SPIN Protocol for transmission of data of mobile sink in Wireless Sensor Network

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***Abstract*—Transmission of data is one of the major challenges in the field of wireless sensor network. Various routing protocols have been proposed in order to save energy during data transmission in WSN. Therefore, the main aim of routing techniques is to minimize the consumption of energy in order to increase WSN lifetime. In this paper, we present a family of adaptive protocols, called SPIN (Sensor Protocols for Information via Negotiation), that disseminate information efficiently in an energy-constrained wireless sensor network. The sensors in sensor networks have limited energy and therefore, energy preserving technique is important. A family of adaptive protocols called (SPIN) is used that disseminates all the information at each SN to other SN in the network and provide the guarantee to deliver the data towards the sink node in mobile sink sensor network. Here in this paper we will show how SPIN protocol will work in the mobile sink wireless sensor network, in which our assumption is that all the sensor nodes are static other than the sink node. We apply the property of SPIN to check the data delivery to the mobile sink and mathematically proved the cost taken to deliver the data and the energy consumed in delivery of data to the nodes. We prove that mobility of the sink doesn't matter, cost and energy depends on the distance from the source to sink node. We also provide the random mobility model of the sink in sensor network. This is moving randomly within the restricted area**

Keywords— ***Wireless Sensor Network, SPIN, mobile sink, routing protocol***

I. INTRODUCTION

Wireless Sensor Network (WSN) [1] consists of large number of sensor nodes which are small in size, low cost and small memory size with sensing, and computational capabilities. Sensor nodes measure the critical conditions from the surrounding environment. The applications of WSN ranges from health monitoring to battle field, environmental monitoring etc. The practice of remote sensing has become greatly simplified by useful and affordable sensors and by required software packages too. Moreover, users can monitor and control the environment from any remote location. SPIN is a three-stage protocol and contains three types of messages as ADV, REQ and DATA for communication. ADV message is used to advertise new data, REQ message is used to request data, and DATA message is the actual message itself. Other protocols of the SPIN family are:

• SPIN-BC
This protocol is designed for broadcast channels. All SNs overhearing a SN will get the message. However, SNs have to wait for transmission if the channel is busy. Also, SNs do not immediately send out REQ message when they hear the ADV message. Instead, each SN sets a random timer and upon expiration, the SN sends the REQ message. If other SNs, waiting for their timers to expire, overhear this message, they stop their timers. This prevents sending redundant copies of the same request.

• SPIN-PP
This protocol is used whenever two SNs can communicate in exclusive communication with each other without any interference from the other neighbouring nodes. It is designed for a point to point communication, i.e., hop-by-hop routing. SPIN-PP assumes that energy is not a major constraint and that packets are never lost. Similar to SPIN-1, SPIN-PP is also a simple 3-way handshake protocol. One major advantage of SPIN-PP is its simplicity and the fact that each SN needs only know its single-hop neighbours while not requiring any other topology information [4].

• SPIN-EC
This protocol works similar to SPIN-PP, but with an energy threshold added to it. A SN participates in the protocol if it is able to complete all stages of the protocol without having its energy [4] drop below a given threshold value.

• SPIN-RL
In SPIN-PP, it is assumed that packets are never lost. Therefore, this protocol is not appropriate for error prone channels.
Instead, another protocol called SPIN-RL is used where two patches are added to SPIN-PP as to account for the lossy channel. First, each SN keeps track of all ADV messages it receives.

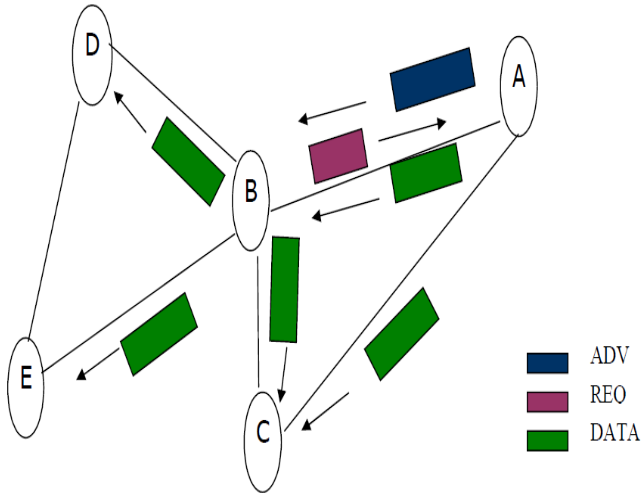

Figure 1: The SPIN PP Protocol

In addition, it may also request data to be retransmitted if it did not get it within a specified window of time. Second, in order to adjust the rate of data retransmission, SNs wait for a certain pre-determined time before replying to the same REQ messages again. This procedure guarantees that data is retransmitted only after ensuring that the reply to the previous REQ message failed.

The strength of this protocol is that it is very simple to implement. Every node in the network has to perform a small decision making when it receives a new data, and hence wastes a small amount of energy in computation. In addition, each node should know only about its one hop network neighbors.

The remainder of the paper is organized as follows. Section II motivates the workflow of sink mobility models and SPIN working model. Section III specifies the objective of the data transmission and our proposed mathematical model. Finally section IV offers some concluding remarks and future work.

II. Work Flow of Sink Routing

This work focuses on the assumption that we have made. We assumed that all nodes are static except the sink node which is mobile. Our intension is to show the mobility model of sink node and how efficiently SPIN can work in the mobile sink WSN

In our assumption all nodes are static other then the sink node. Sink node moves randomly in the field. We propose a random mobility model of sink in the Section-III where speed, direction, position and energy calculates randomly in Equation 1,2,3,4,5 and 6 after each step of movement of a node. As we know that in SPIN, sensors communicate with the sink via negotiation. Whenever a sensor node starts sending the data to the sink node, then each time it finds the path based on negotiation based approach to reach at sink as described above. Because SPIN protocol does not have previously establishes paths to the sink node when it is going to send. It follows the three step process to communicate with the sink node. It uses ADV, REQ, and DATA messages to communicate with sink node.

Figure 2 shows the data transmission to the mobile sink according. Here K1 till K6 are the static nodes and S is the mobile sink node. Form figure.2 node k1 sends the packet to the sink node when it is at position P1 and deliver the data to the sink when it is at position P2. Sink node move from P1 to P2 position during the data transmission. Situations where sink always changes the position dynamically as derived in the Equation 1, so SPIN is the better protocol then those traditional protocols which first establish the path then transmit the data to sink. Hence it is not feasible to establish the path and follow to transmission of data to the sink. According to the mathematical derivation Equation 5 and 6 states that SPIN works efficiently in mobile sink WSN.

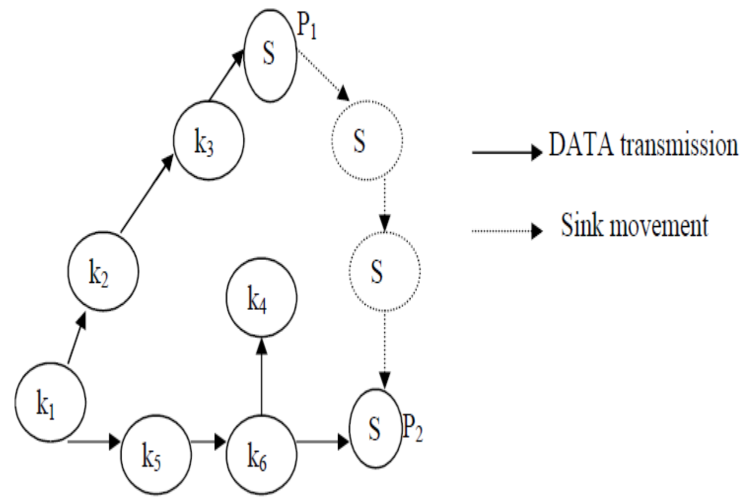

Figure 2: Data transmission with mobile sink

III. System Model

A. Mobility model of sink

The proposed mixed mobility model which is the combination of random way point and modified Gauss-Markov model. Gauss-Markov mobility model is initially proposed for PCS [2] and this model has been used for an ad hoc network protocol [3]. Here we describe how it works for mobile sink in the WSN.

i. Modified Gauss-Marko model

Assume that at time t1 sink is at position p1(x1; y1). Initially we need to specify the actual position of the sink. Then it starts its movement which is based on previous position, speed and direction.

Therefore, at the nth position:

$$xn = xn-1+sn-1\cos(dn-1)$$

$$yn = yn-1+sn-1\sin(dn-1) \quad (1)$$

Where (xn, yn) and (xn−1, yn−1) are the (x, y) coordinate of the current and the previous position of the sink node respectively. Sn−1 and dn−1 shows the speed and direction of xn−1 and yn−1 positions.

The Gauss-Markov Mobility Model was built in order to adjust to different levels of randomness of a node. Concisely, the value of speed and direction at the nth instance of time is calculated as per the value of position, speed and direction of the (n-1)th instance of time and a random variable shown in the following equations:

$$s_n = \alpha s_{n-1} + (1-\alpha)s' \sqrt{(1-\alpha^2)s_{x_{n-1}}} \quad (2)$$

$$d_n = \alpha d_{n-1} + (1-\alpha)d' \sqrt{(1-\alpha^2)}d_{x_{n-1}} \quad (3)$$

Where sn and dn are the new speed and direction of the sink at time interval n, s′ and d′ are constants representing the mean value of speed and direction as $n \rightarrow \infty$; $0 \leq \alpha \leq 1$, is the parameter used to vary the level of randomness, and sxn−1 and dxn−1 are random variables for speed and distance as per Gaussian distribution. As the assumption of our proposed model is the random motion of the mobile sink, so it is as per the values of α, and sxn−1 and dxn−1 are taken randomly. The total random values are obtained by setting the value of $\alpha = 0$ and linear motion is obtained by setting the value of $\alpha = 1$. In order to obtain the intermediate levels of randomness, we can vary the value of α between 0 and 1. When sink node reach at the boundary of the network then it returns back to the previous position. And for each time sink needs to save the previous position in order to calculate the next position and return back when it heats boundary.

ii. Random Waypoint Mobility Model

A random waypoint mobility model is the model that includes pause time between the position changes. Here sink is constant at one location for a certain period of time (pause time). At each step sink node remains constant for a fixed amount of time. Once the pause time expires, it moves towards the newly chosen position at the selected speed.

iii. Mixed mobility Model

Speed, direction and position calculate at Gauss-Markov model, random waypoint only gives the pause time. Here we are using pause time because sink needs to collect the packet/data before changing its position and here we have taken long pause time i.e. of 10 second. We implemented the proposed mixed mobility model for sink in MatLab. It randomly covers the maximum area within the specified region for data collection. Before changes its position it halts for a fixed amount of time (i.e. 10 seconds).

B. Mathematical model for data transmission

Figure 3 shows the data transmission to the sink when sink is at the P_1 hop distance from source (a) and P_2 hop distance from source (b). Following the property of SPIN source starts to send the data. Every time it starts with the greedy

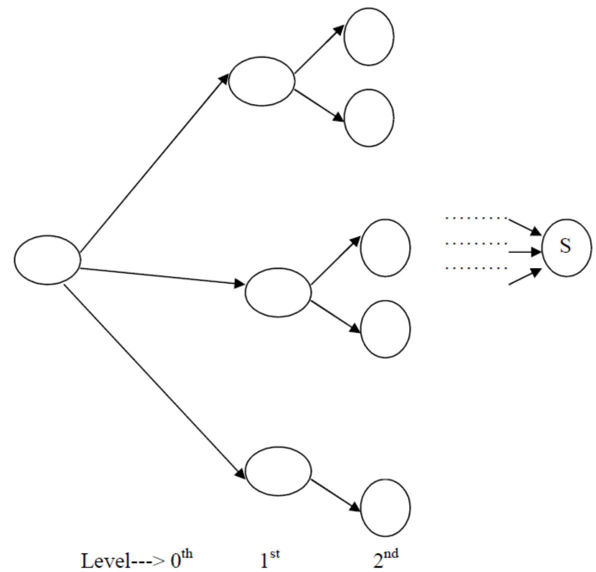

Figure3. Transmission of data when sink is (a) at P1 hop distance from source (b) P2 hop distance from source.

node, every node in the tree (except the sink) makes the transmission reach at the sink. Therefore GIT starts from source node. In this case the number of transmission should be equal to number of edges of the tree. And number of the edge of the tree includes the cost for transmission. Assuming, the distance from source to sink is *Dx*, the cost to transmit the data with distance *Dx* is *Cx,* and energy required to transmit the data with distance *Dx* is *Ex* and each node can disseminate the maximum 'n' number of packets.

When sink is at position *P*1 shown in Figure 3(a), the maximum number of packet dissemination to reach at the sink node at distance:

Can be formulated as

$$C1 = \frac{(n^{p1} - n)}{n-1} + k \quad (4)$$

Where $k < n$, number of packets at last step of flowing to reach at the sink.

For the distance (*D*1) is directly proportional to cost (C1)

i.e $D1 \propto C1$

Similarly at the position of sink at *P*2 ($D2 \propto C2$);

In general $Dx \propto Cx$ (5)

For the distance (*D*1) is directly proportional to energy

i.e $D1 \propto E1$

Similarly at the position of sink at *P*2 ($D2 \propto E2$);

In general $Dx \propto Ex$ (6)

Cost and energy depends on distance between the sources and sink node not the position and the direction. Here we show the the distance from sink node to the source node. Following equations shows that; i.e. $p(x1, y1)$ = distance from position $(x1, y1)$ to the sink node.

Now,
if P(x1, y1) > P(x2, y2)
then D1> D2;C1> C2;E1>E2

if P(x1, y1) < P(x2, y2)
then D1< D2;C1< C2;E1<E2

And if P(x1, y1) = P(x2, y2)
then D1= D2;C1= C2;E1=E2

Hence, the increase in delay is approximately proportional to:

(Distance between farthest source and sink) - (Distance between closest source and sink) (7)

Cost and energy depends on distance between source and sink, not on the directions and speed using the SPIN protocol.

IV. Conclusion And Future Work

In this paper we have presented the random mobility mode of sink in Equation 1 and SPIN efficiency in the mobile sink wireless sensor network. We therefore have proved mathematically as per Equation 7 SPIN is efficient for mobile sink data delivery. It doesn't depend on direction or position; it depends on the distance between the source and destination. We have also shown how cost and energy varies with respect to change in distance. Our proposed protocol for mobile sink wireless senor network can be simulated. Here also proved mathematical that SPIN protocol doesn't depend on mobility of sink. This can be further enhancing to probably efficient and secure routing protocol. SPIN can be used various energy.Most of the current protocols assume the sensor nodes and sink are stationary. Our protocol assumes all nodes static except sink node which is mobile, so future work can be done to prove SPIN efficiency in case of all mobile sensor nodes and mobile sink.

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