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Maximizing the Network Lifetime Using PEGASIS based on Mobile Sink in Wireless Sensor Networks

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Abstract: The Wireless Sensor Networks consist of sensors with computation and wireless communication capabilities. In general, sensor nodes have some limitations such as limited battery power, storage capability and restricted computing ability. So it is essential to design effective and energy aware protocols in order to prolong the network lifetime. PEGASIS is one of the well-known chain-based routing protocols for improving energy efficiency and it is based on a chain-based greedy algorithm. However, PEGASIS protocol causes redundant data transmission since one of the nodes on the chain is selected as a head node and data transfer is carried between the head nodes. In this paper the problem of redundant data transmission is overcome PEGASIS based on concentric clustering scheme with mobile sink (MS), as mobile sink helps in enhancing network lifetime. Based on the location of the mobile sink, the concentric clustering of the network is carried out.

Keywords— Concentric clustering, Mobile Sink.

I. INTRODUCTION

Wireless sensors networks (WSN's) consist of terribly tiny sensors that are characterized by restricted power and energy resources. WSN's are employed in numerous domains like military applications, medical, engineering and industrial task automation. The network must be associated such that its processing power is used at the most. Technological advances have brought the chance to develop and use sensing element devices with terribly tiny dimensions, low consumption and processing power. Consequently WSN are usually reconciling networks that use knowledge of data aggregation and hierarchy to scale energy consumption to and from the nodes.

The architecture of a Wireless Sensor Network [1] and details on how the clustering phenomenon is an essential part of the organizational structure of the network is as follows.

Sensor Node: A sensor node is the core component of a WSN. Sensor nodes possess multiple roles in a network, such as data processing, simple sensing, data storage and routing.

Clusters: Clusters are the organizational unit for WSNs. The dense nature of these networks requires the need for them to be broken down into clusters to simplify tasks such a communication.

Challenges of clustering:

There are several key challenges that may become a bottleneck to the designers and which are of particular importance in wireless sensor networks namely, Cost of Clustering, Selection of Cluster heads and Clusters, Real-Time Operation, Synchronization, Data Aggregation, Repair Mechanisms, Quality of Service (QoS).

Cluster heads: Cluster heads are the organization leader of a cluster. They often are required to organize activities in the cluster. These tasks include but are not limited to data-aggregation and organizing the communication schedule of a cluster.

Base Station: The base station is at the upper level of the hierarchical WSN. It provides the communication link between the sensor network and the end-user.

Mobile sink: Mobile Sinks are mobile devices that gather data from the sensor nodes. These are mobile nodes which represent the endpoints of data collection. They can either autonomously consume collected data for their own purposes or make them available to remote users by using a long range wireless Internet connection. Example mobile sinks are: Simple base stations mounted on movable devices such robots, planes or even animals. Smart devices such as cell phones with WSN interface moving with the subscribers.

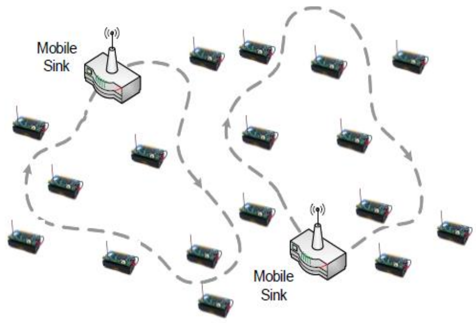

Fig 1.1 Architecture of Mobile Sink

End User: The data in a sensor network can be used for a wide-range of applications [1]. Therefore, a particular application may make use of the network data over the internet, using a PDA, or even a desktop computer. In a queried sensor network (where the required data is gathered from a query sent through the network). This query is generated by the end user.

WSN creates a local network hierarchy on one or more levels represented by nodes chosen by certain criteria that are aggregating and sending data to a central base station (BS). Most times it is not necessary to identify the exact location of the node and it's ID. Communication is done mostly from node to BS, the BS sends requests to obtain data from nodes. The answer of a particular node is not important, but the area of origin is. All data has to be aggregated by the cluster-head before reaching the BS. Generally, routing protocols on the basis of network structure are divided in to 3 main groups:-

- Flat based
- Hierarchical based
- Location based

The use of wireless sensor networks is increasing day by day and at the same time it faces the problem of energy constraints in terms of limited battery lifetime. As each node depends on energy for its activities, this has become a major issue in wireless sensor networks. The failure of one node can interrupt the entire system or application. Every sensing node can be in active (for receiving and transmission activities), idle and sleep modes. In active mode nodes consume energy when receiving or transmitting data. In idle mode, the nodes consume almost the same amount of energy as in active mode, while in sleep mode, the nodes shutdown the radio to save the energy.

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The following steps can be taken to save energy caused by communication in wireless sensor networks [2].

- To schedule the state of the nodes (i.e. transmitting, receiving, idle or sleep).
- Changing the transmission range between the sensing nodes.
- Using efficient routing and data collecting methods.
- Avoiding the handling of unwanted data as in the case of overhearing.

In WSN's the only source of life for the nodes is the battery. Communicating with other nodes or sensing activities consumes a lot of energy in processing the data and transmitting the collected data to the sink. In many cases (e.g. surveillance applications), it is undesirable to replace the batteries that are depleted or drained of energy. Many researchers are therefore trying to find power-aware protocols for wireless sensor networks in order to overcome such energy efficiency problems as those stated above.

All the protocols that are designed and implemented in WSNs should provide some real-time support as they are applied in areas where data is sensed, processed and transmitted based on an event that leads to an immediate action. A protocol is said to have real-time support if and only if it is fast and reliable in its reactions to the changes prevailing in the network. It should provide redundant data to the base station or sink using the data that is collected among all the sensing nodes in the network. The delay in transmission of data to the sink from the sensing nodes should be short, which leads to a fast response.

II. RELATED WORK

1. PEGASIS Protocol

The main idea in PEGASIS is for each node to receive from and transmit to close neighbors and take turns being the leader for transmission to the BS. This approach will distribute the energy load evenly among the sensor nodes in the network. We initially place the nodes randomly in the play field, and therefore, the i^{th} node is at a random location. The nodes will be organized to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the BS can compute this chain and broadcast it to all the sensor nodes [3]. The greedy approach to constructing the chain works well and this is done before the first round of communication. To construct the chain, we start with the furthest node from the BS. We begin with this node in order to make sure that nodes farther from the BS have close neighbors, as in the greedy algorithm the neighbor distances will increase gradually since nodes already on the chain cannot be revisited. Figure 2 shows node 1 connecting to node 3, node 3 connecting to node 7, and node 7 connecting to node 6 in that order. When a node dies, the chain is reconstructed in the same manner to bypass the dead node.After the chain Construction process in PEGASIS protocol the data transmission process is performed. Each node Transfers the data to the Base station in turns by delivering its own sensed data to the neighbor node. Future the neighbor node aggregates the data to transmit the aggregated data to its neighbor node. As shown in figure 2, node 1 transfers the data to the node 3, node 3 aggregates the data with its own sensed data and transfers it to the node 7, Node 7 follows the same procedure and transfers it the head node or leader node, which further aggregates the data collected by different node and sends it to the base station [4] [5].

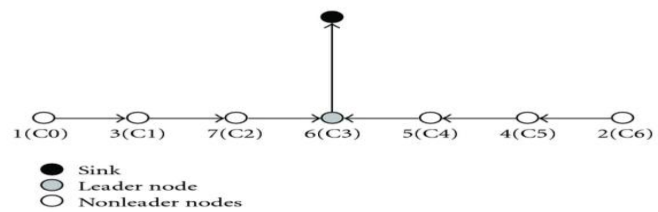

Figure 2 .1 The Flow of Data in PEGASIS forming Chain to reach BS

Drawback of PEGASIS

The PEGASIS protocol may have several problems as follows [2] [6] [7]:

- Each sensor node is required to have extra local information about the wireless sensor network.
- When the PEGASIS protocol selects the head node, there is no consideration about the energy of nodes.
- When the PEGASIS protocol applies to the greedy algorithm to the construct chain, some delay may occur.
- Redundant data transmission within the head nodes of the network.

2. **Concentric based clustering in PEGASIS**

An enhanced version of the PEGASIS protocol based on the idea of a concentric clustering scheme with static sink has been proposed in [9]. According to this scheme, the sensor network is logically divided into several concentric circles or levels, with the sink node being the center of each circle. The radius of each concentric circle and the number of such levels is dependent on the network density and the location of the sink. The level that is closest to the sink is said to be the lowest level and the level that is farthest from the sink is said to be the highest level as shown in the figure 2.2(a). A chain is constructed among the sensor nodes in each level as shown in figure 2.2 (b). The same greedy-distance based heuristic used in the original PEGASIS protocol is used for the chain construction. A head node is randomly selected for each level and a head node informs its location information to peer head nodes above and below its level in the network as shown in figure 2.3(a). At each level, data gets aggregated towards the head node at that level. The aggregated data at each level is further aggregated along a chain of the head nodes, starting from the highest level and ending at the lowest level. The head node at the lowest level forwards the aggregated data to the sink node as shown in figure 2.3(b). The figure 2.2 and figure 2.3elaborates the overall process of enhanced PEGASIS protocol based on concentric based clustering with static sink.

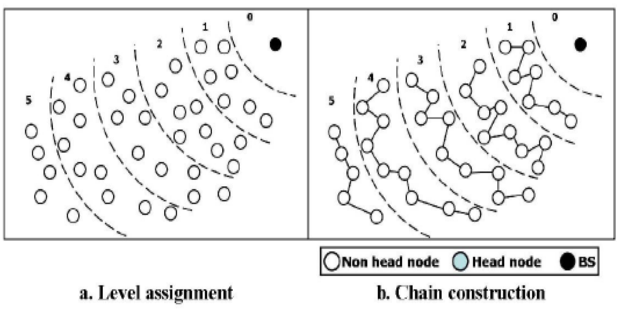

Figure 2.2 Level assignment and Chain construction in enhanced PEGASIS

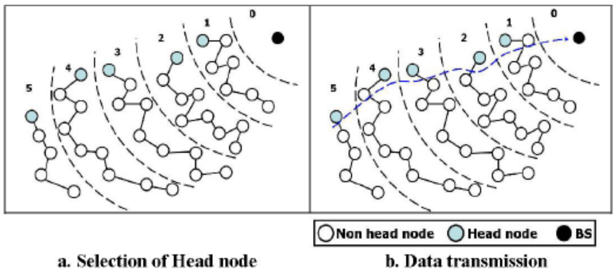

Figure 2.3 Selection of Head node and Data transmission

III. Proposed Work

The Concentric Clustering Scheme with Mobile Sink:

In concentric clustering scheme network is divided in the form of concentric shaped clusters as shown in figure 2.2 based on the Sink location the clusters are formed. We assume sink mobility as the sink moves through the center of equally spaced regions and complete its full trajectory in 1 entire round. Sink stays at the location for specific time duration that duration is termed as sojourn time. The sink divides the area into different clusters in which nodes are deployed by uniform random distribution. The sink moves in these clusters 1 by 1, with the particular speed and completes its course in a round. Each sensor compresses the received bits by a data aggregation (DA) factor of 0.6 using distributed compressive sampling.

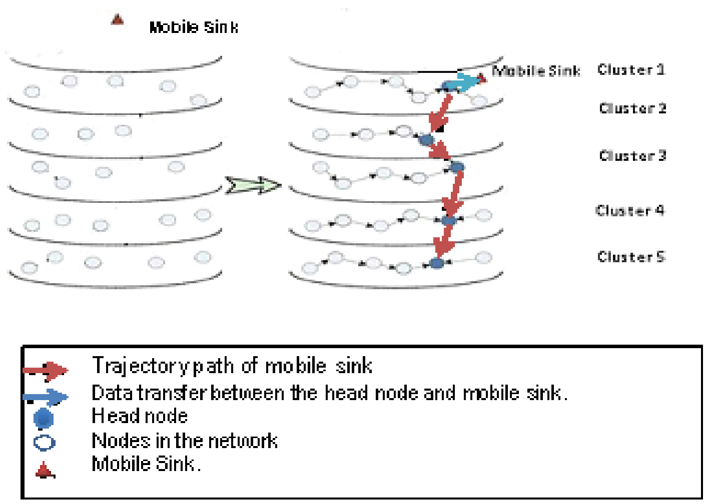

Figure 2.4 PEGASIS PROTOCOL with mobile sink

Step 1: Level assignment

The sink divides the area into different clusters; each node in the sensor networks is assigned its own level from the sink. The level assignment in the form of concentric circle is based on the signal strength as shown in Figure 2.4. Based on the values set in the sink the interval between the concentric levels varies. Additionally, the numbers of other parameters on which the number of levels depend are the number of nodes in the specific location, or the location of the base station.

Step 2: Chain construction in the level area

The process of chain construction is same as that of PEGASIS protocol. In each level area, the chain construction is started at the farthest node from the sink using the greedy algorithm as shown in Figure 2.4. In the mobile sink based PEASIS protocol, the level closer to the sink is the lowest level and the farthest level from the sink is the highest level.

Step 3: Head node construction in chain

The head node is the node which gathers the information from all the sensor nodes of same level and transfers the aggregated data to the sink when the sink is in contact with the head node. Each level in the sensor network has a head node and is selected based on the formula i mod N, where I is the node and N is total number of nodes in that level. Once the head node is selected its Id and location information is sent to the sink in each round. The details of information transfer and head node selection is shown in the figure 2.4

Step 4: Data transmission

The data transmission process is carried out in two steps mainly, firstly within the level i.e. all the nodes in the same level transfer the information to the head node in the same level. The second step is when mobile sink come in contact with the head node in each level and transfers the aggregated data to the mobile sink. Mobile sink covers all the clusters in sojourn time. The path of the mobile sink is based on the location, ID and level information of the head node at each level as shown in figure 2.4. In summary, the overall data flow diagram of the PEGASIS protocol with concentric based clustering scheme with mobile sink is as follows:

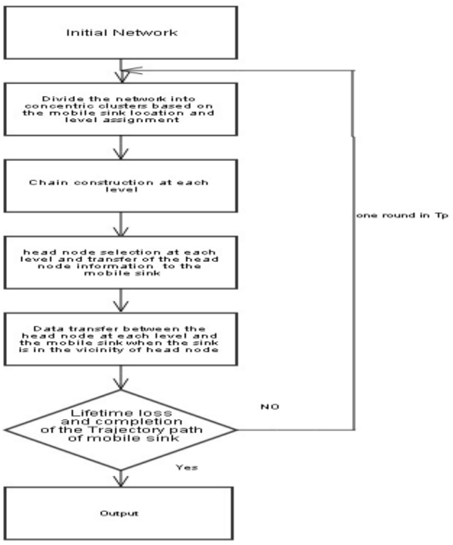

Figure 2.2 Flow chart of PEGASIS protocol with concentric based clustering with mobile sink

IV. PERFORMANCE EVALUATION

Radio model of PEGASIS protocol

In this paper, we use the formal radio model [3] [10] to compare the performance of the PEGASIS and the Mobile sink based PEGASIS protocol. Variables used in this paper are in the table 1.

Table 1. Variables

Type	Parameter
Transmitter Electronics	Eelec
Transmit Amplifier	εamp
Data bit	k
Energy for Aggregation	Eagg
Sojourn time	ti
Trajectory path	Tp

The k –bit message exchange at the distance d is carried out as follows by a radio model:

Transmission:

$$E_T(k, d) = E_T elec(k) + E_T amp(k, d)$$
$$E_T(k,d) = Eelec \times k + \varepsilon amp \times k \times d^2 \qquad (1)$$

Receiving:

$$E_R(k) = E_R elec(k)$$
$$E_R(k) = Eelec \times k \qquad (2)$$

Energy consumption comparison between the PEGASIS and the mobile sink enabled PEGASIS protocol.

The energy consumption of the PEGASIS and the mobile sink based PEGASIS protocol can be compared as follows:

When nodes transmit and receive the data to head node on the chain in the PEGASIS protocol, the energy consumption in one round can be formulated as follows:

During transmission:

$$E = n \times Eelec \times k + \varepsilon amp \times k \times Y \sum [d(m-1,m)^2] \qquad (3)$$

During receiving:

$$E = n \times Eelec \times k \qquad (4)$$

Where, n is number of nodes in each cluster level. d(i,j)indicates the distance from i node to j node. As the data transfer process to the neighboring node in the mobile sink based PEGASIS protocol is same as PEGASIS protocol, so it is presumed that the energy consumption of the mobile sink based PEGASIS protocol is the same with the PEGASIS protocol.

Data aggregation

Let us assume that the energy consumption of the aggregation at one node is Eagg in the PEGASIS protocol and for entire nodes in one round is

$$E = n \times Eagg \qquad (5)$$

It is also presumed that the energy consumption of the mobile sink based PEGASIS protocol is the same with the PEGASIS protocol.

- Data transmission from head node to the base station

In wireless sensor networks, the head node at each level aggregates the data acquired by the entire nodes in that level and it transfers the aggregated data to the base station in PEGASIS protocol.

The energy consumption is formulated as follows:

$$E = Eelec\ X\ k + \varepsilon amp\ X\ k\ X\ d(i, BS)^2 \qquad (6)$$

Other level without first level

$$E = E_{elec}\ X\ k + \varepsilon amp\ X\ k\ X\ d_L^2 \qquad (7)$$

As the head node transfers the data only to the mobile sink when it is in the vicinity of the mobile sink, this scenario differs from that of the PEGASIS protocol. The mobile sink generates the trajectory path (T_p)to move along the network based on the two values, location and the ID of the head nodes in concentric clusters. Let us assume that the distance between the two levels remain same and is indicated as $d_{L.}$ The mobile sink requires time T seconds to complete 1 round and ti seconds it is contact with the head node that is termed as sojourn time. So energy consumption at each level is termed as:

$$E = E_{elec}\ X\ k + \varepsilon amp\ X\ k\ X\ d(i ,MS)^2 \qquad (8)$$

Here d is very small in the above formula and hence the Energy consumed is also less due to proportionality as other parameters are constant.

In sum, as the energy consumed in each level is very less and the data aggregation at other levels due to head node to head node data transfer is eliminated by this method, the overall energy consumed is reduced drastically.

V. CONCLUSION AND FUTURE WORK

In this paper, we examined the redundant data transmission between the head nodes of the different levels in concentric based clustering to transfer the data to base station which is static and the energy consumed to transfer the data between the head nodes. In order to improve the network lifetime and reduce the data redundancy, we proposed the mobile sink based PEGASIS protocol with concentric based clustering.

The main idea about this scheme is mobile sink increases the network lifetime, as the data is directly transferred to the mobile sink from the head nodes in each level. Data aggregation is only carried out at head nodes of each level and mobile sink as there is no head node to head node transfer of data between levels. This reduces the redundant data flow and also the energy consumption at each level which future increases the Network lifetime.

In the future research the experiment is conducted under the simulation environment and the results are included to know the exact percentage of energy reduction each level and overall network lifetime increase

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