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# Trajectory of mobile sink node using GPSR in WSN to enhance energy efficiency

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**Abstract** — *Wireless Sensor Network cover a large geographical area and enable the acquisition of sensed data and uploading to data sinks. Multi hop communication is required while nodes relay information between the source nodes and the sinks. The lifetime of the Wireless sensor network largely depends on the energy of the sensor nodes neighboring the sinks that relay all messages to sink and act as a last hop. One of the most critical problems in WSNs is achieving energy efficiency in data collection. The drawbacks of using a static sink are well known. Mobile sink maybe used to improve the energy efficiency compared to a static one. As the sink moves in the sensor field, it leads to high control overhead for a sensor node to find a route to the sink and transfer packets to it. An energy efficient routing protocol for event driven sensor networks is proposed to define the trajectory of the mobile sink node. The mobile sink uses GPSR (Greedy Perimeter Stateless Routing Protocol) to define the path towards source node which enhances the network lifetime.*

***Keywords***-*Data dissemination, energy hole, trajectory, stateless routing, greedy forwarding*

## I. INTRODUCTION

Wireless Sensor Networks (WSNs) has a wide variety of applications. It consists of a large number of distributed sensors, each having some computational power, storage and communication capability. Sensors enable the acquisition of sensed data from the deployed environment and uploading to sinks. The sensor node is also equipped with a processor to process the collected data and communication hardware to exchange data with other local sensor nodes within its radio range. Data collected at the sensor nodes is propagated to control centers called sinks where the information is required for further processing and storage. These sinks are mostly static and the data collected is disseminated to the sinks using sensor-to-sensor multi-hop data propagation. This approach normally incurs significant energy consumption at the energy-constrained sensors. Sensor nodes spend lot of energy in coordinating and transmitting data through multi-hop paths to reach the sink. Nodes near the sink fail relatively earlier due to repeated relaying of data from nodes that are farther away.

The lifetime of a sensor network is often defined as the first time the network gets disconnected due to the failure of certain sensor nodes that keep the network connected. Replacing or recharging the batteries of sensor nodes periodically is difficult considering the environmental limitations. An entire network would be disconnected as a result of energy depletion in the sensors nodes near the sink nodes thus disconnecting the sink from the remaining sensors that still have plenty of energy. This is called the energy hole problem.

Mobile sink can avoid or reduce the energy hole problem and increase the network lifetime. Sink mobility may be classified as uncontrollable or controllable in general. The former is obtained by attaching a sink node on certain mobile entity such as an animal or a shuttle bus, which already exists in the deployment environment and is out of control of the network. The latter is achieved by intentionally adding a mobile entity e.g., a mobile robot or a unmanned aerial vehicle, into the network to carry the sink node. In this case, the mobile entity is an integral part of the network itself and thus can be fully controlled [3].

Mobile data sinks in our system is a solution for data collection to balance the energy consumption among the sensor nodes in the network. This not only solves early death problem of the one-hop neighbors of the sink but also extends the network lifetime by distributing the responsibility of relaying data to the sink among many nodes in the sensor network[4].Even though a mobile sink is desirable, it poses new challenges for designing energy-efficient sensor network protocols. As the sink moves in the sensor field, it leads to high control overhead to find a route to the sink and route packets to it. The majority of published methods assume periodic sensing, where sensors are continuously monitoring the network and reporting data to the sink. However, there are a large number of applications where an event driven approach is more appropriate.

So we implemented an energy-efficient data collection protocol for event-driven sensor networks. It uses GPSR (Greedy Perimeter Stateless Routing) as routing protocol for finding the path from source node to mobile sink node. Then establishes the route of mobile sink up to source node by moving along the path obtained using GPSR and disseminates the data.

 

## II. RELATED WORK

Wireless Sensor Network (WSNs)are an emerging technology typically formed by thousands of small nodes, with less computational power, few resources (e.g., memory) and non-rechargeable battery. WSNs have usually a dynamic topology and each node has a type of sensing equipment to analyze a given phenomenon (e.g., temperature). Through this device, it can capture the phenomenon occurred, and transmit it to a sink node, responsible for disseminating the data to the observer or the Internet [20].

### 2.1. WSNs with a static sink

In a WSN composed of static sensor nodes and a static sink placed inside the observed region multi-hop communication is required for sending data from sources to sink nodes. So the energy consumption depends on the communication distance. Using multiple static sinks and each node routing data to its closest sink node can reduce the communication distance[24].

This reduces the average path length from source to sink compared to the case of single static sink. On the other hand, reduction is also observed in routing load on the nodes located in the vicinity of a single sink and also gets distributed among all the nodes located in the vicinity of multiple static sinks. These multiple static sinks partition the WSN into small sub-fields each with one static sink. By simulation it was shown that the proposed scheme leads to energy efficiency and better data delivery ratio compared to schemes based on a single sink. However, a major problem with multiple static sinks is that one has to decide where to deploy them inside the monitored region so that the data relaying load can be balanced amongst the nodes.

The model proposed by Hanieh Alipour and Alireza Nemaney Pour[13] is based on tree structure. The root represents the sink and the intermediate nodes are used for data forwarding. There are two kinds of intermediate nodes. The one with high priority is used to forward data. The other intermediate nodes with lower priority are reserved for the time when the node with higher priority has failed. The leaf nodes just collect information from the environment and forward it to intermediate nodes.

Directed diffusion was proposed as a data dissemination protocols for wireless sensor networks with a static sink. This approach assumes that each sink needs to periodically flood its location information through the sensor field. In this method each sensor is aware of the sink location for sending future events and measurements. However, such a strategy does not scale with the network size and increases the network congestion. The static sink may limit the network lifetime as the 1-hop neighbors of the sink are the bottleneck of the network [22].

Also, Partial Network Coding is proposed as a tool for continuous data collection. Data segments are combined using network coding techniques to extend the network lifetime. For periodic data collection a cascading data collection mechanism has been proposed. In each round, only a subset of the nodes sends data directly to the link. Intermediate nodes combine all the information using network coding and forwards the data to the sink. An adaptive sampling approach to data collection collects data directly from a dynamically changing subset of sampler nodes. And for the non-sampler node is predicted based on the use of probabilistic models. This is an energy-efficient approach for periodic data collection, for static sensor networks [6].

Some of the benefits of multiple static sink for energy efficiency can also be realized with a single static sink by logically partitioning the sensor field at a single level or hierarchically. Such a partitioning can be either static or dynamic. Besides the field partitioning, the selection of a cluster head in each partition is an important issue. In order to avoid the dying of nodes close to the sink, partitioning of the field into clusters is carried out. Within each cluster, a cluster head is determined to which local nodes send their data. Cluster heads tend to have higher capacity than regular nodes and are responsible for forwarding collected data to the sink over single or multiple hops. Both the cluster formation and the selection of the cluster head is done in such a way that the energy dissipation during routing can be minimized. This approach can also be extended to multilevel hierarchies. Clusters and the hierarchical structures can either be determined once (statically) or can be changed dynamically. To define a cluster, either a self-organizing algorithm can be used where each sensor independently determines whether it would like to be a cluster head or not, or a fixed regular structure of the clusters is given at the beginning of the entire process. Using the concept of multilevel hierarchies, the lifetime of the WSN can be optimized. Also data aggregation can be performed at each cluster head before data is transferred to the sink in order to reduce the amount of data to be transmitted to the sink. In order to extend the lifetime of the cluster head node, the task of being a cluster head can be rotated within a cluster [23].

Another approach for extending the lifetime of the nodes close to the sink is the utilization of a mobile sink. Mobile sinks improve the data delivery rate and reduce energy dissipation of the sensor nodes. In some aspects, this is similar to using several static sinks; however, using several static sinks requires additional global communication for collecting all data at a single final point.

### 2.2. WSNs with a mobile sink

Energy of nodes near to sink exhausts very quickly in hierarchal protocols where the base station is fixed, and as a result networks get disconnected. To overcome this problem and prolong the life time of network mobile sink is used to collect the data. A mobile sink can follow different types of mobility patterns in the sensor field, such as random mobility, predictable/fixed path mobility, or controlled mobility, which has different effects with respect to energy efficiency and data collection strategies [23].

#### 2.2.1. **Random mobility:**

In this class, the sink follows a random path in the sensor network. The sink uses a pull strategy for collecting data from the sensor nodes. In a pull strategy, a node forwards its data only when the sink initiates a request for it, whereas in a push strategy a node proactively sends its data towards the sink. Chatzigiannakis et al. have shown in [26] that random sink mobility can be used to reduce Emax and Ebar compared to the case of a static sink. Single hop data collection leads to the strongest reduction of energy consumption, because no data relaying load on the sensor nodes exists. However, it can also result in incomplete data collection from the WSN, because with a random mobility pattern there is no guarantee that the sink will reach all nodes in the sensor field or it might take too much time to do so.

#### **2.2.2. Fixed mobility**

Here the sink is programmed to follow a fixed path in a round robin fashion. This fixed path is predetermined and is not influenced by the behavior of the WSN at runtime. Coverage of the sensor field has to be guaranteed by an appropriate strategy for determining the routing paths for the data packets. A reactive data forwarding mechanism using a pull strategy based on request messages broadcasted by the sink can be used [27]. Moreover, sink mobility is planned such that the complete sensor field can be traversed in minimum possible time. As a result, energy dissipation can be very low. In case the sink is able to predict its future positions it can communicate this information to a node located in the vicinity of its future position. This node is responsible for collecting the sensor data in its vicinity so that when the sink actually arrives at this position, it should not have to wait for the data.

#### **2.2.3. Controlled mobility**

Controlled mobility refers to schemes where sink mobility is controlled or guided based on a parameter of interest, such as residual energy of the nodes, or on a predefined objective function, or on predefined observable events [26]. A mobile sink with energy conscious approach tries to stay away from the nodes with less residual energy and tries to be in the vicinity of those nodes that have high residual energy. This helps balancing the energy dissipation from the nodes.

A multi-sink heuristic algorithm (HOP) is proposed by Ben Saad and Tourancheau to find the best way to move mobile sinks in order to improve the lifetime of large scale sensor networks. Sinks are relocated to nodes located the maximum number of hops from a sink as it is assumed that these node will have higher residual energy as the nodes will not be required to re-transmit messages destined for a sink [25]. The minimum amount of time a sink will spend at a specific location is 30 days. The results of simulations indicate the HOP algorithm achieves significant improvement in network lifetime over the other algorithms and that there is more even distribution of residual energy per sensor node. However HOP assumes that the sinks are not continuously mobile but are moved after a specified number of days to different locations within the building.

A greedy maximum residual energy (GMRE)[28] heuristic moves the sink only to those sites where the residual energy of the node is maximum. However, the communication required for retrieving the residual energies of the nodes adds extra overhead. ASAP an adaptive sampling approach to energy efficient periodic data collection in sensor networks was proposed in [7].ASAP uses a dynamically changing subset of the nodes as samplers such that the sensor readings of the sampler nodes are directly collected, whereas the values of the non-sampler nodes are predicted through the use of probabilistic models that are locally and periodically constructed.

A framework was proposed [29] for real time calculation of the sink mobility path based on a given objective function. Various metrics were used for defining the objective function, such as residual energy of the nodes, network congestion and average distance between nodes and the sink. Whenever degradation in the objective function is observed sink is mobilized to a new location.

## III. PROBLEM DESCRIPTION AND SPECIFICATION

Wireless Sensor Network (WSN) consists of large number of sensor nodes to collect data from external world and sink node or base station to collect data. Nodes near the sink have to transfer their own data and data from other sensor nodes to the sink node. While transferring data these neighboring nodes loose their energy completely thus creating the energy hole problem. To reduce the energy hole problem and increase the network lifetime mobile sink nodes have been used. Mobile sink node has to move in the vicinity of the source node to disseminate the data. Different algorithms have been used to solve this issue. We describe an algorithm that defines the trajectory of mobile sink where we focus on achieving high data delivery and energy efficient network.

Mobile sink nodes in our work uses GPSR (Greedy Perimeter Stateless Routing) algorithm to define its trajectory towards the source sink node. Then moves along the path using either the greedy forwarding or perimeter forwarding to reach near the source node. And then it disseminates the data from the source node.

 

- **Objectives**

We describe the system model and introduce the basic concepts through an overview of the GPSR architecture. The proposed work will practically reduce the energy hole problem by defining the trajectory of mobile sink in an efficient way. In particular, the main contributions of our work can be summarized as follows:

- To reduce and evenly distribute the electric energy consumption while improving overall network lifetime- Sink mobility removes energy-hole problem and also improves the lifetime of nodes thereby reducing the multi-hop communication. The sensor nodes are considered as energy constrained devices whereas the sink, being external to the network, does not have any energy constraints. The communication module is the main consumer of a node's energy reserves and if the sink moves closer to the sensor nodes, greater energy savings could be obtained, thereby limiting the multi-hop communication.
- To remove relay frequency of sensor nodes near by the sink to prevent failure in sensing data- Sensor nodes send their data and relay the data received from other nodes of network towards the sink. After some time nodes near sink will discharged because of sending and receiving many packets and thus creates energy hole. As the nodes near the sink are discharged they fail to sense data and forward it to sink.

- **Modules**

Our proposed scheme addresses several issues in reporting observed data to the mobile sink. A mobile sink comes in contact with some sensors that come across in its communication range. The time for which a node is in communication range of a sink is the contact time and the area in which the sink is reachable by the node within its communication range is the contact area. A node can pass sensed data to sink if either it detects the presence of sink in its radio communication range or it knows the intermediate nodes who can possibly come in contact with the sink. That is a node can communicate with the sink either through single hop communication or multi hop communication.

The sink nodes are supplied with larger energy and computational power. The functions of sensor nodes in terms of power consumption can be divided into three areas: sensing, communication, and data processing. From the above three, a sensor node expends maximum energy in data communication. Using a mobile sink the communication cost can be minimized by providing a good trajectory to the sink to move towards the sensor node. Also it can achieve the optimal power efficiency.

For reducing energy consumption, mobile sinks shift the burden from the sensors to the sink node. We can allow the sink node to be mobile and traverse in the WSN to look for the sensors which are sending data and move closer to them. Thus this sink mobility approach reduces the burden of data processing and energy consumption from the sensors to the sink so as to extend the network lifetime. The energy consumption in data communication mostly depends on communication range, and moving the sink node near the sensor node reduces the transmission distance. Therefore, the energy consumption gets evenly distributed in the network and the energy hole problem is removed. It improves the performance of network by improving lifetime and quality of service.

Maximum network lifetime with a sink mobility approach can be achieved by controlling the mobile sink to achieve most efficient data gathering to provide the quality of service and to reduce energy consumption. The following are the different stages to define the trajectory of mobile sink towards the sensor node. Firstly the node has to detect the event and should send the request to mobile sink nodes. Now when the mobile sink nodes decide to respond it has to broadcast that decision in the network. And then it has to move towards the source sensor node to receive the data.

Enhancing the network lifetime using mobile sink includes how to control the movement of the sink to achieve most efficient data gathering and to reduce energy consumption. Depending on the system requirements, mobility approaches can decide

a. When to move the sink to respond to any event or change in the network.
b. The actual position of a sink node and the routing paths to the sink.
c. The trajectory of the mobile sink.

In the proposed work whenever the sensor node senses any data it starts sending the request to the mobile sink. Now one of the mobile sink nodes has to respond to the request and move towards sensor node to gather the data in single hope. We are using the Greedy perimeter stateless algorithm to define the trajectory of sink node.

**a. Detecting the event and sending the request**

In the application of WSNs a large number of sensors are used to monitor the activities in the sensing area and send report of any events when necessary. So an event-driven approach is used where sensors send data whenever an event occurs into those areas than a time driven approach, where sensors send data to the sink periodically.

The objective of this phase is to sense event and send request to the available mobile nodes in the network for disseminating data. The sensor node sense the event and becomes a data source. It then broadcasts the request for data dissemination in the network. All the nodes in network forward this broadcast message towards the sink nodes. In our proposed work when the source node sends the request, with that request it sends its location. Every forwarding node will extract that location information and save it at the sink location table. The sink node receiving the request will know data sources location. If the sink node is free to disseminate the data it starts the next step.

**b. Broadcasting the decision of response**

In this module the request of data source node is received by sink node in the local area with its location. Sink node that has decided to respond will broadcast about its decision of response in the network. The other sink nodes in the network after receiving this broadcast message will not respond to the request. When the data source sensor node will not find any response from any of the mobile sink nodes then it will again broadcast the request. In this case the other mobile sink node from service area will take the decision of response.

**c. Moving towards source node and data dissemination**

After receiving the request and broadcasting the reply the sink node has to move towards the source node. The existing systems use intermediate locations or some number of hopes to disseminate data. The proposed work defines the trajectory of the mobile node by using the GPSR routing protocol. By getting the path the mobile sink will move near to the data source node so that it can directly receive the data.

## IV. METHODOLOGY

The data source node has attached its location information with the request. The sink node which has replied for the request of data dissemination knows the location of the source node. So it has to move towards the destination. We define the trajectory of the mobile sink by Greedy Perimeter Stateless Routing (GPSR) algorithm. The GPSR routing algorithm consists of two methods for forwarding packets: greedy forwarding, which is used wherever possible, and perimeter forwarding, which is used in the regions where we cannot do greedy forwarding [6].

- **Greedy Forwarding:**

In GPSR, the originator includes the destination location in the packets. So a forwarding node can make a locally optimal, greedy choice in choosing a packet x's next hop. If a node knows its radio neighbors positions, the locally optimal choice of next hop is the neighbor geographically closest to the packet x's destination. Forwarding in this way is carried out until the destination is reached. An example of greedy next hop choice appears in Figure 1. Here, x receives a packet destined for D. x's radio range is denoted by the dotted circle about x, and the arc with radius equal to the distance between y and D is shown as the dashed arc about D. x forwards the packet to y, as the distance between y and D is less than that between D and any of x's other neighbors. This greedy forwarding process repeats, until the packet reaches D.

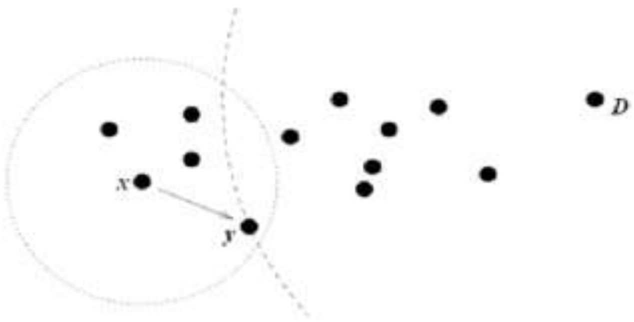


*Figure 1. Greedy forwarding.*

There are topologies in which the only route to a destination requires a packet move temporarily farther in geometric distance from the destination.

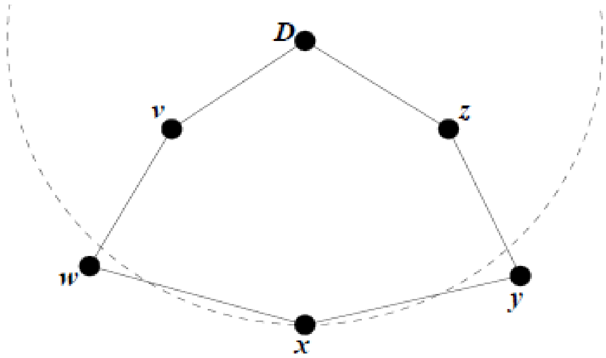


*Figure 2. Greedy forwarding failure.*

 

From Figure 2 x is closer to D than its neighbors w and y. Again, the dashed arc about D has a radius equal to the distance between x and D. Now 2 paths exists x-w-v-d and x-y-z-d.

- **The Right Hand Rule: Perimeters**

Figure 3. shows the intersection of x's circular radio range and the circle about D of radius x D is empty of neighbors.

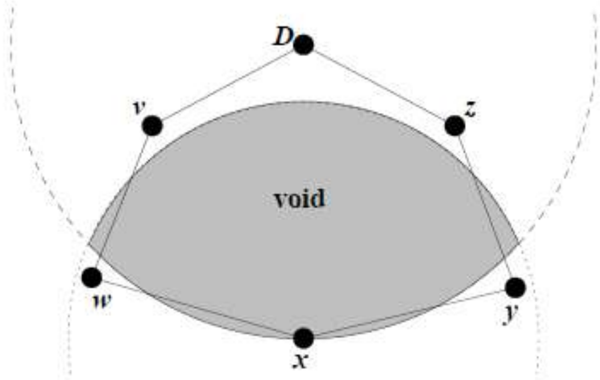


***Figure 3. Node x's void with respect to destination D***

Node x will term the shaded region without nodes a void. x seeks to forward a packet to destination D beyond the edge of this void. The right-hand rule for traversing a graph states that when arriving at node x from node y, the next edge traversed is the next one sequentially counterclockwise about x from edge (x,y). Traversing the cycle by the right-hand rule gives the navigation around the pictured void, towards the nodes closer to the destination than x. We call the sequence of edges traversed by the right-hand rule a perimeter. We can use this path to forward packets to destination D.

The energy lost in traditional data forwarding routing protocols will be saved at each of the node coming in between as router in the route form source to sink node. As energy is saved network life time will also increase. Within the Analysis phase we will compare the results obtained with the results of other protocols.

### 5.1. Simulation Platform

NS (Version 2) is an open source network simulation tool. It is an object oriented, discrete event driven simulator written in C++ and Otcl. The primary use of NS is in network researches to simulate various types of wired/wireless local and wide area networks; to implement network protocols such as TCP and UPD, traffic source behavior such as FTP, Telnet, Web, CBR and VBR, router queue management mechanism such as Drop Tail, RED and CBQ, routing algorithms such as Dijkstra, and many more.

### 5.2. Simulation scenario

The following is the description of the simulation setup. All nodes communicate with identical, half duplex wireless radios that are modeled after the commercially available 802.11 based Wavelength wireless radios, which have a bandwidth of 2Mbps and a nominal transmission radius of 250m. Each node has a queue (called IFQ) for packets awaiting transmission by the network interface that holds up to 50 packets and is managed in a drop tail fashion. GPSR, AODV and DSDV protocols were used for moving mobile sink.

- **Varying the number of nodes:** Each sink node moves at 10 m/s speed from its position to a node selected from within the simulation area. To select the next hop it uses one of the two ways either greedy forwarding or perimeter forwarding. When a sink node moves it uses the greedy forwarding method to reach the location. And if greedy forwarding is not possible it uses the perimeter forwarding to reach up to the sink node.
  The experiment is carried out by considering different scenarios by varying number of nodes from 10 to 90. Some nodes are considered as mobile nodes and remaining are the source nodes. After the sink node gets the location of source node it starts moving towards it using one of the two ways. Analysis is carried out by having 10, 30, 50, 70 and 90 number of nodes. These simulations were carried out for 100 seconds.

- **Varying the nodes speed:** The experiment is carried out by varying node speeds such as 10, 30, 50, 80, 100. In this case number of nodes is kept constant as 10. The experiment is carried out by considering different scenarios for experimentation. The scenario shows changing speed of nodes and its effect on network performance. These simulations were carried out for 100 seconds.

 

## V. RESULTS AND ANALYSIS

We analyze the results gathered from the simulated scenarios. This section displays the comparative status of parameter-wise readings in different scenarios recorded for AODV, DSDV and GPSR for mobile sink. The data is represented in the form of tables and graphs.

### a. Comparison of AODV, DSDV and GPSR by varying number of nodes.

AODV, DSDV and GPSR were compared with varying number of nodes from 10 to 90.

- **Performance comparison of Energy of Nodes**

Table 1 and Fig.4 show the comparative status of energy of nodes by considering different scenarios. Result shows that with the increasing number of nodes, the utilization of energy decreases for GPSR. For AODV and DSDV the utilization of energy goes on increasing with the number of nodes.

*Table 1: Comparison of energy of nodes*

| No. of nodes | AODV | DSDV | GPSR |
|---|---|---|---|
| 10 | 4.179597 | 6.1971853 | 4.603677 |
| 30 | 4.430092 | 8.110283 | 4.179873 |
| 50 | 8.55306 | 10.574282 | 4.095456 |
| 70 | 7.511713 | 9.979161 | 3.347948 |
| 90 | 10.890253 | 9.851167 | 2.122751 |

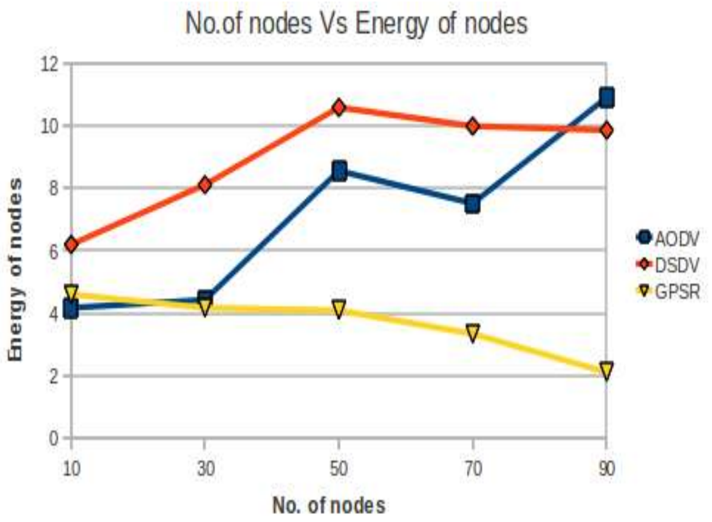


*Figure 4. Comparison of energy of nodes*

- **Performance comparison of Packet Delivery Ratio**

Table 2 and Figure 5. show the comparative status of Packet delivery ratio by considering different scenarios. It is found that packet delivery ratio for AODV, DSDV goes on increasing for number of nodes. For GPSR with less number of nodes it is higher and as the number of nodes increases it goes on decreasing. As compared to AODV and DSDV the GPSR protocol has a higher packet delivery ratio for all values.

*Table 2. Comparison of Packet Delivery Ratio*

| No. of nodes | AODV | DSDV | GPSR |
|---|---|---|---|
| 10 | 0.799288 | 0.54444 | 0.858473 |
| 30 | 0.534422 | 0.248546 | 0.726704 |
| 50 | 0.522948 | 0.281674 | 0.738872 |
| 70 | 0.474144 | 0.331932 | 0.788028 |
| 90 | 0.42938 | 0.219942 | 0.652111 |

 

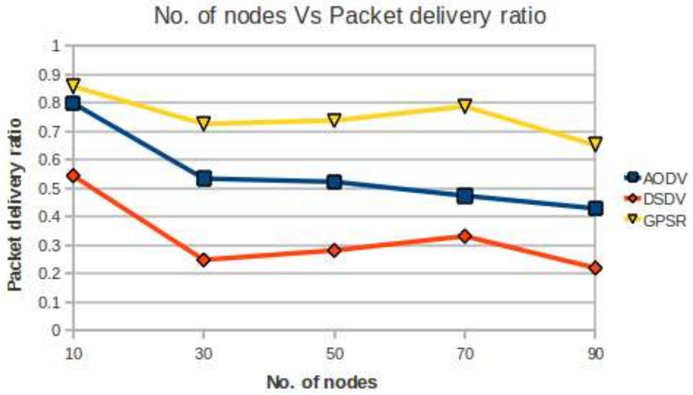


*Figure 5. Comparison of Packet Delivery Ratio*

- **Performance comparison of throughput**

Table 3 and Figure 6. show the comparative status of throughput by considering different scenarios. It shows that the performance margins of GPSR and AODV are very close for 30 to 70 nodes and it reduces for larger number for GPSR.

*Table 3. Comparison of Throughput*

| No. of nodes | AODV | DSDV | GPSR |
|---|---|---|---|
| 10 | 647.218824 | 548.238117 | 730.8144 |
| 30 | 649.56858 | 507.197187 | 648.245509 |
| 50 | 643.288343 | 480.577343 | 653.764196 |
| 70 | 656.108318 | 553.9767 | 671.916039 |
| 90 | 658.656977 | 475.345552 | 493.294447 |

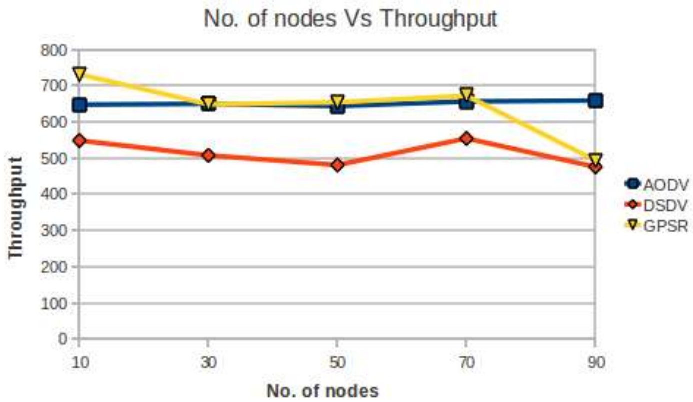


*Figure 6. Comparison of Throughput*

**b. Comparison of GPSR with AODV and DSDV by Varying Nodes Speed**

Here we have compared GPSR with AODV and DSDV as the speed of node varies from 10 to 100 m/s.

- **Performance comparison of Energy of Nodes**

Table 4 and Figure 7.show the comparison of energy of nodes by considering different scenarios. Energy utilization for GPSR is less as compared to AODV and DSDV for all values. For GPSR it goes on increasing slowly for increasing speed.

*Table 4. Comparison of Energy of Nodes*

| Node speed | AODV | DSDV | GPSR |
|---|---|---|---|
| 10 | 7.183288 | 7.47885 | 2.290706 |
| 30 | 9.722126 | 7.85391 | 2.547301 |
| 50 | 9.649033 | 7.91241 | 2.759576 |
| 80 | 9.818986 | 7.870347 | 3.133323 |
| 100 | 9.250605 | 7.886015 | 3.34172 |

 

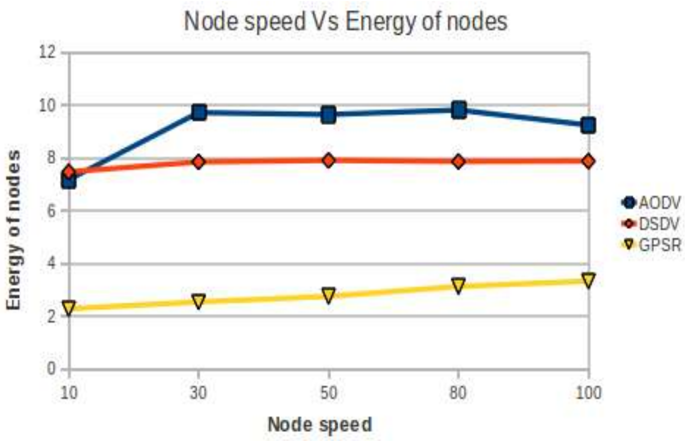


*Figure 7. Comparison of Energy of Nodes*

- **Performance comparison of Packet Delivery Ratio**
  Table 5 and Figure 8. show the comparative status of Packet delivery ratio by considering different scenarios. PDR of GPSR is higher than AODV and DSDV for less speed. For rest of the values AODV has good ratio.

*Table 5. Comparison of Packet Delivery Ratio*

| Node speed | AODV | DSDV | GPSR |
|---|---|---|---|
| 10 | 0.34276 | 0.469457 | 0.641837 |
| 30 | 0.724063 | 0.563976 | 0.652111 |
| 50 | 0.754444 | 0.642751 | 0.648823 |
| 80 | 0.771332 | 0.644633 | 0.647781 |
| 100 | 0.771574 | 0.644291 | 0.647781 |

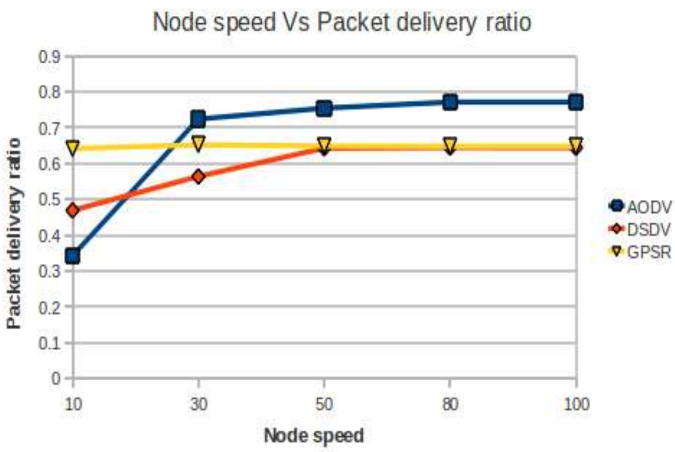


*Figure 8. Comparison of Packet Delivery Ratio*

- **Performance comparison of Throughput:** Table 6 and Figure 9 show the comparative status of throughput by considering different scenarios. Throughput of GPSR is better than throughput of DSDV but is less as compared to AODV.

*Table 6. Comparison of Throughput*

| Node speed | AODV | DSDV | GPSR |
|---|---|---|---|
| 10 | 636.367691 | 488.566747 | 497.623507 |
| 30 | 652.058813 | 467.771741 | 493.294447 |
| 50 | 652.248791 | 458.962472 | 493.466786 |
| 80 | 650.50898 | 456.9478 | 492.022893 |
| 100 | 651.928722 | 457.811736 | 492.027506 |

 

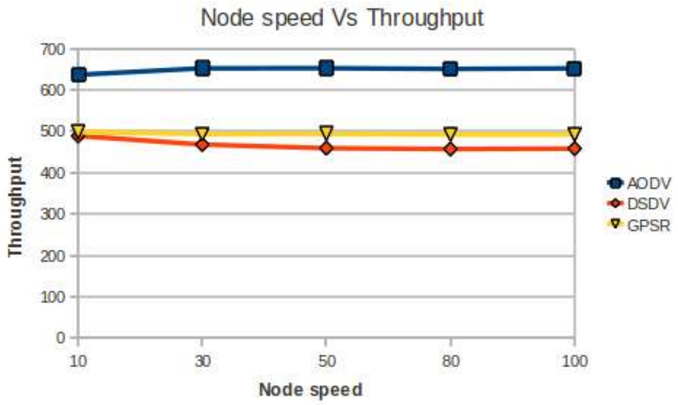


*Figure 9. Comparison of Throughput*

## VI. CONCLUSION AND FUTURE SCOPE

According to the analysis of the results obtained from simulation the mobile sink uses the GPSR algorithm to define the trajectory and successfully moves towards the source node. Also average energy utilization is reduced and hence the network lifetime is increased. GPSR used to define the trajectory is more efficient than AODV and DSDV on the ground of Throughput & Packet Delivery Ratio. Detecting & moving towards the source node resulted in increased Routing Packet overhead & End-to-End delay.

In future, extensive complex simulations could be carried out using the project code, in order to gain in-depth performance analysis of the mobile sink and its energy efficient trajectory. The results of the paper can be both applied to practical situations and can be used as benchmarks for studying energy-efficient network design.

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