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Energy Efficient Orbital Unequal Clustering (EOUC) Algorithm in Heterogeneous WSN

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Abstract: Wireless sensor node is a combination of many small sensor nodes, also called motes and each mote has a capability of sensing and forwarding the data to the other motes and a gateway (to send information globally on internet) which is commonly known as sink. Sensor nodes limited energy and memory are important factors to be worked upon. Energy consumption rate increases highly if all sensor nodes send data individually to the base station which reduces survival time of node. This is commonly known as hot spot problem. On the other hand the equal size clusters waste energy according to the network density. This problem is called equal size clustering problem. In this paper, both the hot spot and equal clustering problems are addressed. And an Energy Efficient Orbital Unequal Clustering (EOUC) Algorithm is proposed. EOUC improves the network lifetime when compared to other clustering protocols.

Keywords: Sensor node, internet, sensing, hot spot problem, clustering

I. INTRODUCTION

A wireless sensor network (WSN) is usually self-organized wireless ad hoc network which consists of sensor nodes which are randomly dispersed over the interested area. Sensor nodes generates data, based on its sensing mechanisms observation and transmit sensed data packet to the base station (sink). The role of a base station is to collect all data received from the various sensors, analyse them and ultimately make decisions. Sensor nodes could be deployed in home, military, science, and industry applications such as transportation, health care, disaster recovery, warfare, security, industrial and building automation, and even space exploration. Among a large variety of applications, phenomena monitoring is one of the key areas in wireless sensor networks and in such network. Depending on the application, sensor node deployment can be either deterministic or random, stationary or mobile, homogeneous or heterogeneous.

At the same time wireless sensor networks offer numerous challenges due to their peculiarities, primarily the stringent energy constraints to which sensing nodes are typically subjected. These challenges include, but are not limited to: energy, memory, and throughput constraints. Energy efficiency is crucial because of the scale and application environments in which sensors are deployed. One of the well-known approaches is to apply clustering techniques to effectively establish an ordered connection of sensor nodes whilst improving the overall network lifetime. Clustering organizes the WSN into sets (clusters). A sensor from each set is elected as cluster head (CH). A CH coordinates and aggregates data of nodes within its cluster (intra-cluster communication). CHs communicate with each other and/or with an external base station (BS) (inter-cluster communication) on behalf of their nodes. In the equal size clusters, the nodes nearer to the sink are overburdened by means of huge traffic load as the data from the entire region are forwarded through them to reach to the sink. As a result, their energy is shaded rapidly and the network is partitioned. This is commonly known as hot spot problem. A quit common solution to the energy hole problem is unequal clustering where clusters far away from the BS will have a larger size when compared to clusters closer to the BS. By creating unequal sized clusters, the amount of intra-cluster traffic is considerably reduced for the CHs nearer to the BS.

In homogeneous networks all the sensor nodes are identical in terms of battery energy and hardware complexity. With purely static clustering (cluster heads once elected, serve for the entire lifetime of the network) in a homogeneous network, it is evident that the cluster head nodes will be over-loaded with the long range transmissions to the remote base station, and the extra processing necessary for data aggregation and protocol co-ordination. As a result the cluster head nodes expire before other nodes. On the other hand, in a heterogeneous sensor network, two or more different types of nodes with different battery energy and functionality are used. The motivation being that the more complex hardware and the extra battery energy can be embedded in few cluster head nodes, thereby reducing the hardware cost of the rest of the network.[7]

II. Survey of Literature

A lot of literature is available on equal and unequal size clustering techniques for wireless sensor networks. In the following we first introduce some work on equal clustering protocols then we discuss some unequal size protocols.

Srikanth Jannu al. proposed a energy efficient unequal clustering (EEUC) technique which address both the hot spot and equal clustering problems and present unequal size clustering and routing algorithms by considering the energy efficiency of the WSN. This paper address the problem of balancing of the energy consumption among sensor nodes and propose unequal clustering and routing algorithms (combinedly called UCRA) towards the solution of the hot spot problem. The algorithms are experimented considering several scenarios of WSN. Also shows the efficiency of the algorithms in terms energy efficiency, balancing the load and lifetime of the network.[1]

Vijay M. Galshetwar, Amutha Jeyakumar made comparative study of HEED. HEED (Hybrid Energy-Efficient Distributed) is a distributed clustering protocol, which involves grouping nodes into clusters and electing cluster heads periodically such that members of a CH can communicate with their cluster heads and these CHs send aggregated data received from its members to a base station. A set of cluster heads can be selected from the set of nodes in the network. Cluster heads are responsible for coordination among the nodes within their clusters and aggregation of their data (intra cluster coordination) and communication with each other and with external observers on behalf of their clusters (inter cluster communication).[2,6]

UHEED proposed by E. Ever, R. Luchmun, L. Mostarda, A. Navarra, and P. Shah, is an unequal clustering protocol that combines HEED and EEUC. it uses the competition radius formula which creates unequal clusters as they are further away from the base station, in order to create unequal clusters. This effectively allows more intercluster or relay traffic and less intra-cluster communication for nodes nearer to the base station, hence preventing their early death. Since the lifetime of the leaders closer to the BS is more critical, the clusters further away have larger sizes compared to the clusters close to the BS. More precisely, it uses the leader election algorithm that is defined in HEED and each cluster head computes the competition radius by using the formula defined by EEUC.[4]

W.R. Heinzelman, A. Chandrakasan, H. Balakrishnan proposed,Low Energy Adaptive Clustering Hierarchy (LEACH) which is one of the primary adaptive hierarchical clustering. LEACH divides the network into small areas called clusters. In each cluster, a dedicated node called a Cluster Header (CH) is selected. The LEACH protocol is divided into rounds and each round consists of two phases: the set-up and steady phases. In setup phase each node decides independently if it will become a CH or not. This election probability is based on the last time a node has been elected as a CH. The node that hasn't been a CH for long time is more likely to elect itself than other nodes that have been CHs recently. The Steady-state phase starts after the setup phase. In this phase, the data transmission is started. Member nodes send their data during their allocated Time Division Multiple Access (TDMA) slot to the CH. This transmission uses a minimal amount of energy which is only that required to reach the CH (calculated using the received strength of the CH advertisement). When all the data has been received, the CH aggregates these data and transmits it to the base station. But because of the election of cluster head is randomized, it may cause some problems such as uneven distribution of the cluster head, uneven energy loading and so on.[5]

M. Mehdi Afsar and Mohamed Younis proposes an Energy- and Proximity-based Unequal Clustering algorithm (EPUC) which imposes a condition on the distance among cluster-heads that is adaptively adjusted, so that the inter-clusterhead proximity is smaller as they get closer to the base-station. In addition, the cluster population is set while factoring in the inter-cluster relaying activities in order to balance the load on cluster-heads. EPUC models the area as tracks around the BS. EPUC opts to overcome the uneven energy consumption rate of nodes in the vicinity of the BS due to the increased data relaying activity. CHs are selected in EPUC based on proximity to the BS and their energy reserve. So the area is divided into tracks centered at the BS and the cluster count is increased as we get closer to the BS. Nodes with the most remaining energy are designated as CHs through a track-based competition.[3]

III. Proposed System

a) *Network Model*

Sensor nodes are uniformly deployed in a two dimensional field with the following assumptions:

Each node is identified with a unique ID;

- Nodes can transmit at various power levels depending on the distance of the receivers;
- Nodes are not mobile that is they remain stationary;
- Nodes are equally distributed in the field;

The BS is located away from the sensing field with no energy constraints. It is considered to be a node with enhanced communication and computation capabilities. The BS is stationary. The data captured in a cluster is highly correlated, therefore it can be aggregated before being transmitted to the base station. CHs aggregate data during intra-cluster communication and forward to the BS via multihop. Network operation model is composed of multiple rounds. A round starts by triggering the cluster election and formation phases. When the clusters have been formed, the network starts a data exchange phase where each aggregated data is sent by the CH to the BS (multi-hop data transmission among cluster heads is performed). The round ends when all aggregated data sent by the CHs reach the base station.

Heterogeneous WSNs may contain two, three, or multitypes of nodes with respect to their energy levels and termed as two, three, or multi-level heterogeneous WSNs respectively. Proposed system considers three-level heterogeneous network that contains three different energy levels of nodes: normal, advanced, and super. Normal nodes have E0 energy. Advanced nodes of fraction m have a times more energy than normal ones, i.e. E0(1+a). Whereas, super nodes of fraction m0 have b times more energy than the normal ones, i.e., E0(1+b).[7]

The total initial energy of super nodes in WSN is as follows:

$$E_{super} = NE_0(1+b) \quad (1)$$

The total initial energy of advanced nodes is as follows:

$$E_{advanced} = NE_0(1+a) \quad (2)$$

Similarly, the total initial energy of normal nodes in the network is calculated as follows:

$$E_{normal} = NE_0 \quad (3)$$

The total initial energy of three-level heterogeneous WSNs is therefore calculated as:

$$E_{total} = E_{super} + E_{advanced} + E_{normal} \quad (4)$$

b) *Algorithmic Strategies*

The proposed algorithm works in three phases:

Phase I: Clustering Phase:

In the clustering phase, sensor nodes select their CHs. The initializing phase assigns to each node the probability of becoming a tentative cluster head.

Probability of node for becoming cluster head is assigned based on the distance of a node from the base station. Smaller clusters are formed for the nodes nearer to the base station, so as they transmit more data as compared to other nodes they will not die early. Hence improving energy efficiency and so prolonging network lifetime. We will calculate the distance of a node from the base station according to the following formula :

d(x,y) = √ (x2-x1)2 + (y2-y1)2

The node having less distance from the base station will have more probability of becoming cluster head.

Phase II: Rotation Phase:

In the rotation phase, based on the highest residual energy of member nodes, next CHs are selected in their corresponding clusters and there is no need of re-clustering until any of the nodes deplete completely its energy.

Phase III: Re-Clustering Phase:

When any of the node dies re-clustering is performed by repeating step 1.

c) Block Diagram

Nodes closer to base station will require more energy since they have to transmit more data than other nodes. Therefore these nodes will die earlier which is nothing but known as hot spot problem.

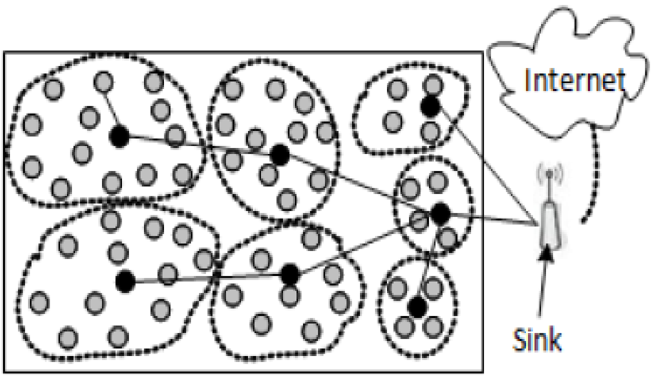

Fig. 1 Block diagram of proposed system

So as shown in Fig. 1, according to proposed system, nodes closer to the base station i.e. sink are clustered as small clusters and CH heads are rotated. So there will be no requirement to form new cluster. In this way, hot spot problem can be solved.

IV. Conclusion

Here we have proposed an energy efficient clustering algorithm EOUC (Energy efficient Orbital Unequal Clustering) for heterogeneous wireless sensor network. EOUC improves RUHEED with the heterogeneous network. The proposed scheme can significantly reduce energy consumption and increase the lifetime of the network compared to the existing schemes.

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