A new Routing Protocol for Mobility in Wireless Sensor Networks

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Abstract—**Recent advances in wireless sensor networks have led to many new protocols specifically designed for sensor networks where energy awareness is an essential consideration. Most of the attention, however, has been given to the routing protocols since they might differ depending on the application and network architecture. In this paper, we propose an energy efficient data forwarding protocol called Energy Aware Geographic Routing Protocol (EAGRP) for wireless sensor networks to extend the life time of the network. The proposed protocol is an efficient and energy conservative routing technique for multi-hop wireless sensor networks. The significance of this study is that there has been a very limited investigation of the effect of mobility models on routing protocol performance in Wireless Sensor Network. We have considered the influence random waypoint mobility models on the performance of EAGRP routing protocol. The performance measures have been analyzed with variable number of nodes. Our simulation results indicate that the proposed algorithm gives better performance in terms of higher packet delivery ratio, throughput, energy consumption, routing overhead, and delay.**

***Index Terms*—Wireless sensor Networks, Energy efficient, Mobility, Routing protocol**

I. Introduction

WIRELESS Sensor Networks(WSNs) are being used in a wide variety of critical applications such as military and health-care applications. WSNs are deployed densely in a variety of physical environments for accurate monitoring. Therefore, order of receiving sensed events is important for correct interpretation and knowledge of what actually is happening in the area being monitored. A WSN is usually deployed with static sensor nodes to perform monitoring missions in the region of interest. However, due to the dynamic changes of events and hostile environment, a pure static WSN could face the following severe problems:

1. The initial deployment of a WSN may not guarantee complete coverage of the sensing field and connectivity of the whole network. Usually, sensor nodes may be scattered in a hostile region from the aircraft or by robots [1]. However, these randomly deployed sensors could not guarantee to cover the whole area and may be partitioned into several non-connected sub networks, even though we scatter a huge amount of nodes. Moreover, the dynamic change of regions of interest and the existence of obstacles could make the problem become more difficult.
2. Sensor nodes are usually battery-powered and prone to errors. As some nodes die due to the exhaustion of their energy, there could exists holes in the WSN's coverage. In addition, these death nodes may break the network connectivity. However, in many scenarios, it is quite difficult to recharge sensor nodes or deploy new nodes to replace these death nodes.
3. The WSN may be required to support multiple missions under various conditions [2]. For example, in an object tracking application, sufficient sensor nodes should be deployed along the track of the target, while in a boundary detection mission; there should be adequate nodes along the pre-described perimeter. These different requirements cannot be easily satisfied by deploying a large amount of sensor nodes, since provisioning for all possible combinations of mission requirements could not be economically feasible.
4. Some applications may need sophisticated (and thus expensive) sensors to involve in. For example, one can imagine that in a military application, pressure sensors may be deployed along the boundary to detect whether any enemy intrudes in. However, these sensors can only report something passing but cannot describe what passes through them. In this case, more sophisticated sensing devices like cameras should be required to obtain more information. Nevertheless, it is infeasible to equip camera on each node because of their large number.

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By introducing mobility to some or all nodes in a WSN, we can enhance its capability and flexibility to support multiple missions and to handle the aforementioned problems. Although a WSN is usually considered as an ad hoc network in which nodes are extended with sensing capability, a mobile WSN and a mobile ad hoc network (MANET) are essentially different. Mobility in a MANET is often arbitrary, whereas mobility in a mobile WSN should be "intentional". In other words, we can control the movement of mobile sensors to conduct different missions.

In wireless sensor networks geographic routing is a key paradigm that is quite commonly adopted for information delivery, where the location information of the nodes is available. The implication of geographic routing protocols is efficient in sensor networks for several reasons. Firstly, nodes need to know only the location information of their direct neighbors in order to forward packets and therefore the state stored is minimized. Secondly, since discovery floods and state propagation are not required beyond a single hop hence, such protocols conserve energy and bandwidth [3].

When sensor nodes forwards messages in the network they use their energy in forwarding mechanism but at some point when node depletes its all energy it fails to transmit further messages resulting in loss of data. Usually, in greedy forwarding, the closest neighbor node will be heavily utilized in routing and forwarding messages while the other nodes are less utilized. This uneven load distribution results in heavily loaded nodes to discharge faster when compared to others. This causes the failure of few over-utilized nodes which results in loss of data, resulting in increase of failed messages in the network [4]-[5].

In this paper, the above mentioned problems faced by greedy forwarding approach will be taken care of in sensor networks by proposing an energy efficient routing strategy that will minimize the data loss and maximize the lifetime of the network.

The rest of this paper is organized as follows: Section II presents related work. Section III presents motivation and objectives of the proposed research. Section IV describes the proposed algorithm. Section V describes the details of simulation model. Simulation results and discussions are presented in section VI. Section VII concludes this paper.

II. Related work

Here we discuss some recently proposed routing protocols for reliable and efficient many to one routing in multi-hop WSNs. Greedy forwarding routing algorithm called Greedy Perimeter Stateless Routing for wireless networks (GPSR) has been discussed to minimize the number of hops [6]-[7]. GPSR is a geographic routing protocol for wireless networks that combines greedy forwarding and face routing (perimeter routing). Packets contain the position of the destination and nodes need only local information about their position and their immediate neighbors' positions to forward the packets. Each node forwards the packet to the neighbor closest to the destination using greedy forwarding. When greedy forwarding fails, face routing is used to route around dead-ends until closer nodes to the destination are found. Thus, each node forwards the message to the neighbor that is most suitable from a local point of view. The most suitable neighbor can be the one who minimizes the distance to the destination in each step (Greedy). The main objective of the GPSR is to minimize the number of hops in the network and maximize the data packets transmitted successfully. Putting Greedy Forwarding and Perimeter Forwarding together makes the final GPSR which will use the necessary algorithm(s) to find the best path in a given topology.

The Dynamic Source Routing (DSR) allows nodes to dynamically discover a source route across multiple network hops to any destination in the network. To do this, each packet header contains the complete, ordered list of traversed nodes. If an intermediate node is not the destination or it does not have any route to the destination in its route cache, it will initiate a route discovery process via request broadcast to its neighbors. If available, the complete route to the destination is found and returned to the initiator. Otherwise, the neighbor appends its address to the route record and rebroadcasts to its neighbors. When routes become invalid, DSR adapts by sending a route error packet to the source node, which stops using the route. For better reliability, DSR maintains multiple route entries in its routing table. The complete routing algorithm is described in [8]-[9].

Ad Hoc on-Demand Distance Vector Routing Protocol (AODV) is a routing protocol designed for wireless networks. AODV builds routes using a route request / route reply query cycle. When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet across the network. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables. In addition to the source node's IP address, current sequence number, and broadcast ID, the RREQ also contains the most recent sequence number for the destination of which the source node is aware. A node receiving the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it unicasts a RREP back to the source. Otherwise, it rebroadcasts the RREQ. The complete routing algorithm is described in [10]-[11].

III. Motivation of current work

Many routing algorithms for WSNs have been developed but most of them do not take into consideration the limited energy resources for sensor nodes. This is a main drawback in most routing algorithms where they should choose the routes based on the energy available at nodes. This will prolong the lifetime of the sensor nodes and thus the network lifetime. The algorithm should guarantee Quality of Service (QoS) while taking into consideration the limited power and energy supplies of nodes. As the lifetime of a node is strictly bounded to its battery capacity, the algorithm should wisely utilize nodes while preserving their energy [12].

In some cases, sensor nodes have the ability to move, although their mobility is restricted in range to a few meters at the most. Mobility of sensor nodes raises the possibility that nodes might go out of range and new nodes might come within the range of communication. The routing protocols for sensor networks must take these changes into account when determining routing paths. Thus, unlike traditional networks, where the focus is on maximizing channel throughput or minimizing node deployment, the major consideration in a sensor network is to extend the system lifetime as well as the system robustness.

Energy consumption is the most important factor to determine the life of a sensor network because usually sensor nodes are driven by battery and have very low energy resources. This makes energy optimization more complicated in sensor networks because it involves not only reduction of energy consumption but also prolonging the life of the network as much as possible. This can be done by having energy awareness in every aspect of design and operation. Due to energy constraints in WSNs, geographic routing has been a challenging issue for researchers. The nodes in the network cooperate in forwarding other nodes packets from source to destination. Hence, certain amount of energy of each node is spent in forwarding the messages of other nodes. Lots of work has been done in this respect but still energy depletion of sensor nodes is a big challenge in sensor networks. The performance of the routing protocol also has to scale with network size. The challenge is then to develop a routing protocol that can meet these conflicting requirements while minimizing compromise [13]-[16].

The aim of this paper is to address the problem of providing energy-efficient geographic routing for WSNs that guarantees QoS and at the same time minimizes energy consumption by calculating the remaining energy level of nodes. We propose a geographic routing protocol called EAGRP which takes into consideration both nodes location information and energy consumption for making routing decisions. EAGRP is simple, scalable as well as energy efficient.

IV. EAGRP ALGORITHM DESCRIPTION

In sensor networks, building efficient and scalable protocols is a very challenging task due to the limited resources and the high scale and dynamics. Geographic routing protocols require only local information and thus are very efficient in wireless networks. First, nodes need to know only the location information of their direct neighbors in order to forward packets. Second, such protocols conserve energy and bandwidth since discovery floods and state propagation are not required beyond a single hop. It is based on assumption that the node knows the geographical location of the destination node. This approach to routing involves relaying the message to one of its neighbors that is geographically closest to the destination node. A node that requires sending a message acquires the address of the destination. After preparing the message, it calculates the distance from itself to the destination. Next, it calculates distance from each of its neighbors to the destination.

The greedy approach always tries to shorten the distance to be traveled to the destination to the maximum possible extent. Therefore, the node considers only those neighbors that are closer to the destination than itself. The sending node then chooses the node closest to the destination and relays the message onto the neighbor. A node receiving a message may either be the final destination, or it may be one of the intermediate nodes on the route to the destination. If the node is an intermediate hop to the message being relayed, the node will calculate the next hop of the message in the manner described above. Usually, in the greedy forwarding the closest neighbor node will be heavily utilized in routing and forwarding messages, while the other nodes are less utilized. Due to this uneven load distribution it results in heavily loaded nodes to discharge faster when compared to others. This causes few over-utilized nodes which fail and result in formation of holes in network, resulting in increase number of failed/dropped messages in the network. Energy efficient routing scheme should be investigated and developed such that its loads balances the network and prevents the formation of holes.

The concept of neighbor classification based on node energy level and their distances used in Energy Aware Geographic Routing Protocol has been used to cater of the weak node problem. Some neighbors may be more favorable to choose than the others, not only based on distance, but also based on energy characteristics. It suggests that a neighbor selection scheme should avoid the weak nodes. Therefore, the procedure used in the proposed (EAGRP) first calculates the average distance of all the neighbors of transmitting node and checks their energy levels. Finally, it selects the neighbor which is alive (i.e. having energy level above the set threshold) and having the maximum energy plus whose distance is equal to or less than the calculated average distance among its entire neighbors. Hence, the proposed scheme uses Energy Efficient routing to select the neighbor that has sufficient energy level and is closest to the destination for forwarding the query.

Figure1 shows the flow chart of EAGRP algorithm. It starts and initializes the network by giving the input of number of nodes and establishes their links with the time delay between each link. Then it locates the position of each node and save it in mapping table. Then it finds the all next hop neighbors of the sending node and calculated their average distance from the sending node. It checks if the node is still in the same neighborhood or has moved to a new neighborhood, if the node has moved greater than the flooding distance. Send out a flood of the new position of the node. Determine the coordinates of the new quadrant that the node has moved to and send out a flood of the new position of the node to all the concerned neighborhoods that need to know. It selects the node among its next hop neighbors which having energy level above than the set threshold and make the decision. If no node among its neighbors it will drop the packet otherwise it will select the neighbor node whose distance is less than or equal to the calculated average distance plus having maximum energy level among those neighbors and transmit the packet to it by deducting the transmitting energy of the sending node. The selected neighbor will receive the packet and this process will continue until the packet reaches to its destination and all other packets will follow the same procedure.

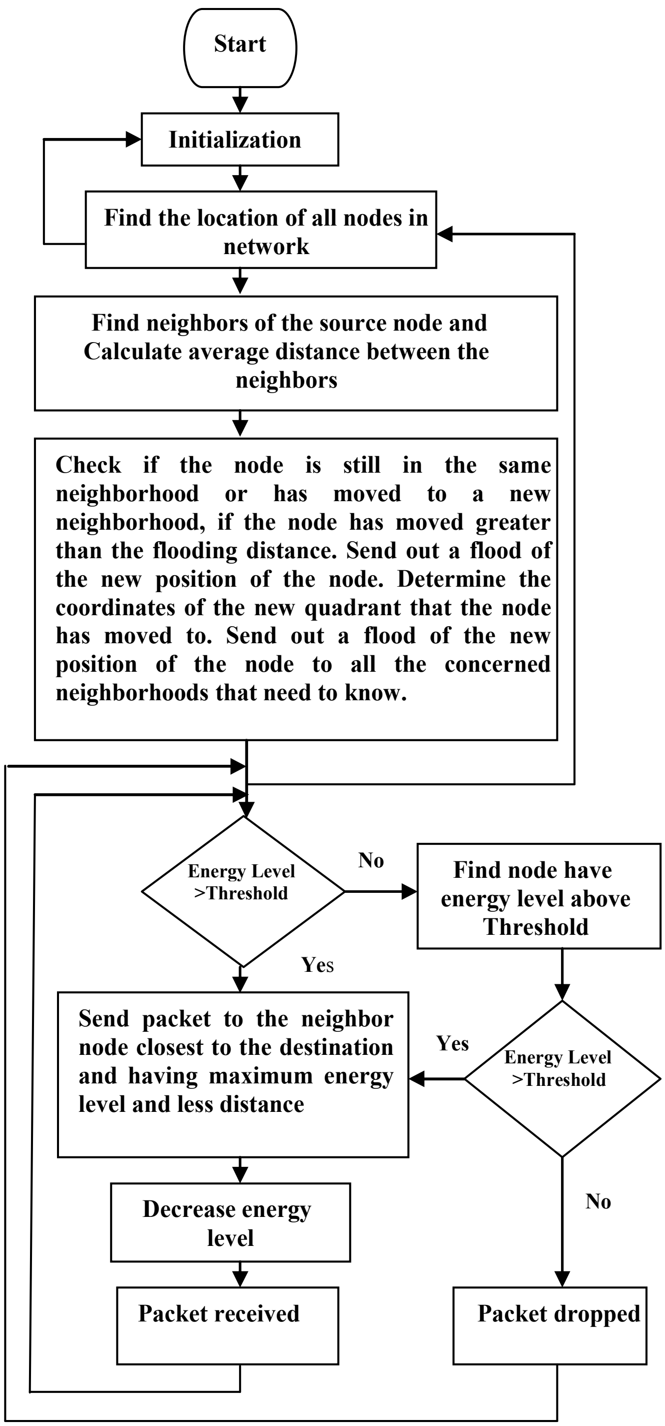

Fig. 1. Flow chart for EAGRP

V. SIMULATION MODEL

A. Simulation Tool (OPNET)

In this section a comparative study between the behaviors of the four routing protocols: EAGRP, GPSR, DSR, and AODV will be given by simulation of WSN chosen to represent application. The well known OPNET simulation tool is used. OPNET provides a comprehensive development environment for modeling and performance evaluation of communication networks and distributed systems. Different simulation results are presented with different number of nodes in order to check performance of the proposed algorithm. The goal of the study was to investigate the behavior of EAGRP, GPSR, DSR and AODV for packet delivery ratio, throughput, and energy consumption, routing overhead, and delay.

B. Mobility Model

Mobility models play a key role during the simulation of Wireless Sensor Networks. Mobility of sensor nodes specifies the dynamic characteristics of node movement and is one of the characteristics of wireless sensor network. Its potential use found in variety of applications ranging from vehicular networks and military missions to reconnaissance. The relative movement between nodes creates or breaks wireless connections and changing the network topology. This affects the performance of the network and plays a vital role in the evaluation of sensor networking protocol. The patterns of movement of nodes can be classified into different mobility models and each is characterized by their own distinctive features. The random waypoint mobility [17] model tries to approximate the reality by introducing pause time between changes in direction or speed of the nodes, and it has been widely used to validate communication protocols in WSNs. Firstly, each node randomly chooses an initial position (x, y) in the network, where x and y are both uniformly distributed over $[0, X_{max}]$ and $[0, Y_{max}]$, respectively. Then, every node selects a destination (x^{-}, y^{-}) uniformly distributed in the network area and a speed ν uniformly chosen from the range $[V_{min}, V_{max}]$, where V_{min} and V_{max} are the minimum and maximum velocities, respectively, that a node can choose, such that $0 < V_{min} < V_{max}$. A node will then start traveling toward the (x^{-}, y^{-}) destination on a straight line using the chosen speed ν. Upon reaching the selected destination, the node remains there for a pause time, either constant or randomly chosen from a given distribution. Upon expiration of the pause time, the next destination and speed are selected in the same way and the process repeats until the end of the simulation. The movement pattern of a mobile node using the random waypoint mobility model is similar to random walk mobility model if pause time is zero. For a mobility model, the instantaneous average node speed is defined by [18].

$$\bar{v}(t) = \frac{1}{N}\sum_{i=1}^{N} v_i(t) \qquad (1)$$

where N is the total number of nodes, ν_i (t) is the speed of node i at time t.

C. Energy Model

For the simulations, a simple energy model has been used in which every node starts with the same initial energy and forwards a packet by consuming one unit of energy. Initially, all nodes have energy level equal to 1 joule .We let the size of a data transmission (including all headers) be L bits and the transmission rate of the sensor be R bps. The time $t_{transmit}$ (in sec) taken to transmit one data packet is:

$$t_{transmit} = L / R \quad (2)$$

We denote the received time $t_{receive}$, the energy required in the receive state by $E_{receive}$, the energy required to transmit a data packet by $E_{transmit}$, the energy of a fully charged node by E_{total}. We let receive and transmit power of the sensor be $P_{receive}$ and $P_{transmit}$ respectively. Therefore, we have

$$E_{transmit} = P_{transmit} \times t_{transmit} \quad (3)$$

$$E_{receive} = P_{receive} \times t_{receive} \quad (4)$$

$$E_{total} = E_{transmit} + E_{receive} \quad (5)$$

D. Simulation Setup

We designed WSN according to the application we selected for this study. WSN is made of static nodes and mobile nodes representing data gathering and object tracking applications.

In the simulation, all nodes generated data packets that are routed to the destination node located in the centre of the WSN. We simulated network sizes from 25 to 200 nodes with 100% active source nodes. In all these scenarios, 30% number of nodes enabling mobility. Random topology has been considered in this implementation. WSN was simulated in the presence of different factors having effect on routing protocols performance. We categorized our simulation on the basis of nodes type, scalability, and different number of source nodes. The random waypoint model has been selected to be used in all simulations presented in this study.

Simulation time for each scenario was set to 500 seconds and repetitive simulations for each scenario were performed to verify the reliability of our results. The network was modeled on an area having dimension of 300 x 300 meters. The packet size is of 128 bytes, and the packet rate is 4 packets /sec. All nodes in this network are considered as source nodes communicating with constant bit rate 1 Mbps. The numbers of nodes chosen are 25, 50, 75, 100, 125, 150, 175 and 200 nodes. The input parameters used for all scenarios were the same as shown in Table I except the number of nodes.

The application type simulated was File Transfer Protocol (FTP). Initially, each node has the same energy level (1Joule). Any node having energy less than or equal to a set threshold will be considered as dead, this was chosen to be in the simulations presented in this paper. One node is located as the destination i.e. one node is declared as target node for all data receiving as was mentioned in the assumptions that many to one scenario has been considered.

TABLE I
SIMULATION PARAMETERS

Simulation time	500 sec
Simulation area	300 m x 300m
Number of nodes	25, 50, 75, 100, 125, 150, 175, 200
Packet size	128 bytes
Packet rate	4 packets/sec
Mobility model	random waypoint
Initial node energy	1 Joule
Data rate	1 Mbps

E. Selected Performance Metrics for Simulation

In order to check the four protocols performance in terms of its effectiveness there are a number of metrics that can be used to compare between them. We used packet delivery ratio, throughput, energy consumption, routing overhead and end-to-end delay for the evaluation. The metrics that we selected are defined as follow:

1) Packet Delivery Ratio

Measures the percentage of data packets generated by nodes that are successfully delivered, expressed as:

$$\frac{\text{Total number of data packets successfully delivered}}{\text{Total number of data packet sent}} \times 100\%$$

2) Throughput

The throughput reflects the effective network capacity. It is defined as the total number of bits successfully delivered at the destination in a given period of time. Throughput shows protocol's successful deliveries for a time; this means that the higher throughput the better will be the protocol performance.

3) Energy Consumption

The energy metric is taken as the average energy consumption per node calculated through simulation time.

4) Routing Overhead

To find routes, routing protocols used to send control information (packets). These control information along includes basically route request sent, route reply sent and route error sent packets. Each hop of the routing packet is treated as a packet. Normalized routing load are used as the ratio of total number of control packets sent to the total number of traffic sent (routing packets + data packets).

Routing overhead = Control packets sent / Total traffic sent

5) End-to-End Delay of Data Packets

There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the Medium Access Control (MAC), and propagation and transfer times. This metric measure the average time it takes to route a data packet from the source node to the destination node. The lower the end-to-end delay the better the application performance. If the value of End-to-end delay is high then it means the protocol performance is not good due to the network congestion.

VI. RESULTS & DISCUSSIONS

Packet Delivery Ratio: DSR nodes can obtain the latest routing information and packets are routed on valid paths with high probability. Multiple paths are kept in the routing table giving DSR a good degree of reliability. DSR exhibits moderately high packet delivery ratio. Although the route discovery process in AODV is similar to DSR, each node only maintains a single routing table entry for each destination. A single route discovery in AODV reveals less information data than in DSR. Hence, within the same time, fewer routes are discovered with consequence that the number of packets delivered is less.

It is evident from Figure 2 that the proposed EAGRP algorithm provides better data delivery rate ratio than GPSR, DSR and AODV algorithms. The successful packet delivery ratio of EAGRP achieved about 95% on average compared to 90% for GPSR, 76% for DSR and 65% for AODV. The main focus is on varying size of network by keeping other parameters constant. The objective is to design an algorithm that can scale to thousands of nodes in future sensor networks, therefore the research has been focused on how the algorithm scales and performs better with networks of different sizes. It has been observed that the amount of packets delivered ratio is larger for all the network size. It means that EAGRP improves the performance much more as the number of nodes increases.

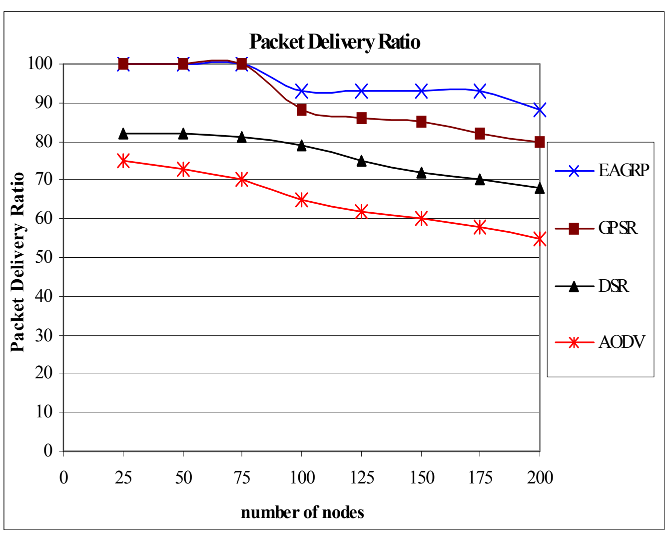

Fig. 2 Packet Delivery Ratio versus number of nodes

Throughput: Figure 3 shows the throughput of EAGRP, GPSR, DSR, and AODV protocols for all scenarios. The throughput depends on the simulation parameters regarding data generation and request for delivery. It can be observed that the four protocols have the same throughput, but when the traffic load is increased we can show that EAGRP leads to more throughput than GPSR, DSR, and AODV. DSR showed that it was able to deliver packets more than AODV because it already had routes to destination stored in its cache and had no need to route discover again.

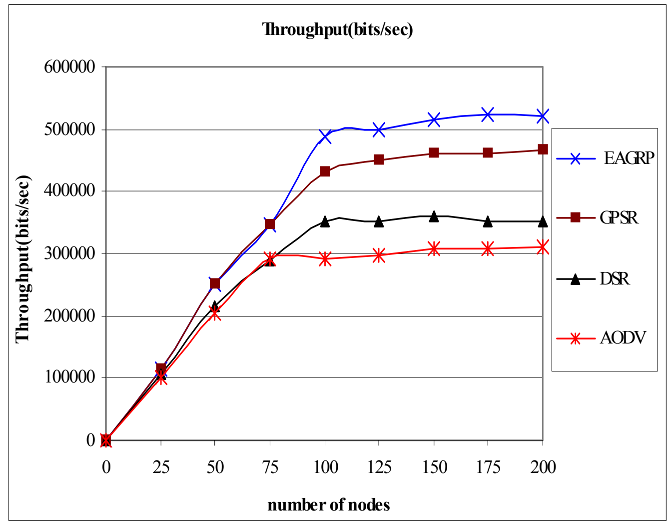

Fig. 3. Throughput versus number of nodes

Energy Consumption: Figure 4 presents the energy consumption for the four protocols. Route discovery in AODV is energy intensive. The data packet carries pointers to the full route in itself, which incurs additional energy overheads during routing compared to data packets of routing protocols that carry only neighborhood information. The additional energy consumed is proportional to network size. With an operating environment, it may be very difficult to establish a full route from source to the destination at given point in time. The source will keep sending route discovery but will not receive a definite route response from the destination. Route discovery packet will accordingly flood the network consuming more energy. As in AODV, however, route discovery broadcast in DSR can lead to significant energy consumption especially in larger networks. As an improvement over AODV, DSR uses a route cache to reduce route discovery costs.

Under energy constraints, it is vital for sensor nodes to minimize energy consumption in radio communication to extend the lifetime of sensor networks. From the results shown in Figure 4, we argue that EAGRP and GPSR routings tends to reduce the number of hops in the route, thus reducing the energy consumed for transmission. EAGRP exhibit the lowest energy overheads as shown in Figure 4. Energy overheads of EAGRP are competitive with that of DSR. It is also indicated that the packet drop rate is very small in EAGRP approach as compared to the GPSR and AODV algorithms. Hence, EAGRP approach conserves more energy and is more efficient than GPSR, DSR and AODV algorithms. The slightly improvement over DSR with larger networks size may be attributed in part to EAGRP dynamically accounting for selecting shortest path to destination.

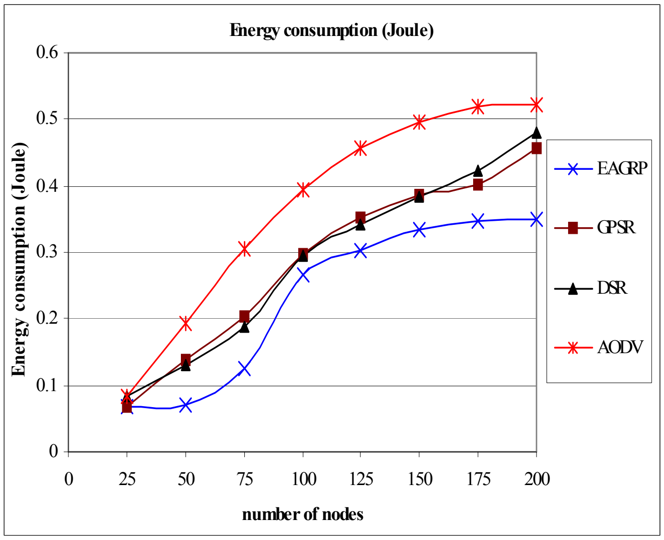

Fig. 4. Energy consumption versus number of nodes

Routing overhead: In order to check the protocol effectiveness in finding routes towards destination, it is interesting to check how much control packets it sends. The larger the routing overhead of a protocol, the larger will be the wastage of the resources (bandwidth). Considering the results in Figure 5, we observed that EAGRP and GPSR routing algorithms used a relatively low number of control packets. The only control packets used in EAGRP and GPSR are a periodic beacon that is why their results coincide to each other. Most control packets in DSR and AODV are used in route acquisition. Because AODV initiates route discovery (flooding) whenever a link breaks due to congestion, it requires a large number of control packets. DSR uses a route cache extensively, so it can do route discovery and maintenance with a much lower cost than AODV.

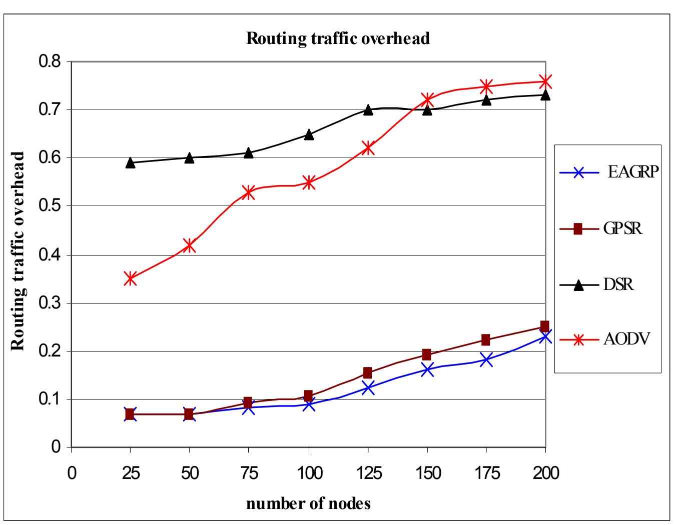

Fig. 5. Routing traffic overhead versus number of nodes

Delay: Figure 6 presents the delay encountered by the four routing protocols during the simulation period for all scenarios. It is clear from figures that DSR incurs the highest delay, especially on large network size. DSR exhibits large packet delay because its routes discovery takes more time. Every intermediate node tries to extract and record information before forwarding a reply. The same thing happens when a data packet is routed from node to node. Hence, while route discovery in DSR yields more information for delivery, packet transmission slows down. AODV gives the lowest delay as compared to DSR. For AODV, routes are established on demand and destination sequence numbers are used to find the latest route to the destination, the connection setup process is less. DSR does not have a mechanism for knowing which route in the cache is stale, and data packet may be forwarded to broken links. Also the delay is affected by buffering and queuing delays, route discovery is also considered in the delay and gives advantage to AODV routing protocol. The destination node in AODV routing protocol only replies to the first arriving route request RREQ which favors the least congested route instead of the shortest route as with DSR. This happens because DSR replies to all RREQ which makes it difficult to determine which route is the shortest. Figure 6 indicates that EAGRP has always the smallest delay than GPSR and DSR even when the number of nodes is increasing. So EAGRP is successful in terms of time delay.

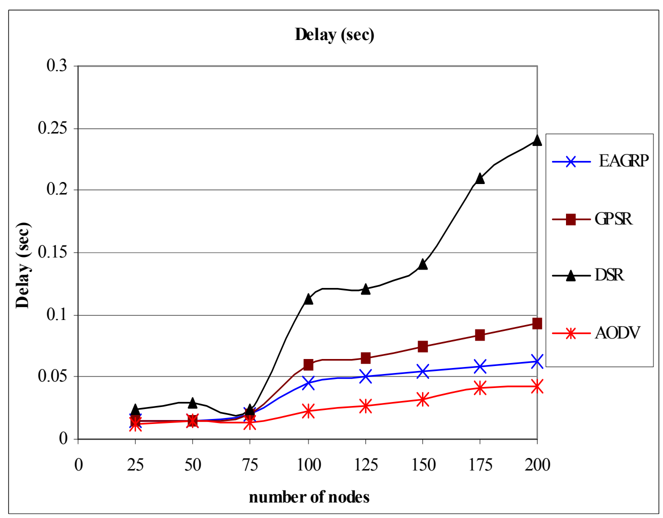

Fig. 6. Delay versus number of nodes

VII. Conclusion

Many excellent protocols have been developed for ad hoc networks. However, sensor networks have additional requirements that were not specifically addressed. Here, we explored how node mobility might be exploited to create enhanced greedy forwarding techniques for Energy Aware geographic routing protocol. In this paper we have proposed a new protocol EAGRP for efficiently and reliably routing data packets from mixing static and mobile information source nodes to sink through a multi-hop wireless sensor network. The simulation results demonstrate the evaluation of performance of EAGRP routing protocol with random waypoint mobility model.

The simulations are carried out for different number of nodes employing these four algorithms considering the different metrics. Simulation results have shown that the EAGRP performs competitively against the other three routing protocols in terms of packet delivery ratio, throughput, energy consumption, routing overhead, and delay. Consequently, it can be concluded that EGARP can efficiently and effectively extend the network lifetime by increasing the successful data delivery rate.

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