Efficient Estimation of Energy Bounds to Ensure Predictability in WSN

G. Vasantha Suganthi and E. Srie Vidhya Janani

Abstract--- *One of the major issues prevailing in Wireless Sensor Network is Network Lifetime. The lifetime of nodes depends on how long it could perform its task completely within the limited power. To obtain optimality, predictability and reliability in Wireless Sensor Network, Cluster Head selection plays a vital role. Optimal Cluster Head utilizes the limited energy in an efficient manner and hence network lifetime is maximized. Hence the work focuses on an optimal Residue Energy Based algorithm for Cluster Head Selection. In this algorithm, node with maximum residual energy and good link quality is selected as a Cluster Head in each round of transmission. To predict whether all nodes, are able to complete its task within the given lifetime requirement, energy bounds are estimated and test will be conducted to check if all nodes are within the bounds or not. The work focuses on determining optimized techniques to predict the lifetime of sensors and research on the impact of deploying high energy nodes to enhance energy conservation over the network.*

Keywords--- *Cluster Head Selection, Energy Estimation, Energy Bounds, Cluster Managers*

NOTATIONS

Notations	Definitions
NN	Number of Nodes
NC	Number of Clusters
NR	Number of Rounds
CH	Cluster Head
$E_{Tr}(p,dt)$	Transmission Energy
$E_{Tr-elec}$	Electronic Energy Consumption
E_{Tr-amp}	Amplifier Energy Consumption
β	Spreading Factor
PL_{fs}	Path Loss Factor for Free Space
PL_{mp}	Path Loss Factor for Multipath Fading
$E_{Rx}(p,dt)$	Reception Energy
EC_{Mkn}	Energy Consumption of Member Node
$EC_{max(MN)}$	Maximum Energy Consumption of Member Node
$EC_{min(MN)}$	Minimum Energy Consumption of Member Node
EC_{CH}	Energy Consumption of Cluster Head
E_{Ag}	Energy for Aggregation
$EC_{max(CH)}$	Maximum Energy Consumption of Cluster Head
$EC_{min(CH)}$	Minimum Energy Consumption of Cluster Head
TE	Total Energy Consumption
TE_{max}	Maximum Total Energy Consumption
TE_{min}	Minimum Total Energy Consumption
CS_i	Cluster Set

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I. Introduction

WIRELESS Sensor Network [12],[15],[16],[19],[24](WSN) consists of autonomous sensors to monitor physical or ecological surroundings[13], such as temperature, sound, pressure, etc. and to transfer their data over the network to destination. The development of wireless sensor networks are used in many manufacturing and end user applications, such as radiation sensor networks [17], natural environment protection, and control and health monitoring [14], etc. Sensor nodes are equipped with processing unit, with limited computational power and limited memory. Sensors are used to sense, process and record conditions in different location. Every sensor node has a power source typically in the form of a battery. The base stations are one or more components of the WSN with infinite energy and communication resources. They act as an interface (gateway) between sensor nodes and the end user as they typically forward data from the WSN to a server.

The limited energy constraint [20], [23] is considered to be a chronic issue prevailing in WSN. Each and every individual sensor node in the network should perform sensing, processing and communication tasks. Due to limited energy, nodes die in earlier before they complete their entire operation. This leads to the necessity of efficient utilization of limited power. Another leading issue in sensor network is reliability [11]; because of its wide range of application real time environment. In the case of time critical events, data should be delivered within the specified time deadlines. If suppose sensor nodes are not able to deliver or complete its operation due to link failure or low energy level or prone to death because of energy depletion, then it leads to heavy damages in the system. Hence, Prediction mechanism is needed to observe the energy level and lifetime of sensors.

This work focuses on ensuring optimality, predictability and reliability in WSN by introducing Residue Energy Based algorithm for Cluster Head selection. The energy bounds are estimated at each round of transmission. Based on these bound values, the sensor nodes that are schedulable for transmission are predicted. To avoid packet loss that is to ensure reliability, Cluster Manager Nodes (high energy nodes) are deployed and those act as a gateway that performs aggregation. Hence it reduces the load of Cluster Head, and in turn energy will be utilized in an efficient manner; which leads to the ultimate lifetime maximization of the network.

II. RELATED WORK

Due to the challenges in WSN such as limited power, clustering architecture is used to maximize network lifetime. In hierarchical cluster [10], certain number of leaders is elected; and these leaders are called as Cluster Head. After the Cluster Head election, clusters are formed by selecting its member nodes. Cluster Head performs data collection and compression work on the data collected and finally transfers the compressed data to the base station. Once optimal Cluster Head is selected, network life time will be maximized. Various algorithms are proposed for Cluster Head selection. LEACH [2],[25] protocol selects Cluster Head based on the probabilistic manner. During CH selection energy level of nodes is not considered; therefore nodes were prone to run out of energy in earlier. ACW [3] mechanism is based on back off procedure and if initial length of contention window is not properly set, then Cluster Head selection is not efficient. But compared to LEACH, Cluster Head selection is uniformly distributed over the network. CIPRA [4] based on in-networking aggregation; each node performs aggregation, so amount of data transferred is minimized. In the case of multiple Cluster Head selection energy parameter should be considered. ERA [5] based on residual energy concept. Cluster Head selection is same as LEACH; but cluster formation is based on the path which has maximum residue energy. LEACH –C [6], in this base station calculates the average energy of the network by collecting energy information from all other nodes. If any node could not communicate with base station, then Cluster Head selection is not optimal. In the case of EECHSSDA [7], Cluster Head selection is same as LEACH –C. In this, if energy drains out in Cluster Head, then Associate Cluster Head will acts as a Cluster Head. Here there is no need to select Cluster Head periodically. HEED [8] based on residual energy and intra cluster communication cost. In practical, for large networks estimation of communication cost is very difficult. In Probalistic Clustering algorithm [9], is the extended version of HEED. This algorithm is used to generate a small number of CH in relatively few rounds, especially in sparse networks. In HEF [1] the Cluster Head is elected based on maximum residual energy among the sensor nodes. It supports for deriving life time bounds for performing schedulability test to ensure predictability of the nodes.

From these earlier algorithms, it is observed that all of them unconditionally prolong network lifetime, but optimality cannot be ensured. Some of the algorithms [2], [3], [4], do not consider the energy level of the nodes, in such cases it is impossible to predict the lifetime of sensors. On the other hand some algorithms, with reference to [5], [6], [7], [8], [9] energy factor is considered. Therefore it is possible to obtain the Optimal Cluster Head which can prolong the network lifetime. But none of these algorithms consider the prediction of network life time and reliable delivery of packets. But with HEF [1], ensures predictability in terms of finding the lifetime of sensor nodes.

The work introduces, Residue Energy Based algorithm which focuses on the prediction of lifetime and selects an Optimal Cluster Head. Cluster Managers are used for ensuring reliable delivery of packets without any loss. These Cluster Managers are act as gateway nodes for Cluster Heads and reduce the load of Cluster Head by performing aggregation. This in turn leads to maximization of network lifetime and increase in packet delivery rate in comparison to previous approaches.

III. OPTIMAL CLUSTERING

Residue Energy Based algorithm (REB) considers residual energy as well as link quality of nodes. Link quality is estimated by four bit estimator[26] that measures the asymmetry level of nodes. Nodes those are having low asymmetry level will be considered as good quality link. REB is based on hierarchical clustering model. In hierarchical model, each cluster set has one leader called as Cluster Head (CH) and set of member nodes. Member nodes send data to their corresponding CH. CH performs aggregation and transfer data to base station. The execution of REB algorithm is divided into rounds. Each round consists of three main processing areas; i) Cluster Head Selection ii) Cluster Set Formation iii) Data Transmission.

A. REB Algorithm

```
1. Declare nc, nr, and nn;
2. for round 1: to nr
// CLUSTER HEAD SELECTION
    Select CH based on maximum residual energy and
with good link quality
// CLUSTER SET FORMATION
3. For each selected CH
Broadcast ADV message to other nodes along with its ID
4. Nodes receiving ADV message except CH
   i) Select their CH according to closest proximity
  ii) Send ACK message to their CH
5. After receiving ACK from member nodes,
   i) CH creates time schedule for their member set.
  ii) Announces the time slot to their members for their
communication
// DATA TRANSMISSION
6. Based on the allocated timeslot member nodes transfer
data to CH.
7. After receiving data from all members
   i) CH does the aggregation process
  ii) Transfer compressed data to base station.
8. Calculate energy consumption for each node
End
```

This pseudo code describes the overview of the REB procedure and provides detailed description of cluster set formation area. For estimating energy consumption, energy consumption model should be designed. This will be described in detail in the following section.

IV. ENERGY CONSUMPTION MODEL

Energy is the major constraint in WSN. Energy consumption of nodes vary depends on their operation. In our work, first order radio model [2], [21] is used for energy estimation. Each and every node in sensor network senses the data, processes the data, and communicates the data to next level. In the case of CH, it additionally performs aggregation. Hence it spends more energy than other nodes.

In Free space propagation [18], [22] the transmitter and receiver have a clear line of sight path between them. But if there is any obstruction, then the signal waves take multiple path in order to reach the receiver. Free space propagation model considers the distance as the important factor for estimating power consumption. In this model, signal strength at receiver is inversely proportional to square of the distance. Here, both free space and multipath fading channel models were considered for estimating energy consumption at each round.

In REB, during the communication phase in each round, both CH and member nodes transmit and receive data to and from their respective nodes. Communication task includes both transmission and reception of data. So, energy consumption model should estimate transmission energy as well as reception energy for each node. Consider a node that transmits *p*- bit data over a distance *dt ;* transmission energy is calculated as the sum of electronics energy consumption and amplifier energy consumption. Electronics energy consumption is based on coding, modulating and spreading factor. Amplifier energy consumption should be considered because amplifiers are used to amplify the radio waves, allowing wider distribution by reducing distortion in the transmission. In general, an amplifier increases the power of a signal; practical amplifiers have finite distortion and noise which they invariably add to the signal. Therefore in our energy consumption model, path loss factors also considered. Free-space path loss is proportional to the square of the distance (dt^2) between the transmitter and receiver, and also relative to the square of the frequency of the radio signal. In Multipath loss, signals will be reflected and they will reach the receiver via a number of different pathways.

$$E_{Tr}(p,dt) = E_{Tr\text{-}elec}(p)+E_{Tr\text{-}amp}(p,dt) \quad (1)$$

$$E_{Tr}(p,dt) = \begin{cases} p.\beta.E_{elec}+p.PL_{fs}.dt^2 & \text{if } dt<dt_0 \\ p.\beta.E_{elec}+p.PL_{mp}.dt^4 & \text{if } dt>=dt_0 \end{cases}$$

Here, $E_{Tr\text{-}elec}$ is the electronic energy consumption, $E_{Tr\text{-}amp}$ is the amplifier energy consumption, β is spreading factor, PL_{fs} is path loss factor for free space, PL_{mp} is path loss factor for multipath fading. Threshold value is derived from the experimental result such as $dt=dt_0=\sqrt{PL_{fs}/PL_{mp}}$

Reception energy consumption depends only on the number of bits it receives rather than considering distance (dt). Reception energy estimation is expressed as,

$$E_{Rx}(p,dt)= E_{Tr\text{-}elec}(p) = p.\beta.E_{elec} \quad (2)$$

From (1) and (2) we could estimate energy consumption for member nodes and CH. Energy consumption for CH is always higher than that of member nodes because it does additional computations.

A. *Energy Consumption at Member Node*

Consider the k^{th} member node in the cluster set *n*. All member nodes perform sensing, processing and communication. Energy consumption of the member node is expressed as,

$$EC_{Mkn}=Es + Ep + E_{Tr} + E_{Rx} \quad (3)$$

To estimate the minimum energy and maximum energy consumption in each round the distance from member node to CH should be considered. If member nodes are resided at the end of square sensing field then the distance between CH and member node is maximum. This value is expressed as, $\max(dt_{CH}) = dt_{max(MN\text{-}CH)} = \sqrt{2}S$. Similarly minimum distance value is obtained, when the member nodes are nearer to CH; means that distance value is approximately equal to zero. This value is expressed as, $\min(dt_{CH}) = dt_{min\,(MN\text{-}CH)} \approx 0$. Now we express the maximum and minimum energy estimation for member nodes as,

$$EC_{max\,(MN)} = \max\{Es\} + \max\{Ep\} + 2p.\beta.E_{elec} + p.PL_{mp}.dt_{max(MN\text{-}CH)}^{4} \quad (4)$$

$$EC_{min\,(MN)} = \min\{Es\} + \min\{Ep\} + 2p.\beta.E_{elec} \quad (5)$$

B. *Energy Consumption at CH Node*

All CHs perform sensing, processing, communicating and aggregating the data. Additionally it is necessary to consider energy requirement for aggregation process as well as compression ratio (**α**) for compressing the data. Moreover, energy consumption at CH depends on number of member nodes in the cluster set CS_i and distance from CH to base station. Maximum number of members in a cluster set is (NN-NC+1) and minimum number of members in a cluster set is 1. Now energy consumption of CH is expressed as,

$$\begin{aligned} EC_{CH} &= Es + Ep + E_{Rx} + E_{Ag} + E_{Tr} \quad (6) \\ &= Es + Ep + p.(|CS_i|-1).\beta.E_{elec} + p.|CS_i|.E_{Ag} + \alpha.|CS_i|.(p.\beta.E_{elec} + p.PL_{mp}.dt^4_{BS}) \end{aligned}$$

The value of dt_{BS} refers the distance between the CH and base station. Maximum distance value is obtained by $\max\{dt_{BS}\} = dt_{max(CH\text{-}BS)} = \sqrt{(S/2)^2+(S+\Delta S)^2}$. Minimum value of the distance is $\min\{dt_{BS}\} = dt_{min\,(CH\text{-}BS)} = \Delta S$. Now we express the maximum and minimum energy estimation for CH as,

$$\begin{aligned} EC_{max(CH)} = {} & \max\{Es\} + \max\{Ep\} + p.[(NN-NC)(\alpha+1)+ \\ & \alpha].\beta.E_{elec}+p.(NN-NC+1).E_{Ag}+p.(NN-NC+1). \\ & \alpha.PL_{mp}.dt_{max(CH\text{-}BS)}^{4} \end{aligned} \quad (7)$$

$$EC_{min(CH)} = \min\{Es\} + \min\{Ep\} + p.E_{Ag} + \alpha.(p.\beta.E_{elec} + p.PL_{mp}.dt_{min(CH\text{-}BS)}^{4}) \quad (8)$$

C. Total Energy Consumption at Each Round

Total energy consumed in each round could be calculated by the sum of energy consumed by Cluster Head and member nodes. Hence we get,

$$TE = \sum_{i=1}^{NC} EC_{CHi} + \sum_{i=1}^{NC} \sum_{j=1}^{|CSi|-1} EC_{Mji}$$

From the equations (4), (5), (7), (8), we can obtain the maximum and minimum energy consumption at each round respectively as,

$$TE_{max} = NC.\ EC_{max\,(CH)} + (NN-NC).\ EC_{max\,(MN)} \quad (9)$$

$$TE_{min} = NC.\ EC_{min(CH)} + (NN-NC).\ EC_{min\,(MN)} \quad (10)$$

V. PREDICTABILITY OF LIFETIME

In the case of time- critical constraints, predictability is important criteria than speed or energy efficiency because if life time requirements are not satisfied by the sensors, it leads to heavy damage in the system. Therefore reliability of the system is affected. In time critical WSN, it is necessary to predict whether all sensor nodes are able to perform its function completely within the available energy. Here, it is possible to monitor the behavior of system that is how much energy could be consumed by sensors at each round and how many sensors can survive after each round with respect to energy bounds. In order to carry out the prediction, three steps should be followed:

1. Define the Network topology with the required configuration parameters.
2. Estimate the maximum and minimum energy consumption value for both Cluster Head and member nodes.
3. Derive the energy bounds and conduct schedulability test. If all nodes are schedulable, then the system ensures reliability. Otherwise, topology should be changed.

A. Derivation of Energy Bounds

The lifetime of the network is considered to be number of rounds and it is denoted as NR.

1. Check whether the node runs out of its energy before reaches its NR. If it is true, then the node is not schedulable under the given lifetime requirement.

To do this, we estimate the minimum energy consumption for given network lifetime and it is obtained from the equation (10) as,

$$EC_{min(NR)} = NR\ .\ TE_{min} \quad (11)$$

It is cleared that, if sum of total maximum energy consumption of all nodes under the given lifetime is below the $EC_{min\,(NR)}$, then REB is not feasible.

2. Check whether it is possible to select the specified number of CHs (NC) at the given lifetime requirement. If not, then REB is not feasible. If this occurs, it is possible to select only (NC-1) CHs at a particular round and remaining nodes have maximum residual energy as ($EC_{max(CH)} - u$).It is cleared that, if sum of total maximum energy consumption of all nodes under the given lifetime is above the maximum energy consumption under given (NR-1), then REB can schedule the nodes.

$$EC_{max\,(NR)} = (NR-1).\ TE_{max} + \Phi + u \quad (12)$$

where Φ is expressed as,

$$\Phi = (NC-1).\ EC_{max\,(CH)} + (NN-NC+1).(EC_{max(CH)} - u)$$

B. Schedulable Conditions for Nodes

1. If any node has its maximum possible energy less than $EC_{min(NR)}$, then that node is not schedulable because even it could not act as a member node.
2. If any node has its maximum possible energy greater than or equal to $EC_{min(NR)}$ and less than $EC_{max(NR)}$, then it may or may not be schedulable.
3. If any node has its maximum possible energy greater than $EC_{max(NR)}$, then it is possible to schedule.

VI. SIMULATION RESULTS

In the Simulation Environment, 100 sensor nodes are deployed in a square region1500 *1500 meters in size. Nodes are distributed in random manner. Base station is located outside the sensing field. The performance of REB is learnt from comparisons with the protocols HEED and LEACH through simulation. The following are the simulation parameters considered

Table I: Simulation Parameters

Parameters	Value
Number of Nodes	100
Number of clusters	5
Network Size	1500 * 1500
Radio Electronics Energy (E_{elec})	50 nJ/bit
Radio amplifier Energy for free space (PL_{fs})	10 pJ/bit/m^2
Radio amplifier Energy for multipath fading (PL_{mp})	0.0013 pJ/bit/m^4
Data Aggregation Energy (E_{Ag})	5 nJ/bit
Compression ratio (α)	0.5

A. Minimum Energy Level

To provide guarantee for scheduling all nodes within the given life time requirement, it is necessary to calculate minimum remaining energy for all nodes. Here, simulation samples minimum energy level of all sensor nodes for every 10 rounds. X axis represents life time in terms of number of rounds. Y axis represents minimum energy level at each round. REB is compared with LEACH as well as HEED protocol.

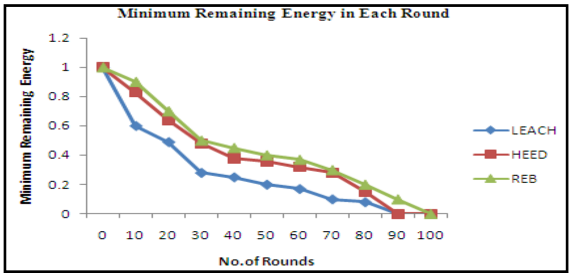

Fig. 1**:** Minimum Remaining Energy with Respect To Network Lifetime

Table II: Minimum Remaining Energy with Respect to Network Lifetime

Protocol	Life time (X axis)	Minimum Energy (Y axis)
REB	10,20,30,50,70, 80, 90,100 rounds	1,0.9,0.7,0.5,0.45, 0.4,0.37,0.3,0.2,0.1,0
HEED	10,20,30,50,70, 80, 90 ,100 rounds	1,0.83,0.64,0.48,0.38, 0.36,0.32,0.28,0.15,0,0
LEACH	10,20,30,50,70, 80, 90,100 rounds	1,0.6,0.49,0.28,0.25, 0.2,0.17,0.1,0.08,0,0

With the same energy distributions, REB has higher minimum residual energy than LEACH and HEED. REB, LEACH and HEED have the same residual energy in the beginning, but REB gradually has exhibits higher minimum residual energy than LEACH and HEED after a certain period of time. The results show that REB prolongs the network lifetime far better than LEACH and HEED.

B. Initial Energy Level

By varying initial energy from 1 J to 5 J, the network lifetime is analyzed. With the increase in initial energy, the lifetime for all schemes increases, but REB prolongs the network lifetime to the maximum when compared to LEACH and HEED.

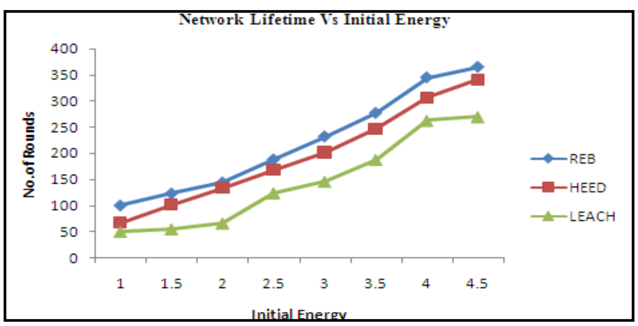

Fig.2: Comparison of Network Lifetime with Respect to Initial Energy Levels

Table III: Network Lifetime Exhibited With Respect To Initial Energy Levels

Protocol	Initial Energy (X axis)	No.of Rounds (Lifetime) (Y axis)
REB	1,1.5,2,2.5,3,3.5,4,4.5	100,123,144,188,232,277, 345,365
HEED	1,1.5,2,2.5,3,3.5,4,4.5	67,102,133,168,202,247, 306,341
LEACH	1,1.5,2,2.5,3,3.5,4,4.5	50,55,66,124,146,188, 263,270

The above graph concludes that, for the higher initial energy levels, REB prolongs the network lifetime to the maximum when compared to LEACH and HEED.

In this, REB is statistically proved by conducting experiments repeatedly. For every 50 rounds, experiments were conducted repeatedly for 10 iterations. It is found that the deviation between the current iteration and previous iteration is approximately equal to zero. Hence it is proved that, REB is the best one for prolonging network lifetime.

Table IV: Mean Energy Values For REB in Iterative Manner

Rounds	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
50	1.02597	1.02596	1.02596	1.02596	1.02596	1.02596	1.02597	1.02597	1.02597	1.02597
100	1.5005	1.5002	1.5005	1.5002	1.5005	1.5002	1.5005	1.5002	1.5005	1.5002
150	2.1	2	2	2	2	2	2.1	2.1	2.1	2.1
200	2.5	2.3	2.3	2.3	2.3	2.3	2.5	2.5	2.5	2.5
250	3	2.9	2.9	2.9	2.9	2.9	3	3	3	3
300	3.8	3.6	3.6	3.6	3.6	3.6	3.8	3.8	3.8	3.8
350	4.1	4	4.1	4	4.1	4	4.1	4	4.1	4

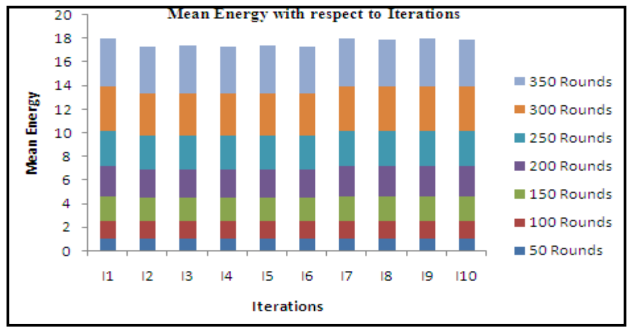

Fig. 3 Mean Energy Value with Respect to Iterations

It also shows that, by increase in initial energy, remaining mean energy increases. It is concluded that REB prolongs network lifetime in a deterministic manner.

a. Mean Energy Vs Lifetime

The following graph shows that, mean energy level for REB is higher than HEED and LEACH with respect to network lifetime. This in turn indicates that network lifetime is maximized in REB when compared HEED and LEACH.

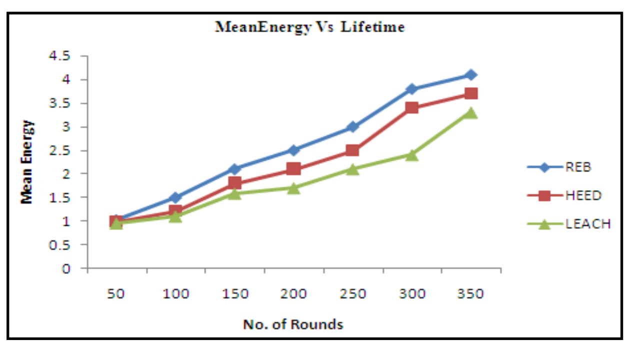

Fig. 4 Comparison of Mean Energy Level with respect to Network Lifetime

Table V: Mean Energy with Respect to No. of. Rounds

Protocol	No.of Rounds (X axis)	Mean Energy (Y axis)
REB	50,100,150,200, 250,300,350	1.02597, 1.5005, 2.1, 2.5, 3.0,3.8,4.1
HEED	50,100,150,200, 250,300,350	0.9834, 1.19835, 1.8, 2.1,2.5,3.4,3.7
LEACH	50,100,150,200, 250,300,350	0.9515, 1.10153, 1.585, 1.7, 2.1, 2.4, 3.3

b. Mean Energy Vs Initial Energy

With increase in initial energy remaining mean energy level for REB is higher than HEED and LEACH. This indicates that, REB prolongs the network lifetime to the maximum when compared to LEACH and HEED.

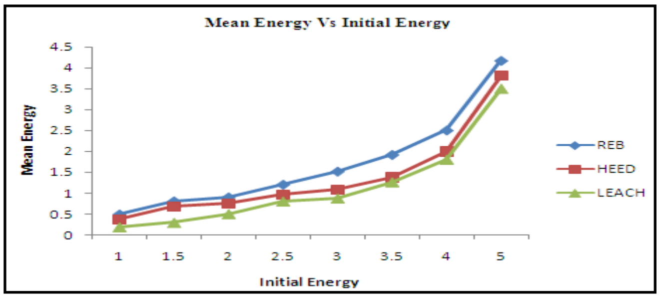

Fig.5: Comparison of Mean Energy with respect to Initial Energy Levels

C. Schedulability Bounds

The Upper Bounds and Lower Bounds are estimated based on the minimum energy requirement for the given lifetime and maximum energy consumption required for previous round respectively. X-axis refers to the total sum of the maximum energy consumption for the lifetime requirement and Y-axis refers to the corresponding lifetime.

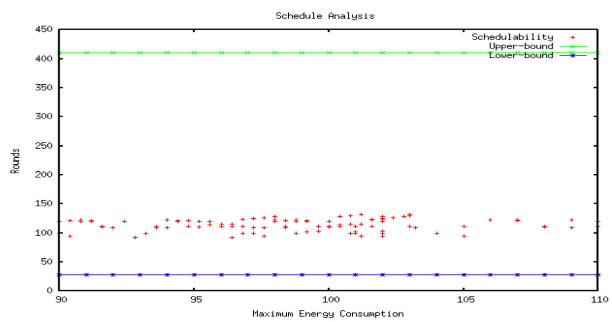

Fig. 6: Schedulability Bounds

In this graph, for the given lifetime requirement total maximum energy consumption of the node set is compared with its estimated bounds. If they satisfy the schedulability criteria then the node set are scheduled. In our work, schedulability test is conducted for 100 times. All the experimental results are bounded within the estimated bounds. Hence it indicates that, by conducting schedulability test based on energy bounds, it is easy to predicate the lifetime of sensor nodes. Here the energy bounds ensure that the N-of-N network life time that is, it provides guarantee for scheduling all the sensor nodes with respect to their lifetime.

VII. CONCLUSION AND FUTURE WORK

REB algorithm ensures both optimality and predictability in WSN especially in time – critical WSN. By obtaining the optimal Cluster Head in each round, energy efficiency is maximized and hence network lifetime is maximized. Here, we were able to derive the upper and lower bounds of network lifetime. These bounds are helpful to predict whether the sensor set is schedulable or not, within the given lifetime requirement.

In future, REB should be fine tuned to focus on reliability of the system. To ensure reliability, that is to avoid packet loss and also to minimize the energy consumption, Cluster Managers Nodes (high energy nodes) are deployed. The Cluster Managers are similar to Gateways that collect data from Cluster Head and performs aggregation and forwards it to Base Station. For each cluster, one Cluster Manager is deployed. Placement of Cluster Manager is based on, finding the data point which is nearest to CH and then add/subtract Δx and Δy values with the closest index. To minimize energy consumption, CM is located nearer to the CH. Load of Cluster Head is minimized by assigning aggregation task to Cluster Manager. Hence energy consumption at Cluster Head is minimized and lifetime of the network is maximized. In terms of reliability, Average end – to- end Delay, Throughput, Packet Delivery ratio, Percentage of Packet Dropped metrics are analyzed with existing approaches. Due to the placement of Cluster Managers, the performance of network becomes better than previous techniques. The work focuses on determining optimized techniques to predict the lifetime of sensors and research on the impact of deploying high energy nodes to enhance energy conservation over the network. The future work is expected to provide better results in terms of network lifetime and reliability.

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