Energy Aware DSDV and FSR Routing Protocols in Mobile Ad Hoc Networks

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***Abstract*— Energy efficient routing protocols for Mobile Ad hoc Network (MANET) and Wireless Sensor Network is a challenging task. Many different routing protocols based on different features have been proposed to the IETF. Performances of many of these routing protocols have been evaluated focusing on metrics such as delay, routing overhead, and packet delivery. Thus, this paper will discuss about the power consumption aspect of the MANET routing protocols. A performance comparison of Fisheye State Routing (FSR) and Destination Sequenced Distance-Vector (DSDV) routing protocols with respect to average energy consumption and routing energy consumption are explained thoroughly. Then, an evaluation of how the varying metrics in diverse scenarios affect the power consumption in these two protocols is discussed. A detailed simulation model using Network Simulator 2 (NS2) with different mobility and traffic models are used to study their energy consumption. Finally, an evaluation of these routing protocols based on energy consumption is presented.**

***Keywords*— Mobile Ad-Hoc Network, MANET Routing Protocols, DSDV, FSR.**

I. Introduction

Wireless systems, both mobile and fixed, have become an indispensable part of communication infrastructure. Their applications range from simple wireless low data rate transmitting sensors to high data rate real-time systems such as those used for monitoring large retail outlets orreal-time broadcasting of sport events. The existing wire-less technology is based on point-to-point technology. An example is GSM system with an architecture that is based on mobile nodes communicating directly with central access points. Sometimes there are networks which cannot rely on the centralized connectivity such as Mobile Ad-Hoc Networks (MANET). MANET is a wireless net-work having mobile nodes with no fixed infrastructure. These kinds of networks are used in areas such as environmental monitoring or in rescue operations. The main limitation of ad-hoc systems is the availability of power. In addition to running the onboard electronics, power consumption is governed by the number of processes and overheads required to maintain connectivity.

A number of protocols have been developed for noncentralised networks, e.g. Temporally Order Routing

Algorithm (TORA) [1] TORA is a protocol for multi-hop networks. The choice of a route in a multi-hop network influences the performance of the network, measured in terms of power consumption. There are some protocols that strive for energy efficient routing such as DSR (Dynamic Source Routing [2], Fisheye State Routing (FSR) and DSDV (Destination-Sequenced Distance Vector) [3]. These protocols offer varying degrees of efficiency.

This research focuses on communication protocols specifically aimed at limiting power consumption and prolonging battery life whilst maintaining the robustness of the system. It also proposes further research into more efficient protocols or variants of existing protocols such as TORA [1] and network topologies. Emphasis is on protocols that could be suitable for the implementation of scalable systems in high node density environments such as in manufacturing or product distribution industries. The main objective of this paper is to analyze the TORA protocol for efficiency in terms of power and suggest ways it could be improved. This will be made by measuring the energy with respect to different network size and taking into consideration the remaining battery power.

II. Protocol Overview

A. *Destination Sequenced Distance-Vector (DSDV)*

In DSDV [4] protocol messages are exchanged between nearby mobile nodes (i.e. mobile nodes that are within range of one another). Routing updates may be triggered or routine. Up-dates are caused when routing information from one of the neighbours forces a change in the routing table. If there is a packet which the route to its destination is unknown it is cached while routing queries are sent out. The packets are cached until route-replies are received from the destination. The buffer has a size and time limit for caching packets beyond which packets are dropped. All packets which have destination to the mobile node are routed directly by the address dmux (dmux port hands the packets to the respective destination agents) to its port dmux. In the event that a target is not found (which happens when the destination of the packet is not the mobile node itself), the packets are forwarded to the default target which is the routing agent. The routing agent designates the next hop for the packet and sends it down to the link layer.

B. Fisheye State Routing (FSR)

Fisheye State Routing (FSR) [4] protocol is a proactive (table driven) ad hoc routing protocol and its mechanisms are based on the Link State Routing protocol used in wired networks. FSR is an implicit hierarchical routing protocol. It reduces the routing update overhead in large networks by using a fisheye technique. Fisheye has the ability to see objects the better when they are nearer to its focal point that means each node maintains accurate information about near nodes and not so accurate about far-away nodes. The scope of fisheye is defined as the set of nodes that can be reached within a given number of hops. The number of levels and the radius of each scope will depend on the size of the network. Entries corresponding to nodes within the smaller scope are propagated to the neighbors with the highest frequency and the exchanges in smaller scopes are more frequent than in larger. That makes the topology information about near nodes more precise than the information about far away nodes. FSR minimized the consumed bandwidth as the link state update packets that are exchanged only among neighboring nodes and it manages to reduce the message size of the topology information due to removal of topology information concerned far-away nodes. Even if a node doesn't have accurate information about far away nodes, the packets will be routed correctly because the route information becomes more and more accurate as the packet gets closer to the destination. This means that FSR scales well to large mobile ad hoc networks as the overhead is controlled and supports high rates of mobility.

III. RELATED WORK

A. Energy optimization in DSDV and FSR

An energy efficient routing protocol decreases the power consumption of the nodes by routing data on paths that consume the least amount of energy. There are some special mechanisms to achieve this goal. Ref. [5] used an efficient caching technique for storing information to propose an energy efficient routing protocol. They showed that it has a better performance in terms of energy savings compared to FSR protocol. Moreover, [6] proposed a loop-free energy conserving scheme which tries to decrease routing and storage overhead to provide optimization of resources use in large scale networks. They also evaluated the performance of this scheme by simulation and showed better results. Furthermore, proposed a comprehensive energy optimized routing algorithm based on FSR protocol. This algorithm was created based on the combination of device runtime battery capacity and the real propagation power loss information. Moreover, [7] proposed algorithm used the DSDV routing protocol to select the optimal route based on the basis of the maximum energy of each route. Furthermore, [8] proposed a new routing algorithm based on the energy level of the node. The results showed the advantages of this protocol in terms of energy consumption. In addition, investigated DSDV based algorithm with less energy consumption during route founding by establishing routes that are lower congested than the others. Their scheme decreased more than 20 % of total energy consumption. Ref. [9] presented new routing protocol EMRP by combining the prediction of the node mobility and residual energy state. According to simulation results, EMRP can increase the lifetime of the network.

B. Evaluation of Energy Consumption in MANET Routing Protocols

Many routing protocols for MANET have been proposed; but only some of them have been evaluated their performances in term of energy consumption. For instance [10] and [11] presented some evaluations for routing protocols in Mobile Ad hoc Network in terms of routing overhead, throughput, packet loss, and delay but not energy consumption. Ref. [12] evaluated DSDV and FSR in order to judge delay and packet delivery ratio. Moreover, [13] analyzed these four routing protocols and showed that the energy consumption in small size networks is ahnost same in all protocols. But, in large and medium networks, they found a high efficiency for FSR and DSDV and a poor efficiency in terms of power for TORA protocol. In another study, the performance of DSDV and FSR routing protocols was compared with respect to packet delivery, end-to-end delay, route length, and energy consumption. Finally, some suggestions related to protocol design were presented to save the node energy and decrease energy consumption [14]. In addition, performance of two reactive routing protocols including Anycast Routing based FSR and Anycast routing protocol based on DSDV was evaluated with respect to fraction of packets delivered, end-to-end delay, routing load, and energy consumption for given traffic and mobility model [15]. According to literature, it is still necessary to evaluate energy consumption of FSR and DSDV routing protocols in terms of routing energy consumption and average energy consumption through detailed simulation.

IV. MATERIALS AND METHODS

A. Simulation Tool

Simulation research tool is being used by the majority of MANET community that estimates how event might occur in the real world. Commonly, this method is used to evaluate the performance of network in terms of different metrics. Discrete Event Simulation is a software-based method to employ the models of real environment to draw a conclusion from the output. Therefore, a Discrete Event Simulator is used in this study. There are many Discrete Event Simulators available for MANET community; but the research shows that Network Simulator (NS2) is the most widely used Discrete Event Network Simulator in the MANET research [16]. The most important reasons for using NS2 are software availability, large community of developer, and also supporting energy model.

B. Simulation Scenario

Designing simulation to study a protocol inherently involves making choices about which scenario details to implement or use. There are some risks both in simulating with too much detail or too little. Too much detail simulation results in slow simulations and long implementation time. On the other hand, simulations which lack necessary details can result in incorrect results. The aim is to choose the simulation with as much detail as possible to offer a realistic simulation.

C. Simulation parameters

A random traffic pattern with TCP connections between mobile nodes is used in the simulation. The starting time of various connections are generated randomly by the simulation [17]. Other parameters are shown in Table I.

TABLE I
SIMULATION PARAMETERS

Component	Type
Chanel Type	Channel/Wireless Channel
Antenna Model	Omni Antenna
Radio Propagation Model	Two Ray Ground
Mac Layer Protocol	IEEE 802.11
Maximum Packet in Interface queue	50
Number of Nodes	10,20,30,40,50,100
Topology Size	250mx250m,500mx250m, 500mx500m, 750mx750m,1000mx1000m
Simulation Time	900 Seconds
Packet Size	512 Bytes
Packet Rate	1,2,4,8 packets/seconds
Traffic Type	Constant Bit Tate(CBR)
Mobility Model	Random Waypoint(RWP)

D. Energy Model

Energy Model is a node attribute that represents level of energy in a mobile node [17]. The basic energy model is determined by Class Energy Model in NS-2 with following attributes: -txPower: Transmitting power in watts

-rxPower: Receiving power in watts

-initialEnergy: Starting Energy in joules

E. Mobility Model

The mobility model shows the movement of nodes in the simulation area. Random Waypoint mobility model (RWP) is commonly used in most simulations [18]. In RWP mobility model, the nodes move from one point to the next point with pause time in some point. This pause time can be equal to zero in the case of a network with continuous mobility nodes and equals to the duration of the simulation in the case of fixed topology network.

F. Energy Performance Metrics

Routing energy consumption and average energy consumption are energy performance metrics in this study. In routing energy consumption, protocols are evaluated in term of energy consumption only in network layer. In contrary, the average energy consumption is simply the total consumed energy over the number of nodes. In Ad hoc network, energy consumption is sum of transmit, receive, idle and sleep power in all layers.

V. RESULTS

Routing energy consumption

To compare the routing energy consumption, four varying parameters are chosen. These parameters are:

- The traffic pattern
- The node's mobility pattern
- The mobile nodes number
- The simulation area size

Varying Traffic Patterns In varying traffic patterns, DSDV and FSR protocols are evaluated by number of traffic source and rate of source sending. According to Fig. 1, when the number of sources grows, an increase of routing packets can be seen in FSR and DSDV protocols. The result shows that the energy consumption of FSR has a slower trend compared to DSDV. It shows that when the traffic sources numbers increase from 10 sources to 20 sources, routing energy consumption grows 88% in DSDV and 28% in FSR. However, when this factor moves from 20 sources to 30 sources, routing energy consumption grows 20% in DSDV and 46% in FSR. So, the increase of energy consumption of DSDV is more than FSR in low traffic and FSR is more than DSDV in high traffic. Source routing characteristic of FSR and caching may be the main reasons for this behavior. Fig. 2 shows a similar manner for both protocols. They perform in a consistent manner as the amount of source sending rate is increased

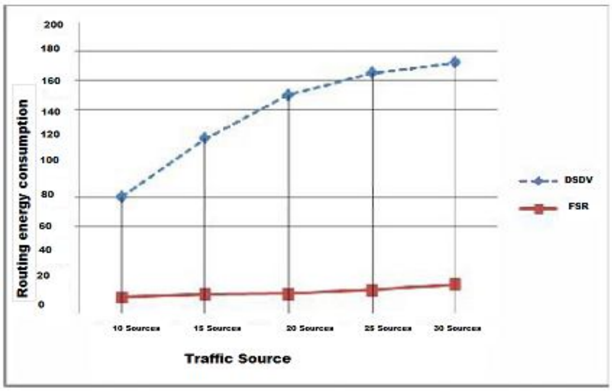

Fig.1.Routing energy consumption vs. number traffic source

Varying Mobility Pattern

Mobility is categorized by two factors: pause time and maximum speed. Fig. 3 shows a series of scenarios that start from continues motion nodes and ends to static ones. In the static network, both protocols have a similar behavior. But in scenarios with constantly changing network, they start to act in a different way. In these scenarios, the FSR caching mechanism makes less route discovery overhead than in DSDV. So, the results show better perfonnance inFSR than DSDV.

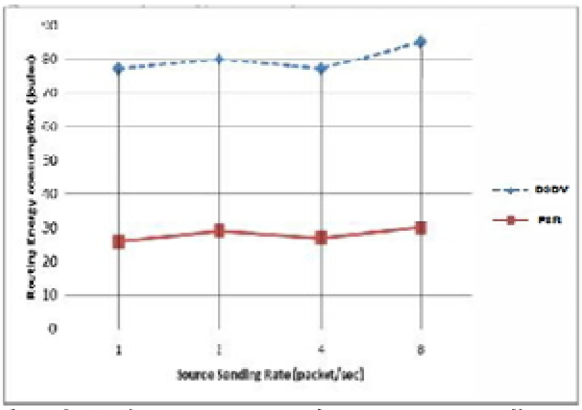

Fig.2.Routing energy consumption versus source sending rate.

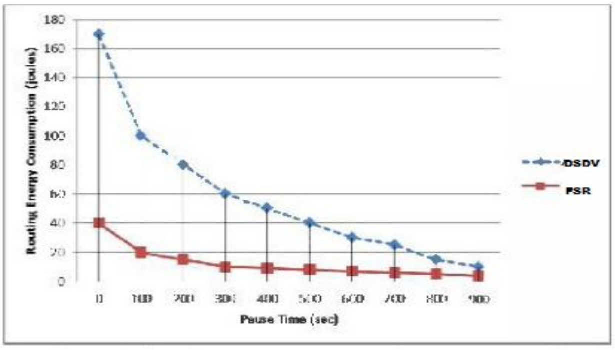

Fig.3.Routing energy consumption versus pause time

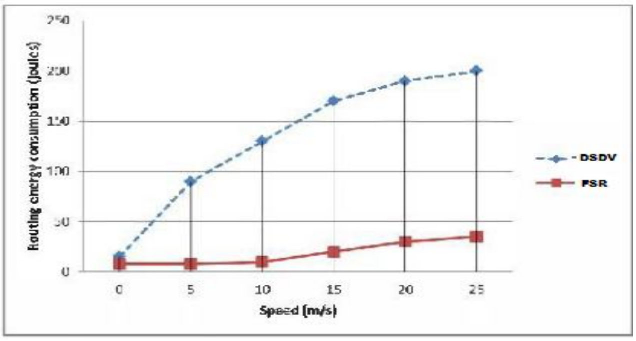

Fig.4. Routing energy consumption versus speed

As Fig. 4 shows, static network, humans walking MANET, cyclists MANET community, urban cars MANET, and road cars MANET are simulated by these scenarios. The result shows that the power consumed by two reactive protocols grows by increasing the maximum speed. When the speed changes from hn!s (walking human's speed) to 25mJs (road car's speed), the difference between energy consumption of DSDV andFSR grows from 3.1 to 5.3. It means that in case of road car MANET applications, using FSR routing protocols is strongly recommended.

Varying Node Number

According to Fig. 5, energy consumption of FSR and DSDV form 10 nodes to 20 nodes are quite similar; but a significant difference of energy consumption which starts from 20 nodes and this value is increased to 50 nodes. In 50 nodes, the energy consumption of DSDV due to the routing packets is 2.9 times FSR. Route maintenance process of DSDV can be the main reason of this increase.

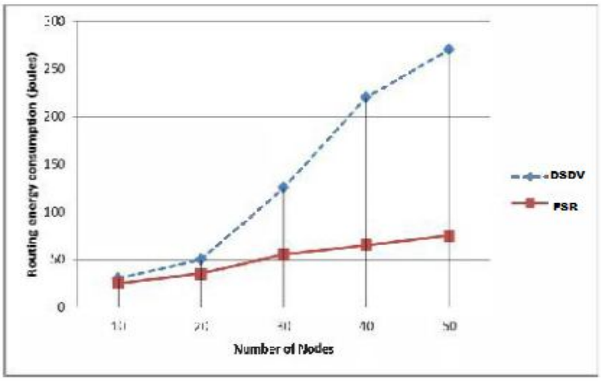

Fig.5. Routing energy consumption versus number of nodes

Varying Area Size

Fig. 6 shows that routing energy consumption of FSR and the DSDV protocols are increased by incrementing the area. Again, in this scenario FSR is more efficient than DSDV protocol.

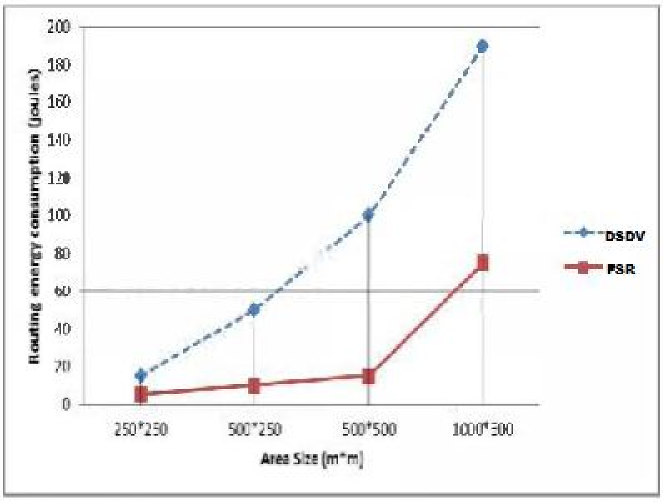

Fig.6. Routing energy consumption versus area size

Average Energy Consumption

Energy consumption is mostly used by transmission and reception of data packets, including routing packets, transport layer packets, and data link layer packets. Evaluations of two routing protocols based on four selected parameters are as follows:

Varying Traffic Pattern

A similar behavior of the routing protocols can be seen from the results as shown in Fig. 7 and Fig. 8. Also, FSR consumes less energy in high traffic (high source number and sending rate) than DSDV due to its source routing characteristic.

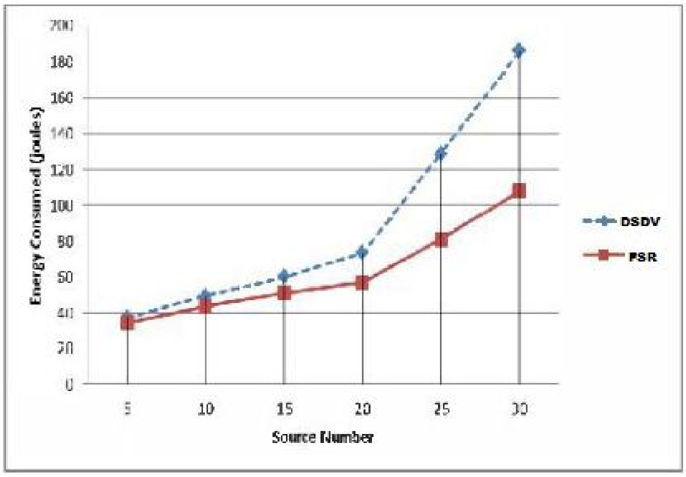

Fig.7. energy consumed versus source number

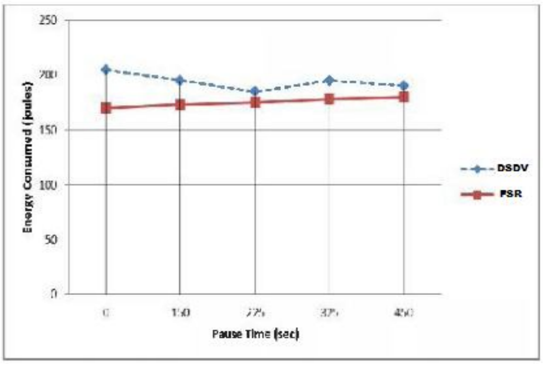

Fig.8. energy consumed versus source sending rate

Varying Mobility Pattern

Mobility of model changes by varying the pause time of the node and the speed of node. Fig. 9 shows that FSR is more efficient one and consumes less energy. The similar pattern applies to DSDV. In varying speed (Fig. 10), DSDV consumes higher volume of energy than the FSR and this gap becomes higher as the speed increases.

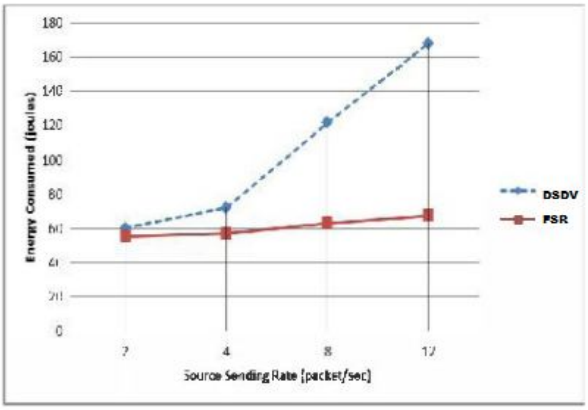

Fig.9. energy consumed versus pause time

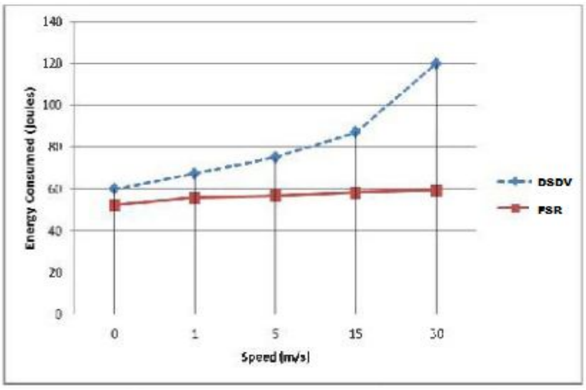

Fig.10. energy consumed versus speed

VI. CONCLUSION

In this study, an energy performance comparison of FSR and DSDV routing protocols for mobile Ad hoc network was presented. FSR and DSDV have different routing mechanisms. However, FSR and DSDV have the same on-demand behavior. DSDV applies routing tables with one route for each destination. In contrast, FSR applies route caches and uses source routing without using any periodic transmission. It also uses caching and keeps more than one route for each destination. Type of routing protocol affects the energy consumption due to the different routing overhead used for sending and receiving the routing packets. The experiments show that FSR is efficient with most mobility scenarios; but source routing increases the overhead of routing in this protocol. On the other hand, DSDV is efficient with some mobility scenarios by eliminating source routing overhead of the FSR protocol. But in DSDV, discovery route requires more overhead and actually is more expensive than FSR. The overall results show a better performance of FSR rather than DSDV except in static networks while DSDV uses hop-by-hop routing and FSR uses source routing with longer header. The reason is that FSR uses caching mechanisms to reduce the discovery routes overhead. It also shows that FSR resulted in the least energy consumption for low density networks and DSDV generated higher volume of energy than the FSR in high density networks. They have a similar behavior in static network. The reason for this behavior can be less overhead in FSR due to source routing. Also, the results demonstrate that FSR performs better than DSDV in low and high loads. However, DSDV is found effective for low loads. Therefore, as an overall conclusion, routing protocols used currently in MANET may require some effort to minimize the energy cost of interface in the network. A comparison of results of first section and second section shows that the cost of sending packets in DSDV protocol is very significant. So, energy consumption is increased mostly due to the increase in the routing packet overhead like RREQ and RREP packets. DSDV is more efficient when the cost of application layer and transport layer are added in second section. So, by considering the routing overhead of DSDV protocol and reducing the number of control packets, energy consumption can be decreased and the lifetime of the network can be increased.

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