Location Aided Optimized SPIN in Wireless Sensor Network

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Abstract: *In a Wireless Sensor Network (WSN), nodes are scattered densely in a large area. Sensor nodes can communicate with the sink node directly or through other nodes. Data transmission is the major issue in WSN. Each node has limited energy which is used in transmitting and receiving the data. Various routing protocols have been proposed to save the energy during the transmission of data. In WSN, SPIN (Sensor Protocol for Information via Negotiation) protocol is based on data centric approach which efficiently propagates information between sensor nodes in an energy constrained mode. This paper proposes a modified version of Optimized SPIN named as Location Aided Optimized SPIN. The main objective of this protocol is to use the location information while advertising, to reduce the energy consumption by the nodes in transmitting and receiving the data. Implementation of Basic SPIN, Optimized SPIN and proposed Location Aided Optimized SPIN protocols will be done using MATLAB.*

Keywords: SPIN, Optimized SPIN, Location, WSN, Energy.

1. Introduction

Wireless Sensor Network (WSN) has gained world-wide attention in recent years due to the advances made in wireless communication. Efficient design and implementation of wireless sensor networks has become a hot area of research. A wireless sensor network consists of spatially distributed sensors without using wires to sense the different conditions such as temperature, sound, humidity, pressure, motion or pollutants, and to transmit their data through the network to a base station. Because of no fixed infrastructure WSN are more flexible for obtaining data from the environment. The purpose of base station is to collect data from the nodes and forward control information from the users. Sensor nodes are of small sized and low cost. The basic task of sensor nodes is sensing, gathering and processing the data while communicating with other connected nodes in the network.

WSN is having a characteristic of sending data from one sensor node via another by coordinating with each other to a base station or sinks, these sinks may be stationary or moving while receiving data or waiting for a query response. While moving, a sink should continuously update its topological position information in the sensor nodes to maintain paths. This may require large signalling overhead, resulting in excessive energy consumption.

WSNs nodes are battery powered which are deployed to perform a specific task for a long period of time, even years. Because of the advantages of wireless sensor network they have been employed in a wide range of applications [1]. Application domain of WSNs varies from environmental monitoring, to health care applications, military operation, to transportation, to security applications, to weather forecasting, to real time tracking. There are various challenges in the design of effective wireless sensor networks. The lifetime of a network is based on the battery power. It is very difficult to recharge or replace the battery once nodes are deployed. Therefore it is very important to use energy efficient routing protocols as energy consumption is an important consideration.

Routing protocols in WSNs are responsible for discovering and maintaining the routes in the network. In WSNs routing protocols might be different depending on the application and network architecture. In WSN, routing protocols are divided into three main categories such as data centric, hierarchical and location based routing protocols [2] [4].

1.1 Data Centric Routing Protocols

Data centric routing is a query based. All nodes participating in routing play the same role of collecting data and communicating with the sink. The sink sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute based naming is necessary to specify the properties of data. SPIN is the first data-centric protocol, which considers data negotiation between nodes in order to eliminate redundant data and save energy.

1.2 Hierarchical Routing Protocols

Hierarchical routing is a cluster based routing. The goal of the protocol is to perform energy-efficient routing in WSNs by avoiding an overload of sink nodes by too many received messages, as well as reducing the amount of overall message transmissions. To achieve this, nodes are grouped into clusters, where each cluster has cluster head and cluster

nodes. The higher energy nodes are used to process and send the information while low energy nodes are used to perform the sensing in the proximity of the target.

1.3 Location Based Routing Protocols

Sensor nodes are addressed by means of their locations. In most cases location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated. Each node calculates the distance to his neighbor node from the incoming signal strength. In some location-based schemes in order to save energy, the nodes must change their state from active to sleep if there is no activity. [3] It saves the energy of nodes by reducing the number of transmissions. The query is send only to the particular region using the location of the sensor nodes.

This paper uses a location scheme in data centric protocol SPIN and introduces a new version of SPIN named as Location-Aided Optimized SPIN protocol. This protocol is based on Basic SPIN and Optimized SPIN. It saves the amount of energy by avoid flooding of data and transmits the data to the sink by using location information of sensor nodes [5]. The rest of the paper is organized as follows: Section II presents related work. Short description of Basic SPIN and Optimized SPIN is given in Section III. In Section IV, proposed system model is presented. Section V elaborates the results and discussions while Section VI concludes the paper.

2. Related Work

This paper is focusing on SPIN (Sensor Protocol for Information via Negotiation) protocol. It belongs to the data centric routing protocols. It works on two basic ideas:
- To operate efficiently and to conserve energy, sensor applications need to communicate with each other about the data that they already have and the data they still need to obtain. Exchanging sensor data may be an expensive network operation, but exchanging data about sensor data need not be.
- Nodes in a network must monitor and adapt to changes in their own energy resources to extend the operating lifetime of the system.

In [6], authors proposed a new algorithm for SPIN named as Modified SPIN (M-SPIN). In this, only the nodes which are nearer to sink node send REQ packets in response to ADV packet from the source node. A new phase known as distance discovery phase is added to find the distance of each sensor node in the network from sink node and vice versa. Distance is measured in terms of hop count i.e. the more number of hops in path increases the distance between sink and sensor nodes. Total phases in M-SPIN are:

- Distance Discovery
- Negotiation
- Data Transmission

Performance of four different SPIN protocols are analyzed and compared by the authors in [7]. For appoint-to-point network SPIN-PP and SPIN-EC are optimized and for a broadcast network SPIN-BC and SPIN-RL are optimized. SPIN-PP and SPIN-BC are based upon the process of 3 way handshaking. Three stages in the process are data broadcasting, data requesting and data transmission phase. SPIN-EC is an energy conservation version of SPIN-PP. In this, a node reduces its participation when it achieved low energy threshold value. SPIN-RL is reliable version of SPIN-BC in which reliability is achieved by resending the request of not received data in a particular time.

In [8], authors compared the energy consumption used by LEACH and SPIN routing protocols. They used 50 nodes and simulated for 2 min and concluded that spin fares much better than the LEACH protocol in terms of energy consumption. In SPIN and LEACH protocols the LEACH protocol has limited amount of energy but it has more energy consumption as compared to SPIN just because of cluster head selection (CHs) and the other reason of consuming more energy is it follows 4 steps to transmit the data which are Advertisement phase, Cluster setup phase, Schedule creation phase and Data transmission phase. In all the phases the most energy consumes in the rotation of cluster heads as it changes randomly its role of cluster head. But in SPIN there is no concept of cluster heads so energy is being saved. SPIN protocol uses the concept of metadata and number of dead nodes in SPIN is comparatively less than in LEACH.

In [9], authors proposed a mechanism to optimize the SPIN Routing Protocol. This will reduce the energy consumption by sending only the interested portion of data to the destination. This protocol is implemented in MATLAB and results shows that Optimized SPIN becomes more energy efficient in comparison to existing SPIN. In Optimized SPIN dead nodes are approx 50% lesser than Basic SPIN. The network will survive more in Optimized SPIN.

Authors in [10] proposed a routing protocol that supports image retrieval known as SPIN-IT. In this paper, an image is considered as data and by using techniques of SPIN data received will be chosen as optimal sources. This protocol provides low bandwidth query-based communication prior to the transfer of image data to set up routes to desired data rather than routes to specific nodes. Results showed that SPIN-IT is more efficient when the arrival of new data at each node is greater than the arrival of new requests for data in each node.

SPIN is used to increase the energy efficiency. SPIN is modified to SPIN-I in [11] to avoid two basic problems, one is blindly forward and another is data inaccessible. SPIN-I works on the concept of three way handshaking in which there are three phases:

- Data Broadcasting Phase,
- Data Requesting Phase, and
- Data Transmission Phase

Authors in [12] discussed the existing protocols SPIN, SPIN-1 and Modified SPIN. They proposed a new protocol named EEM-SPIN after facing some problems in Modified SPIN. The problem in M-SPIN was that while sending the

data only in the direction toward sink, there is the possibility that some of the nodes may be used several times for sending the data, so those nodes may lead to dead nodes due to low energy. So resolving this problem author proposed a new protocol which is an enhanced version of M-SPIN. They introduced the concept of clusters and dynamic cluster head selection in M-SPIN to reduce the problem faced. As in dynamic cluster head selection the cluster heads are chosen randomly i.e. the nodes which were used for forwarding the data repeatedly may save their energy.

3. SPIN Routing Protocol

In data-centric protocols, when the source sensors send their data to the sink, intermediate sensors can perform some form of aggregation on the data originating from multiple source sensors and send the aggregated data toward the sink. This process can result in energy savings because of less transmission required to send the data from the sources to the sink. SPIN routing protocol is a routing protocol which comes under the category of data centric routing protocols. This paper works on the concept of Basic SPIN and Optimized SPIN.

3.1 Basic SPIN

SPIN (Sensor Protocol for Information via Negotiation) is a data centric protocol. Nodes use the meta-data information. Nodes negotiate through a set of protocols to request the data they do not possess. SPIN use three types of messages:

• ADV message: This allow sensor node to advertise particular Meta data
• REQ message: Request specific data.
• DATA message: Carry actual data.

When a node obtains new data, it broadcasts an ADV message to all of its neighbors with the meta-data describing the new data. Nodes that have received the ADV message check the meta-data to see if it already has the data. Otherwise, it sends a REQ message to the sender of the ADV message requesting the data. The sender responds with a DATA message containing the requested data and the protocol terminates. The working of SPIN protocol is shown in Figure 1 [13] [14]. SPIN achieves energy savings by eliminating requests for redundant transmissions of data. Upon receipt of an ADV message, a node need not send a REQ message if it already has the data. Similarly, a node can aggregate its data with the newly received data and send an ADV message for the aggregated data.

SPIN protocol was designed to improve classic flooding protocols and overcome the problems they may cause, for example implosion and overlap. The SPIN protocols are resource aware and resource adaptive. [15] The sensors running the SPIN protocols are able to compute the energy consumption required to send, receive and compute data over the network. Thus, they can make informed decisions for efficient use of their own resources. The transfer of packets in Basic SPIN is shown in Figure 2.
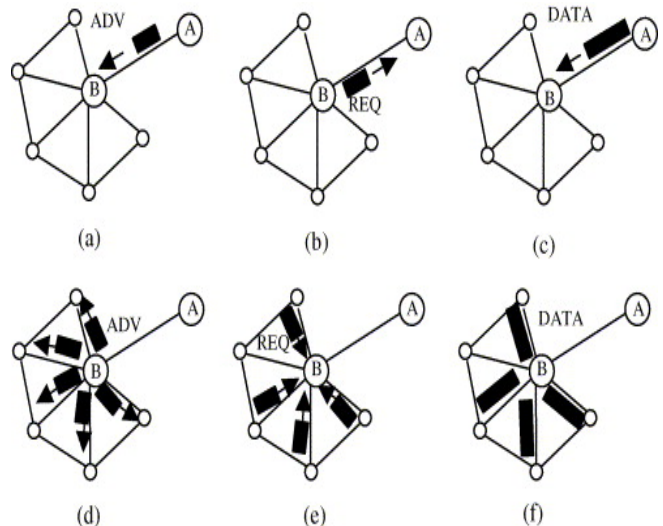
(a) Node A sends ADV message to Node B.
(b) Node B requesting for a data by sending REQ message.
(c) Node B receiving the requested data.
(d) Node B then sends out advertisements to its neighbors.
(e) Who in turn send requests back to Node B.
(f) Node B sends data to requested nodes.

**Figure 1:** Working of SPIN protocol.
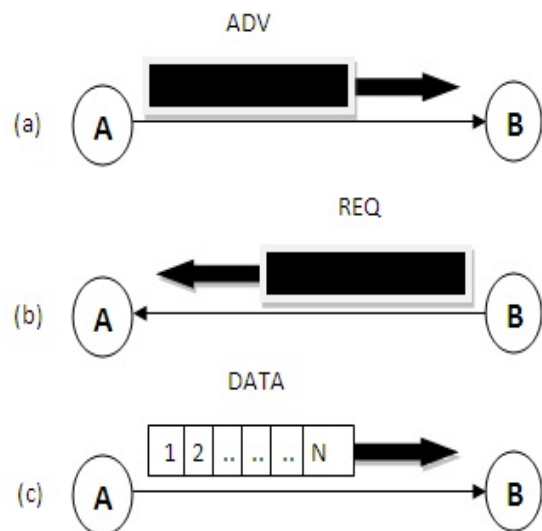
(a) Node A sends Advertisement Packet (ADV) to B.
(b) Node B sends Request Packet (REQ) to A.
(c) Node A sends complete Data Packet (DATA) to B.

Figure 2: Packet Transfer in Basic SPIN Protocol.

The transfer of packets in Basic SPIN is shown in Figure 2. Any of the nodes, who want to send its data will first, advertises its ADV packet then request packet REQ is being sent by the interested nodes who wants to receive the data. After that DATA packet is sent by the initiator node and then the receiver node accepts that data according to the need, rest of it will be discarded, i.e. the receiver node dissipated its energy in receiving the data and discarding the useless data which causes high amount of energy loss. To overcome this problem, Optimized SPIN was proposed.

3.2 Optimized SPIN

In Optimized SPIN, the energy is saved by reducing the amount of data to be transferred. After receiving the advertisement message from the sensor node, the requestor node only sends REQ message for the particular data of its need. [9] The packet transfer in Optimized SPIN is shown in Figure 3. In Figure 3 if a node B doesn't need the whole data it sends a REQ message only for a part of needed data (say 2 & 5) to node A and can receive only the requested part of data. By using this method the energy dissipated by a node that is sending DATA packet will be reduced as well as the receiver node who is accepting the DATA packet will also use less amount of energy in receiving the data packet. That leads to less dead nodes and survivability of the sensor network will be increased.
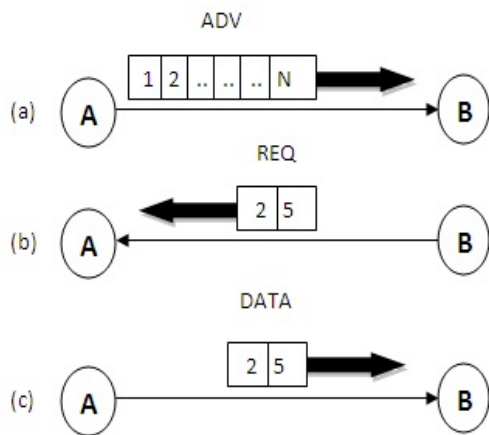
a) Node A Advertise Packet (ADV) having Meta-Data to B.
b) Node B sends Request Packet (REQ) having selected data request (2 & 5) to A.
c) Node A sends only requested data (2 & 5) in Data Packet DATA to B.

Figure 3: Packet Transfer in Optimized SPIN Protocol.

4. Proposed Work

This paper proposes a new algorithm named as Location Aided Optimized SPIN algorithm. This protocol avoids the use of flooding of the data in all the directions. In order to achieve an energy efficient protocol, use of location scheme is the best and simple technique. By using location information in sensor network every node knows its own position as well as its neighbouring node's position. When a node has some data to advertise, it will advertise data only in the direction of sink node by knowing its position. There are various methods available to identify the location of the nodes such as GPS, received radio signal strength. GPS (Global Positioning System) can be used to get the location information directly through satellite. The distance between the neighbouring nodes can be estimated on the basis of incoming signal strengths and by exchanging such information between neighbours, relative coordinates of the neighbouring nodes can be obtained.

Location Aided Optimized SPIN uses the location information of destination to transmit the data only in the certain direction in which the destination node is situated. By using this method the energy dissipated by a node in sending the DATA packet in all directions will be reduced. That may lead to less dead nodes and survivability of the sensor network will be increased. In Basic and Optimized SPIN the sensor node flood the data in all the directions without knowing the exact location of the sink node as shown in Figure 4. Therefore, more energy is used in data transfer process.
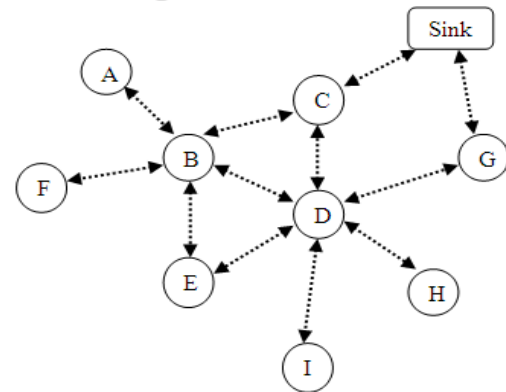

Figure 4: Data Sending in Basic and Optimized SPIN.

In the Location Aided Optimized SPIN, the location of sink node is known to the sensor node and it sends data only towards the sink location as shown in Figure 5. This will consume less energy of nodes.
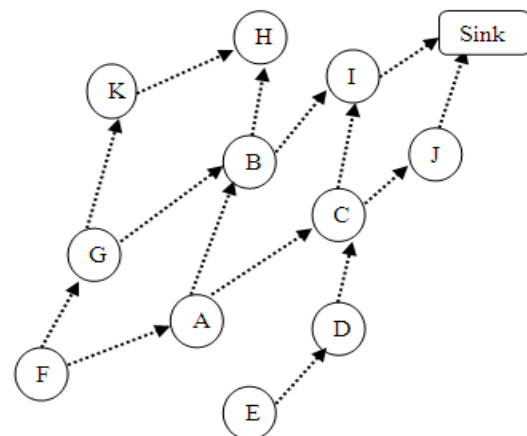

Figure 5: Data Sending using Location Aided Optimized SPIN

5. Results and Discussion

The purposed Location Aided Optimized SPIN, Optimized SPIN and Basic SPIN have been implemented using MATLAB. The goal of the implementation is to demonstrate the advantages of Location Aided Optimized SPIN over Optimized SPIN and Basic SPIN. Table 1 shows the list of simulation parameters.

Table 1: Simulation Parameters

Parameters	Values
Number of Sensor Nodes	100
Sink	(100,100)
Initial Energy	0.5 units
Platform	Matrix Laboratory 2009 v2
Operating System	Windows XP

By using these parameters all the three algorithms are implemented. The goal of this implementation is just to show, how Location Aided Optimized SPIN reduces the number of dead nodes in the field after transmission is completed.

Figure 6, shows that, in Basic SPIN the no of dead nodes lays in between the range of 40-50. While working in same environment Figure 7, shows that, in Optimized SPIN the no of dead nodes lies in between the range of 25 to 30 after the completion of transmission. Figure 8 shows that using Location Aided Optimized SPIN the amount of dead nodes is reduced to the range of 18-28. So this implementation shows that in Location Aided Optimized SPIN sensor network will survive more than the Optimized SPIN.
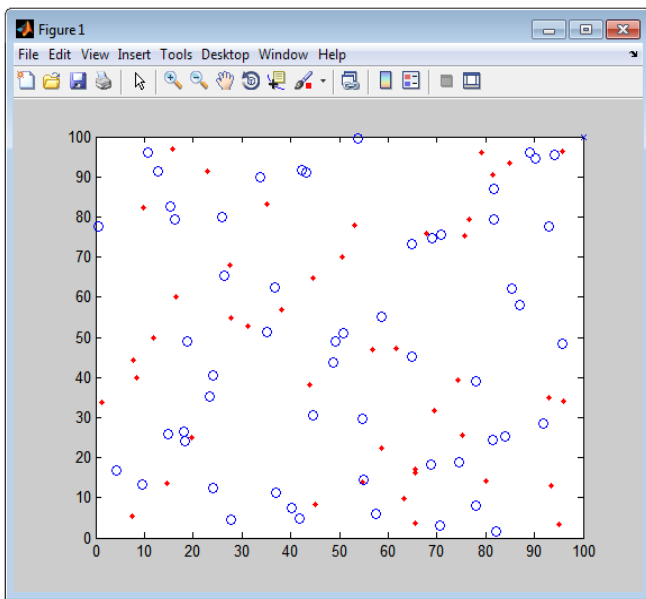

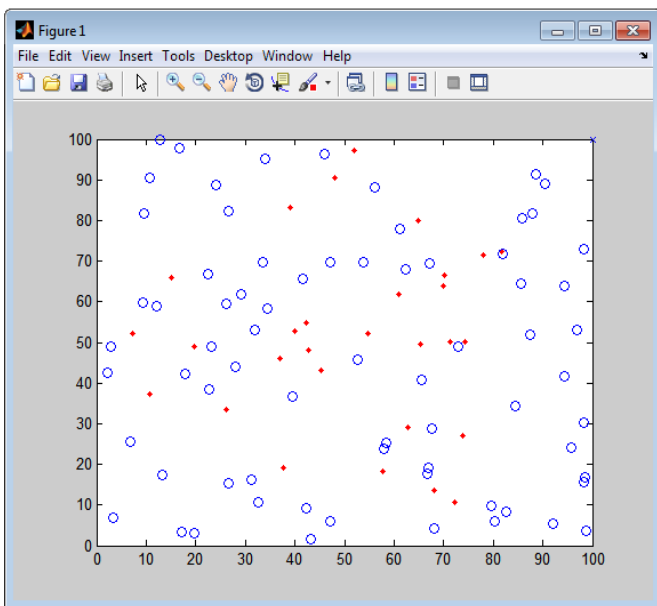**Figure 6:** Existing Basic SPIN, No of dead nodes: 44.

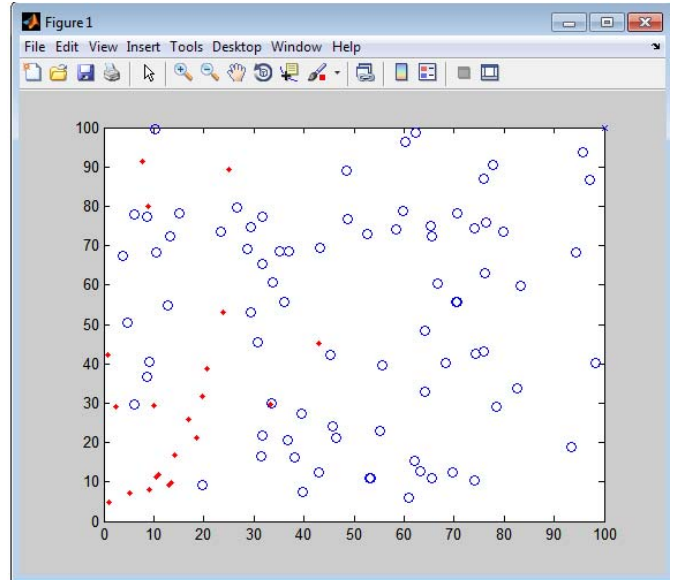**Figure 7:** Optimized SPIN, No of dead nodes: 29.

Figure 8: Location Aided Optimized SPIN, No of dead nodes: 21.

Figure 9, shows the comparison graph between all the three algorithms. The simulation runs show that the number of dead nodes in Basic SPIN lies between the range of 40-55, in Optimized SPIN range is reduced to 20-30 and for the same number of simulation runs the number of dead nodes lies between the range of 12-25.
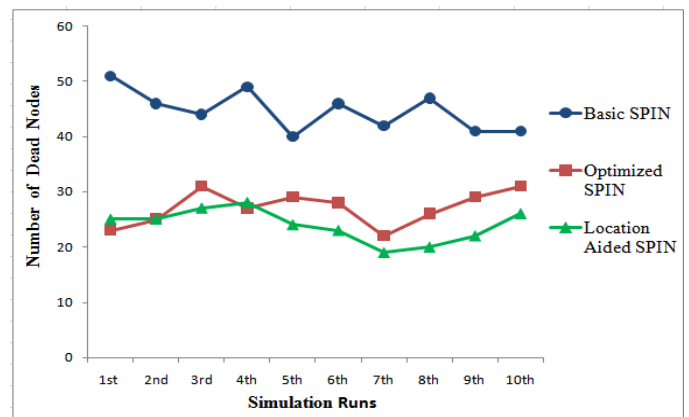

Fig 9: Comparison Graph in between Basic SPIN, Optimized SPIN and Location Aided Optimized SPIN.

6. Conclusion

This paper presents a Location Aided Optimized SPIN to reduce the energy consumption using the location information. It saves the energy of nodes used in transmitting data in all the directions and increase the lifetime of network. The proposed protocol is implemented in MATLAB. The implementation results show that Location Aided Optimized SPIN becomes more energy efficient in comparison to Basic SPIN and Optimized SPIN.

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1524