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A STUDY ON LEACH PROTOCOL OF WIRELESS SENSOR NETWORK

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ABSTRACT
LEACH protocol is one of the clustering routing protocols in wireless sensor networks in which time is divided into many rounds. In each round, all the nodes contend to be cluster head according to a predefined criterion. The main problem with LEACH protocol lies in the random selection of cluster heads. There exists a probability that the cluster heads formed are unbalanced and may remain in one part of the network making some part of the network unreachable. Due to limited amount of energy the sensor nodes are constrained which results the short network life in number of conventional routing protocols. We are taking this as main objective and we can design new algorithm to improve the network life.

Keywords: LEACH, Clustering routing protocol, Network life, Wireless sensor network.

1. INTRODUCTION

WSNs consist of a large number of limited capabilities (power and processing) Micro Electro Mechanical Systems (MEMS) capable of measuring and reporting physical variables related to their environment. A WSN consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants.

Sensor networks are being deployed for a wide variety of applications [1], including by military applications such as battlefield surveillance and is now used in many industrial and civilian application areas, environment and habitat monitoring, healthcare applications, home automation, and traffic control. In surveillance applications, sensors are deployed in a certain field to detect and report events like presence, movement, or intrusion in the monitored area. Data collected by sensors are transmitted to a special node equipped with higher energy and processing capabilities called “Processing Node” (PN) or “sink”. The PN collects, filters, and compiles data sent by sensors in order to extract useful information. We consider the sensor network architecture depicted in Figure 1.1. In the architecture SNs are grouped into clusters controlled by a single command node. Sensors are only capable of radio-based short-haul communication and are responsible for probing the environment to detect a target/event. Every cluster has a gateway node that manages sensors in the cluster. Clusters can be formed based on many criteria such as communication range, number and type of sensors and geographical location. Sensors receive commands from and send readings to its gateway node, which processes these readings.

Gateways can track events or targets using readings from sensors in any clusters as deemed by the command node. However, sensors that belong to a particular cluster are only accessible via the gateway of that cluster. Therefore, a gateway should be able to route sensor data to other gateways. Gateway nodes interface the command node with the sensor

network via long haul communication links. The gateway node sends to the command node reports generated through fusion of sensor readings, e.g. tracks of detected targets. The command node presents these reports to the user and performs system-level fusion of the collected reports for overall situation awareness.

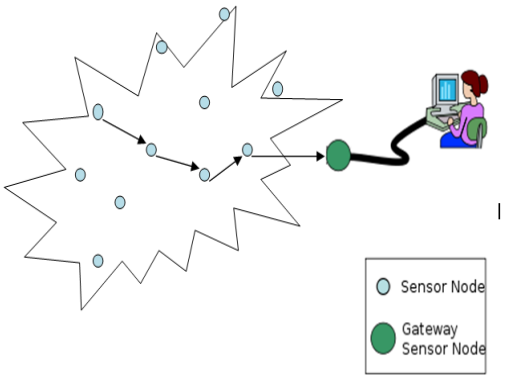

Figure 1.1: Typical Wireless Sensor Network Architecture

2. LITERATURE SURVEY

Wireless sensor network is composed by hundreds or thousands of small compact devices, called sensor nodes, equipped with sensors (e.g. acoustic, seismic or image), that are densely deployed in a large geographical area. These sensors measure ambient conditions in the environment surrounding them and then transform these data into electric signals which can be processed to reveal some characteristics about phenomena located in the area around these sensors. The applications may be environment control such as office building, robot control and guidance in automatic manufacturing environments, interactive toys, high security smart homes, and identification and personalization [2]. Wireless sensor networks (WSNs) are the products which integrate sensor techniques, embedded techniques, and distributed information processing and communication techniques. The appearance of the wireless sensor network is a revolution in information sensing and detection. Although there have been significant improvements in processor design and computing, advances in battery technology still lag behind, making energy resource considerations the fundamental challenge in wireless sensor networks. Consequently, there have been active research efforts on performance limits of wireless sensor networks. These performance limits include, among others, network capacity and network lifetime. Network capacity typically refers to the maximum amount of bit volume that can be successfully delivered to the base station ("sink node") by all the nodes in the network, while network lifetime refers to the maximum time limit that nodes in the network remain alive until one or more nodes drain up their energy. In this dissertation consider an overarching problem that encompasses both performance metrics. In particular, study the network capacity problem under a given network lifetime requirement. Specifically, for a wireless sensor network where each node is provisioned with an initial energy, if all nodes are required to live up to a certain lifetime criterion, what is the maximum amount of bit volume that can be generated by the entire network? At first glance, it appears desirable to maximize the sum of rates from all the nodes in the network, subject to the condition that each node can meet the network lifetime requirement

Sudhanshu Tyagi, Neeraj Kumar et al in their paper "A systematic review on clustering and routing techniques based upon LEACH protocol for wireless sensor networks" said that these networks consist of many Sensor Nodes (SNs), which are not only used for monitoring but also capturing the required data from the environment. Most of the research proposals on WSNs have been developed keeping in view of minimization of energy during the process of extracting the essential data from the environment where SNs are deployed. The primary reason for this is the fact that the SNs are operated on battery which discharges quickly after each operation. It has been found in literature that clustering is the most common technique used for energy aware routing in WSNs. The most popular protocol for clustering in WSNs is Low Energy Adaptive Clustering Hierarchy (LEACH) which is based on adaptive clustering technique. This paper provides the taxonomy of various clustering and routing techniques in WSNs based upon metrics such as power management, energy management, network lifetime, optimal cluster head selection, multihop data transmission

etc. A comprehensive discussion is provided in the text highlighting the relative advantages and disadvantages of many of the prominent proposals in this category which helps the designers to select a particular proposal based upon its merits over the others[3].

Nitin Mittal et al in their paper "Improved Leach Communication Protocol For Wsn" [4] proposed that wireless sensor network with a large number of sensor nodes can be used as an effective tool for gathering data in various situations. One of the major issues in wireless sensor networks is developing an energy-efficient routing protocol which has a significant impact on the overall lifetime of the sensor network. This paper focuses on reducing the power consumption of wireless sensor networks. Therefore, a communication protocol named LEACH (Low-Energy Adaptive Clustering Hierarchy) is modified. The author proposed a clustering routing protocol that partitions the network into clusters; the cluster contains, CH, sub-CH (the node that will become a CH of the cluster in case of CH dies), cluster nodes; thus extends network lifetime. The author had conducted simulation-based evaluations to compare the performance of the proposed protocol against Low-Energy Adaptive Clustering Hierarchy (LEACH).

Yunxia Chen, Qing Zhao et al in their paper "On the lifetime of wireless sensor networks " [5] proposed a general formula for the lifetime-of wireless sensor networks which holds independently of the underlying network model including network architecture and protocol, data collection initiation, lifetime definition, channel fading characteristics, and energy consumption model. This formula identifies two key parameters at the physical layer that affect the network lifetime: the channel state and the residual energy of sensors. As a result, it provides not only a gauge for performance evaluation of sensor networks but also a guideline for the design of network protocols. Based on this formula, the author proposed a medium access control protocol that exploits both the channel state information and the residual energy information of individual sensors. Referred to as the max-min approach, this protocol maximizes the minimum residual energy across the network in each data collection.

3. LEACH PROTOCOLS

3.1 LEACH (Low-Energy Adaptive Clustering Hierarchy)

W. R Heinzeolman proposed LEACH [6] protocol, which based on cluster structure and hierarchical technology. Relative to the traditional protocol, LEACH could save a greater degree of energy. For most sensor nodes, the short-distance communication saved more energy, in LEACH, the more communication was limited within clusters, only a few Next Node, node communicated with base stations long distance. It used adaptive technology and Next Node, node rotation technology, the LEACH was more efficient than the original class network structure; the whole WSN was more balanced on load distribution, and could extend the WSN lifetime greatly. In addition, each cluster could calculate locally and remove redundant data, reduce the communication burden of Next Node, node. As the energy consumption of calculation was much less than the energy consumption of communication, so LEACH could save energy greatly. But there were still problems in LEACH: Firstly, the node used power control when sending data, the energy consumption of node was not same. When Next Node, node election, it was considered that the number of Next Node, node in the past, without the energy difference between the remained nodes, leading to uneven distribution of energy consumption. Secondly, LEACH selected Next Node, node randomly, the number of Next Node, node closed to the optimal value could not be guaranteed.

3.1.1 Operation: 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 Next Nodes. Each node electing itself as a cluster-head broadcasts an advertisement message announcing its intention. Non-cluster-head nodes receive possibly several advertisements and pick one cluster to join based on the signal strength of the advertisement received from the

corresponding cluster-head. 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.

3.1.2 Clustering: Clustering is a good approach which, if implemented properly, can lead to energy efficient networking in WSNs. LEACH assumes that all nodes can communicate with each other and are able to reach the sink (therefore, it is only suitable for small size networks), LEACH assumes that all nodes have data to send and so assign a time slot for a node even though some nodes might not have data to transmit, LEACH assumes that all nearby nodes have correlated data which is not always true, LEACH requires that all nodes are continuously listening (this is not realistic in a random distribution of the sensor nodes, for example, where cluster-heads would be located at the edge of the network), there is no mechanism to ensure that the elected cluster-heads will be uniformly distributed over the network, hence, there is the possibility that all Next Nodes will be concentrated in one part of the network), periodic dynamic clustering carries significant overhead which may off-set energy gains derived by the clustering option.

3.2 LEACH-C

An enhancement over the LEACH protocol, LEACH-centralized (LEACH-C), is proposed, LEACH-C uses a centralized clustering algorithm, where an attempt is made to distribute clusters throughout the entire sensor field. As a result of dispersing clusters throughout the network, LEACH-C protocol records better performance compared to LEACH. LEACH-C operation can be subdivided into two phases:[7, 8]

Setup phase: the base station receives information from each node about their current location and energy level. The nodes may get their current location by using a global positioning system (GPS) receiver that is activated at the beginning of each round. After that, the base station runs the centralized cluster formation algorithm to determine the clusters for that round. Before running the algorithm that determines and selects the clusters, the base station makes sure that only nodes with enough energy are participating in the Next Node selection.

Steady phase: Once the clusters are created, the base station broadcasts the information to all the nodes in the network. Each of the nodes, except the Next Node, determines its TDMA slot used for data transmission. Then, the node goes to sleep until it is time to transmit data to its Next Node. LEACH offers no guarantee about the placement and/or number of Next Nodes. An enhancement over the LEACH protocol was proposed. The protocol, called LEACH-C, uses a centralized clustering algorithm and the same steady-state phase as LEACH. LEACH-C protocol can produce better performance by dispersing the Next Nodes throughout the network. During the set-up phase of LEACH-C, each node sends information about its current location (possibly determined using GPS) and residual energy level to the sink. In addition to determining good clusters, the sink needs to ensure that the energy load is evenly distributed among all the nodes. To do this, sink computes the average node energy, and determines which nodes have energy below this average. Once the Next Nodes and associated clusters are found, the sink broadcasts a message that obtains the Next Node ID for each node. If a Next Node ID matches its own ID, the node is a Next Node; otherwise the node determines its TDMA slot for data transmission and goes sleep until its time to transmit data. The steady-state phase of LEACH-C is identical to that of the LEACH protocol.

3.3 LEACH-F

LEACH with Fixed clusters (LEACH-F) is based on clusters that are formed once and then fixed. The Next Node position then rotates among the nodes within the cluster. The advantage with this is that, once the clusters are formed, there is no set-up overhead at the beginning of each round. To decide clusters, LEACH-F uses the same centralized cluster formation algorithm as LEACH-C. The fixed clusters in LEACH-F do not allow new nodes to be added to the system and do not adjust their behavior based on nodes dying. Furthermore, LEACH-F does not handle node mobility [9].

3.4 E-LEACH

Energy-LEACH protocol improves the CH selection procedure. It makes residual energy of node as the main metric which decides whether the nodes turn

into CH or not after the first round. Same as LEACH protocol, E-LEACH is divided into rounds, in the first round, every node has the same probability to turn into CH, that mean nodes are randomly selected as CHs, in the next rounds, the residual energy of each node is different after one round communication and taken into account for the selection of the CHs. That mean nodes have more energy will become a CHs rather than nodes with less energy[8,10].

4. CONCLUSION

WSN is a network that consists of microelectronics system nodes having limited power and processing capability which record and report various physical variables related to the environment in which they are deployed. The main problem with LEACH protocol lies in the random selection of cluster heads. We have studied various papers and concluded that there is scope to design new protocol to improve the network life.

5. FUTURE SCOPE

By improving the network life, we can extend the heterogeneity of nodes by having three levels like normal node, intermediate node and advanced for deployment in our multi-level energy transmission and Multi sinks can be taken for the same idea in case application area in which network is to be deployed is having such possibility.

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