DEVELOPMENT OF AN IMPROVED HYBRID – LOW ENERGY ADAPTIVE ERING HIERARCHY (HYBRID - LEACH) PROTOCOL FOR WIRELESS SENSOR NETWORK

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ABSTRACT

This paper developed an improved hybrid – low energy adaptive clustering hierarchy (Hybrid - LEACH) protocol for wireless sensor networks (WSNs). In order to effectively utilize the network energy, a residual energy level of cluster head (CH) and threshold energy value were used in determining if a CH head should be changed or continue after a round. The base station (BS) calculates and sets the threshold energy based on the network energy map using predictive approach. The simulated results in MATLAB 2015b showed 99.78% packet delivery success, the first sensor node (SN) died after 1600 rounds and the last sensor node in the network died after 6400 rounds. The developed system when compared with hybrid –leach protocol had a 33% improvement in terms of network before the death of the first SN and 63.77% before the last node in the network died.

1. INTRODUCTION

The advancement in electronics and wireless communications has ease the development of low power, low cost and multifunctional smaller devices for distance monitoring applications [1]. More so, the continual application of embedded computing systems (i.e., systems designed for performing a limited numbers of dedication functions by interacting closely with the physical environment) in larger numbers of areas [2] has increased the ability of exploiting sensor networks consisting of intelligent sensors that enables the collection, processing, analysis and dissemination of sensitive information collected from different environments [3]. A wireless sensor network consists of sensing nodes deployed in a geographical area for monitoring physical phenomena such as humidity, vibration, temperature, seismic events etc. [4]. The sensing nodes also have the capability of processing and communicate the data. The sensor nodes workflow entails generation of data packages containing the sensing area and remotely transmitting them to either the sink node (or base station) or other sensor nodes [5]. A sensor node is a miniature device with three essential components: a sensing subsystem for acquiring data from the physical environment, a processing subsystem for processing and storing local data, and also a wireless communication subsystem for transmitting the data [6]. In addition, energy from a power source are supply to the device in order to perform the specific tasks. However, this power sources are basically batteries whose energy are limited [7]. The basic structure of wireless sensor network system is as shown in Figure 1.

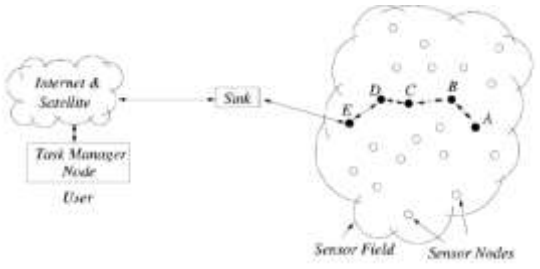

Figure 1: Wireless Sensor Network Basic Structure [8]

A variety of disciplines uses WSNs in numerous applications such as environmental monitoring, structural monitoring, animal monitoring, transport and logistics, military and healthcare [8]. In all these

applications, the sensor nodes generate a very large volume of data which must be transmitted to the sink node. It has been proven experimentally that energy consumption during data transmission is very expensive compared to data processing [9]. Hence, the need for new methods of date storage and data query at the sensor nodes [10] to reduce the transmitted data to sink node [11].

2. REVIEW OF SIMILAR WORKS

Variance of energy efficient model such as [12] novel energy efficient protocol for wireless sensor networks for mobile sensor and sink nodes have been proposed. This protocol is clustered based and hierarchical, with each cluster having a cluster head and two assistants cluster head nodes for routing. Also the protocol minimized energy by allowing a dormant state once not in use. [13] considered node mobility issues (such as energy consumption and packet loss) and proposed a cluster-based routing protocol for mobile nodes (CBR-Mobile). The CBR-Mobile is a traffic and mobility adaptive protocol where sensor nodes uses received signal strength in sending data to cluster heads in an efficient manner. This protocol used cluster – based routing protocol with a hybrid MAC protocol for supporting mobility of sensor nodes. [14] focused on the scalability and energy efficiency of broadcasting over cluster heads (CHs) in multi hop cluster-based WSNs, where there is no direct link between the cluster heads. A heuristic protocol was presented called Broadcasting Over Cluster Heads (BOCH) with a static sink for an inter cluster communication that is better, scalable and more efficient. [15] presented an efficient energy routing protocol called Improved Stable Election based Routing protocol for WSNs using a mobile sink. This protocol deployed random nodes while employing mobile sinks. A new version of stable election protocol (SEP) was adopted where the cluster heads were selected based on their nodes residual energy within the cluster and data transmission was done in a designed manner. Results obtained showed that the algorithm had a better performance when compared with the conventional routing algorithms such as LEACH and SEP. [16] designed analytically a clustered based multi hop WSN for maximizing network lifetime. Network was modeled which consists of a number of concentric layers where each layer contained unequal sizes of clusters. The Nodes which were not far from the base station formed the first layer and had no locally sensed data of their own, but used their energy in relaying data from other cluster to the base station. Thereby eliminate the problem of hotspot in the network. **[**17] presesnted an energy efficient protocol called ED-LEACH that was based on the conservation of energy in a clustered base WSN. In this protocol energy was conserved by considering the distance between the node and its neighbors, duty cycle of every section and energy of nodes when choosing CH. The effect of these considerations is to avoid choosing a node with lower energy as the cluster head which can affect the energy consumption and the lifetime of the whole network. Simulation results showed that this protocol achieved 20% decrease in energy consumption than LEACH protocol. [18] presented an efficient data dissemination protocol based on dynamic power threshold. It used to balance the network load within the sensor nodes by introducing a mobile new sink and thus improved their performances. The protocol has two phases, firstly, the initialization phase which organizes the sensor nodes into clusters with each clusters having a cluster head. Secondly, the data transmitting phase, where the disseminated data are collected and transmitted by the cluster head. In this phase, mobile sensor sink can move towards any cluster using the frequency of sensed data frequency in minimizing the energy consumption of sensor nodes which are closer to the fixed sinks relaying larger amount of data. This process equally eliminates the problem of hot spot that existed when using static sink. [19] presented a WSNs energy efficient communication protocol called Hybrid-LEACH which organizes the individual sensor nodes into cluster forms, with each cluster electing a CH. The elected CHs collects sensor nodes data and aggregates before transmitting them directly to the sink node. These CHs are changed and elected regularly using their threshold energy values which evenly distributes the energy load among sensor nodes in the network. To avoid

selecting nodes with lower energy as CH which could cause energy holes and coverage problems, a second channel head was provided to give priority to low power nodes. These methods outperformed the LEACH and HEED in terms of energy consumption as evident in the simulated. However, in this protocol like other LEACH based protocols, CH is rotated among cluster members and this consumed energy which can shorten the lifetime of the network. From the state of art, it is obvious that energy consumption management has been a major challenge in a WSN. Meaningful research attention is being given to reduce the effect of energy consumption in the sensor network through various energy management techniques. Most of the works reported have been on efficient energy management of either the sink node or that of the cluster head node to improve the life time of the sensor network. The life time of a sensor network is most commonly defined as the length of time from the network deployment to the first sensor node failure [20]. Therefore, minimizing the number of times that CH is changed in clustered environment can significantly reduce the energy consumption of the sensor network and increase its lifetime. Improved Hybrid – LEACH protocol which replaces CH in energy efficient way is proposed. The technique is expected to reduce energy consumption, thereby extending the network lifetime as CHs are only replaced when their energy falls below a set threshold. The technique will be implemented using MATLAB R2015b simulation environment.

3. METHODOLOGY

The methodology used in carrying out this work is as follows:

1) Development of the hybrid – leach protocol for wireless sensor networks.
   a. Deployment of the sensor nodes.
   b. Virtual grid was formed by the sensor nodes.
   c. The base station calculated and sets the threshold energy used in selecting cluster heads using prediction based approach.
   d. Clusters were formed and cluster heads were selected for each cluster which depends on the energy availability of the sensor nodes within each cluster.
   e. A protocol that will be checking the residual energy of current CH after every round and compare it with the threshold energy value set by the base station was developed.
2) The scenario used in the hybrid-leach protocol to sense the target area using the following simulation parameters was developed in matlab 2015b (No. of nodes = 100, Coverage area = 100m x 100m, No. of rounds = 6500, X_m = 100m, Y_m = 100m, sink.x = 0.5*X_m and sink.y = 0.5*Y_m.)
   a) Deployment of the randomly generated sensor nodes with uniform distribution within the target area.
   b) Grid topology was formed so that sensor nodes within range can establish connection.
3) Application of the two models developed in 1) using the scenario 2).
4) Performance evaluation of the developed model using number of alive nodes after every round and energy consumption as performance metrics.

Table 1: Network Parameters used for Simulation

S/N	***Simulation Parameters***	***Values***
1	Total Nodes used	100
2	Coverage Area	100*m* x 100*m*
3	Node Transmission radius	10*m*
4	E_{elec}	50 * 10^(-9)J
5	E_{amp}	100 * 10^(-12)J
6	Maximum Interval	6500 rounds
7	Initial Energy	0.5J
8	Kbit	4Kb
9	Band Width	1 * 10^(6) hz
10	X_m (x-axis limit)	100
11	Y_m (y-axis limit)	100
12	Sink.x	0.5*X_m

S/N	*Simulation Parameters*	*Values*
13	Sink.y	$0.5*Y_m$
14	Probability of becoming a CH	0.1
15	Transmission energy (ETX)	50 * 0.000000001 J
16	Energy for receiving data (ERX)	50 * 0.00000000001 J

To ensure efficient data delivery in an energy efficient manner, the following assumptions were made:

a) The network consisted of randomly deployed sensor nodes and base stations.
b) The base stations are more powerful than the sensor
c) nodes and are connected to a replenished energy source.
d) The sensors are deployed in a square field area of $10000m^2$
e) The sensor nodes are inter connected with each other and the density of the wireless sensor network is high enough to allow adequate connectivity.
f) The sensor nodes have a maximum transmission range of *20m.*
g) When the base stations are communicating with the sensor nodes, they are assumed to have the same transmission range in order to ensure adequate symmetric communication.
h) The data information control packet was assumed to be encrypted.

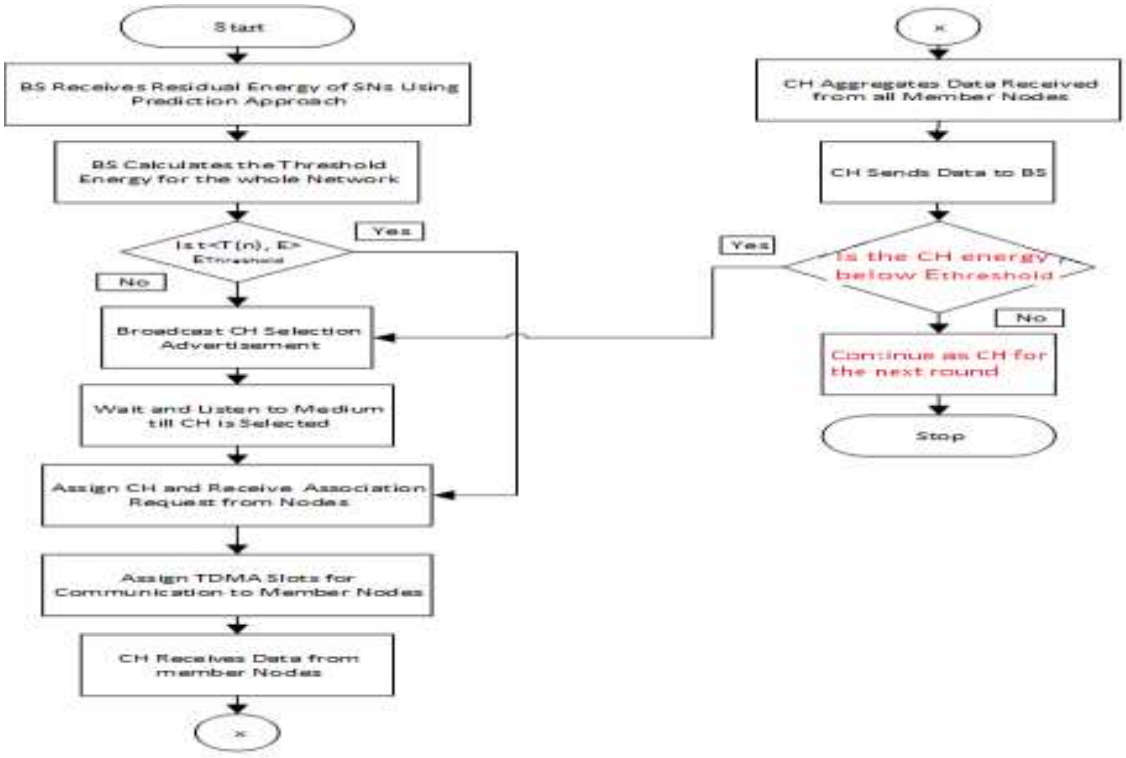

Figure 2: Flowchart for Improve Hybrid – LEACH Protocol

4. RESULTS AND DISCUSSIONS

a. Results obtained using Hybrid – Leach protocol for WSNs

The graph that shows the result obtained after replicating the Hybrid – Leach protocol is as shown in Figure 3.

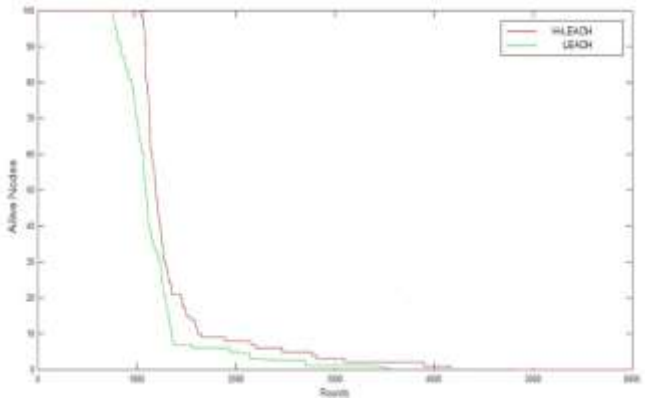

Figure 3: Number of alive nodes against number of rounds

From figure 3, it can be seen that the hybrid – leach protocol it more efficient in terms of energy utilization than the leach protocol. The first node died after 1200 rounds in hybrid – leach while in leach protocol the death of the first node occurs after 750 round, which is 60% improvement in extending the lifetime of the sensor network.

b. Results obtained using the improved Hybrid – Leach Protocol

The improved hybrid – leach protocol seek to improve on the performance of the hybrid – leach by reducing the energy consumption in the sensor network, thereby extending the lifetime of the network. Figure 4.2 shows the result of using the improved hybrid – leach protocol.

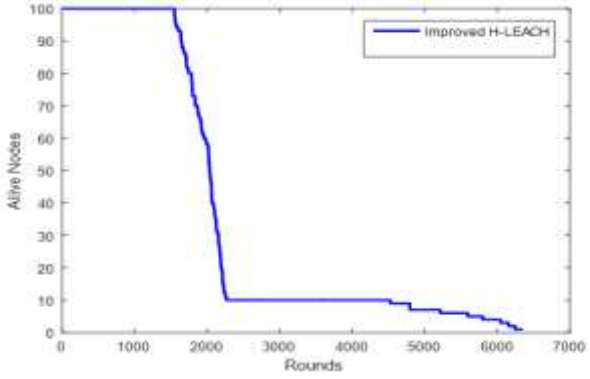

Figure 4: Number of alive nodes against number of rounds

From figure 4, it can be seen that the first node in the network died after 1600 rounds and the last node in the network died after 6400 rounds.

c. Comparison between the Hybrid – Leach and the Improved Hybrid – Leach protocols

Comparison analysis was carried out using number of alive nodes after each round and number of dead nodes after each round

i. Result of Residual Energy Ratio against number of rounds

The chart that shows the percentage of packets successfully delivered to the base station using hybrid – leach and improved hybrid – leach protocols is shown in Figure 5.

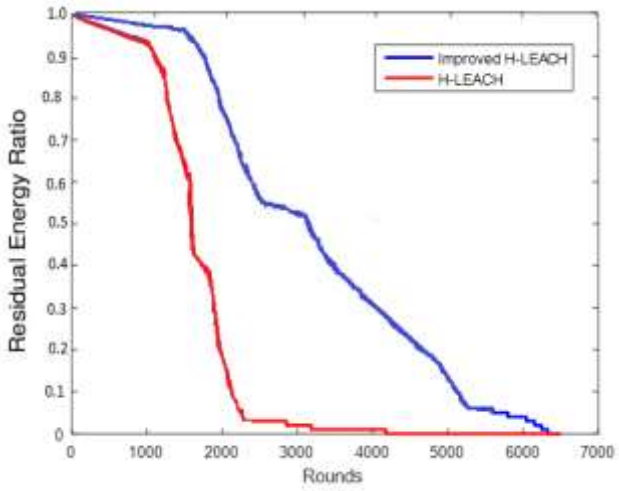

Figure 5: Residual Energy Ratio against Number of Rounds

Figure 5 shows the relationship between the amounts of sensor node's remaining energy and the number of rounds. We can see that cluster heads send more packets to the BS using the improved hybrid – leach protocol than using hybrid-leach protocol, implying that improved hybrid-leach protocol achieved higher energy efficiency than the other protocol.

ii. Number of alive nodes after each round

The number of alive nodes after every round is used to determine the length of time it will take the network to perform its designated task. When the number of nodes was 100, the number of alive nodes after every round was determined as shown in Figure 6.

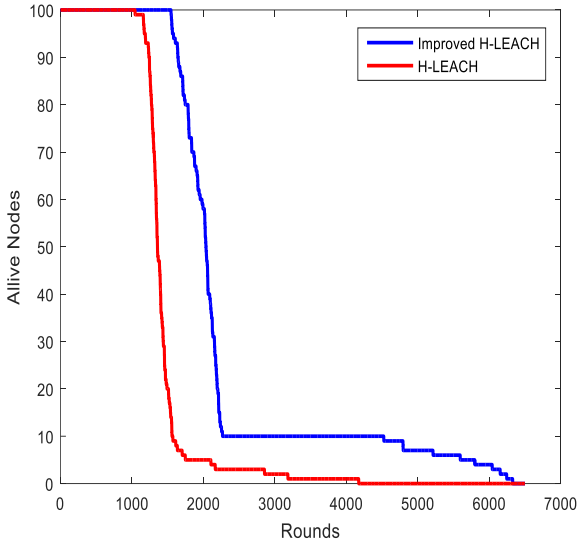

Figure 6: Number of alive nodes after every round

From Figure 6, it was observed that it takes a longer time before the dead of the first node using the improved hybrid – leach protocol than using the hybrid leach - protocol. This was expected, since sensor nodes saves more energy due to elimination of routing overhead cost when selecting CH after every round. For hybrid – leach, the first node died after 1200 rounds while the first node died after 1600 rounds using the improved hybrid – leach protocol. This indicates an energy efficiency of 33.3% of the improved protocol. Also, when using hybrid – leach protocol the last node died after 3450 rounds while some nodes are still alive after 6400 rounds using improved hybrid – leach protocol. This shows 63.77% increase in energy efficiency when using the improved protocol.

iii. Number of dead nodes after each round

Dead nodes in sensor network negatively affect the whole network as data cannot be obtained from such area. This can also result into a network partition situation, which implies that there are two nodes which can no longer communicate with each other. Figure 4.3 shows the number of dead nodes in every round.

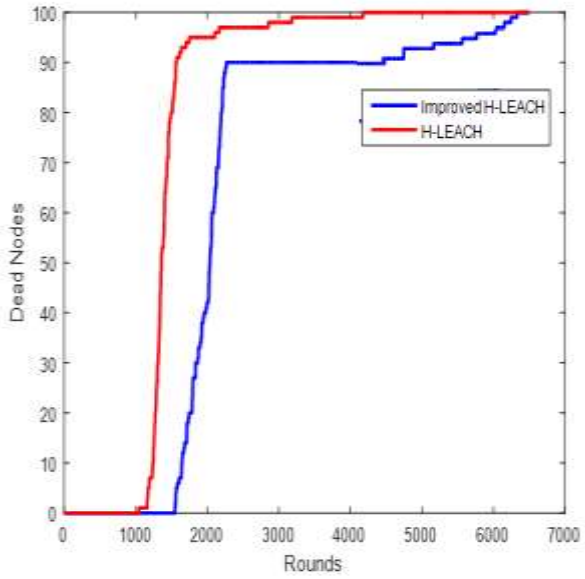

Figure 7: Number of dead nodes after every round

From figure 7 it was observed that using the hybrid – leach protocol nodes could not stay alive after 3600 rounds. However, the network is still alive after 6400 rounds in the case of the improved hybrid – leach, which is more than 63.77% improvement in the life time of the network.

5. CONCLUSION AND FURTHER RECOMMENDATION

This paper presents the development of an improved hybrid – low energy adaptive clustering hierarchy (Hybrid - LEACH) protocol for wireless sensor networks (WSNs), which is an added capabilities and energy savings over the Hybrid – LEACH protocol. The developed improved hybrid - leach showed a packet delivery improvement of 99.78%, lifetime improvement of 33.3% before the death of the first node and 63.77% lifetime improvement before the death of the last node over the Hybrid – LEACH protocol. The improved hybrid – leach protocol for static nodes can be tested with static nodes and mobile BS on an increased coverage area, so as to determine its efficiency as the complexity of wireless sensor network environment increases.

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