum routing protocol (LEACH) which is a clustering based protocol was implemented. The various proactive protocols like DSDV and LEACH result in routing overhead [7]. Energy consumption is also more in case of large number of nodes. The performance of these protocols becomes cumbersome in case of large ad hoc networks. The solution could be by using dynamic routing algorithms in order to reduce routing overhead without any loss of information. It also helps to decrease the energy consumption of nodes while sending the data.

## III. Performance Evaluation of Reactive Protocols

The efficiency of the ad hoc network depends on how well the nodes are distributed, and the network's throughput. The on demand routing protocols perform well as they provide routes only when data has to be sent. The routing overhead is less in case of on demand routing protocols. Another factor that depends on the network's performance is that the total amount of energy consumed by the nodes during data transfer.

Here Comparisons based on Energy consumption and throughput of the ad hoc network is done between the on demand reactive protocols namely AODV (Ad Hoc on demand distance vector), EEAODV (Energy Efficient Ad Hoc on demand Distance Vector), and EEDSR (Energy Efficient Dynamic Source Routing).

### *A. AODV (Ad Hoc on Demand Distance Vector) Protocol*

An Ad-hoc On-Demand Distance Vector (AODV) is one of the reactive routing protocols. It is very simple, efficient, and effective routing protocol for ad-hoc networks which has two phases namely, route discovery phase and route maintenance phase [1]. In route discovery phase, source S broadcasts RREQ (Route Request) where destination number of RREQ is the last known number. The destination replies by unicasting RREP (Route Reply). The intermediate nodes which are called as neighbors discard duplicate requests, and reply if they have an active route with higher sequence number. Otherwise, they broadcast the request on all interfaces. There is a two path setup in this process: the first one is reverse path setup where a node records the address of the neighbor sending RREQ, the second is a forward path setup that unicasts RREP back to the reverse path, each node along the path setting up a forward pointer to the node from which the RREP came, and updating its routing table entry.

The node propagates the first RREP or the RREP that contains a greater destination sequence number or the same sequence number with a smaller hop count. The neighboring nodes with active routes periodically exchange hello messages. If a next hop link in the routing table fails, the active neighbors are informed. The source performs a new route request when it receives a RERR (Route Error). AODV maintains a time-based state in each node if node routing entry not recently used is expired. If a route is broken the neighbors can be notified. HELLO messages are used for detecting and monitoring links to neighbors. Although AODV is a reactive protocol, it uses these periodic HELLO messages to inform the neighbors that the link is still alive. When a node receives a HELLO message, it refreshes the corresponding lifetime of the neighbor information in the routing table. Due to hello messages, the control overhead increases linearly with the network size. It is possible that a valid route is expired in AODV and determining the reasonable expiry time is also difficult. The AODV has an evident weakness: its end-to-end delay. The route discovering delay can be a crucial factor in wireless sensor networks. For AODV, the number of control packets steeply increase when traffic load is increased from low to high at perpetual mobility.

### *B. EEAODV (Energy Efficient Ad Hoc on Demand Distance Vector) Protocol Design*

As the size of network grows, various performance metrics of AODV begin decreasing [2]. It is vulnerable to various kinds of attacks as it is based on the assumption that all nodes must cooperate and without their cooperation no route can be established. The energy consumption is also more while data transfer and routing overhead increases in worst cases of unavailability of routes. A protocol called EEAODV is presented based on the model for reducing the packet overhead and energy consumption using hello packets to exchange the local routes.

In this algorithm, during route discovery from the source to the destination the energy values along the route are accumulated in the RREQ packets. At the destination or intermediate node (which has a fresh enough route to the destination) these values are copied into the RREP packet which is transmitted back to the source. The source alternates between the maximum remaining energy capacity route and minimum transmission route every time it performs route discovery. The steps are as follows:

Step1: Discover the neighbor node by sending hello packets along with route Information.

Step 2: If no route is available, send the hello packet alone.

Step 3: When RREQ is received, check the local route table to know whether any Neighbor with route to destination exists.

Step 4: If so, send RREP. If not, broadcast RREQ.

### *C. DSR (Dynamic Source Routing) Protocol*

Dynamic Source Routing (DSR) is an Ad Hoc routing protocol which is based on the theory of source-based routing rather than table-based. This protocol is source-initiated rather than hop-by-hop [4].

This Protocol is composed of two essential parts of route discovery and route maintenance. Every node maintains a cache to store recently discovered paths. When a node desires to send a packet to some node, it first checks its entry in the cache. If it is there, then it uses that path to transmit the packet and also attach its source address on the packet. If it is not there in the cache or the entry in cache is expired (because of long time idle), the sender broadcasts a route request packet to all of its neighbors asking for a path to the destination. The sender will be waiting till the route is discovered. During waiting time, the sender can perform other tasks such as sending/forwarding other packets. As the route request packet arrives to any of the nodes, they check from their neighbor or from their caches whether the destination asked is known or unknown. If route information is known, they send back a route reply packet to the destination otherwise they broadcast the same route request packet.

When the route is discovered, the required packets will be transmitted by the sender on the discovered route. Also an entry in the cache will be inserted for the future use. The node will also maintain the age information of the entry so as to know whether the cache is fresh or not. When a data packet is received by any intermediate node, it first checks whether the packet is meant for itself or not. If it is meant for itself (i.e. the intermediate node is the destination), the packet is received otherwise the same will be forwarded using the path attached on the data packet. Since in Ad hoc network, any link might fail anytime. Therefore, route maintenance process will constantly monitors and will also notify the nodes if there is any failure in the path. Consequently, the nodes will change the entries of their route cache.

### *D. EEDSR (Energy Efficient Dynamic Source Routing) Protocol Design*

The limitations of DSR protocol is that this is not scalable to large networks and even requires significantly more processing resources than most other protocols [4]. EEDSR performs well with large network along with low control and packet overhead. It does not support beacon messages. Instead of beacon messages like AODV and EEAODV, it broadcasts simple RREQ message without destination information. When a neighbor node gets this message they update their neighbor table and save neighbor information. When the original RREQ message appear, then the nodes uses this information to enhance route. It has simple steps for broadcasting packets which are given below:

Step 1: Discover the neighbor node by sending a RREQ packet along with route information (with destination information).

Step 2: When RREQ is received, check the local route table to know whether any neighbor with route to destination exists.

Step 3: If so, send RREP. If not, broadcast RREQ.

## IV. Simulation Set-Up

Simulation is carried out in Network Simulator (NS-2.34) in a physical topology area of 500m × 500m which uses bidirectional links. Topology used is Flat grid. At start of simulation, each node waits for a pause time and then moves towards a destination with a speed lying between 0-60 m/sec. On reaching the destination, it pauses again and repeats the above procedure till the end of the simulation time. Mobility models were created for the simulations using the varying number of nodes from 40-100. Initial energy of nodes is assumed to be 1000 Joules. The mobility model used is random waypoint model. Comparison of the routing protocols is done on mainly energy consumption of nodes and their sending rates and throughput of the network. Table I summarizes the general parameters of routing protocols.

*I Simulation parameters of AODV, EEAODV and EEDSR*

| **Parameters** | **Values** |
|---|---|
| Channel Type | Wireless Channel |
| Physical Characteristics | Two way Ground Propagation |
| Mac Type | 802.11 |
| Data Rate | 50 kbps |
| Topology | 500m X 500m |
| Routing Protocol | AODV, EEAODV, EEDSR |
| Number of Nodes | Vary from 40-100 |
| Transmit Power | 0.005 W |
| Packet Size | 512 bytes |
| Mobility Model | Random way point |
| Simulation time | 200s |
| Traffic Source | CBR |
| Speed | 0-60 m/s |

## V. Results and Discussion

All the systems are assumed to have same type of traffic source. Each sender has constant bit rate (CBR) traffic with the rate of data rate/number of stations packet per second. Identical mobility and traffic scenarios are used across protocols to gather fair results.

### *A. Performance Metrics*

The paper focuses on two performance metrics which are quantitatively measured. The performance metrics are important to measure the performance and activities that are running in NS-2 simulation. The performance metrics are energy consumption of nodes, their sending rates and throughput which calculates packet overhead across the route.

#### *1) Energy Consumption*

It represents the capacity or potential of nodes to perform data transfer within given amount of time. It also decides the lifetime of the node within the network.

#### *2) Throughput*

It represents the total number of bits forwarded to higher layers per second. It can also be defined as the total amount of data a receiver actually receives from sender divided by the time taken by the receiver to obtain the last packet. It also represents the packet overhead within the route.

The initial energy of the nodes is 1000 Joules. Fig. 1 shows the comparison between AODV, EEAODV, and EEDSR based on average energy of nodes. Results show

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that the total energy consumption of nodes in EEAODV is lesser as compared to AODV. But EEDSR performs well as compared to both AODV & EEAODV. The numbers of nodes are varied from 40 to 80 for efficiency. Fig. 2 shows the total energy consumption of nodes during data transfer. The data rate varies as the numbers of nodes vary i.e. from 0 to 50. Results show that EEAODV consumes lesser energy when nodes are varied from 10 to 40 as compared to AODV. But AODV consumes constant energy when number of nodes increases beyond 30. EEDSR consumes less energy till 30 nodes but shows linear performance after 30 nodes.

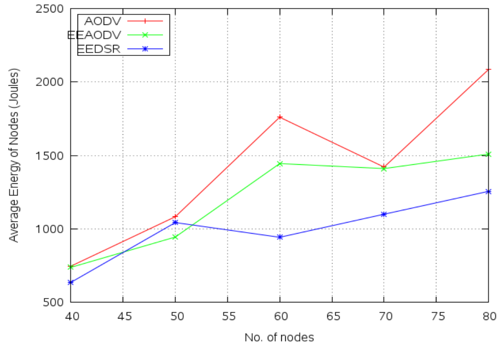


Fig. 1 Average energy of nodes

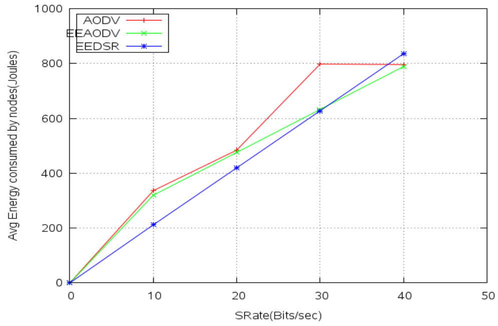


Fig. 2 Average energy consumption of nodes during data sending

The throughput of a network is calculated based on ratio of total number of packets sent and total number of packets received. Fig. 3 shows the result of packet overhead of network with respect to number of nodes varied in a given random area. The throughputs of AODV, EEAODV and EEDSR are in bits per seconds. AODV achieved 590 bits/s when number of nodes was 80, while EEAODV recorded 490 bits/s. As the pause time increases and more network routes are discovered, AODV throughput drops as packet overhead goes on increasing when number of nodes is increased. The EEDSR shows better throughput as compared to AODV and EEAODV. The maximum packet overhead recorded when number of nodes were 80 was 260 bits/s as shown in Fig. 3.

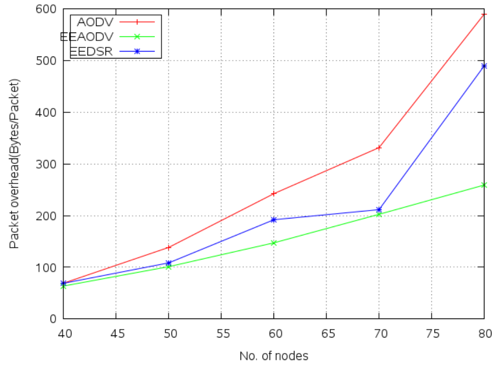


Fig. 3 Packet overhead of nodes

This shows the effect of variation in pause time of a mobile node. All three protocols deliver a greater percentage of the originated data packet at low node mobility.

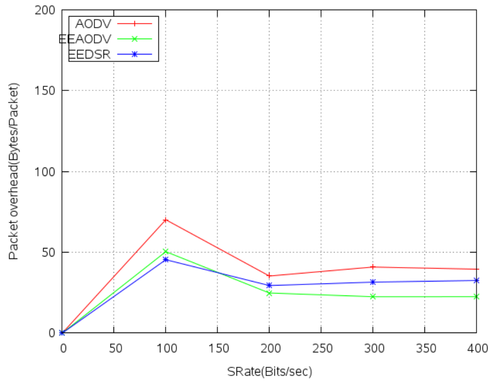


Fig. 4 Packet overhead during data sending

Fig. 4 shows the packet overhead of nodes during data sending. The sending rate is varied from 0 to 400 bits/s. Results show that AODV has larger packet overhead as compared to EE ADOV and EEDSR. But when the sending rate increases beyond 300 bits/s the packet overhead becomes constant for all the three protocols. EEDSR has low routing overhead as compared to AODV and EEADOV. Maximum overhead recorded for AODV is 70. Table II summarizes the comparison of protocols performance.

*II Comparative Summary of Protocols*

| **Performance Metrics** | **AODV Protocol** | **EEAODV Protocol** | **EEDSR Protocol** |
|---|---|---|---|
| Energy Consumption of 80 nodes | 2100 J | 1500 J | 1250 J |
| Energy consumption at 30bits/s | 800 J | 600 J | 600 J |
| Throughput of 80 nodes | 590bits/s | 490 bits/s | 270 bits/s |
| Throughput at 100 bits/s | 70 bits/s | 50 bits/s | 48 bits/s |

## VI. Conclusion

The simulated graphs show that EEAODV and EEDSR routing protocols were optimized to obtain a higher throughput. EEDSR and EEAODV adapts quickly to routing changes by reduction of sending route request packet. Throughput graph shows that EEDSR has lower packet overhead than AODV and EEAODV. It also consumes 12% less energy than EEAODV and AODV. Hence it improves the network performance.

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