Energy Efficient Cluster Head Selection in Wireless Sensor Networks

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Abstract

Sensor webs consisting of nodes with limited battery power and wireless communications are deployed to collect useful information from the field. Gathering sensed information in an energy efficient manner is critical to operate the sensor network for a long period of time. A data collection problem is defined where, in a round of communication, each sensor node has a packet to be sent to the distant base station. If each node transmits its sensed data directly to the base station then it will deplete its power quickly. Since wireless communications consume significant amounts of battery power, sensornodes should spend as little energy as possible receiving and transmitting data. It is necessary for communication protocols to maximize nodes'lifetimes, reduce bandwidth consumption by using local collaboration among the nodes, and tolerate nodefailures. Most of the work in energy efficient data gathering application is motivated by LEACH by allowing rotation of cluster head for load distribution. In this paper, we have presented several existing methods for energy efficient cluster head selection in wireless sensor network.

I. INTRODUCTION

Wireless Sensor Network is an emerging field with lot of applications. Due to its wide applications in the field of defense security, civilian applications and medical research, there is lot of research going on. There are various issues like deployment and routing issues of Wireless Sensor Networks (WSNs). One of the advantages of wireless sensors networks (WSNs) is their ability to operate unattended in harsh environments in which contemporary human-in-the-loop monitoring schemes are risky, inefficient and sometimes infeasible. Therefore, sensors are expected to be deployed randomly in the area of interest by a relatively uncontrolled means, e.g. dropped by a helicopter, and to collectively form a network in an ad-hoc manner [1, 2].

Since WSNs consist of battery-powered devices, the energy efficient network protocols must be designed. Due to large network size, limited power supply, and inaccessible remote deployment environment, the WSN-based protocols are different from the traditional wireless protocols.
Wireless Sensor Networks (WSN) is an active research area in today computer science and telecommunication.

The development of clustered sensor networks have recently been shown to decrease system delay, save energy while performing data aggregation and increase system throughput [4]. These are strong motivational points behind selecting LEACH as the baseline protocol for the analytical study. Also LEACH has a few but very significant disadvantages like it assumes all the nodes to have same energy, which is not the case always in real-time problems, its cannot be applied for mobile nodes, failure of cluster-heads creates a lot of problems and it does not take into account that the systems might have multiple base stations.

The paper is organized as follows: Section II describes applications and limitations of sensor network. Section III describes various existing methods for energy efficient cluster head selection in wireless sensor networks. Finally conclusion is presented in section IV.

II. APPLICATION & LIMITATION OF SENSOR NETWORK

A few examples of the applications are as follows [3]:

(1) Area monitoring application
(2) Environmental application
(3) Health application
(4) Industrial application

Some limitations of the sensor network are as follows:

(1) Lack of a priori knowledge of post-deployment position.
(2) Adversary can capture nodes.
(3) Limited bandwidth and transmission power.
(4) Unreliable Communication
(5) Unattended after deployment
(6) Remotely managed

III. LITERATURE SURVEY

In this section we have presented several existing methods in the literature for energy efficient cluster head selection in wireless sensor network.

3.1 Low Energy Adaptive Clustering Hierarchy [5]

Low Energy Adaptive Clustering Hierarchy (LEACH) is a cluster based protocol. It organizes nodes into clusters with one node from each cluster serving as a cluster-head (CH). It randomly selects some predetermined number of nodes as cluster heads. CHs then advertise themselves and other nodes join one of those cluster heads whose signal they found strongest. In this way a cluster is formed. The CH then makes a Time Class Multiple Access (TDMA) schedule for the nodes under its cluster. The communication between different clusters is done through CHs in a Code Class Multiple Access (CDMA) manner. The CHs collect the data from their clusters and aggregate it before sending it to the other CHs or base station (BS). After a predetermined time lapse, the cluster formation step is repeated so that different nodes are given a chance to become CHs and energy consumption is thus uniformly distributed.

LEACH operation is broken into rounds, with each round having a set-up phase and a steady state phase.

Set-up phase: Each node decides whether or not to be a cluster-head based on its remaining energy and a globally known desired percentage of cluster heads. Each node electing itself as a cluster-head broadcasts an advertisement message announcing its intention.

Steady-state phase: Each cluster-head waits to receive data from all nodes in its cluster and then sends the aggregated or compressed result back to a BS.

Some limitations of the LEACH are as follow:

(1) Due to random selection, cluster head may be elected in one area leaving other area unattended.
(2) Each cluster head directly communicate with the base station that is not efficient if the transmission distance is large.
(3) For every round new cluster head is selected which consumes more energy and decreasing the network life time.

3.2 Hybrid Energy-Efficient Distributed Clustering [6]

HEED considers a hybrid of energy and communication cost when selecting CHs. Unlike LEACH, it does not select cell-head nodes randomly. Only sensors that have a high residual energy can become cell-head nodes. HEED has three main characteristics:

(1) The probability that two nodes within each other's transmission range becoming CHs is small. Unlike LEACH, this means that CHs are well distributed in the network.

(2)Energy consumption is not assumed to be uniform for all the nodes.

(3)For a given sensor's transmission range, the probability of CH selection can be adjusted to ensure inter-CH connectivity.

3.3 LEACH-B [7]

LEACH-B (Balanced) which proposes an enhanced version of LEACH by finding the number of CHs which are near optimal. In LEACH-B, there is a second stage for selecting CHs through considering the residual energy of candidate nodes to become CHs, which modifies the number of CH sat the set up phase considering the node's residual energy. This protocol can save energy consumption by ensuring that the clusters are balanced. The optimal number of CHs is between 3 and 5 from total 100 nodes (3% - 5%).

LEACH-B works similar to LEACH by selecting a random number between 0 and 1 and calculating the threshold value . However, LEACH-B introduced another selection stage: All candidate CHs that are elected will be ordered descending according to their residual energy, and only (n*p) of them, (where n is total number of sensor nodes, and p is the percentage of CHs) will be considered as CH and the remaining candidate and will resume their normal node role. Bydoing that, LEACH-B guarantees the optimal number of CHs. Simulation results of LEACH-B shows an enhancement of lifetime compared to the original LEACH. [8]

3.4 Random competition based clustering (RCC) [8]

The RCC algorithm applies the First Declaration Wins rule, in which any node can ''govern'' the rest of the nodes in its radio coverage if it is the first to claim being a CH. After hearing the claim which is broadcasted by the first node, neighboring nodes join its cluster as member and give up their right to be a CH. To maintain clusters, every CH in the network broadcast a CH claim packet periodically. Since there is a time delay between broadcasting a claim packet and receiving it, concurrent broadcast can possibly create a conflict. Being unaware of on-going claims, many neighboring nodes may broadcast CH claim packets concurrently. To avoid such a problem RCC explicitly employs a random timer and uses the node ID for arbitration. Each node in the network reset its random time value, every time before broadcasting its CH claim packet. During this random time if it receives a broadcast message carrying CH claim packet from another node, it simply ceases the transmission of its CH claim. Since random timer is not a complete solution, RCC resolve further the concurrent broadcast problems by using the node ID. If the conflict persists, node having lower ID will become the CH. Although frequent node mobility still has direct effect, RCC is shown to be more stable than conventional clustering schemes.

3.5 PEGASIS: Power-Efficient Gathering in Sensor Information System [9]

By this author proposed algorithm PEGASIS that is a chain based protocol provide improvement over LEACH algorithms. In PEGASIS, each node communicates only with a close neighbor and takes turns transmitting to the base station, thus reducing the amount of energy spent per round. Using greedy algorithm, the nodes will be organized to form a chain, after that BS can compute this chain and broadcast it to all the sensor nodes. Energy saving in PEGASIS over LEACH takes place by many stages: First, in the local data gathering, the distances that most of the sensor nodes transmit are much less compared to transmitting to a cluster-head in LEACH. Second, only one node transmits to the BS in each round of communication. PEGASIS outperforms LEACH by limiting the number of transmissions, eliminating the overhead of dynamic.

3.6 Energy Efficient Chain Based Routing [10]

The proposed protocol organizes sensor nodes as a set of horizontal chains and a vertical chain. In each chain, a node is selected as chain head. For selecting the chain heads in horizontal chains, EECRP considers residual energy of nodes and distance of nodes from the header of upper level that does not need to reselect leader of the vertical chain. This causes time and energy saving. In each horizontal chain, sensor nodes transmit their data to their own chain head based on chain routing mechanism. EECRP also adopts a chain based data transmission mechanism for sending data packets from the chain heads to the base station.

3.7 Distance Based Cluster Head Selection Method [11]

The author [11] has proposed an algorithm that select cluster head as per the following algorithm.

Step1. Let we have a set S of n nodes in a cluster viz.

Step2. Calculate the distance of one node to all nodes.

Step3. Calculate the sum of all distance from one to all nodes.

Step4. Calculate distance from BS to each node for all nodes.

Step5. Select the cluster head based on all NDBS values.

3.8EECS: Energy Efficient Clustering Schemes [12]

Authors proposed an algorithm in which cluster formation is different from LEACH protocol. In LEACH protocol cluster formation takes place on the basis of a minimum distance of nodes to their corresponding cluster head. In EECS, dynamic sizing of clusters takes place which is based on cluster distance from the base station. The results are an algorithm that addresses the problem that clusters at a greater distance from the sink requires more energy for transmission than those that are closer. Ultimately it provides equal distribution of energy in the networks, resulting in network lifetime. Thus main advantage of this algorithm is the full connectivity can be achieved for a longer duration. So we can say it provides reliable sensing capabilities at a larger range of networks for a longer period of time. It provides a 35 percent improvement in network life time over LEACH algorithm.

3.9MST-PSO: Minimum Spanning Tree-PSO [13]

Authors proposed a minimum spanning tree-PSO based clustering algorithm of the weighted graph of the WSNs. The optimized route between the nodes and its cluster heads is searched from the entire optimal tree on the basis of energy consumption. Election of cluster head is based on the energy available to nodes and Euclidean distance to its neighbor node in the optimal tree. Others have concluded that network life time does not depend on the base station location or residual energy of the node. Once the topology decided to then network life time becomes almost settled. Author's shows two techniques for improving network life time: reduce the startupenergy consumption of the transmitter and receiver, and optimized the network topology.

IV. CONCLUSION

Sensor nodes are resource limited devices, so energy is a crucial issue. Minimizing energy consumption can enhance the network lifetime. We have presented several techniques for energy-efficient cluster head selection for wireless sensor networks. Still it is an active research area.

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