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Survey of LEACH Protocol for Sensor Network

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Abstract: Wireless sensor networks are equipped to handle more complex functions. In a network processing may require these battery powered sensor to judiciously use their constrained energy to prolong the effective network life time especially in a heterogeneous settings. Nodes are organized into clusters and in each cluster all non-cluster nodes transmit their data only to the cluster-head. Because of energy limitation in sensor nodes are energy reduction in each data transmission; appropriate cluster-head election can significantly reduce energy consumption and enhance the life of the network. Clustered techniques have since been employed to optimize energy consumption in this energy constrained wireless sensor networks. In this paper, we consider LEACH protocol in which most nodes transmit to cluster heads and explore how to elect the cluster heads with mobility as its parameter. Efficient distributed algorithms for cluster-head election in terms of energy are provided. Mobility based communication can prolong the life time of WSNs and increases the connectivity of cluster head.

Keywords: Routing, LEACH, Energy Efficiency, Energy Level, Number of Cluster Head NCH, Network Lifetime

1. Introduction

WSN is a very large array of diverse sensor nodes that are interconnected by a communication network. The elementary components of a sensor node are sensing unit, a processing unit, a transceiver unit and a power unit. The sensor node senses the physical quantity being measured and coverts it into an electrical signal. Then, the signal is fed to an A/D converter and is ready to be used by the processor [3]. The processor will convert the signal into data depending on how it is programmed and it sends the information to the network by using a transceiver. The sensing data are shared between the sensor nodes and are used as input for a distributed estimation system [4] [5]. The fundamental objectives for WSN are reliability, accuracy, flexibility, cost effectiveness, and ease of deployment. WSN is made up of individual multifunctional sensor nodes [4]. As we know that wireless sensor network mainly consists of tiny sensor node which is equipped with a limited power source. The lifespan of an energy-constrained sensor is determined by how fast the sensor consumes energy. A node in the network is no longer useful when its battery dies. Researchers are now developing new routing mechanisms for sensor networks to save energy and pro-long the sensor lifespan. The dynamic clustering protocol allows us to space out the lifespan of the nodes, allowing it to do only the minimum work it needs to transmit data [2]. The WSN can be applied to a wide range of applications, such as environment management, environmental monitoring, industrial sensing, infrastructure protection, battlefield awareness and temperature sensing. So, it is essential to improve the energy efficiency to enhance the quality of application service [2] [7].

2. Low Energy Adaptive Clustering Hierarchy (LEACH)

As we all know that all the networks have a certain lifetime during which nodes have limited energy by using that, the nodes gather, process, and transmit information. This means that all aspects of the node, from the sensor module to the hardware and protocols, must be designed to be extremely energy-efficient. Decreasing energy usage by a factor of two can double system lifetime, resulting in a large increase in the overall usefulness of the system. In addition, to reduce energy dissipation, protocols should be robust to node failures, fault-tolerant and scalable in order to maximize system lifetime [1].

LEACH is the first network protocol that uses hierarchical routing for wireless sensor networks to increase the life time of network. All the nodes in a network organize themselves into local clusters, with one node acting as the cluster-head. All non-cluster-head nodes transmit their data to the cluster-head, while the cluster-head node receive data from all the cluster members, perform signal processing functions on

the data (e.g., data aggregation), and transmit data to the remote base station. Therefore, being a cluster-head node is much more energy-intensive than being a non-cluster-head node. Thus, when a cluster-head node dies all the nodes that belong to the cluster lose communication ability [6] [8].

LEACH incorporates randomized rotation of the high-energy cluster-head position such that it rotates among the sensors in order to avoid draining the battery of any one sensor in the network [5]. In this way, the energy load associated with being a cluster-head is evenly distributed among the nodes. Since the cluster-head node knows all the cluster members, it can create a TDMA schedule that tells each node exactly when to transmit its data. In addition, using a TDMA schedule for data transfer prevents intra-cluster collisions. The operation of LEACH is divided into rounds. Each round begins with a set-up phase when the clusters are organized, followed by a steady-state phase where several frames of data are transferred from the nodes to the cluster-head and onto the base station [9].

We have stated that wireless sensor sense data, aggregate them and then send data to the base station Data which is collected by the sensor is sent to the base station. LEACH is well suited to reduce the data aggregation an issue using a local data fusion which performs a compression of the amount of data is collected by the cluster head before it sends it to the base stations. All sensors form a self-organized network by sharing the role of a cluster head at least once. Cluster head (Figure1) majorly responsible for sending the data that is collected by the sensors. It tries to balance the energy dissipation within the network and enhances the network's life time by improving the life time of the sensors [5].

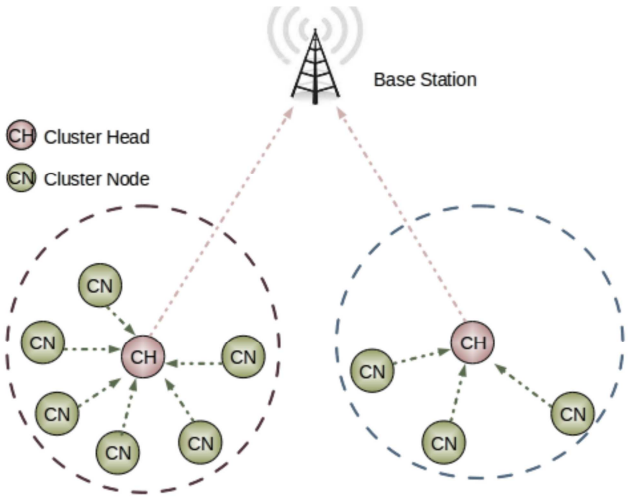

Figure 1. *Architecture of cluster head and cluster nodes.*

1. Set-up phase.

In LEACH, nodes take autonomous decisions to form clusters by using a distributed algorithm without any centralized control. Here no long-distance communication with the base station is required and distributed cluster formation can be done without knowing the exact location of any of the nodes in the network. In addition, no global communication is needed to set up the clusters. The cluster formation algorithm should be designed such that nodes are cluster-heads approximately the same number of time, assuming all the nodes start with the same amount of energy [8]. Finally, the cluster-head nodes should be spread throughout the network, as this will minimize the distance the non-cluster-head nodes need to send their data. A sensor node chooses a random number, r, between 0 and 1. Let a threshold value be T(n): $T(n)= p/1-p \times(r \bmod p-1)$. If this random number is less than a threshold value, T(n), the node becomes a cluster-head for the current round. The threshold value is calculated based on the above given equation that incorporates the desired percentage to become a cluster-head, the current round, and the set of nodes that have not been selected as a cluster-head in the last (1/P) rounds, p is cluster head probability. After the nodes have elected themselves to be cluster-heads, it broadcasts an advertisement message (ADV). This message is a small message containing the node's ID and a header that distinguishes this message as an announcement message. Each non-cluster-head node determines to which cluster it belongs by choosing the cluster-head that requires the minimum communication energy, based on the received signal strength of the advertisement from each cluster-head. After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits a join-request message (Join-REQ) back to the chosen cluster-head. The cluster-heads in LEACH act as local control centers to co-ordinate the data transmissions in their cluster [9]. The cluster-head node sets up a TDMA schedule and transmits this schedule to the nodes in the cluster. This ensures that there are no collisions among data messages and also allows the radio components of each non cluster-head node to be turned off at all times except during their transmit time, thus minimizing the energy dissipated by the individual [8][10].

2. Steady-State Phase.

The steady-state operation is broken into frames where nodes send their data to the cluster-head at most once per frame during their allocated transmission slot. The set-up phase does not guarantee that nodes are evenly distributed among the cluster head nodes. Therefore, the number of nodes per cluster is highly variable in LEACH, and the amount of data each node can send to the cluster-head varies depending on the number of nodes in the cluster. To reduce energy dissipation, each non-cluster-head node uses power control to set the amount of transmits power based on the received strength of the cluster-head advertisement. The radio of each non-cluster-head node is turned off until its allocated transmission time. Since all the nodes have data to send to the cluster-head and the total bandwidth is fixed, using a TDMA schedule is efficient use of bandwidth and represents a low latency approach, in addition to being energy-efficient [5] [9]. The cluster-head must keep its receiver on to receive all the data from the nodes in the cluster. Once the cluster-head receives all the data, it can operate on the data and then the resultant data are sent from the cluster-head to the base station.

Disadvantages of LEACH.

1. LEACH does not provide clarity about position of sensor nodes and the number of cluster heads in the network.
2. Each Cluster-Head directly communicates with BS no matter the distance between CH and BS. It will consume lot of its energy if the distance is far.
3. The CH uses most of its energy for transmitting and collecting data, because, it will die faster than other nodes.
4. The CH is always on and when the CH die, the cluster will become useless because the data gathered by cluster nodes will never reaches the base stations.

3. Mobile-LEACH (M-LEACH).

LEACH considers all nodes are homogeneous with respect to energy which is not realistic approach. In particular round uneven nodes are attached to multiple Cluster-head; in this case cluster-head with large number of member ode will drain its energy as compare to cluster-head with smaller number of associated member nodes. Furthermore mobility support is another issue with LEACH routing protocol, to mitigate these issues, M-LEACH is proposed. M-LEACH allows mobility of non-cluster-head nodes and cluster-head during the setup and steady state phase. MLEACH also considers remaining energy of the node in selection of cluster-head. Some assumptions are also assumed in M-LEACH like other clustering routing protocols. Initially all nodes are homogeneous in sense of antenna gain, all nodes have their location information through GPS and Base station is considered fixed in M-LEACH. Distributed setup phase of LEACH is modified by M-LEACH in order to select suitable cluster-head. In M-LEACH cluster-heads are elected on the basis of attenuation model. Optimum cluster-heads are selected to lessen the power of attenuation. Other criteria of cluster-head selection are mobility speed. Node with minimum mobility and lowest attenuation power is selected as clusterhead.

M-LEACH. Then selected cluster-heads broadcast their status to all nodes in transmission range. Non-cluster-head nodes compute their willingness from multiple cluster-heads and select the cluster-head with maximum residual energy. In steady state phase, if nodes move away from cluster-head or cluster-head moves away from its member nodes then other cluster-head becomes suitable for member nodes.It results into inefficient clustering formation. To deal this problem MLEACH provides handover mechanism for nodes to switch on to new cluster-head. When nodes decide to make handoff, send DIS-JOIN message to current cluster-head and also send JOIN -REQ to new cluster-head. After handoff occurring clusterheads re- schedule the transmission pattern.

Classification and comparison of leach and its modified routing protocols in wireless sensor networks.

Each routing protocol addresses specific problem and tries to enhance the conventional clustering routing protocol LEACH. Each routing protocol has some advantages and features. These routing protocol face some challenges like Cost of Clustering, Selection of Cluster-heads and Clusters, Synchronization, Data Aggregation, Repair Mechanisms, scalability, mobility, and initial energy level all nodes. We compare above mention routing with respect to some very important performance parameters for wireless sensor network. These parameters are following. Classification: The classifications routing protocol indicate that it is flat, location-based or hierarchal. Mobility: it specifies that routing protocol is designed for fixed are mobile nodes. Scalability: it how much routing protocol is scalable and can be efficient if the network density is increased. Self-organization: it is very important for routing protocol to adopt the changes in network. Nodes configuration and reconfiguration should be performed by routing protocol by selforganization at the time when nodes enter or leave the network. Randomized Rotation of Cluster-head: randomized Rotation of cluster-head is very necessary in order to drain the battery of all nodes equally [1]. Distributed clustering algorithm: clusterheads are self-elected in distributed clustering algorithm also nodes select their cluster-head in distributed manner [1]. Centralized clustering algorithm: cluster-heads are selected by Base station by central control algorithm [3]. Single-hop or Multi-hop: it is also important feature of routing protocol. Single-hop is energy efficient if it is smaller area of network and multi-hop is better for denser network. Energy Efficiency: it is the main concern of energy efficient routing protocol to maximize the life time of the network [1], [2], [4]. Resources awareness: sensor network has limited resources like battery and sensing capability routing protocol should be well aware from the resources [8]. Data Aggregation: in order to reduce the data amount to be transmit to Base station, Cluster-head perform dataaggregation in this way cluster-head transmission energy cost is reduce [1], [2]. Homogeneous: homogeneity of all nodes is considered in the all routing protocol which describe that initial energy level of all the nodes is similar. All routing protocol are hierarchal, homogeneous, having fixed BS despite M-LEACH, perform Data aggregation, self-organization and randomized rotation of CHs. LEACH RADIO CHARACTORISTICS Operation Energy Dissipation Transmitter Electronics (EelectTx) 50 nj/bit Receiver Electronics (EelecRx) 50 nj/bit Transmit amplifier (Eamp) 100 pj/bit/m2 LEACH-SC, ELEACH, and Multi-Hop LEACH are use distributed algorithm for Cluster-head selection. LEACH-C uses central control Algorithm for cluster-head selection and sLEACH is designed for both centralized and distributed algorithm. LEACH, sLEACH and M-LEACH are routing protocol in which Base Station is at single-hop and in Multi-Hop LEACH Base station can be at multi-hop distance from the cluster-head. LEACH and M-LEACH allow limited scalability. sLEACH allows good scalability while Multi-Hop LEACH is providing maximum scalability feature due to multi-hop communication option for cluster-heads.

Analytical comparison for energy efficiency of routing protocols.

For analytical comparison, it is essential to be aware from Radio model assumption adopted by energy efficient routing protocol. All energy efficient routing protocols proposed in previous research provide different assumptions about the radio distinctiveness. These different characteristics cause

significant variation in energy efficiency of routing protocols. These assumptions differentiate energy dissipation to run transceiver and receiver circuitry per bit. Radio dissipates? amp for transmit amplifier to attain suitable Eb/NO [1]. These are also multiple assumptions in selection of suitable? amp. Most acceptable value of these radio characteristics which is assumed by extensive research work. Transmitter and receiver Radio model. Mainly energy dissipation of a individual node depends upon the number of transmissions, number of receiving, amount of data to be transmit and distance between transmitter and receiver. So first we describe the possible ways of energy consumption and then compare selected routing protocols and analyze how energy efficiency is enhanced through these routing protocol.

4. Conclusion and future work.

The main concern of this work is to examine the energy efficiency and performance of LEACH protocol using own set of parameters. We compare the lifetime and data delivery characteristics with the help of analytical comparison and also from our simulation results. From this work we find that LEACH provides better results for number of cluster heads as 3 and 4. This paper has covered performance of LEACH protocol only, we can also compare this protocol with other routing protocols that may or may not be hierarchical in nature. The process of data aggregation and fusion among clusters is also one of an interesting problem to explore. It is needed to satisfy the constraints introduced by factors such as fault tolerance, topology change, cost, environment, scalability, and power consumption for realization of sensor networks. Since these constraints are highly specific and stringent for sensor networks, new wireless ad-hoc networking techniques will have to be explored further.

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