A Multi-hop approach for sensing coverage in wireless sensor network

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Abstract-Wireless sensor networks (WSNs) are recently rapidly growing research area in wireless communications. WSNs are studied widely and usefully applied in many applications like military surveillance, environmental monitoring etc. In WSNs, a large number of sensor nodes are deployed arbitrarily over the considered area; therefore, the sensing regions of different sensor nodes may be partially overlapped. In this paper, we are trying to realize maximum sensing coverage problem in WSNs. In our method, we have taken the concept of both gateway node and redundant node removal technique. Many protocols have been developed to collect, receive and transferring data more energy efficient. In this paper, we propose a multi-hop cluster based routing protocol and compare it with some single-hop approaches.

Keywords- Energy efficiency, wireless sensor network, sensing coverage, multi-hop communication, gateway node.

I. INTRODUCTION

Wireless sensor nodes have existed for decades and first time used in 1978 DARPA- sponsored Distributed Sensor Nets Workshop Carnegie Mellon University(CMU), tracking for military applications[1]. Advances in wireless networking technology and portable information appliances have brought about two implementations of wireless networks defined by IEEE 802.11: infrastructure network and ad-hoc network. MANETS (Mobile Ad-hoc Networks) and sensor networks are two classes of the wireless Ad-hoc networks with resource constraints. Low-cost, low power, multifunctional sensor nodes that are small in size and communicate short distances have been developed due to the recent advances in micro-electro-mechanical system (MEMS) and wireless communication[1]. These tiny sensors have the ability of sensing , data processing, and communicating with each other. Wireless Sensor Networks which rely on collaborative work of large number of sensors are realized. Sensor nodes can be used within many deployment scenarios such as continuous sensing, event detection, event identification, location sensing, and local control of actuators for a wide range of applications such as military, environment, health , space exploration and disaster relief[2]. Although a large volume of research has been performed and some algorithms are proposed, there is ongoing research on this subject in recent years.

A sensor is a device which sensed the environment and performs processing such as collect data and transmit to other nodes in the network. In wireless sensor network the sensor node having information is known as source node, source node sent this information to base station via other sensors known as active sensor or active node. The nodes which do not participate in transmission are in sleeping mode so called as sleeping nodes. Sleeping nodes are completely shut down, as sensor network lifetime depends upon battery power and nodes which are in active state also consume energy , so sleeping nodes are not only in inactive state but completely shut down so without using battery power it increases network lifetime[3].

Wireless sensor networks consist of tiny sensor nodes that can communicate with each other to perform sensing and information processing tasks. The performance of a sensor network depends to a large extent on the sensor field coverage and its lifetime is determined by its energy consumption.

II. RELATED WORKS

Wireless sensor networks are consist of large number of low-cost sensor nodes with a limited amount of energy and power consumption. One of the important requirements of wireless sensor network is to perform its functionality long amount of time. For the proper functioning of the network routing should be optimal so that in minimum consumption of energy maximum amount of task can be performed.

Routing is the process of data transmission. The researchers have developed a large number of protocols to intensify the life of wireless sensor network. To manage the energy efficiency of a wireless sensor network there are many clustering technique in routing protocols are hierarchically organize in a network.

Wendi Rabiner Heinzelman et al [4] describe LEACH is the first protocol which was proposed for reduction of energy consumption. The main methodology of LEACH is to create a cluster first, then select a cluster-head as router to transfer data from the sensor nodes to the base-station via one-hop.

Harneet kour et al [5] proposed heterogeneous – hybrid energy efficient distributed protocol to prolong the network life time and make the network energy efficient. In the paper heterogeneity in terms of node energy is described.

Takumi MYOSHI et al [6] defined a maximum sensing coverage problem in wireless sensor network in his paper, where he proposed an algorithm to solve this problem. He was trying to define how minimum number of active sensor nodes can monitor maximum area.

Lotfi Benmohamed et al [7] describe the concept of gateway nodes. They have described that on consideration of a wireless sensor network with deployment of large number sensors, a subset of sensors are covering the sensor field equipped with special communication capability to communicate with the sensor outside the sensing field. These sensors are called as gateway nodes.

Multi-hop inter cluster is made up of one cluster-head (CH) and cluster members. The respective CH receives the sensed data from sensor nodes of a cluster, then aggregates the data and then sends the data to the Base Station via multi-hop way.

Multi-hop intra-cluster use single hop communication within a cluster for communication between the sensor nodes and the cluster heads, but it may not be the optimum choice. When the sensor nodes are deployed in dense regions it may be beneficial to use multi-hop communication among the nodes in the cluster to reach the cluster-head (CH).

III. THE PROPOSED MULTI-HOP ALGORITHM

The main purpose of multi-hop algorithm is to transmission of data from cluster-head(CH) to the base station(BS). For this purpose multilevel hierarchical data gathering network architecture is used. Here at the bottom most level all the redundant nodes are first removed, then the remaining active sensor nodes senses data and send the data to cluster-head. Thereafter the cluster-head sends data to gateway nodes. In the next level of hierarchy , all the gateway nodes communicate with a base station (BS) .

A. Some Assumptions

The required assumption for the multi-hop algorithm are as follows :

- Base station is located outside from the network field and remain stationary all the time .
- All the sensor nodes spread over a two dimensional space and can't be recharge after deployment.
- All the nodes remain stable after deployment and they are consistently distributed.
- Sensor nodes have the authority to transmit information to the gateway nodes.
- Gateway nodes know the location of the base station .
- Gateway nodes can receive data from cluster-heads and transmit data to the base station.
- One gateway node can connect only with one cluster-head.
- Cluster-head does the data aggregation.

B. Proposed algorithm

Proposed algorithm works in rounds. Performance of each rounds are given below.

- New round number is incremented from the previous one periodically by the base station.
- After incrementing the round number, cluster-head should be selected with probability 0.1 on the basis of Leach protocol .
- Decision of selecting the cluster-head is done by choosing a random number between 0 and 1 . If the number is less than a threshold value T(l). The node becomes a cluster-head for the current round. The threshold value is set as following.

  $T(l) = \{D/1-D*(z \bmod 1/D)\}$ if $l \in U$, if not its 0.

  Where D is the desired cluster-head probability, z is the number of the current round and U is the set of nodes that have not been cluster-heads in the last 1/D rounds.

- After formation of the cluster-head, it selects a gateway node lies closest to it.
- After selection of the cluster-heads, the next step is to form the clusters.
- During creating the clusters, have to find out the redundant nodes and then remove them to keep only the active nodes.
- For making the redundant node free cluster, have to give some consideration.
  - S^i : it defines a cluster i with a set of nodes.
  - $S^u_{overlap}$: it defines node u which is overlapped by a set of nodes.
  - S^i_{MSCR} : it defines a subset of nodes which shows MSCR (maximum sensing coverage region) problem.
- After all the consideration
  - Set S^i as S^i_{MSCR} , so $S^i_{MSCR} = S^i$.
  - For $\forall u \in S^i$, it determines overlapped nodes $S^u_{overlap}$ by calculating the distance between node u and its neighbor nodes :
    $d(u,\alpha) < 2R_s$, where $\alpha \in S^u_{overlap.}$
  - Then find out the boundary arc between node u and each node in $S^u_{overlap}$ and transform them into the angle in $[0, 2\pi]$.
- For redundancy node removal set the node for following two conditions:
  - $U\, arc_i \geq 2k\pi$, where $\forall i \in S_{overlap}$ and k as a natural number.
  - $d(u,i) \leq R_s, \forall i \in S_{overlap}$.
- After following these two condition redundant nodes are removed from the subset S^i_{MSCR} .
  Set $S^i_{MSCR} = S^i - \{u\}$.
- Repeat the steps until all the redundant nodes are found .
- After finding all the redundant nodes set them to sleep mode.
- In each cluster, only a small subset of nodes is on-duty while the remaining nodes within cluster are off-duty.
- Then on-duty nodes sense data and send the data to the respective CHs.
- On the basis of one-to-one communication the CHs aggregate data from the sensor nodes and then send the data to the gateway nodes.
- And finally the gateway nodes send the data to the base station (BS).

IV. COMPARISION WITH RELATED WORKS

In case of single-hop routing protocol like LEACH[4] and HEED[5], when a base station away from its cluster-heads it consumes more energy. It is really the wastage of energy if the cluster-heads away from the base station, but this energy should not be wastage. Again in case of single-hop routing protocol sometimes redundant nodes are also formed. Because of redundant nodes formation, too much energy lost. So the proposed Multi-hop protocol is compared with that of the single-hop protocols LEACH and HEED in terms of energy consumption. This multi-hop protocol using the concept of both gateway node and redundant node removal technique. Because of using the concept of gateway nodes, they receive the aggregate data from the cluster-heads and then send to the base station. This process use less energy than single-hop LEACH and HEED in sending the data to the base station. Again using the redundant node removal approach, it can remove unnecessary redundant nodes from the clusters and it saves lots of energy than LEACH and HEED protocols during cluster formation. So this new approach has certain advantages over both LEACH and HEED protocols regarding energy consumption.

V. CONCLUSION AND FUTURE WORK

Energy consumption is a very important issue in case of wireless sensor network..In this paper, we have proposed a Multi-hop approach regarding multi-hop routing for wireless sensor network. The main purpose of the Multi-hop approach is to minimize the consumption of energy. In this paper we have made some comparison of the proposed technique with some existing single-hop techniques and trying to show its advantages over the existing techniques . In future we will implement the proposed technique and compare it with existing techniques experimentally in sensor network environment.

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