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Efficient Data Aggregation in Sensor Nodes Through Linear Motion of Mobile Sink

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Abstract: The advancement in semiconductor technology has enabled the evolution of low cost and less power sensor nodes for transmitting the data through wireless communication. Different sensing applications have also come in to existence. The sensors applied in various environmental monitoring such as battlefield surveillance for military purpose, intrusion detection in secure data transmission etc., the most important challenge in a Wireless Sensor Network (WSN) is to preserve the limited power resources of sensors and extend the network lifetime of the WSN. The sensor nodes deliver sensed data back to the sink through multiple hops. The sensor nodes that are located near the sink will observe more battery power and quickly drain out their battery energy, results in shorter network lifetime. By the relocation of sink, the lifetime of the network is extended as well as to minimize battery energy consumption in a particular group of sensor nodes. In this study, we propose a moving strategy for the sink. The sink movement is based on their residual energy of the cluster head. The lower the residual energy the closer is the sink with the cluster head. The proposed mechanism uses information related to the battery energy of cluster heads and the relocating scheme for the sink. Secondly the comparison between the circular movement of sink and movement of sink along diameter of the circle is done.

Key words: Mobile sink, sink relocation, diameter, circular movement, wireless sensor networks

INTRODUCTION

The recent improvements in science and technology have made the technology and its implementation cheaper. This lead to the usage of technology enhanced mechanisms in almost all the areas ranging from agriculture to space research. The development of Wireless Sensor Networks (WSNs) to aid the toughest job to look simple. Right from the inception the WSN has got its development to the vertical limits.

The WSNs are implemented in the places where the human beings cannot survive. The WSNs help to transmit the data acquired by the sensors to the sink. Sink is a device that is capable of transmitting the data through the conventional network. The WSN finds its application in a various fields such as war fields, surveillance wild life monitoring, space research and so on.

The WSN have a sensor customized for the specific purpose, a transmitter-receiver unit and a micro processor. It is operated by battery power. The transmission range is limited to few meters. The major challenge in WSN is to transfer the data acquired by the sensor to the sink before the sensor node dies i.e., runs out of battery. The sensor nodes periodically transmit the sensed data to the sink with the help of cluster heads. A sink is a special node that collects data from the cluster heads and sends the data to the supervisor.

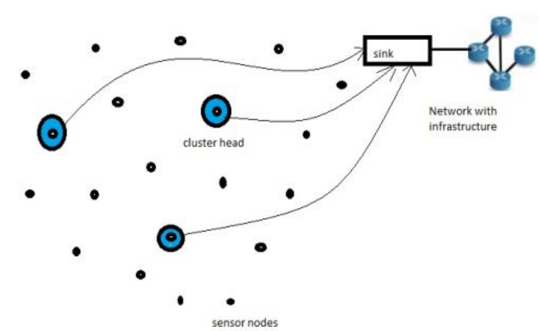

Fig. 1: Wireless sensor network basic infrastructure

The basic infrastructure of the wireless sensor network is depicted in Fig. 1, a sensor node detects an event and passes a warning message to cluster head then the cluster head sends a presence of data signal to the sink. The sink moves in to the range of the cluster head. The data is then notified to the controller through a predetermined routing path. The routing path selected may be either static or dynamic, depending upon their routing algorithm (Wang *et al*., 2014). In general, a main drawback of sensor node is its inability to get recharged or replaced when their batteries goes out of power.

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Sink relocation: The relocation in WSNs can be classified into two parts such as stationary and relocation. Stationary WSN gets a fixed position for sensor nodes that are deployed permanently, for the purpose of sensing and message reporting tasks till a sensor node drain out its energy. The next classification is the relocation of WSNs, through this method the sensor nodes/sink can able to move within the given radius. The reason behind the movement of sink is that when a communication hole is created for low energy nodes, the higher energy nodes can replace the low energy nodes to fulfill the data transmission for making the normal operation of WSN, even though the relocation method enhances the life time, the relocation process itself will consume more energy that should be handled efficiently (Sivakumar and Diwakaran, 2014; Shi *et al*., 2008).

Related work: The following situation emerges when a sensor node drains out its energy, when it acquire coverage hole that creates problem in communication. In order to overcome the problems, the duty cycle scheduling may be adopted by making some of the sensor nodes to enter into sleep state to conserve energy power periodically.

Second solution would be the usage of energy-efficient routing algorithms to minimize the consumption of the battery energy (Ke *et al*., 2011). By, using any of the data aggregation methods, similar data from different nodes are grouped into a single datum (Li *et al*., 2006). Consumption of battery power in WSNs: consists of two parts:

- Energy consumed by transceiver
- Energy consumed by amplifier
- Let us consider, the equation

$$ETx(s,d) = (Eelec\times s) + (amp\times s\times d) \quad (1)$$

This gives the total energy consumed by a sensor node, Eelec×s represents the energy consumed by the node for the transceiver unit operation and amp×s×d represents the energy consumed by the amplifier unit. Hence, the total energy consumed by the sensor node is the sum of the energy consumed by the transceiver and the amplifier. Where‘s’ is the number of bits transmitted/received,‘d’ is the distance between the nodes. The nodes that transmits the sensed data needs both the components to operate but the intermediate nodes that only retransmits the data requires only the transceiver components to operate through the equation:

$$ER_x(k) = Eelec\times s \quad (2)$$

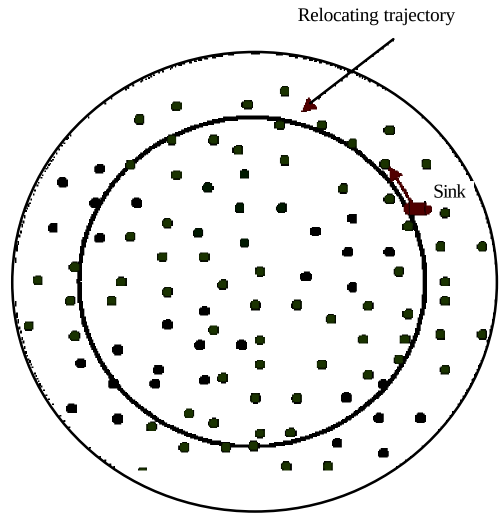

Fig. 2: The sink relocation scheme

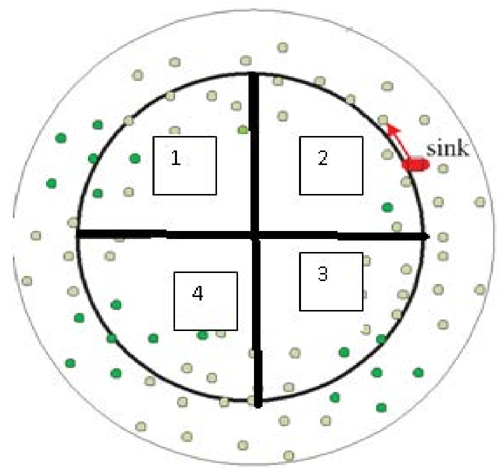

Fig. 3: The sink relocation in quadrants

Circular movement of sink: The sink relocation scheme demands the sink to move in a circular fashion. The sink relocates its position periodically in a circle as shown in (Fig. 2).

The sink moves along a predetermined path and with a constant velocity (Prasanth and Ganeshkumar, 2015). The distance travelled by the sink along the perimeter of the circle is given by 2 or where ‘r’ is the radius of the circular area in which the sensor nodes are deployed. The location of the sink may be fixed dynamically based on the residual energy of the sensor nodes. The circular plane considered may be divided in to four quadrants. The sink can find its position in each quadrant at least once to get the information from the sensor nodes in that particular quadrant.

Figure 3 sink relocation scheme considers the nearby sensor nodes’ residual battery energy and then moves the sink to a new position with a higher total residual energy than others. In addition to the relocation scheme routing algorithms are to be considered. The routing will have greater impact on the total residual energy and hence the life time of the WSNs. In this proposed approach, we have designed a sink relocation scheme where the sink moves in a linear fashion along the diameter of a circle. The sink aggregates the information from the nodes that are within the range. Other nodes that the not in the range of sink transmits the information to the nearest cluster head (Liu, 2012). which in turn re-transmits the data to the sink.

MATERIALS AND METHODS

Movement of the sink along the diameter: In this proposed approach, the sink moves in a linear fashion along the diameter of a circle. The sink aggregates the information from the nodes that are within the range. Other nodes that are not in the range of sink transmit the information to the nearest cluster head which in turn re-transmits the data to the sink. Figure 4 shows the movement of the sink along the diameter of the circle. The cluster heads retransmits the information to the sink; the sink in turn sends the information to the supervisor. The distance travelled by the sink (S_{d1}) in the circle for one duty cycle using the proposed method:

$$S_{d1} = 2_r \quad (3)$$

The distance travelled by the Sink (S_{d2}) in the circle for one duty cycle using LEASAR with circular movement:

$$S_{d2} = 2\pi_r$$

Where, r is the radius of the circle considered.

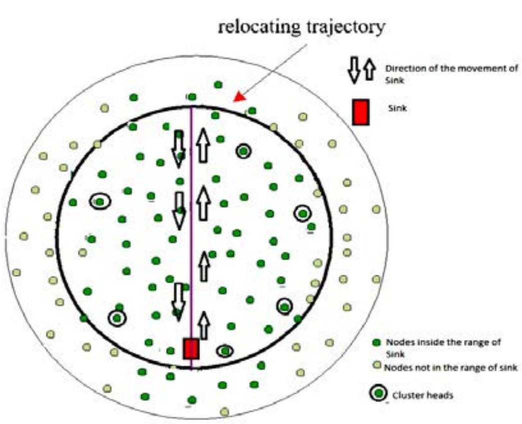

Fig. 4: Linear movement of the sink along the diameter

RESULTS AND DISCUSSION

Theoritical analysis of circular and linear movement: The movement of the sink in a circular path with an angular velocity will consume more energy when compared to the linear movement. The sink during its relocation has to fix its location. The identification of the next location by the sink requires the relocation algorithm which also consumes extra energy. During its relocation period the sink have to communicate with the neighboring nodes. The sink collets the details of the surrounding nodes and the movement should be directed towards the node with lower residual energy.

On the other hand the linear movement will have the linear velocity with no effect of the centrifugal force. The movement of the sink along the diameter of the circle does not need any calculation of the residual energy. The cluster heads will have the statistics of the nodes that are within the coverage area.

The sink has to collect the information from the cluster head. The sink will maintain the only the statistics of the cluster head. The overhead of maintaining the details of more number of nodes is reduced in linear movement along the diameter.

The cluster heads that are within the range of sink will directly send the aggregated information to the sink in a single hop. The cluster heads that are not falling in the range of the sink will deliver the information to the nearby sink that is within the communication range. Thus the information reaches the sink through multiple hops.

The linear movement of the sink has an advantage of covering more sensor nodes with minimal movement and the comparison is given (Table 1). The life time of the WSN is decided by the environment and the purpose for which it is deployed. The efficiency of the WSN may be improved by extending the life time of the WSN. The life time of the WSN can be improved by utilizing the battery power effectively.

Table 1: Comparision of circular movement and linear movement

Circular movement of the sink	Linear movement of the sink along the diameter
Distance travelled in one duty cycle = 2πr	Distance travelled in one duty cycle = 2πr
Movement along the perimeter of the circle with angular velocity	Movement along the diameter of the circle with linear velocity
Information about the residual of nodes is considered in each quadrant	Information about the number of nodes in the range alone is required for sink relocation

CONCLUSION

The nodes with lower residual energy shorten the life time of a WSN. Energy efficient routing algorithm would enhance the life time. The linear movement of the sink along the diameter of the circle would shorten the distance travelled by the sink and also enhance the coverage of the sensor nodes. This approach will overcome the problem of information lost in the nodes with lower residual energy. Theoretical analysis proves that the linear movement of the sink along the diameter can prolong the lifetime of the WSN.

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