Clustering in Homogeneous Nodes with WSN using LEACH Protocol

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Abstract: In this paper we are study about clustering in homogeneous nodes with WSN using LEACH protocol. Wireless sensor networks are beginning to become a reality, and therefore some of the long overlooked limitations have become an important area of research. The rapid advancements led to a very fast market in which computers would participate in more and more of our society's daily activities. Energy consumption of communication is a key factor of the lifetimes of wireless sensor networks. One of the limitations of wireless sensor nodes is their inherent limited energy resource. Besides maximizing the lifetime of the sensor node, it is preferable to distribute the energy dissipated throughout the wireless sensor network in order to minimize maintenance and maximize overall system performance.

IndexTerms **– WSN, Cluster, LEACH, Protocol, Nodes.**

I. INTRODUCTION

Over the last half a century, computers have exponentially increased in processing power and at the same time decreased in both size and price. These rapid advancements led to a very fast market in which computers would participate in more and more of our society's daily activities. In recent years, one such revolution has been taking place, where computers are becoming so small and so cheap, that single purpose computers with embedded sensors are almost practical from both economical and theoretical points of view. Wireless sensor networks are beginning to become a reality, and therefore some of the long overlooked limitations have become an important area of research.

Energy consumption of communication is a key factor of the lifetimes of wireless sensor networks. This dissertation presents an energy-efficient routing protocol for wireless sensor network. In the protocol, each sensor node detects the distance between the base station and itself. Then, it calculates a tier ID in according to the distance. A lower tier ID indicates a shorter distance between the base station and the node. Nodes with higher tier IDs send data to their neighbors with lower tier IDs, where data is compressed and forwarded toward nodes of even lower tiers. Eventually the data reaches the nodes at the lowest tier, and then the system selects a node sending data to the base station. Because long-distance communication between the base station and the node is energy-consuming, it will have its energy drained off faster than other nodes. The protocol employs a mechanism to shift the long-distance communication among all network nodes. Thus, energy consumption is evenly distributed among all network nodes.

One of the limitations of wireless sensor nodes is their inherent limited energy resource. Besides maximizing the lifetime of the sensor node, it is preferable to distribute the energy dissipated throughout the wireless sensor network in order to minimize maintenance and maximize overall system performance. Any communication protocol that involves synchronization of peer nodes incurs some overhead for setting up the communication. We will introduce a new algorithm energy-efficient Distributed Dynamic routing algorithm and compare it to two other algorithms, namely directed, and random clustering communication. We will take into account the setup costs and analyze the energy-efficiency and the useful lifetime of the system. Our simulation results show that this protocol performs comparable to its optimal counterpart while having significant less overhead.

Wireless sensor networks having limitations such as: limited energy resources, varying energy consumption based on location, high cost of transmission, and limited processing capabilities. All of these characteristics of wireless sensor networks are complete opposites of their wired network counterparts, in which energy consumption is not an issue, transmission cost is relatively cheap, and the network nodes have plenty of processing capabilities. Routing approaches that have worked so well in traditional networks for over twenty years will not suffice for this new generation of networks. Besides maximizing the lifetime of the sensor nodes, it is preferable to distribute the energy dissipated throughout the wireless sensor network in order to minimize maintenance and maximize overall system performance.

Any communication protocol that involves synchronization between peer nodes incurs some overhead of setting up the communication. Each node could make the most informed decision regarding its communication options if they had complete knowledge of the entire network topology and power levels of all the nodes in the network. This indeed proves to yield the best performance if the synchronization messages are not taken into account. However, since all the nodes would always need to have global knowledge, the cost of the synchronization messages would ultimately be very expensive. For both the diffusion and clustering algorithms, we will analyze both realistic and optimum schemes in order to gain more insight in the properties of both approaches. [1]

This gives a brief survey of previous work that is related to Wireless Sensor Networks. Many protocols have been proposed for ad-hoc and sensor networks in the last few years. Proposed protocols can be classified into data-centric, hierarchical, etc.. Data dissemination protocols proposed for sensor networks consider energy efficiency a primary goal [8, 7, and 6]. SPIN [8] attempts to reduce the cost of flooding data, assuming that the network is source-centric (i.e., sensors announce any observed event to interested observers). Directed diffusion [7], on the other hand, selects the most efficient paths to forward requests and replies on, assuming that the network is data-centric (i.e., queries and data are forwarded according to interested observers).

II. Drawbacks Of Distributed Leach Protocol

Though there are various advantages offered by the distributed LEACH protocol, it carries with it some disadvantages that can't be neglected. The problems with the LEACH protocol can be listed as follows:

1. The cluster head node is selected on random basis due to which some shortcomings occur. After some rounds the chances of each node to become a cluster head node is same. The nodes of different energy levels have the same chances of becoming cluster head node. In case if a node with less energy remaining becomes cluster head node then it will die earlier & will consequently make the network lifetime shorter.
2. The clusters are formed dynamically in each round which also affects the overall performance of network. Some clusters have more nodes while some will have lesser nodes. In some clusters, the cluster head remains at the center while in some clusters it has its position at the circumference. This uneven distribution of clusters indirectly creates an unbalanced energy loads on the cluster head nodes.
3. In the steady state phase of LEACH protocol, the cluster head node of each cluster sends the fused data to the Base Station directly. Different cluster head nodes are located at different distances from the Base Station. The cluster heads which are located at farther distances from the Sink consume more energy to communicate with the Sink than the energy needed by the nearer cluster heads. This drawback gets highlighted more in the larger network.
4. The radio of cluster head nodes is always on and their energy keeps on dissipating continuously. Due to this they are more prone to failure & when any cluster head node fails, then the cluster to which it belongs will collapse & the data aggregated by the head node will get lost & will never reach the base station.
5. Random selection is done for the cluster heads, so there is a possibility that many cluster head nodes are concentrated in the same area.
6. Extra overhead is required for repeated cluster formation, cluster head selection, advertisement messages, etc.

III. 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.

IV. Constraints On Routing Protocols In Wireless Sensor Networks

As the wireless sensor networks use low power tiny sensors, the routing protocols must be capable to satisfy the following requirements:

4.1 Autonomous operations

A dedicated unit to control the routing decisions cannot suit the architecture of Wireless sensors network because they can be attacked very easily. So the routing procedures need to be transferred among the sensor nodes.

4.2 Energy efficient & scalable

A Wireless sensor network consists of several thousands of nodes and therefore the routing protocol must be able to work efficiently with this number of nodes. And also when the number of nodes further increases the protocol should be able to maintain the performance along with a fair communication among the nodes.

4.3 Fault tolerant

If at any time the sensor fails, the routing protocol should execute alternative decisions in order to leave the other nodes unaffected and to make the Wireless sensor network work continuously and gracefully.

4.4 Adaptable to mobility

Different applications of Wireless sensor network demand the mobility of sink & source. In this case the routing protocol is needed to provide support for the sensor nodes to adapt according to the mobility.

V. CATEGORIES OF WIRELESS SENSOR NETWORK ROUTING PROTOCOLS

Different categories of the routing protocols are given in the following table:

TABLE 1: WSN ROUTING PROTOCOLS

Categories	Routing Protocols
Data-centric	Flooding, Gossiping, SPIN, Directed Diffusion, Rumor Routing, Energy-aware routing for low-energy ad-hoc WSN, STCP, Gradient-based, COUGAR, ACQUIRE, Information dissemination by negotiation, EAD, Information-directed
Hierarchical	LEACH, PACT, HEED, PEGASIS, Hierarchical-PEGASIS, TEEN, APTEEN, Energy-Aware Routing for Cluster-based WSN, SecRout, SCR
Location-based	GAF, SPAN, GEAR, GeRaF, TBF, ALS, BVGF, MECN, SMECN, Geographic Routing in Lossy WSNs
Mobility-based	SEAD, TTDD, Joint Mobility and Routing, Data MULEs, Dynamic Proxy Tree based dissemination, MMAC, MS-MAC, VBF
QoS	SAR, SPEED, Energy-Aware QoS, RL-MAC, MMSPEED, DAPR
Network flow	Max Lifetime Energy, Max Lifetime Data Gathering and Aggregation, Min Cost forwording
Multipath-based	Node-disjoint, Braided Path, N-to-1 Multipath Discovery, SEEM, REER,HMPR
Heterogeneity-based	CADR, IDSQ, CHR, HDMRP, SEP, EEHC

VI. CONCLUSION

The main concern of this report is to analyze the role of LEACH protocol in balancing & managing the energy load in wireless sensor network. In this report we have studied only the LEACH protocol, it can also be compared with other protocols which may or may not be hierarchical in nature. We studied the positive effects of this protocol & also its disadvantages. LEACH protocol is good enough to manage the energy requirement but still it needs some improvement. The field of Wireless Sensor Network is rapidly growing & hence it needs protocols that in addition to efficient communication also reduce the energy dissipation and balance the energy load in the network which in turn will prolong the life-time of the network.

Wireless Sensor Network is composed of numbers of tiny sensors (nodes) which have the capability of gathering the data about environmental activities and making certain computations on them so that they can be communicated to the next node & finally to the Base Station. All the sensors work in co-ordination with each other to make communication successful. These sensors have to be continuously in active mode in order to receive and transmit data which increases their energy requirement. As these sensors are battery-powered, this continuous monitoring activity reduces their lifespan. Efficient management of energy is a critical requirement

for the optimal design of a wireless sensor network. Thus, a protocol is critically needed that can make the wireless sensor network energy efficient. In this report a detailed view and analysis of LEACH Protocol will be discussed. LEACH Protocol is a cluster-based hierarchical protocol which creates an energy balance in the network saves the node energy and hence increases the lifetime of the network.

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