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Improved Lifetime by Mobile Sink based Energy Efficient Adaptive Threshold Clustering Hierarchy Algorithm for WSN

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Abstract: WSN is the emerging and fast growing field which consist of low cost, battery operated and multi functional sensor nodes. In wireless sensor network improving lifetime of the network is the main challenge. With static sink energy whole problem or hot spot is a major problem in WSN. The sensor nodes which are located near to the sink, act as relay for those of the nodes which are far apart from the sink. This causes the lifetime of the network reduced. The concept of mobile sink solves the problem of energy hole problem and also does the load balancing in the wireless sensor network. In this paper we propose to improve the lifetime of the wireless sensor network by using mobile sink based energy efficient adaptive threshold clustering hierarchy algorithm. Here we use hybrid routing protocol APTEEN which gives overall snapshot of the network at periodic intervals and also react to time critical situations. The results obtained from the proposed algorithm have been compared with that obtained from MSIEEP protocol. It can be accessed from results that the proposed algorithm works better than MSIEEP. The simulation result is performed in MATLAB.

Keywords: Mobile sink, APTEEN, lifetime, energy efficient.

I. INTRODUCTION

Wireless sensor network have many sensor nodes with limited power resources that communicate to the high energy base station to communicate the sensed data. The sensor node consists of data sensing unit, communication unit, data processing unit, and power supply unit [1]. Sensor nodes are widely used in different applications in areas such as environment condition monitoring, forest data analysis, industrial process monitoring, traffic situation analysis [2], and hostile battlefield surveillance.

The main objective of the wireless sensor network is to prolong the energy efficiency and the lifetime of the network. Rapid growing of WSN faces the problem of energy constraint because of sensor node equipped by limited battery power. This limits the lifetime of the network. Lifetime of the network may also affected by the energy hole problem.

The wireless sensor nodes which are located in vicinity of the sink node, they act as relay for all those sensor nodes which are located at larger distances from the sink. Due to this reason the usage of these sensor nodes is very high and they tend to dissipate their energy very fast. This phenomenon causes the energy hole problem in the sensor network where the nodes near to the sink node are very soon deprived of the energy [3]-[8]. The unavailability of sensors near to the sink nodes causes the sink node to become inaccessible from rest of the network locations while the many of the sensor nodes still have energy to communicate data and are alive in the network. The lifetime of the wireless sensor network is reduced due to occurrence of this problem. The possibility of the movement of sink node has widely been accepted as a solution to the problem of the energy hole problem.

Since the sink mobility overcomes a major problem of the wireless sensor network, tremendous research is going on currently in this field. The mobile sink technique balances the traffic load inside the network and thus improves the performance of the network [9-10]. If mobile sink is moved at a certain speed through the monitored area, the data from the static sensor nodes can be collected by it either in a single hop communication in places where the distance between the sensor node and mobile sink is less or in a multi hop communication method in places where the distance between the mobile sink and the sensor node is high. Since in this condition the sink node remains moving, the energy overhead caused in the nodes near to sink is reduced an thus the availability of the sensor network is significantly increased. In order to maintain the connectivity of sensor nodes placed at far apart from each other, the transmission capability i.e. the range of individual transmitters shall be enhanced.

In this paper we propose an energy efficient adaptive threshold clustering hierarchy algorithm for WSN based on mobile sink concept. In this concept, the mobile sink is used to solve the problem of energy hole creation and to improve the overall lifetime of the wireless sensor network. APTEEN is used here for the periodically scan

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the network and also react for time critical situations and it increases the energy efficiency, reduce delay and data redundancy and useful to increase network lifetime.

This paper organised as: Section I gives introduction about proposed technique and explain, section II gives a brief review on previous work done on energy consumption and lifetime by using mobile sink, section III explain the proposed algorithm and section IV provides simulation result and section V and VI gives conclusion and future scope of the proposed work.

II. RELATED WORK

Many approaches have been proposed for maximizing the lifetime and energy efficiency in wireless sensor network. Some of them are discussed here In [11] proposed that a mobile sink based adaptive immune energy efficient clustering protocol (MSIEEP) reduces the problem of energy hole creation. The author focuses on techniques to reduce the energy consumed in sending the control packets and communication packets. Adaptive Immune Algorithm (AIA) is used by MSIEEP to assist the mobile sink in the movement. In this paper the author compares the protocol MSIEEP with other protocols by using MATLAB. It is found that MSIEEP is more efficient in terms of energy consumption as compared to other protocols discussed in the paper. In [12] proposed a WRP (weighted rendezvous planning) algorithm in which each node assigned a weight according to its hop distance from the tour and the number of data packets forward to the closest RP(rendezvous point). Mobile sink is used to decrease the energy consumption of the node and avoid the energy hole problem. These advantages is depends on the selection of mobile sink path strategy. To form a hybrid moving pattern in which a mobile sink only visit RPs. Which sensor nodes are not RPs send data via multi-hopping to the closest RPs. In [13] proposed a scheme where in delay tolerant applications the network lifetime can be increased by using the concept of mobile sink. In this concept, it is not necessary for the sensor node to transmit sensed data in real time to the sink node. The sensor node is configured to hold and save the data in its memory and is programmed to transmit the sensed data to sink node when the location of the mobile sink is at the most favourable location for least energy consumption to achieve longer life time of the network. This framework is useful for those applications which are not very time critical and can bear the lag in transmission of data caused by store and forward type of communication done by system.
In [14] the author proposed enhanced developed distributed energy efficient clustering (EDDEEC) strategy for wireless sensor networks which have heterogeneous network. This scheme uses three factors mainly for classification of the networks. The sensor nodes in a heterogeneous network model consist of different energy levels. EDDEEC decides the chance of selection of a node as cluster head in an energy efficient and dynamic way. This scheme improves the lifetime of the network.
In [15] propose a new approach mobile node rotation in which the high power consumption location is shared by the mobile sensors. In this approach without manipulating the existing topology the mobility of nodes is to mitigate differential power consumption. By movement of mobile node relatively small energy is expended during the network lifetime. It improves the network lifetime by more than a factor of eight.
In [16] the author gives an idea of a hybrid routing protocol (APTEEN). This hybrid protocol is very efficient and is useful and data gathering and information retrieval from the wireless sensor network. This algorithm gives a complete network overview repeatedly in a very optimum fashion. APTEEN is useful in time critical events and works on the generated queries like historical, one time and persistent. This algorithm transmits data based on soft and hard threshold values. The protocol APTEEN is a hybrid protocol and its efficiency in the WSN field is found to be in the range of two protocols which are LEACH an TEEN in terms of lifetime of the network and consumption of energy in data transmission.

III. PROPOSED ALGORITHM

The proposed concept uses N number of sensor nodes. These sensor nodes are assumed to be uniformly scattered in a M X M square area. With no loss of generality, the base station location is considered to be at the center of the region taken. The proposed concept initially takes heterogeneous [17] WSN model having three levels followed by energy consumption model proposed by us. Depending on the energy levels of the sensor nodes, a heterogeneous WSN may have two, three or multiple types of nodes.

The network proposed by us consists of three types of nodes namely super node, advanced node and normal node. The initial energy contained in the normal node is E0. The number of advanced nodes is the network is fraction m and the energy contained in the advanced node is " a " times greater than that contained by the normal nodes i.e. E0(1 + a). The number of super nodes in the network is taken as fraction m_0 and the energy contained [18] in these is considered to be " b " times greater than that contained in the normal nodes i.e. E0(1 + b).Since, N is the total number of nodes in the sensor network, the count of nodes specified as super node in the network as per discussion above is Nmm_0, the number of advanced nodes is $N(1-m_0)$ and the number of normal nodes is N(1-m). When the rounds of the sensor nodes start, at each round start it is decided by nodes whether to become cluster head or not. This decision is based on threshold. The threshold for cluster head selection is selected as per following formula:

$$Th(Si) = \begin{cases} \dfrac{pi}{1 - pi(r \bmod \frac{1}{pi})} & \text{If } Si \in G \\ 0 \quad otherwise \end{cases}$$

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Here, G is the set of nodes in round r which have the eligibility to become the cluster head and p is the required probability for the cluster head. The probability of selection as cluster head is more for super node and advanced nodes as compared to that of normal nodes. Once the cluster head selection process is over, the selected CH receives the attributes from user. These attributes like soft threshold (ST), hard threshold, count time (CT) and schedule are broadcasted to the sensor nodes i.e. cluster members continuously [19]. Whenever the sensor node senses a data value which is higher than the HT, the value is stored as a internal variable and the value is sent to the CH through schedule following TDMA scheduling method assigned to it.

The purpose of using a mobile sink is to make the network more energy efficient and increase its overall lifetime as well as to provide more flexibility to the network. The usage of mobile sink balances the energy consumption among the sensor nodes and reduces the hotspot creation in the network. The decision of movement of the mobile sink is made based on the overall residual energy of wireless sensor nodes at any region in the WSN. Every data packet sent to the CH contains a field to record the position information and residual energy of the nodes having maximum and minimum residual energy. The nodes which come in the path of can access these fields and can change its value if they qualify as node having least or maximum residual energy. The sink upon receiving the packets from the network nodes reads then and comes to know about the location of the sensor nodes which have the maximum and minimum residual energy, The decision of the next destination of the mobile sink is based on this data received from some of the network's sensor nodes, The location of the node having maximum residual energy is chosen as the next location for the destination of mobile sink.

IV. SIMULATION RESULT

The simulation of the proposed algorithm has been done using MATLAB 2013b. The simulation result is compared with that obtained with the MSIEEP protocol. In the simulation 200 number of nodes have been taken which have been randomly distributed in a 200X200 square area field. The initial energy of sensor nodes has been taken as 0.2J. Assumption is made that each sensor node sends one data packet per round to the sink node. Figure 1 and Figure 2 shows the network lifetime and FDN, HDN and LDN respectively for the MSIEEP and proposed algorithm. Figure 1 shows that the number of alive nodes with respect to number of rounds of packet transmission. As we can seen in table1 the network lifetime is improved by 121% over and above the MSIEEP. This signifies that proposed algorithm is more energy efficient than MSIEEP protocol because the sensor node works for a long time. It is obtained that the number of alive nodes has been significantly increased as compared to that in the MSIEEP based protocol.

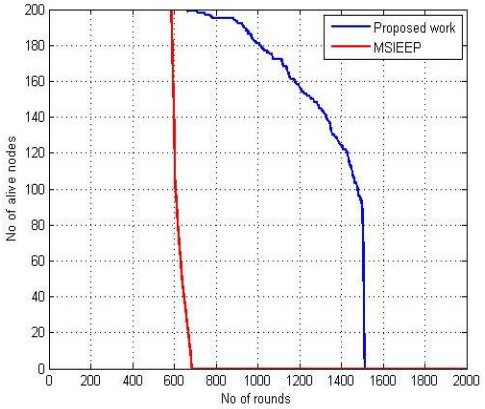

Figure 1 Number of alive nodes in the network against number of rounds

Table1. Comparison table for network lifetime

Performance Measure	MSIEEP	Proposed Algorithm	%Age Improvement In Lifetime
Number Of Rounds	682	1510	121%

From the figure 2 we can see the first dead node in case of MSIEEP was at the end of 584th round whereas in case of our proposed algorithm, the first dead node appears after 665th round. The proposed network also lasts for longer duration i.e. survives for more number of rounds as compared to earlier modes based on MSIEEP protocol. The last dead node comes at the end of 682th round in case of MSIEEP whereas in case of our proposed algorithm the last dead node comes at the end of 1510th node. The comparison data of the MSIEEP protocol and proposed protocol is listed in the table2.

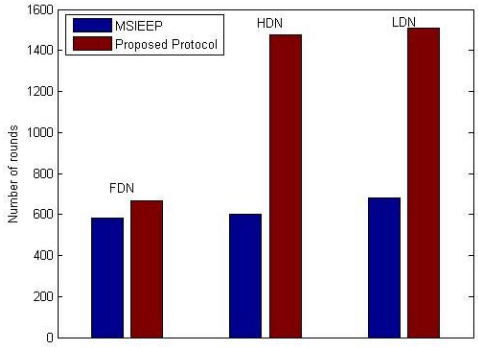

Figure 2 Comparison of first dead, half dead and last dead nodes

Table2. Comparison data for protocols

Sr No	Protocol	First Dead Node	Half Dead Node	Last Dead Node
1	MSIEEP	584	603	682
2	Proposed Protocol	665	1476	1510

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V. CONCLUSION

In this paper we proposed a protocol which uses the APTEEN hybridization with mobile sink. We performed simulation with the help of MATLAB and the result data was analyzed. The result obtained from the proposed algorithm shows that it improves the network lifetime and energy efficiency in data transmission and also reduces the network overhead which overall increases the network availability. Proposed algorithm is more reliable and energy efficient as compared to MSIEEP protocol. It eliminates the energy hole problem arise due to static sink.

VI. FUTURE WORK

One of the main parameter which shall be focused in WSN is network lifetime. The method adopted in this paper for improvement of lifetime is consideration of heterogeneous model with mobile sink concept. Future work can be done to increase the network lifetime by combining heterogeneous model of WSN with other routing protocols.

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