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Design Simulation and Perfomance Analysis of Efficient Low Energy Adaptive Clustering Hierarchy Protocol in Wireless Sensor Network

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Abstract— Network life has been defined by the use of nodes to store, process and distribute information, which have restricted energy usage. In other words, all aspects of the node must be designed for extremely energy-efficient applications from sensor module to hardware and protocol. Diminished energy consumption by a factor of two will increase the system's overall utility by doubling the device life. In addition, the protocols should be robust against node failures, tolerant of defects and scalable to optimise device life to minimise energy dissipation.
LEACH is the first protocol for network networks that utilises hierarchical routing to enhance network life. All nodes in a network are grouped into local cluster groups, with the cluster head being one node. Although all non-cluster head nodes transmit their data to the cluster head, the cluster head node collects data from all the cluster members, conducts data signal processing (e.g. , data aggregation) functions and transmits data to the remote baseline. As a cluster-head node, it thus takes much more resources than a non-cluster-head node. So all nodes that belong to the cluster lose communication power if a cluster-head node dies. In this research, we introduced clustering as a means of overcoming this energy efficiency problem. Detailed description on the process of LEACH protocols is available. The information on the simulation and the findings have also been discussed.

Index term: Wireless Sensor Network, LEACH, Energy, Clusters, Routing Protocols, Sensor Nodes.

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I. INTRODUCTION

The Wireless Sensor Network (WSN) means a community of sensors that are dispersed and committed to tracking, capturing and centralizing data collection within the physical state of the environment. Wireless networks are one of the computing networks consisting of small, stand-alone sensor devices that can communicate through wireless connections and are embedded into everyday objects sprayed on the ground.[11]. Wireless sensors networks will eventually allow the automated monitoring, in the large areas, of forest fires, avalanches, hurricanes, failure of land specific utilities, traffic, hospitals and much more. It has already begun with humbling monsters, for example automating meter readings in buildings and generating and regulating processes. It is a community of specialized transductors with a communication network that tracks and records conditions in different locations. Temperature, temperature, heat, wind direction and velocity, light strength, vibration rate, sound intensity, voltage in the power line, chemical concentrations, contaminant rates and critical body functions are generally controlled parameters. A transducer, microcomputer, transceiver and power source is used for multiple detection stations called compact, lightweight and portable sensor node systems.

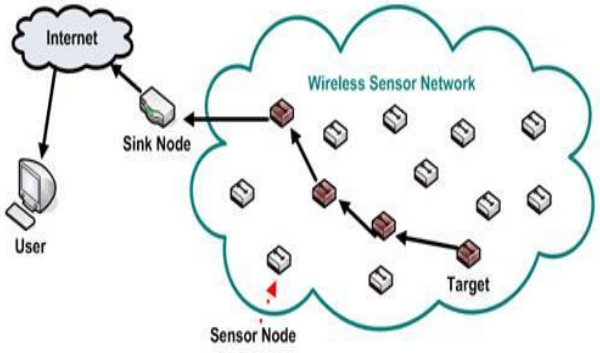

Figure 1.1 Wireless Sensor Network

Electrical signals are produced by the transducer based on sensed physical effects. The microcomputer stores and saves the performance of the sensor. The hardwired or wireless transceiver receives controls from a central computer and transmits data to that computer. Power is extracted from or form a battery for each sensor node.

The paradigm of data transport is such in sensor networks that a base station is usually located at and beyond the boundary of data sensing / measuring. In order to improve the efficiency of various wireless sensor networks, researchers have suggested a range of routing protocols. Most Wireless Sensor Networks protocols are built on one-way routing without taking into account the various effects of various intensity load traffic. A hop by hop data transfer improves the routing table management overhead and rapidly reduces the life of those nodes near the base station as these nodes are commonly used as relay nodes. The energy of the nodes near the base station will rapidly drain. such a network does not exist. To solve these problems, several routing protocols have been proposed. From these, clustering

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algorithms were of great interest because they simultaneously balance many main factors of the operation of the wireless sensor networks. Choosing an arbitrary node to support multiple sensor nodes will increase network life and dramatically reduce power consumption with each attempt to reach the Gateway node. This method of selecting one node to support multiple neighbouring nodes is called "clustering.

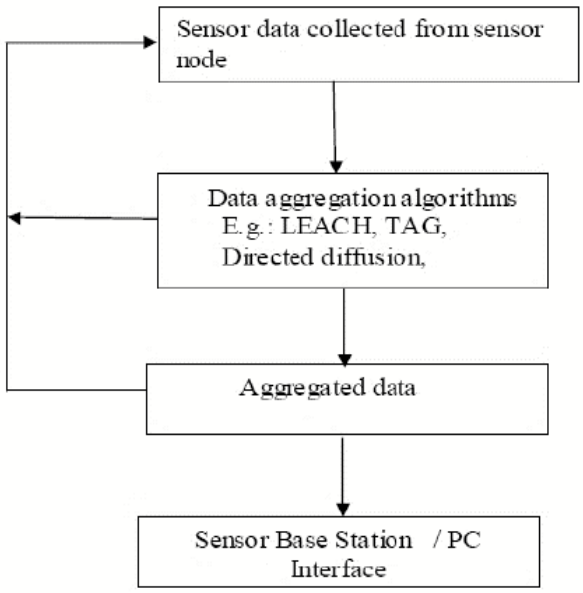

Figure 1.2 Basic Architecture for Data Aggregation

Data aggregation is a mechanism by which sensor data are aggregated through aggregation approaches. As seen in the following figure, the general data aggregation algorithm works. The algorithm uses sensor data from the sensor node then aggregates the data using other aggregation algorithms such as a centralized approach (LEACH), TAG (Tiny Aggregation), etc. By selecting the effective path, this aggregated data is transferred to the sink node.

Data aggregation protocols aim to eliminate redundant data transmission and thus boost the life of the wireless sensor network with reduced resources. Data transmission took place in multi-hop form in the wireless sensor network, whereby each node transmits its data to the nearest node. Because the same data can be sensed by closely located nodes, the solution above can not be seen as energy efficient. An increase over the aforementioned method would be to cluster where every node sends data to cluster head (CH) and then the cluster head aggregates the raw data obtained and then sends it to sink. In addition to WSN providing wired sensor networks with several additional advantages, they place several important constraints directly affecting the design of the network and equipment. Two of the most critical drawbacks are:

Power consumption: this limitation explicitly affects the lifespan of the nodes. With energy-aware and power adjustment protocols for transmitting power, the consumption of energy can be greatly reduced and the network life can thus increase. Power of self configuration and good scalability: the selection and implementation of the appropriate network protocol will solve the problem.Fault Fault tolerance: If the same signal is transmitted to each system (temperature, moisture etc.), the network will be native to replicating. If devices do not have the same feature, the tolerance issue can be resolved by the system replication. .[9][11][14]

II. ENERGY EFFICIENT ROUTING PROTOCOL

The Environmental and bio-process monitoring are some of the areas where the development of sensors has benefited most, particularly bio-sensors and networks of sensors. The replacement of sensor nodes with very fewer power sources is difficult and sensor life depends on the electricity supply. The energy-efficient routing protocol is important to reduce energy consumption. Therefore, it is essential to design the energy-efficient routing protocol. For WSNs a lot of routing protocol is planned. WSN routing is a very challenging job because of the inherent characteristics of the WSNs. Some common problems occurred:

• Coverage: it indicates how well a sensor in a wireless network is monitored or tracked.

• Location evaluation problem: the main challenge is assessing the actual wireless network node position.

• Energy consumption: Most of the energy consumed in the WSN is used to transmit and receive data compared with data collection and treatment. Routing protocols on WSNs may be split in two groups depending on the network structure: flat routing and hierarchical routing. Each node performs the same tasks and functionalities in the network in a flat topology. Data is typically transmitted hop by hop using the flood method. In small scale networks, flat routing protocols are fairly efficacious and are typical of a WSN's flat routing mechanism including flow and bogusing, sensor protocols for negotiation information (SPIN), direct diffusion (DD), greedy perimeter stateless routing (GPSR), trajectory-based forwarding (TBF), energy-aware routing (EAR), gradient-based routing (GBR), sequential assignment routing (SAR), etc. However, in large-scale networks it is relatively unnecessary since resources are limited, but all sensor nodes provide more data processing and bandwidth. On the other hand nodes perform various tasks in WSNs, in a hierarchical topology, and are usually clustered according to different requirements or measurements into numerous clusters. In general, each cluster includes the cluster head (CH) and other nodes (MN) or ordinary nodes (ONs) and CH may be arranged to form additional levels of hierarchy. In general , high energy nodes function as CHs and perform the task of processing and transmission of data, while low-energy nodes act as MNs and perform the task of sensing information. In WSN, traditional clustering protocols include Low Energetic Adaptive Clustering (LEACH), Hybrid Energy Efficiency Distributed (HEED), Weight-Based Distributed Energy Efficient hierarchy (DWEHC), Position-Based Aggregator Node Election (PANEL) Protocol, LEACH (TL-LEACH) two-level hierarchy, Unven Clustering size (UCS), Energy Efficiency (EEE) Model. .[21][11] Energy Efficient Network Sensor (TEEN) protocol, Adaptive Threshold Sensor Sense Efficient Energy Sensor Network (APTEEN), two stage data distribution (TTDD), Focus Clustering Scheme (CCS), HGMR, etc. Due to many advantages, including greater scalability, data aggregation / fusion, less load, less energy consumption, more robustness, etc. Clustering routing is becoming an important field for routing technology in WSNs

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III. PROPOSED METHODOLOGY

The LEACH combines random rotation of the cluster-head location with a high energy effect, so that it rotates between the sensors, so that a single sensor on the network does not drain the battery. The energy load of a cluster head is distributed equally between nodes. Since the node with cluster heads knows all cluster members, a TDMA schedule can be established, which indicates when each node will transmit its information. Moreover, the use of a TDMA data transfer schedule avoids collisions within a cluster. The LEACH process is split into pieces. A round of the clusters starts with a set-up process and a continuation phase is followed by several frames of data from the nodes to the cluster head and the base station, which are transmitted into the cluster head.

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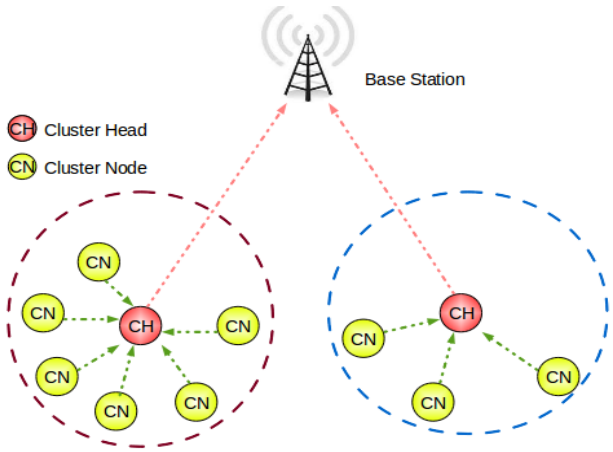

Figure 3.1 Illustration of LEACH Protocol

This protocol is divided into rounds and each round has two phases as shown in Figure 3.2. In addition, the setup process is split into 2 parts:

1. Step of publicity
2. Set-up process of cluster

In LEACH, nodes make autonomous decisions by using a distributed algorithm to form clusters without any centralised control. In this regard no long-distance communication is needed with the base station and distributed cluster creation can be carried out without knowing exactly where every node in the network is located. Moreover, there is no need for global communication to set capacity.

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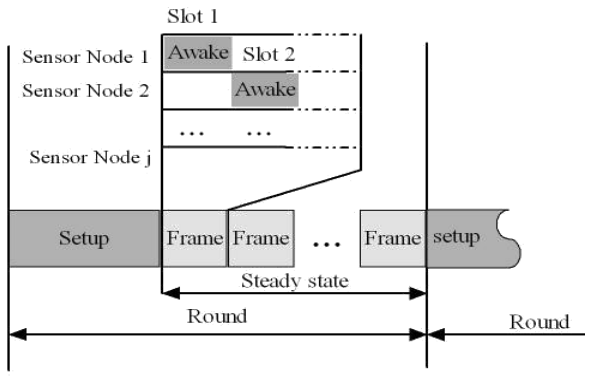

Figure 3.2 One Round of LEACH Operation

Finally, the head nodes for the cluster will be distributed throughout the network as this minimises the distance to be transmitted by the non-cluster head nodes. A sensor node selects an arbitrary number, r, 0 to 1. Let T(n) be a threshold value:

$P, n \in G$

(3.1)

$$T(n) = 1 - P \times [r \bmod (1/P)]$$

(3.2)

Otherwise,

$$T(n) = p/1\text{-}p \times (r \bmod p\text{-}1)$$

(3.3)

The node will become a cluster-head for the current round, if the random number has less than a threshold value, T (n). The threshold value is determined on the basis of the above equation which includes the percentage needed in the last (1 / P) round, the current round, and the number of nodes, p being of a cluster head. After the nodes have decided to become clusterheads, the advertising message (ADV) is transmitted. This message is a small message containing the ID of the node and a header that makes this message an announcement. Increasing non-cluster head node decides the cluster to which it belongs, based on a signal strength obtained from every clusterhead, by choosing the clusterhead that needs least communications energy. After every node determines which cluster it is part of, the cluster-head node has to be told that it is a cluster member. A Join-REQ message is sent back to the clusterhead chosen by each node. LEACH's cluster heads are locally regulated to manage data transfer in their cluster. The cluster head node sets a TDMA programme and transmits the programme to the cluster nodes. This ensures that data messages do not collide, and also enables the radio components of a non-cluster head node to be disconnected at all times with the exception of their transmitting time , reducing the energy dissipation.Further splitting the steady phase into two parts: .[21][23][14]

1. Creating Timetable
2. Transfer of data

During the assigned transmission time, the constant operation is split into frames where nodes transmit their data to the cluster head at the most once per frame. The setup process does not guarantee an even distribution of nodes among the head nodes of the clusters. The number of nodes per cluster therefore varies widely in LEACH, and according to the number of nodes in the cluster, the amount of data each node will send. Growing node of the cluster head uses power control to minimise energy dissipation to evaluate the transmission power according to the intensity of the cluster head ad. Before the assigned time of transmission, the radio of each node without the cluster is disabled. Since all nodes have data to be sent to the head of the cluster and the total bandwidth is set, the effective use of the bandwidth using a TDMA schedule represents an energy-efficient low latency approach. The head of the cluster will maintain its receiver so that all the data is obtained from the cluster nodes. When the clusterhead receives all the data the cluster head will work on the data and the resulting data are sent to the base station from the cluster head.[11][13][16]

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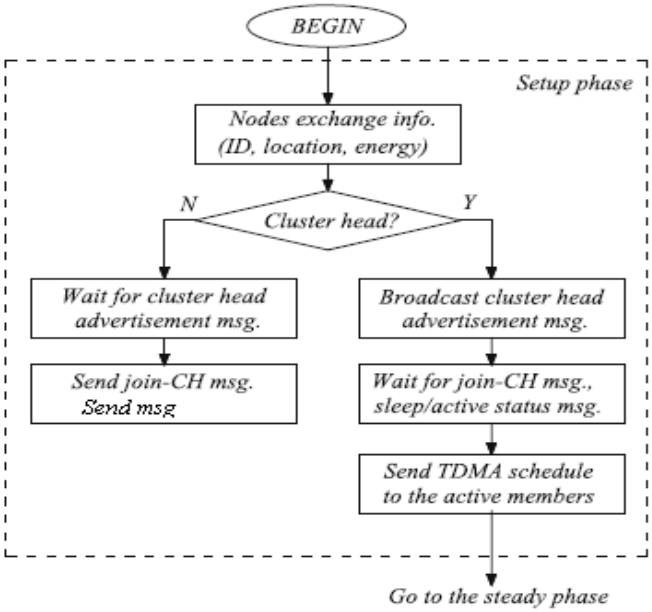

Figure 3.3 Flowchart of LEACH Protocol in Set-up Phase

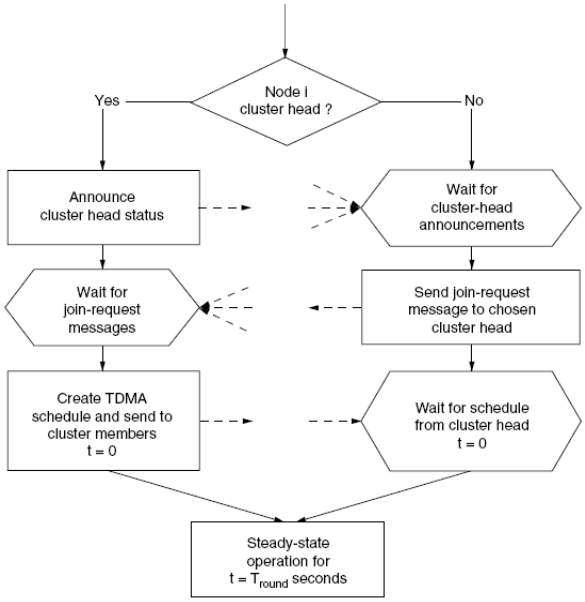

Figure 4.4 Flowchart of LEACH Protocol in Steady Phase

IV. SIMULATION & RESULTS

The simulation has been carried out on MATLAB 2017a software On the basis of the simulation, LEACH more than doubles the useful machine life as shown in Figure 4.6. Relative to direct contact and a factor of 4-8 relative to the Minimum Transmission Energetic Routing Protocol (MTE) and static clustering LEACH improves energy dissipation over a factor of 7. To read more about the effects of the simulation. Although LEACH improved the life of the network and dissipated electricity, it does have some disadvantages. LEACH assumes, for example, that the initial energy occurs at all nodes, but does not occur in real time. In addition, it implies that nodes are static. For mobile nodes, it is also difficult to submit. In addition, the failure of CHs produces other issues and does not take account of the current multiple BSs. Finally, the dynamical clustering

has a further overhead. Many protocols were found to improve and enhance LEACH according to these disadvantages.

Table 4.1
LEACH Simulation Parameters

Parameter	Value
Size of Network	101m*101m
Energy in Initial Stage	0.51j
(C-H %)	0.51
Aggregation of Data and Energy-cost	51pj/bit j
Total Number of Nodes	100
Size of Packet	200 bit
Transmitter-Electronics (Eelect-Tx)	51 nj/bit
Receiver-Electronics (Eelec-Rx)	51 nj/bit
Amplifier (E_{amp}) (Transmit)	100 pj/bit/m^2

MATLAB simulates LEACH in determining the parameters considered as follows:

• Round number v / s Dead Nodes number (with probability variations) •

• Average Node Energy v / s round number (with probability variations)

• Round number v / s Dead Nodes number (with node number variations) •

• Round number v / s Average Node Energy (with node number variation) The results below display the simulation of both the LEACH protocols at 0,01 chance, which is 1 % of the total nodes that can be cluster led.

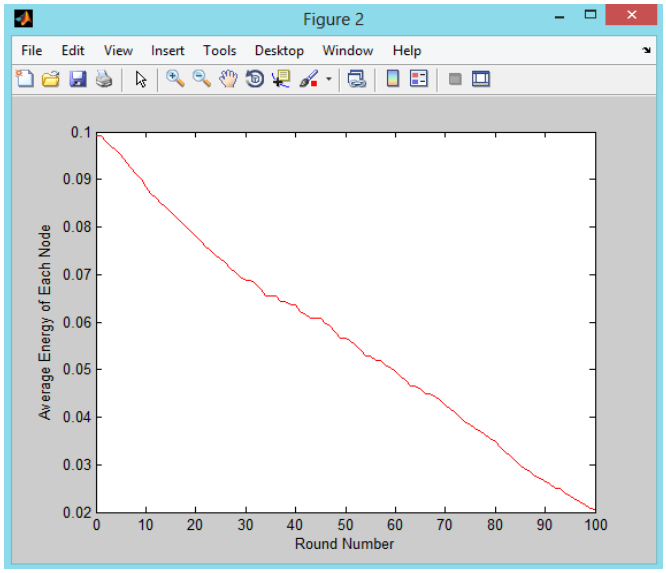

Figure 4.1 Average Energy v/s Round No. (LEACH)

The results show the simulation of LEACH at a probability of 0.5, which corresponds to 50 per cent of the total nodes to be clusters head.

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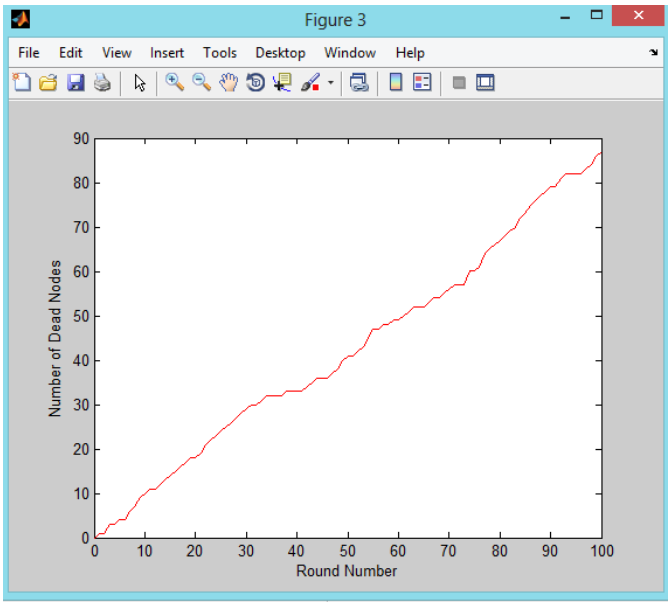

Figure4.2 No. of Dead Nodes v/s Round No. (LEACH)

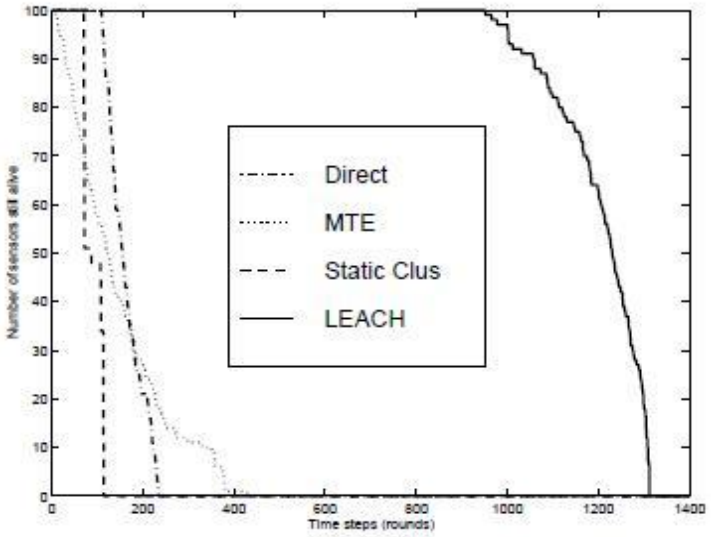

Figure 4.3 System Lifetime Using Direct Transmission, MTE Routing, Static Clustering, and LEACH

Figures show that with the time LEACH improvement both lose energy as the round increase. Often, when a node reaches the zero value, it is not available anymore and is called a dead node..

V. CONCLUSION

In many cases, wireless sensor networks are usually dispersed across broad areas. There is a requirement in this respect for methods that can better manage the WSN. The limited battery capacity is used for wireless sensor networks. The key challenge in designing Wireless Sensor Network protocols is energy efficiency as the sensor nodes are restricted in capacity. The last motivation behind every routing protocol is to make the network work for a longer period of time as energy-efficient as possible. In this research, we introduced clustering as a means of overcoming this energy efficiency problem. Detailed description on the process of LEACH . The information on the simulation and the findings have also been discussed. From the short analysis of the simulation, we concluded that LEACH can be used in smaller grids for effeciency and energy improvement.

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