Survey On Stability Period In The Heterogenous Clustered Wireless Sensor Network

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Abstract—Wireless Sensor Network (WSN) is defined as a network of wirelessly diminutive connected devices known as sensors. Stability of this otherwise resource constrained WSN is one of the major challenges faced by the research community these days. Increasing the lifetime of these unscathed miniature devices is very necessary to seamlessly collect information/data about a particular topic. Various algorithms have been proposed in literature to ensure the stability of WSNs. This paper presents an in-depth literature review of various stability-based protocols in these networks. Thereafter it submits a detailed description of one of the most widely used protocol i.e. Stable Election Protocol (SEP) to ensure stability in hierarchical networks.

Keywords—*Sensor, Cluster, Cluster head, Stability Period, SEP, Network Life time, Residual Energy, Energy Effecient, Wireless Sensor Network.*

I. Introduction

Wireless sensor networks(WSNs) are the networks with wireless sensors disseminated in a region which sense various types of information and then transmit this information to the other nodes or to the final destination[16]. WSNs are used for variety of purposes like military surveillances, habitat monitoring, forest fire detection, landslide detection.

The basic unit in WSNs are sensors which are tiny electronic device which can sense, compute, store, send out and collect data of interest from the environment in which they are deployed[4]. A sensor node is composed of processor, sensor, transceiver and power units. These nodes sense the changes in the physical parameters like-temperature, pressure etc. The data sense by these nodes are then approved to the base station(BS) for estimation.

Appropriate to the miniature size of sensors, a large size battery supply cannot be embedded into them therefore sensors need efficient mechanism for energy utilization[16] to improve the lifetime of sensors in wireless sensor networks. Sensor nodes also face energy optimization and quick route discovery problems. These problems are generally solved by using an energy optimization technique called clustering , which is defined as grouping of similar objects which are similar in one cluster while dissimilar into another cluster, in which one node act as CH while others act as cluster members, clustering depends upon the application in which it is used.

In the clustered network, a particular/special sensor node act as a head of the cluster and other nodes are the cluster members which send their sensed data to their respective cluster head, and cluster head send collective data to the final destination /sink. Base station and cluster heads(CH) are main component of clustered network. In a cluster, sensor nodes are located at minimum communication distance, each cluster is headed by a CH. Member nodes in a cluster send their data to respective CH, and CH aggregates data and sends aggregated data to the base station.

Stability period is another important characteristic of the wireless sensor network[2]. That is when sensor nodes of the sensor network start to die, the sensor network became instable in their functioning. To increase the stability period of the sensor network, a mechanism is needed that can prolong the time interval of death of first sensor node.

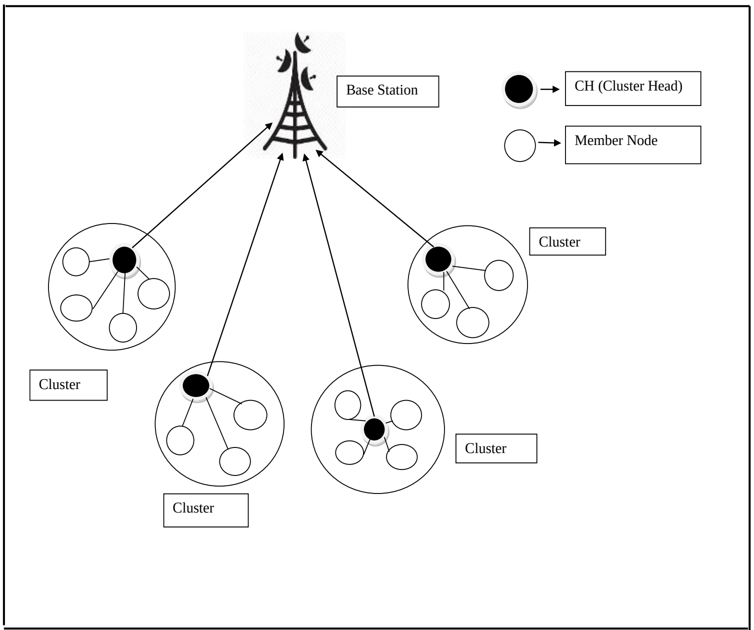

Fig1: A typical sensor network

II. Literature Review of Stability Based Protocols In WSN

Extensive work has been done to increase the stability of WSNs, various researchers have proposed numerous protocols to increase the lifetime of otherwise resource constrained sensor network. This section provides an exhaustive literature survey of such protocols.

PEGASIS [7] is a optimal chain-based protocol. In this, each node communicates only with a close neighbor and transmitting to the base station, thus reducing the amount of energy spent per round. It assumes that all nodes have global knowledge of the network, it maps the problem of having close neighbors for all nodes to the traveling salesman problem. PEGASIS is a greedy chain protocol, Greedy approach considers the physical distance only, ignoring the capability of a prospective node on the chain. But there is disadvantage of PEGASIS, that is a node with a shorter distance but less residual energy may be chosen in the chain and which may die quickly.

Energy Efficient routing algorithm [6] combines hierarchical routing and geographical routing. The process of packet forwarding from the source nodes to the base station consists of two phases—inter-cluster routing and intra-cluster routing. For inter-cluster routing, a greedy algorithm is used to forward packets from the cluster heads to the base station. For intra-cluster routing, a straightforward flooding is used to flood the packet inside the cluster when the number of intra-cluster nodes is less than a prearranged threshold. Otherwise, the recursive geological forwarding approach is used to disperse the packet inside target cluster, that is, the cluster head divides the target cluster into some sub-regions, creates the same number of new copies of the query packet, and then disperse these copies to a central node in each sub region. It also uses greedy algorithm based on the distance only but not on the residual energy of nodes.

Optimal energy aware clustering [10] solves the balanced k-clustering problem optimally, where k represents the number of master nodes in the network. The algorithm is based on the minimum weight matching. It optimizes the sum of geographical distances between the member sensor nodes and the master nodes in the whole network. It effectively distributes the network load on all the masters and reduces the communication overhead and the energy dissipation. However, this work does not consider of residual energy level while choosing a node as the master. Hence, the choice of the cluster head is not suitable for increasing the stability period of the WSNs.

ACE [12] (Algorithm for Clustering Establishment) is a distributed clustering algorithm which establishes clusters into two phases-spawning and migration. There are several iterations in each phase. During the spawning phase, new clusters are construct in a self-elective manner. When a node decides to become a cluster head, then it will broadcast a message to its neighbors to become its cluster members. During migration phase, existing clusters are maintained and rearranged, if required. Movement of an existing cluster is controlled by the cluster head. Each cluster head will periodically be asked (poll) all cluster members to determine which could be the next best candidate to elect as a new leader for the cluster. ACE results in uniform cluster construction with a packing efficiency close to hexagonal close-packing. However, ACE does not consult the residual energy of the nodes while selecting cluster heads. Hence ACE is not optimal energy efficient protocol.

PEACH [9] (Power Efficient Adaptive Clustering Hierarchy) is a cluster formation-based protocol that is based on overheard information from the sensor nodes. According to this approach, if a cluster head node becomes an intermediate node of a transmission, firstly it sets the sink node as its next hop. Then it sets a timer to receive and aggregate multiple packets from the nodes in the cluster. It checks whether the distance between this node and the original destination node is shorter than that of between this node and already selected next hop node. If the distance is shorter, this node couple to the cluster of the original destination node and the next hop of this node is changed to the original destination node. PEACH is an adaptive clustering approach for multi-hop inter-cluster communication. However, it suffers from almost same limitations of PEGASIS due to the choice of physical distance not residual energy of nodes.

LEACH [14] is one of the simplest and popular dynamic clustering techniques used in WSN. LEACH rotates the role of cluster head very effectively among the sensor nodes of a network based only on some locally available information. Leach works in two phases – setup phase and steady phase. In setup phase nodes elects itself CH on the basis of local gathered information. While in steady phase, CH receives data from cluster member nodes and then send the aggregated data to the sink node. However, LEACH does not consider the fluctuations in residual energies of the sensor nodes when it selects the cluster heads. LEACH works on the assumption that, there is homogenous network that is energy level of all the sensor nodes are equal. This is the main limitation of this protocol.

Adaptive Cluster Head Selection [15] (ACH), is a distributed clustering technique based on LEACH, considers the positions but not the relative residual energies of the sensor nodes. That is ACH also suffers from that similar limitations of Leach.

Younis and Fahmy[18] proposed a distributed algorithm considering the residual energy of sensor nodes. Clusters are formed by uniformly distributing the cluster heads across the network. It periodically selects cluster heads according to a hybrid parameter that is primary parameter is, residual energy of a node, and a secondary parameter, such as propinquity of a node to its neighbors or node degree. However, it elect the initial percentage of cluster heads randomly. This random selection remains as a severe limitation of this algorithm.

PADCP [13] (Power Aware Dynamic Clustering protocol) in this approach, the sensor nodes are assumed to have the same transmission capability and the ability to adjust transmission power in five levels. PADCP has four phases—neighbor information collection, cluster head election using a cost function, cluster formation using HEED, and cluster head re-election in case of residual energy lower than a pre-defined threshold value. The mobility of the sensor nodes is considered in cluster construction. However, it suffers from the same randomly chosen initial probability limitations of HEED as it completely follows HEED algorithm for cluster construction in its third phase. Moreover, there is no suggestion about the optimal weights of the cost function used in cluster head selection and the threshold used in cluster head re-election.

Sethi et. all[16] has presented a novel approach for determining an agent's itinerary in a clustered network, and Analysis of the same revealed that this approach is a better solution than the existing spatial based node selection techniques. It considers network lifetime as an important factor for WSN and thus introduces energy awareness into GCF approach. This approach is most suited for non-deterministic WSN where once deployed, sensors are left unattended.

Stable Election Protocol [17] (SEP) consider the nodes heterogeneity in terms of energy level in WSNs. SEP is based on weighted election probability of nodes to become CH according to their residual energy. SEP protocol successfully expand the stable region by being aware of heterogeneity. Qualitative evaluation of the literature reveals that stability period is one of the important parameters of the WSNs.

III. Stable Election Protocol (SEP)

SEP improves the stable region of the heterogeneous clustered sensor network using the characteristic parameters of heterogeneity, namely the fraction of advanced nodes (m) and the additional energy factor between advanced and normal nodes (α).

To boost the stable region, SEP try to maintain the constraint of well-balanced energy consumption. Advanced nodes have to become cluster heads more often than the normal nodes, so that energy consumption is well balanced for the network. The total energy of the system changes. Preassume that Eo is the initial energy of each normal sensor. The energy of each advanced node will be Eo • (1 + α). The total energy of the new heterogeneous setting is equal to:

$$n \cdot (1 - m) \cdot E_o + n \cdot m \cdot E_o \cdot (1 + \alpha) = n \cdot E_o \cdot (1 + \alpha \cdot m)$$

So, the total energy of the system is increased by 1 + α • m times. Our approach is to assign a weight to the optimal probability popt. This weight must be equal to the initial energy of each node divided by the initial energy of the normal node. pnrm the weighted selection probability for normal nodes and padv the weighted selection probability for the powerful (advanced nodes) nodes.

In order to maintain the minimum energy consumption in each round the average number of cluster heads per round must be constant and equal to n×popt. The weighed probabilities for normal and powerful (advanced nodes) nodes are as follows:

$$p_{nrm} = p_{opt} / (1 + \alpha .m)$$

$$p_{adv} = (p_{opt}/1 + \alpha .m) \times (1 + \alpha)$$

T(snrm) the threshold for normal nodes and T(sadv) the threshold for powerful (Advanced nodes) nodes.

$$T(s_{nrm}) = \begin{cases} \dfrac{p_{nrm}}{1 - p_{nrm}.\left(r \bmod \dfrac{1}{p_{nrm}}\right)} & \text{if } s_{nrm} \in G \\ & \text{otherwise} \end{cases}$$

$$T(s_{adv}) = \begin{cases} \dfrac{p_{adv}}{1 - p_{adv}.\left(r \bmod \dfrac{1}{p_{adv}}\right)} & \text{if } s_{adv} \in G' \end{cases}$$

G be the set of clustered sensor nodes that have not become CH. Non-cluster heads periodically attach their remaining energy to the messages they sent during the handshaking process with their cluster heads, and the cluster heads could send this information to the sink. The sink can check the heterogeneity in the field by examining whether one or a certain number of nodes reach this energy threshold. If so, then the sink could broadcast to cluster heads in that round the values for pnrm and padv, in turn cluster heads unicast these values to nodes in their clusters according to the energy each one has attached earlier during the handshaking process.

IV. Conclusion and Future Work

After this survey we can conclude that energy is crucial resource for the sensor network and for well consumption of the energy of the sensor nodes we can rotate the role of CH among the normal and advance nodes on the basis of their remaining energy. This increase the stable region of the wireless sensor network by increasing the time interval before the death of the first node.

Performance of SEP can be extended by making a wise CH in the WSNs so that after death of first CH no more time is consume in further selection of CH in the network.

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