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ABSTRACT

The lifetime of a wireless sensor network is constrained by the limited energy and processing capabilities of its nodes. To extend the life time of the sensor networks it is very important to have high energy efficiency at all the processing nodes and to distribute the energy dissipated throughout the wireless sensor network. So it is essential to design effective and energy aware protocols in order to enhance the network lifetime. Various protocols for sensor network have been developed for which energy efficiency is primary goal. The traditional routing approaches for WSN may not be optimal in terms of energy consumption. So we propose a cluster-based approach for WSN. The clustering algorithm is a kind of key technique used to reduce energy consumption. Many clustering, power management, and data dissemination protocols have been specifically designed for wireless sensor network (WSN) where energy awareness is an essential design issue. This paper reviews some energy efficient clustering based protocols and approach of these protocols is to maximize the lifetime of wireless sensor network. Here Energy consumption and network life time has been considered as the major issues.

Keywords: Wireless Sensor Networks, Sensor Node, Routing, LEACH, PEGASIS, TEEN, HEED

1. INTRODUCTION

Wireless Sensor Network comprised of nodes which have limited energy, memory, computational power, range. It is important to increase energy efficiency by saving the battery power to extend the life time of the WSN [10]. Lifetime of the network is determined by residual energy of the system, hence main and most important challenge in WSNs is the efficient use of energy resources. Some of the routing challenges in WSNs are [21]: fault tolerance, node deployment, and energy consumption without losing accuracy, link heterogeneity, and data reporting model, network dynamic, connectivity, security, transmission media, data aggregation, coverage, scalability and quality of services. Energy efficient route selection can be done using two different ways: maximum network lifetime routing and minimum cost routing [18, 19, 20].

Clustering reduces the overall energy consumption within the cluster by performing aggregation and fusion of data. Clustering provides overall network scalability, efficient use of constrained resources therefore it is used in WSNs [22, 23, 24], as it that gives network topology stability and energy saving characteristics.

Important role of routing protocol in wireless sensor network is to save battery life. The energy is mainly consumed in receiving and sending data. But a significant amount of energy is wasted with regard to data collision, data overhearing, idle listing, interference, control packet overhead [6].

In this paper we are going to review about various clustering algorithms used in WSN. The rest of this paper is organized in the following manner: Section II will discuss some of the cluster based algorithms in WSN. Section III will provide an overview of proposed algorithms and their limitations. We will conclude this paper with Section IV.

2. DIFFERENT ALGORITHMS FOR CLUSTERING IN WSN

Some of the state of art algorithms for clustering are reviewed below.
2.1 Low-Energy Adaptive Clustering Hierarchy (LEACH)

LEACH [4] is the first popular energy-efficient hierarchical clustering algorithm for WSNs to reducing power consumption [15,16]. LEACH is based on an aggregation technique that combines the original data into a smaller size of data that carry only meaningful information to all individual sensors[3].

In LEACH protocol, all the nodes are grouped into the clusters, each cluster is having one nodes assigned as a Cluster Head (CH). CH collects the data from the surrounding nodes and passes it to the base station. Usually, initial assignment of CH is random and rotated for every fixed duration so that each node will act as a CH at least once in its life span. LEACH algorithm has two phases, they are set up phase and steady state phase. Setup phase is used to choose a CH and steady state phase is used to maintain the CH during the transmission of data. A node n is selected as a CH in next round by applying the following formula.

If \( T(n) \) is 1 then the node n will be the CH in next round.

\[
T(n) = \begin{cases} 
  \frac{p}{1 - p \times (r \mod \frac{1}{p})} & \text{if } n \in G \\
  0 & \text{otherwise}
\end{cases}
\]

where, \( p \) is the probability of node n being selected as a CH, \( r \) represents the current round number and \( G \) is the set of nodes that are not selected as a CH in the last \( 1/p \) rounds.

Some of the unique features of the LEACH protocol [2] are,
1. In the set up phase , the coordination and control in the cluster is localized.
2. To randomize and to distribute the energy requirements among the nodes of the network the role of the CH is rotated.
3. Local compression techniques are used in the CH to reduce the total amount of data transmission.
4. LEACH is suitable for homogeneous networks.

Some of the limitations of LEACH routing protocol are,
1. Selection of CH is done randomly and does not consider the consumption of the energy.
2. LEACH clustering does not cover the entire network area.
3. Distribution of the CH is not uniform. Some of the clusters may have CH at the edge of the cluster.

2.2 Power-Efficient Gathering In Sensor Information Systems (PEGASIS)

The protocol, Power-Efficient Gathering in Sensor Information Systems (PEGASIS), is a near optimal chain-based protocol [5,9]. The idea behind the protocol is that in order to extend network lifetime, nodes need only communicate with their closest neighbors and they take turns in communicating with the base-station. A new round will start when round of all the nodes communicating with the base-station ends and so on. This reduces the power required to transmit data per round as the power draining is spread uniformly over all nodes.

![Fig. 2. Flow of Data in Chain to BS](image)

2.3 Hybrid, Energy-Efficient, Distributed Clustering Algorithm (HEED)

HEED is an improvement of LEACH in the manner of choosing CH [7,8]. In each round, HEED selects CHs according to the residual energy of each node and a secondary parameter such as nodes proximity to their neighbors or nodes degrees. By iterations and competition, HEED ensures only one CH within a certain range, so uniform CHs distribution is achieved across the network. Compared with LEACH, HEED effectively prolongs network lifetime and is suitable for situations such as where each node has different initial energy.

The important features of this protocol are as follows:
1) HEED distribution of energy extends the lifetime of the nodes within the network thus stabilizing the neighboring node.
2) HEED does not require location-awareness capabilities in nodes.
3) No assumptions made about node distribution. The nodes automatically update their neighbor sets in multi-hop networks by periodically sending and receiving messages. It operates correctly even when nodes are not synchronized.
4) The nodes only require neighborhood information to form the clusters.
2.4 Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN):
TEEN is a hierarchical clustering protocol, which groups sensors into clusters with each led by a CH. The sensors within a cluster report their sensed data to their CH. The CH sends aggregated data to higher level CH until the data reaches the sink. Thus, the sensor network architecture in TEEN is based on a hierarchical grouping where closer nodes form clusters and this process goes on the second level until the BS (sink) is reached. TEEN uses a data-centric method with hierarchical approach[3].

The main features of this protocol are as follows:
1) Time critical data reaches the user almost instantaneously.
2) Depending on the criticality of the sensed attribute and the target application, the soft threshold can be varied.
3) A smaller value of the soft threshold gives a more accurate picture of the network, at the expense of increased energy consumption.
4) At every cluster change time, the attributes are broadcast afresh and so, the user can change them as required.

3. RELATED WORK
Dakshayini et al. [17] proposed an energy aware routing algorithm by assuming that nodes in a network are equipped with global positioning system (GPS). Initially the nodes are deployed randomly, and after deployment all the sensor nodes inform the location information to the base station before the set-up phase and steady state phase. After the location information is collected in the base station, the network coverage area A is divided into groups A1, A2, A3, etc. The groups are created based on the location of the node and cluster head election probability p. The group’s creation is done by the BS and does not guzzle too much energy. In each group a CH is selected randomly for each round, therefore the elected cluster heads are distributed uniformly in the network. Then each CH sends identity message to the group member nodes before starting the steady state phase. In steady state phase, all the CHs receive and aggregate the data from group member nodes as in LEACH but instead of directly sending the data to the base station. Therefore CH reduces the radio communication distance.
P. K. K. LOH ET AL. [11] propose an energy-aware routing protocol, Energy Clustering Protocol (ECP) that routes messages via cluster heads. Unlike other clustered configurations, ECP exploits nodes at the boundaries of the cluster (border nodes) to assist in the forwarding of packets as well as to reduce dependency on and energy expenditure of cluster heads. Via performance simulations against existing energy-efficient routing protocols that use energy-distance metrics, probabilistic distribution of packet traffic and MAC adaptations, we show that ECP exhibits very low energy variance as well as high energy efficiency over WSNs with increasing number of nodes. ECP is a routing protocol that minimizes route setup energy whilst maintaining low data dissemination energy consumption. Some of the challenges in ECP is improving performance in light to moderate traffic scenarios with multi-hubs, an intra- cluster protocol, reducing inter-cluster interference and the election of uniformly distributed cluster heads.

Zhao Han, Jie Wu, [13] propose a General Self-Organized Tree-based Energy Balance routing protocol (GSTEB). We consider a situation in which the network collects information periodically from a terrain where each node continually senses the environment and sends the data back to BS [12]. Main drawback in GSTEB is it needs BS to compute the topography, which leads to an increase in energy waste and a longer delay.

Mohammad S. Al-Fares [14] proposed routing protocol is to solve the link and node reliability problem. HighSSO routing protocol designed to provide network survivability and redundancy features. HighSSO uses multi-hop hierarchy (to cover large area) and spanning tree (for fast routing and less overhead) as basic ideas to deal with large area of deployment issue. HighSSO is fully distributed that every CH choose the nearest parent-CH to the BS to forward data to in the normal situation. If the network is congested or the parent-CH is dead, then the CH chooses the next best parent with zero communication (because of the wireless broadcast communication nature). Furthermore, HighSSO takes high density SN deployment advantage, to provide network fault tolerance feature through introducing redundant CH. HighSSO also needs to be further investigated under mobility of both BS and SNs, simulation and its application in real life.

4. CONCLUSION

In Wireless sensor network, energy is an important issue. So designing energy efficient protocol is very important. In this paper, different energy efficient routing protocols that are based on clustering mechanism have been discussed. This paper gives review of various techniques to prolong the lifetime of the WSN. Although these routing protocols shows the improvements but still there is possibility of improvements in Wireless sensor networks. The traditional routing approaches for WSN may not be optimal in terms of energy consumption. So we propose a cluster-based approach for WSN and then we propose an efficient routing protocol that uses this structure. With clustering in wireless sensor networks, energy consumption, lifetime of the network and scalability can be improved.

The ultimate objective behind the protocol design is to keep the sensors operating for as long as possible, thus extending the network lifetime.

REFERENCES