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A Novel Approach for Reducing Energy Consumption in Routing Protocol for Clustered Wireless Networks

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Abstract: Due to the vast potential of the sensor networks to enable applications that connect the physical world to the virtual world, the Efficient design and implementation of wireless sensor networks has become a hot area for researchers in recent years. Energy efficiency is a key issue in WSN as the sensor nodes are equipped with limited resources. Clustering based protocols have been suggested in reducing the energy consumption while packet forwarding to the base station. In this research paper, a novel technique to reduce energy consumption has been proposed. The algorithm has been implemented using MATLAB and compared to existing LEACH protocol. The results obtained in terms of number of dead nodes, number of alive nodes and throughput suggest that the proposed technique achieves better results than the LEACH protocol.
Keywords: Wireless Sensor Network, Routing, LEACH, energy efficiency, routing.

I. INTRODUCTION

With recent advances in Micro Electro-Mechanical Systems (MEMS) technology, low-power digital circuitry and RF designs, Wireless Sensor Networks (WSNs) are considered to be one of the potential emerging computing technologies, edging closer to widespread feasibility. Several useful and varied WSN applications such as weather and climate monitoring, detection of threats to chemical or biological agents, and monitoring of health care require collection of information in harsh and inhospitable environments. Cheap and intelligent sensors networked with the Internet through wireless communication have remarkable purposes for controlling and monitoring environment, homes, health care, military, and other strategic applications. These applications require the use of various equipment including cameras, infrared, acoustic and seismic tools and sensors measuring various physical parameters. In order to detect various threats, a network of smart sensors can be deployed in a host of different environments, such as in military scenarios. Thus, these networks can collect intelligence in battlefields, track enemy lines, monitor potentially harmful chemicals and nuclear materials using neutron-based detectors, and detect viruses, toxins using antibody-coated bio-sensor chips to attract particular biological agents. In terms of power supply, processing capability, and available bandwidth, routing, and data forwarding, wireless sensor nodes should be performed with effective use of network resources. Furthermore, in view of the performance requirements of wireless sensor networks, routing algorithms are totally applicable. In this paper, an optimized algorithm for routing of data from the sensor nodes to the base station is proposed. The proposed protocol is based on clustering based technique i.e. LEACH. The below section II gives the Literature Review of common routing protocols in WSN, Section III describes the Proposed Work, Results are discussed in Section IV and finally conclusion is presented in Section V.

II. LITERATURE SURVEY

In hierarchical routing protocols whole network is divided into multiple clusters. One node in each cluster play leading role. Cluster-head is the only node that can communicate to Base station in clustering routing protocols. This significantly reduces the routing overhead of normal nodes because normal nodes have to transmit to cluster-head only. LEACH (Low Energy Adaptive Clustering Hierarchy). Heinzelman et. al.[4] have proposed a distributed clustering algorithm called Low-Energy Adaptive Clustering Hierarchy (LEACH), for routing in homogeneous sensor networks. LEACH selects randomly the nodes cluster-heads and assigns this role to different nodes according to round- robin management policy to ensure fair energy dissipation between nodes In order to reduce the amount of information transmitted to the base station, the cluster-heads aggregate the data captured by the member nodes belonging to their own cluster, and then sends an aggregated packet to the base station. The election probability of nodes to become cluster heads increases in each round in the same epoch and becomes equal to 1 in the last round of the epoch. However, while LEACH can increase the lifetime of the network, it has some limitations. LEACH assumes that all nodes can transmit data with great power to reach the base station and each node has a computing power enabling it to withstand various MAC layers. Therefore, LEACH is not suitable for networks deployed in large areas. In addition, LEACH randomly selects a list of cluster heads and there are no restrictions on their distribution and on their energy level. Thus, the cluster heads can concentrate on one place and therefore there may be isolated nodes (without cluster head) that may occur. On the other hand, in LEACH, the aggregation of data is centralized and is performed periodically. However, in some cases, the periodic transmission of data may not be necessary, which exhausts rapidly the limited energy of sensors.

LEACH-Centralized (LEACH-C) [8] is similar to the LEACH Protocol as far as formatting clusters at the beginning of each round is designed to improve the performance of LEACH. However, instead of nodes randomly self-selecting as a CH, the sink in LEACH-C performs a centralized algorithm. The sink collects location data from the nodes, and then broadcasts its decision of which nodes are to act as CHs back to the nodes. The overall performance of LEACH-C is better than LEACH by dispersing the cluster heads throughout the network. However, LEACH-C is sensitive to the sink location. Once the energy cost of communicating with the sink becomes higher than the energy cost for cluster formation, LEACH-C no longer provides good performance. Sinks may be located far from the network in most WSN applications. So, the dependence on the sink location is a major disadvantage of LEACH-C.

The Distance-Based LEACH (DB-LEACH) proposes to consider the distance factor to the threshold equation and advances in the Distance-Based Energy-Aware (DBEA-LEACH) instead consider the energy factor[9]. And the Mobile Nodes Cluster Based Routing Protocol is proposed to save energy for sensor node mobility using cross-layer design between Medium Access Control (MAC) and network layers[10]. This type of method with mobile sensor nodes performs better in WSNs. Simulation data show that the above algorithms enhance the energy efficiency of the network in different degrees. An improved version of LEACH called Multi-hop LEACH (LEACH-M)[11], where cluster members may be more of a leap from their respective cluster heads and communicate with them in multi-hop fashion. The cases in which M-LEACH outperforms LEACH are thus illustrated. This proposed version, however, requires that each sensor be able to aggregate data, increasing the overhead for all sensors. In[9], the authors focused on heterogeneous sensor networks in which two types of sensors are deployed: high-capacity (Super Sensor) sensors and simple sensors. The sensors have large capacity processing capabilities and communicate intensively with each other and act as cluster heads, while others are simple sensors with limited power, affiliated with their neighborhood's closest cluster head and communicating directly or in multi-hop. In particular, round uneven nodes are attached to multiple cluster heads; in this case, cluster heads with a large number of member odes drain their energy compared to cluster heads with fewer associated member nodes. In addition, support for mobility is another issue with the LEACH routing protocol, which is proposed in [9],[10] to mitigate these issues.

III. OPTIMIZED LEACH

The nodes are randomly deployed in the network. Initially, all the nodes are having intial energy, Eo. Initially, after the node deployment the neighbour node discovery takes place.

For each node, wanting to be the cluster-head chooses a value, between 0 and 1. This random number is compared with the threshold value in stochastic algorithm for election of CH's.

The node regions are divided into clusters and data is aggregated and sent to cluster heads (CH's), these cluster heads then forward this data to the base station. The selection of Cluster head is done as described: The base station transmits a starting message packet to all the nodes. This message and all the nodes respond to it. The sensor nodes are required to forward their location, id and energy information to base station over the network.

This is followed by base station sending another packet to inquire about the node as to which logical zone, they currently belong to. This packet valuable message for the nodes as their logical positioning depends on this message packet. Nodes near BS connect themselves with BS.

Other nodes are divided in two regions and use clustering topology. CHs are elected in each region separately. Let 'r' represent the number of rounds to be a CH for the node Si, we call it epoch. each node elect itself as a CH once every r = 1/p rounds. At the start of first round all node in both regions has equal energy level and has equal chance to become CH. After that CH is selected on the basis of the remaining energy of sensor node and with a probability p alike LEACH, in each round, it is required to have n x p CHs. A node can become CH only once in a epoch and the nodes not elected as CH in the current round feel right to the set C. The probability of a node to (belongs to set C) elect as CH increases in each round. It is required to uphold balanced number of CHs. At the start of each round, a node Si belongs to set C autonomously choose a random number between 0 to 1. If the generated random number for node Si is less than a predefined threshold T(s) value then the node is becomes CH in the current round.

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A. Scheduling

Scheduling is an important concept in clustering. When some nodes are elected as cluster heads and other nodes become member of their corresponding cluster head, member node starts communication with cluster heads. So, it can become fairly impossible for the cluster heads to respond to each and every node in the cluster. Thus a time division is assigned by the cluster heads to all the nodes. All the associated nodes transfer data to cluster heads in its own scheduled time slot. While a particular node is transmitting, all other nodes stay idle. Nodes thus can know their own transmission schedule and need to be turned on only at times its transmission time. This method thus saves lot of energy for the individual nodes and for the network as a whole.

B. Steady-State Phase

The steady state phase refers to the actual operational phase of the network. The cluster heads receive data packets from their respective associated nodes and forward this data packet to the base station. The process continues until the nodes die out of their energy after a certain number of rounds, called the lifetime of the network.

Once the clusters are created, the sensor nodes are allotted timeslots to send the data. When a node receives data from one its neighbours, it aggregates it with its own data. It uses a heuristic function to make this decision and the heuristic function is given by,

$$h = K (Eavg / h\ min * t) \qquad 1)$$

The path with highest heuristic value is chosen or else the path with the next highest heuristic value is chosen.

After the paths are chosen, then their minimum energies are compared for efficient transmission.

It uses a energy relation to make this decision and the relation is given by,

$$Emin > threshold, \text{ where } Emin = Eavg /const \qquad 2)$$

IV. RESULTS & DISCUSSIONS

The various equations defining the energy dissipation process in the wireless sensor network has been implemented in the software. The various network modelling parameters with their values are shown in the Table I. For this simulation the network area is 200mx200m. The base station is placed at location x=100, y=100 in the network area. The division shows the different cluster formation in the network area. The number of nodes is taken to be 200. The network is simulated for 2500 rounds. The rounds are equivalent to a certain time scale. After every round the energy dissipation factor from different sources is accumulated to calculate the average energy left in each node.

Table I: Network Simulation Parameters

Parameters	Values
Network Area	200m
Threshold distance, d0	sqrt(E_{fs}/E_{mp})
Energy consumed in the electronics circuit to transmit in or receive the signal, E_{elec}	50 nJ/bit
Energy consumed by the amplifier to transmit at a short distance, E_{fs}	10 pJ/bit/m_2
Energy consumed by the amplifier to transmit at a longer distance, Emp	0.0013 pJ/bit/m_4
Data Aggregation Energy, EDA	5 nJ/bit/signal
Initial Energy, E0	0.5 J
Selection Probability	0.1

The selection probability for a node to become a cluster head is taken as 0.1, i.e. out of all the available nodes 10 percent can become cluster heads.

The simulation results have been plotted as graphs between various parameters obtained and the number of rounds as shown in below figures.

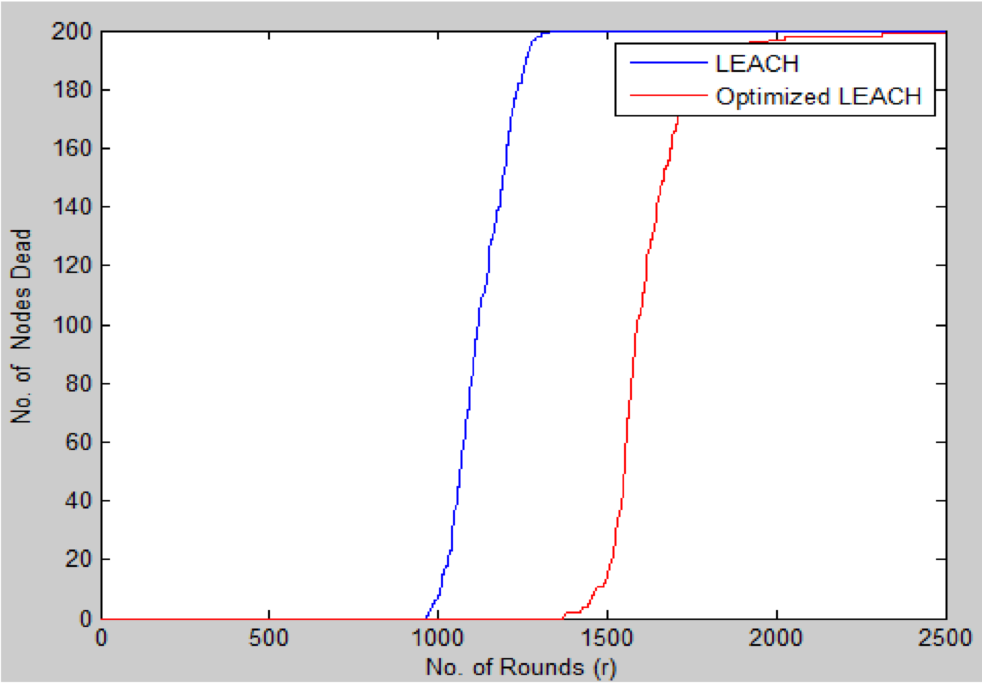

Figure 1: Number of Dead nodes vs rounds

The above figure 1 shows the comparison of the modified LEACH protocol proposed in this research work with that of the LEACH protocol. As shown from the figure 1 the optimized LEACH method has a considerable improvement in terms of nodes getting inactive or dead. The first dead node in the LEACH protocol under similar simulation parameters and network parameters occurs at around 941 rounds whereas in the modified LEACH algorithm the first dead node occurs at around 1395 rounds. This is a notable improvement in the lifetime of the network. Similarly, the nodes die out completely at around 1400 rounds in LEACH protocol whereas in the modified LEACH protocol the network dies out a t round number 2247. This further affirms the effectiveness of the modified LEACH protocol. The below figure shows the number of alive nodes plotted against the number of rounds.

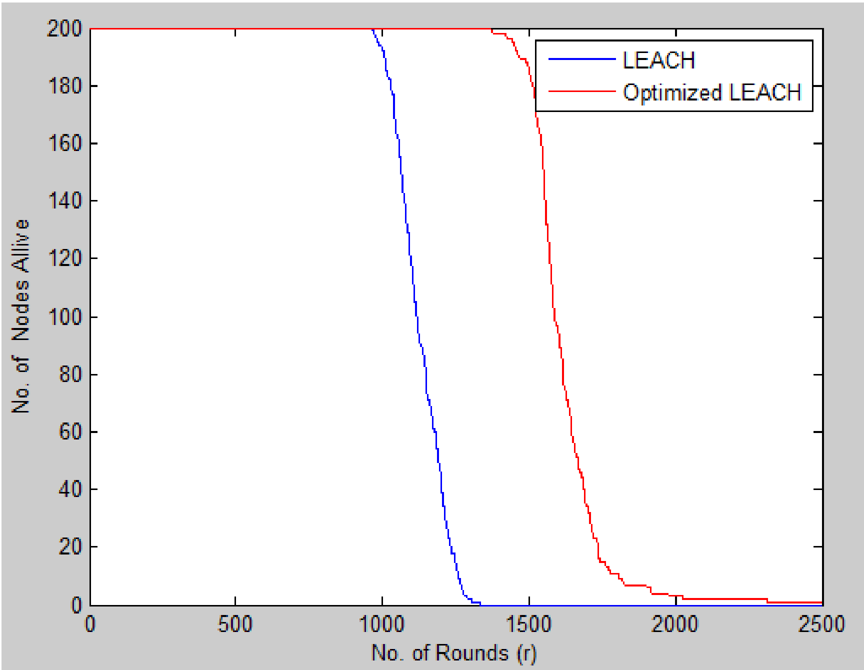

Figure 2: Number of Alive nodes vs rounds

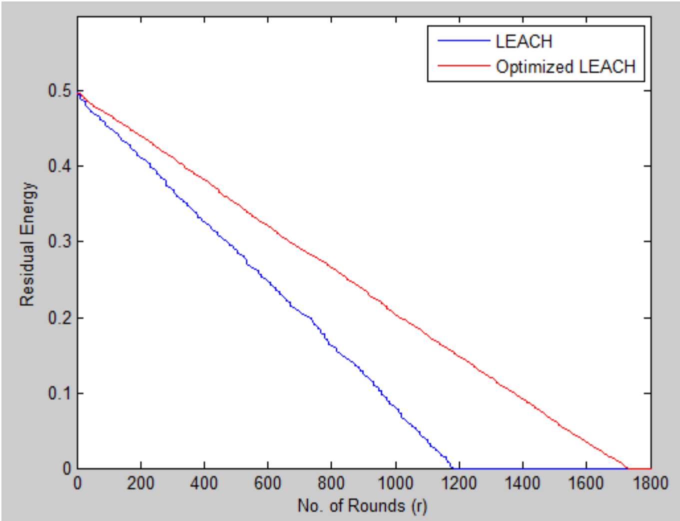

Figure 3: Residual Energy vs rounds

The residual energy graph giving a comparison between the LEACH protocol and the modified LEACH protocol is shown in the figure 3. As shown in the graph the energy of the networks is increased in the proposed protocol and hence the network lifetime.

V. CONCLUSION

The current research work is also focused on suggesting a protocol, which is based on optimizing the energy utilization. They follow a standard LEACH based clustering to send their data packets to the respective cluster heads which in turn send it to the Base Station. The algorithm was successfully implemented on MATLAB software tool, with some standard parameters as available in various previous research methodologies. The results were compared against the LEACH protocol and has shown a considerable improvement in number of alive nodes after 2500 rounds. The number of dead nodes is less as compared to the LEACH protocol, thus showing that this proposed method is more effective and increases the overall network existence time.

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