An Energy Efficient Routing in WSNs with Forward Next Hop Selection

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by

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2015.

Dedicated to my parents and teachers

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Certificate

This is to certify that the work in the thesis entitled **" *An Energy Efficient Routing in WSNs with Forward Next Hop selection* "** submitted by ***Mohd Arif*** is a record of an original research work carried out by him under our supervision and guidance in partial fulfillment of the requirements for the award of the degree of Master of Technology in Computer Science and Engineering, National Institute of Technology, Rourkela. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

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Abstract

Nowadays, wireless sensor networks (WSNs) are dramatically becoming more popular and widely being used in variety of application like battlefield,medicals and several other areas because they are cheap in cost and have the ability to sense data irrespective of environment harshness. When we say wireless sensor network then it refers to a collection of sensor nodes arranged into a Prespecified/random way in the concerned Geographical region.

Sensor Networks are able to fulfill many purpose of human life but they also have limitation, one and most crucial one is its limited battery power because sensor nodes are smaller in size and in most of the cases battery recharging or replenishment is not possible so efficient utilization of energy resources is important, Routing in WSNs consumes the most of sensors nodes energy if we are able to make an energy conserving routing protocol then we will be able to conserve the considerable amount of energy which will enhance the Network lifetime.

We have suggested An Energy Conserving Efficient Routing Protocol with Forward Next Hop Selection in which network is divided into clusters and there is inter cluster routing between cluster heads with an optimized minimum distance next hop selection which have taken the features of clustering and multi-hop we have also partitioned the network in different transmission level so that node can transmit at minimum possible energy level after adjusting its transmission power at the beginning of cluster formation phase.

We have simulated our model in MATLAB and result is compared with LEACH and found it better in terms of Network lifetime and average energy consumed by Cluster Heads.

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List of Acronyms

Acronym	Description
WSN	Wireless Sensor Network
BS	Base Station
FAF	Forward Aware Factor
LEACH	low energy Adaptive clustering hierarchy
CHs	Cluster Head

Chapter 1

Introduction

Architecture of WSN

Protocol Stack for WSN

Comparision of WSN and Ad-hoc Network

Organization of Thesis

Chapter 1

Introduction

This chapter describes the overview of the thesis. In Part 1.1 We have given the basic introduction to wireless sensor Nodes describing its architecture and protocol stacks. In Part 1.2 We have made a basic Comparison between WSN and Adhoc Network ,Part 1.3 gives a brief idea where WSN can be applicable and last part 1.4 tells how we have organized the thesis.

1.1 Formal Introduction to WSN

WSNs are interconnection of vast randomly deployed sensor nodes. These nodes sensed the physical parameters of environment like,humidity,Tempratture,etc [1] .Every node directly or indirectly transmit the data to base station.

Energy is the key issue in WSNs and several routing protocol has been designed and developed for minimizing the consumption of the Energy.Hierarchical or cluster based routing protocol were designed to use the energy efficiently by dividing the network into groups of nodes called cluster in which few nodes works for gathering the data and transmitting it to the Sink called cluster heads while rest lower energy nodes are responsible to sense the environment this model was developed for making network lifetime longer and making network more scalable which makes it very popular in the field of wireless sensor network.

a version of hierarchical routing protocol has been proposed which divides the network at different level of transmission power, at each level different clusters are formed and inter cluster routing between same level cluster and different level cluster are done in multi-hop fashion.

1.1.1 Architecture of WSN

Every sensor node mainly consists of four components.They are to process, to sense, power source and transceiver. A few of them have optional components like power generating source, GPS like system system and mobility monitor.

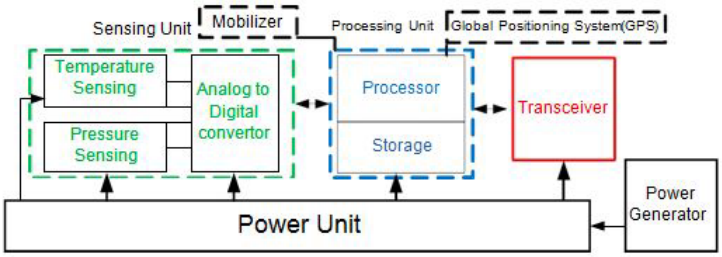

Figure 1.1: Architecture of WSN

To sense it has sensor and ADC (Analog and digital converter). before transmitting its pre converted using ADC circuit. Transceiver Recieving an transmitting the data.Management of the task in sensor unit is done by its processing unit, which have processor and memory, whereas node movement are enable by Mobilizer.

1.1.2 Protocol Stack of WSNs

protocol stack of WSNs Description of each layer is as follows

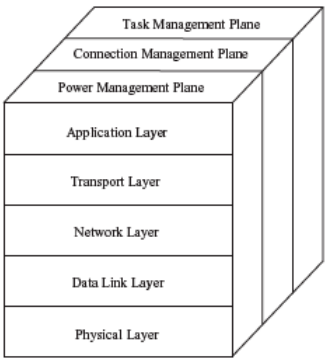

Figure 1.2: protocol Stack of WSNs

- **Physical Layer :** This layer addressing the robust modulation needs,receiving techniques and transmission.

- **Data link layer:** Minimize collision with the neighbouring broadcasts.
- **Network Layer:** Various routing are performed here.
- **Transport Layer:** Flow of data is being maintained here.
- **Application Layer:** Various application software runs here depending upon sensing task. Utmost important part of a sensor node is its battery power.So in order to enhance the network life time it should be utilized properly.For this various methods have been proposed till now.Out of which Routing has utilized the sensors nodes energy very effectively.

1.2 Comparison Of WSNs And Wireless Adhoc Network

- **Network Size:** WSNs nodes varies from few hundered node to thousands of nodes but WANETs consist of limited no. of nodes i.e few hundereds of nodes.Bluetooth pico net is an example of WANET.WLAN is also example of WANET.
- **Network Density:** Network density in WSNs is usually high,with big quantity of nodes are close to each other but in case of WANET very few nodes are close to each other.The size of nodes of WSN is very small.they cons sized but nodes of WANET are generally laptops,palmtops,cellular phones etc.
- **Network Prone to failure:** WSNs nodes are placed in inaccessible areas or isolated areas like forest or disaster areas.Nodes once deployed in this areas are very difficult to replace.The nodes may drain there energy or they may be damaged.But MANETS have rechargeable batteries in their nodes.This node are not for difficult environmental conditions that cause them a damage.
- **Frequency of Topology Change:** Topology change frequency is high in WSNs because of node failure,node addition,node moving and environmental intreference.The network has to adapt iteself to the changing topology.topology may change in few milli seconds in WSNs.In WANETs joining of nodes in network is time taking sometimes sometimes few minutes ,

- **Communication paradigm:** WSNs uses the mechnism of broadcasting in order to communicate with the other nodes but WANETs uses point to point communication.
- **Limitation on resource for nodes:** The Energy resourses of WSN elements cannot be re energized,because unlike WANETs the WSNs do .once the nodes are deployed in the environment, they cannot be re filed.The memories of WSNs is of few Kilobytes but that of WANETs is of Gigabytes.The processors used in WSNs are of few MHz but that of WANETS is of GHz.
- **Node Identification:** : Node identification by globally identifer are not always possible in WSNs,since the no. of node in WSNs is very high and there is a possibility the nodes may exit the network very frequently.In WANETs nodes have unique identifiers like IP(Internet Protocol) address.

1.3 Application of wireless Sensor network:

WSNs are for variety of application they sense the environment process it and do the manipulation based on the requirement of the application.Few from huge variety of application are listed below:

- **Environmental condition monitoring:**It includes sensing Volcanoes, oceans,Glaciers, forest.
- **Industrial monitoring:**It includes Machine health monitoring,Factory.
- **Agriculture:**Irragation management,green houses.
- **Battlefield awareness.**

1.4 Design challenges for routing

The main challenges are

- **Scalability:**Scalability: If Sensor nodes are increased in the sensor networks then networks functionality should not be decreased but it should increase it it is called scalable network. Routing Protocol must be able to handle large size of network without affecting network performance.
- **Fault Tolerance:** The capability of network to function prone to some sensor node failures. Sensor nodes may stop working due toout of energy or damage. Performance of network not depend on inactivity of few nodes.
- **Production Cost:** nodes in the network should be cheap. production should be concentrated on specific application excluding unwanted features and deployment cost should not be affected by the quality of Nodes.
- **Power Constraints:** Large scale WSNs have extremly low energy and power at their disposal.So Routing can be designed in such a way that transmission and reception of data is fully justified.

1.5 thesis Organization

Our thesis is organised as: Chapter 1. presents Introduction,Chapter.2 presents related work, Chapter.3 describes the Proposed work,Chapter.4 describes the Simulation and result and Chapter 5 concluded the thesis and describes what improvement can be done in future.

Chapter 2

Literature Survey

Chapter 2

Literature Survey

In this chapter design issues of WSN are introduced and some well known routing schemes are discussed.

2.1 Overview of routing protocol

Protocols in WSNs routing can be categorized as follows:

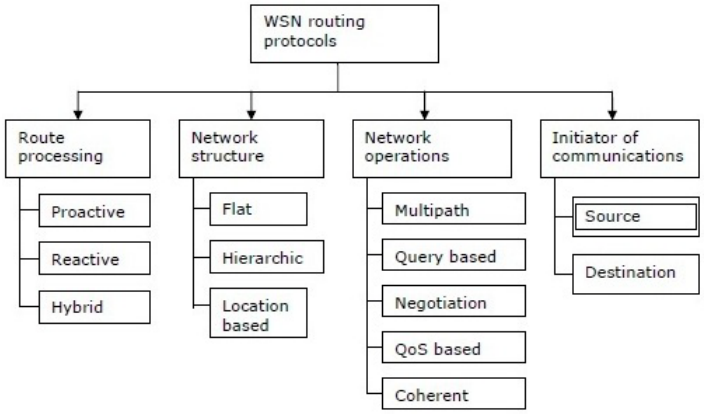

Figure 2.1: Protocols for Routing in WSN

2.1.1 Flat Routing

In a network, the sensing node work together to sense the required feature. The assigning of the global identifier to each node is not possible in the WSN, as the area to be covered is very large. In routing, BS send query to certain region and waits the reply. SPIN(Sensor Protocol For Information Via Negotation)[13,15], Dirrected Diffusion,Rumour Routing, are Data Centric routing.

2.1.2 Hierarchical Routing

Hierarchical protocols in routing are cluster base routing protocols.Hierarchical routing have good scalability and energy efficiency in communication.In this routing protocols the nodes with higher energy does data aggregation/processing and send the aggregated data to the sink and lower energy nodes monitor the environment for data and send the sensed data to higher energy nodes.Hierarchical routing tries to improve network lifetime,overall energy efficiency and scalability of sensor nodes by creating clusters,cluster heads and performing data fusion within the clusters.PEGASIS(Power Efficientt Gathering In Sensor Information Systems), LEACH(Low Energy Adaptive Clustering Hierarchy), SMECN(Small Minimum Energy Communication Network), HEED (Hybrid Energy-efficient Distributed Clustering approach) are few of its examples.

2.1.3 Location Based Routing

Location is used to address the sensor nodes in this type of routing. Incoming signal strenght is used to determine the distance between the nodes. In some instances GPS(Global Positioning System) may be used to find the location of the nodes.GEAR(Geographic And Energy aware Routing), GAF (Geographic Adaptive Fidelity) [21], SPAN[19] are some of the location based routing protocols.

2.1.4 Key Problems Of Routing Protocols

To Design an algorithm for WSNs, following issues must be considered. Sensor nodes are battery-operated and most often constrained in energy due to the inability of recharging of nodes.Hence one important method in protocol design is the energy consumption.

* Sensor nodes should be sensitive and adaptive to the dynamic environment when they are deployed.
* A sensor network algorithm should be self-organizing and distributed since WSNs is infrastructure less.

* The security of the nodes should be considered.
* Scalability is another important factor to be considered when designing a topology for WSN.

Clustering routing protocols[12] have provided much longer network lifetime in contrast to a routing protocol and other routing protocol. In clustering routing protocol network is divided into number of clusters and a special node in each local cluster is the CH(cluster head) which collects data from the sensor nodes within a cluster and then received data is aggregated from sensor nodes, then transmit it to the base station(BS).

2.1.5 Clustering Advantages

Main advantage of clustering routing is that it the try to minimize packets or data transmission.Clustering protocols allows NCH(non cluster head) nodes to transmit data to shorter distance in order to save their energy. Advantages Of Data Aggregation :Various types of data aggregation have been proposed till date.In[11] a new data aggregation was introduced which compresse the data,originally inspired by[10].Theauthor of[11] discussed different data aggregation schemes:in-network,grid based,hybrid based.The most commmonly used data aggregation such as in LEACH and LEACH like protocols assumes perfect aggregation in which multiple packets are send fron the cluster members to their respective cluster-heads but only a single copy is forwarded to the base station.

2.2 Related Work

In Cluster based routing protocols w network is divided into clusters. Then cluster head are formed in each cluster. The role of the cluster head is to collect the data from the other nodes present in the cluster and the transmit it to the Sink. Because of this the routing overhead of the node in the cluster is reduced. Some of the cluster based routing protocols are discussed in upcoming sections.

2.2.1 Direct Communication

Every node in direct communication is considered to be in the range of communication to BS and they have the knowledge, which one is the base station. If nodes don't have any idea about base station then BS announces itself by broadcasting a message . After this each nodes in the range of Sink directly transmits data to central station. So in this way there is direct transmission between Nodes and Base Stations and due to this, nodes deplete their limited energy very rapidly and die.

The main advantage of direct transmission is its simplicity there is no synchronization between Nodes. And very simple broadcast message to sensor nodes from Base station announcing itself a base station. The major con is collision, which can produce a serious problem even in small size network.

2.2.2 LEACH(Low energy adaptive clustering hierarchy)

LEACH(low energy adaptive cluster hierarchy)[2] is one of the famous cluster based routing protocol in WSN in which all sensor nodes in network is grouped into cluster , in each cluster there is special node which take care of gathering the information in its local cluster and transmitting it to the Sink .LEACH uses the random rotational approach to select cluster head in such a way that energy depletion is uniform in the network and participation of nodes in the election of cluster heads is in round robin fashion.

Whole protocol is in two phases

1. setup phase.
2. Seady state phase.

1.setup phase

In this phase wireless sensor nodes in network are grouped into clusters and selection of cluster head is done. For each round, a random number X is chosen in the range of 0 and 1. If X is less than threshold Tn, then that node will become a CH(cluster head).

$$T(n) = \frac{p}{1-p} rmod(p-1)$$

r is the round number in progress, p is the probability to become CH of each node and G defines a set of nodes which could not become cluster head in last 1/p rounds.

After deciding which nodes will serve as a cluster head in current round .An ADV(advertisement message) will be broadcast-ed by each cluster head which is a small message consisting of the Node ID and a header which describe itself as a announcement message. All non-cluster joins a cluster head which require the minimum energyto communicate. Which is calculated by signal strength of message announcement and send a request message(JOIN-REQ) to cluster Head that they are going to be the member of the that particular cluster.CHs setup a TDMA schedule and transmit this schedule to its member nodes.to ensure that there is no collision between the messages.

2.steady state phase

This phase is broken into different frames where nodes transmit data to respective cluster-head. This phase does not ensure that nodes are equally distributed in clusters. So size of cluster varies with considerable number. In LEACH, so the amount of data received to cluster head also vary because of difference in number of nodes in particular cluster.to reduce the energy consumption each cluster head adjust its transmission power according to the received minimum signal strength . Until the non-cluster-head nodes allocated transmission time is not reached, there radio remains off. The TDMA schedule is used for trans-

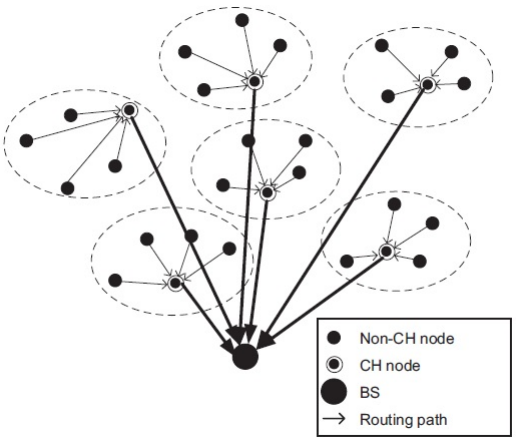

Figure 2.2: Clustering in Leach Protocol

mitting data, as each node had to transmit the data within a fixed total bandwidth. The reason is, it is a energy efficient method and has a low latency [5][9]. And it also uses the available bandwidth efficiently. The cluster-head must be in receiver mode, so that it receive the data from the nodes in the cluster. After receiving the data, it processes the data and then the data are transmitted from the cluster-head to the Sink.

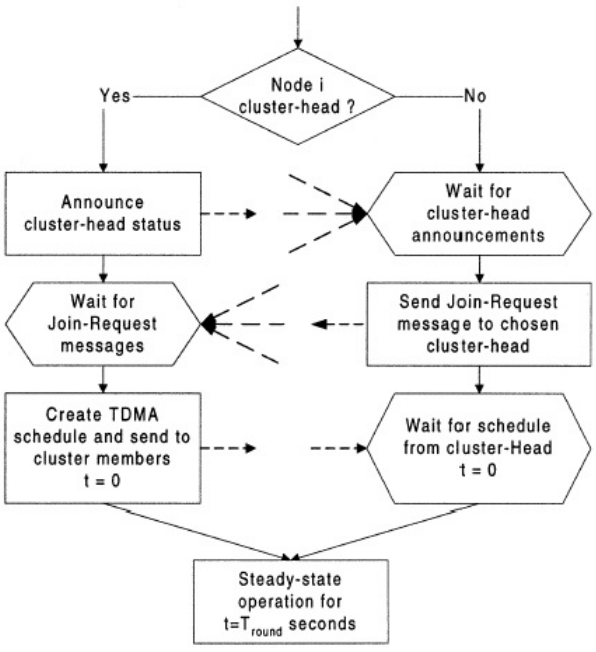

Figure 2.3: Flowchart of Leach Protocol

2.2.3 LEACH-C

LEACH-C[20] also consists of rounds.The setup phase as well as the steady state phase.This differs from traditional LEACH only in steady state phase. LEACH-C in setup phase, each sensor nodes sends their energy status,location information and nodes IDs to the base station. The base station specifies some nodes as CHs and non-CHs by using central algorithm.Using this Base Station analyze the energy of all the nodes with specific energy level (averaged energy).If energy of the nodes is less than specified level,BS categorizes that node as normal node.optimal selection is done by BS for CHs .if nodes are having energy above specified level.Then the BS broadcasts the node IDs of CHs to all network nodes.BS also try to optimize the intra-cluster distance. centralized algorithm has produced significant improvement in clustering than distributed clustering algorithm.in LEACH-C it is assumed that each node have information about its energy,aware of its location and can transmits to BS no matters how far the BS is from that node.

LEACH-C enhance the number of packet recieved at the BS in steady state phase.It is because of Optimal selection of cluster head and their effective location to the non-CH nodes.LEACH-C is slightly better than LEACH.

2.2.4 EEUC(Energy Efficient uneven clustering):

EEUC[1] is an uneven clustering routing protocol in which cluster heads are formed of uneven size because f the uneven competition [8][11].

$$R_c = \langle 1 - c\frac{d_{max} - d(i,sink)}{d_{max} - d_{min}} \rangle R_c^o$$

where d_{min} and d_{max} are the furthest distance and the closest distance between sink and nodes, d(i,sink) distance from node i to sink, $R_{co}$is the maximum of the competition ranges (which is a fixed value, but R_c is changeable, in order to show their difference, so mark it R_{co}, the value of c is between 0 and 1 based on the value of competition ranges. It shows that cluster size is dependenton distance from sink cluster nearer to sink are smaller in size and distant cluster are larger.

2.2.5 FAF-EBRM

forward aware factor energy balance routing scheme[23] is multi-hop routing scheme which is differ from other routing scheme in terms of next hop to the sink.in this routing protocol all nodes are considered as homogeneous nodes aware of the distance of all other sensor nodes and sink.

Whole protocol is based on two major components

1 Forward Transmission Area

2 Forward Energy Density

1 **Forward Transmission Area:**

Forward Transmission Area[1] is subset of Transmission region of a node which eliminate the data transmission in backward direction resulting saving efficient amount of energy which prolongs the network lifetime.

A sensor node have the knowledge of relative distance of sink and other node which is derived from received signal strength. So on the basis of position of sink and node we can calculate the Forward transmission Area for a sensor node

1 **Forward Energy Density:**

Forward Energy[1] describes the Enrgy density of the region (FTA) of a particular node for which we are going to calcutae the energy density. For a node at time t FED(i,t) is defined as

$$FED(i,t) = \frac{\sum E_j(t)}{S_{FTA}(i)}$$

Where $E_j(t)$ is the Energy value of node j at time t. and $\sum E_j(t)$ neighbors combined energy in FTA.

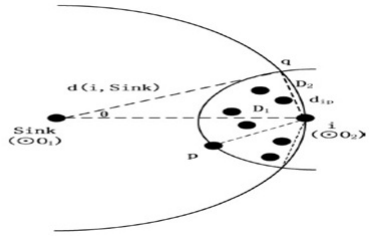

Figure 2.4: Forward Transmission Area for node i

(a) MaxFTA(maximum Forward Transmission Area):

Maximum forward transmission Area tells the possible greatest subset of transmission region of Cluster head Ci .Means forward transmission Area can have the maximum value.

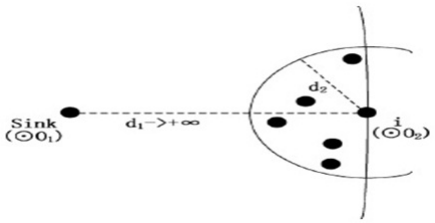

Figure 2.5: Maximum Forward Transmission Area

MinFTA(Minimum Forward Transmission Area):

Minimum Transmission area defines the possible minimum subset of transmission region of cluster head Ci.

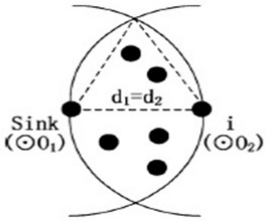

Figure 2.6: Minimum Forward Transmission Area

FAF(Forward Aware Factor)

Based on the Forward Transmission Area and Forward Energy density We will calculate the FAF which will decide the next hop for the transmission of data to sink.FAF is calculated for communication link Determination of FAF between link I and j using FTA and FED is given in the below equation. $\sum FED(j)$ is the combined energy density in the forward transmission area of node i W_{ij} is the weight between edge(i,j).

$$FAF(i,j) = \alpha \frac{FED(j)}{\sum FED(j)} + \beta \frac{w_{ij}}{\sum w_{ij}}$$

W_{ij} is the all of the weight combined α, β are the positive harmonic coefficient.

$$\alpha + \beta = 1$$

Algorithm for FAF Algorithm() {

1 Determine FTA(i);

2 Determine FTA(j) and$S_F TA(j)$;

3 Calculate FED(j) ;

4 Calculate the weight of link;

5 Calculate Forward Aware factor using FTA and FED and

6 determine the next hope according to maximum FAF;

7 If sink is among forward transmission nodes then directly transmit to it.

}

Chapter 3

Assumption

Energy Model

EEFHS

Setup Phase

Cluster Formation

Steady State

OTR and FTA

Chapter 3

Proposed Routing Scheme

3.1 Assumption and network Model

3.1.1 Assumption

- BS is far from the sensing field and the sensor nodes are stable once they are deployed.
- Sensor nodes are homogeneous .i.e all the sensor nodes have same initial energy,a battery.
- Channel Radio is symmetric means the energy consuned to transmit a message is the same to receive it.
- All the sensor nodes have knowledge of its location and energy.

3.1.2 Energy Model

The energy model described in[2,20] is being used by us here for communication energy dissipation.Transmission Energy to transmit l bit of data to distance d is evaluated as:

$$E_{Tx}(l,d) = \begin{cases} lE_{elec} + l\varepsilon_{fs}d^2, d < d_0 \\ lE_{elec} + l\varepsilon_{fs}d^4, d >= d_0 \end{cases}$$

To receive same message energy required will be:

$$E_{Rx}(l) = lE_{elec}$$

E_{elec} is the energy consumed to run the receiver or transmitter amplifier and $\varepsilon_{fs}d^2$ or $\varepsilon_{amp}d^4$ is the amplifier energy,depends upon accaptable bit-error rate. In equation we

can see that in receiving data a lot of energy is required.Thus the no of transmission and receiving should be reduced,in order to maximize the energy usage.

3.2 Energy Efficient Routing in WSN with Forward next hop selection

Whole protocol is divided in two steps

1 Setup Phase

2 Inter Cluster routing

3.2.1 Setup Phase

In the initial phase of protocol base station transmit signal at different transmission power starting with minimum transmission power as level 1, nodes in the network which can hear that signal set their level L_1 and calculate the distance to base station with received signal strength. Base station increased its transmission power to attain the next level And so on up to its predefined ability to transmit at different power level. Nodes which could not hear previous signal set its level according to corresponding signal level. Base station broadcast message containing information about level of that signal ,receiving that information all nodes in the network sets their level of transmission. After dividing the network into different transmission level cluster formation is done

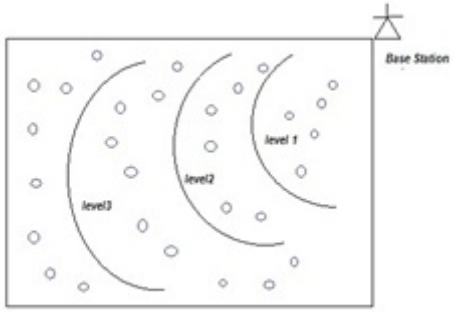

Figure 3.1: level based partition of network

3.2.2 Cluster formation :

In the cluster formation step clusters Heads are formed using the basic clustering protocol (in our case we have taken it as LEACH[2])but it differs in threshold formula and sensor

nodes are assigned to the clusters which has minimum distance to that nodes. After cluster formation all sensor nodes transmits data sensed to corresponding cluster head. that aggregates all data received.

$$T(n) = \begin{cases} \frac{p_r}{1-p_r * rmod\frac{1}{p_r}} * \frac{U_i}{U_i - L_i} : \ if\ n \varepsilon z \\ 0 \ \ Otherwise \end{cases}$$

Where

P = cluster head percentage desired.

r = round in progress.

Z = set of nodes which could not been CHs in the last 1/P rounds.

U_i= the upper limit of $level_i$.

L_i = the lower limit of $level_i$.

3.3 Inter Cluster Routing

In this step multi-hop routing between cluster heads of different level take place.Multi hop data forwarding has two key elements. Optimal transmission radius and Forward transmission area

3.3.1 OTR (optimal transmission radius):

we have calculated the OTR for different cluster heads OTR is the difference between transmission level of that cluster head and next higher level.

$$OTR_{ci} = |level_{i+1} - level_i|$$

Where OTR_{ci} is the optimal transmission radius of the cluster Ci,leveli is the transmission level of that cluster head and $level_{i+1}$ is the next higher transmission level

3.3.2 Forward Transmission Area:

Forward Transmission Area is subset of Transmission region of a node which eliminate the data transmission in backward direction resulting saving efficient amount of energy which prolongs the network lifetime

3.3.3 Weight parameter:

At time t weight between two nodes is given as w_{ij}

$$w_{C_iC_j}(t) = \frac{E_{c_i}(t)E_{c_j}(t)}{d(C_i,c_j)^2}$$

E_{Ci} and E_{Cj} are the residual energy of cluster head C_i, C_j at time t $d(C_i,C_j)$ is the distance between cluster head$C_i and C_j$.

3.3.4 Selection of Next forward hop:

Based on the Forward Transmission Area and weight parameter We will calculate the$w_{C_iC_j(t)}$ which chose the next hop(Higher level cluster head) for the transmission of data to sink.$w_{C_iC_j}(t)$ is calculated for communication link.

$$w_{C_iC_j}(t) = \frac{E_{c_i}(t)E_{c_j}(t)}{d(C_i,c_j)^2}$$

Cluster head having the the highest value of weight will be the next hop at higher level for cluster head Ci.

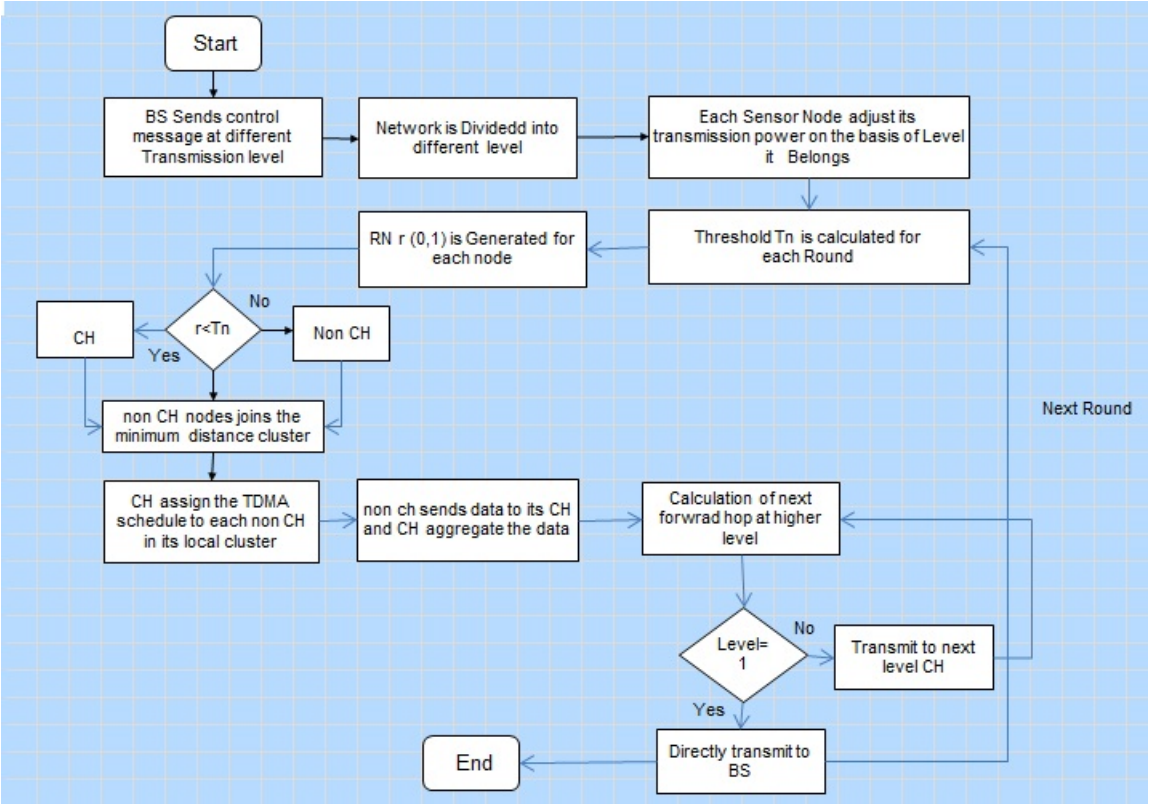

Figure 3.2: flowchart for proposed Model

Chapter 4

Simulation & Results

Chapter 4

Simulation & Results

This chapter gives overview about simulation and comparison with Existing protocol.

4.1 Simulation and Implementation

The performance of Proposed model is being evaluated by simulation.For simulation we have used MATALAB and tested our protocols performance with LEACH.

For performance evaluation following parameters are taken into account:

1 Network Lifetime.

2 Energy consumption of CHs.

3 Number of clusters per Rounds.

4.1.1 simulation parameter

Network size is considered as 100m X 100m and the number of nodes are 100 which are deployed randomly in the sensor field.Base Station is located at (50,175).

Parameters for our simulation is as follows:

Table 4.1: Simulation Parameter

Parameter	Values
simulation Area	100*100
initial Energy	0.1J
Base station	100*100
Transmitter/Receiver Electronics	50 nJ /bit
Efs	100pJ
Ems	0.0013pJ
EDA	5pJ
Number of nodes	100
Data packet size	4000bits
Control packet size	100bits
Number of rounds	200

4.1.2 Network Lifetime

Time span from starting of simulation to first node dies is defined as the network life time. The results of network lifetime are described in Fig. 4.1 It is concluded that the proposed algorithm improves lifetime of nodes. With our approach first node remain alive in the network longer than LEACH .

The result between the number of nodes alive and t rounds is shown by Fig 4.1. The result obtained by measuring the time until the first node dies. node dies for 500 rounds. The first dead node appeared in round 97 for EERFHS, in 82 rounds for LEACH and the last dead node appeared in 446 rounds for EERFHS and in 362 rounds for LEACH. It is observed that the EERFHS much better improves the life time of network than the LEACH protocol.

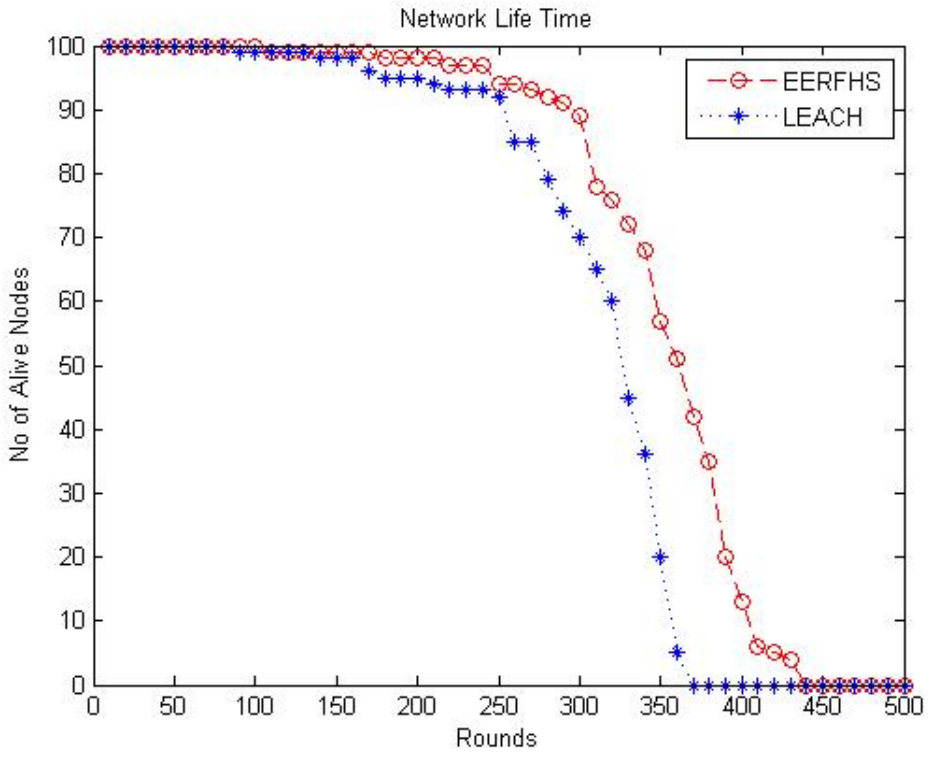

Figure 4.1: Network Lifetime

4.1.3 Energy Consumption of CHs

Fig 4.2 the results for the energy consumed by CHs in EERFHS and LEACH protocol for 30 rounds. The energy consumption for CHs for each round in EERFHS is much lower than that in LEACH. This is because in LEACH, CHs sends their data in sigle -hop fashion to the BS.Therefore; the energy consumption is high. In EERFHS, CHs sends gathered data to the BS through multihop communication. So a significant amount of energy is saved. For example,after the 20 rounds, the LEACH consumed the about 42 of the initial energy while in EERFHS is about 15.

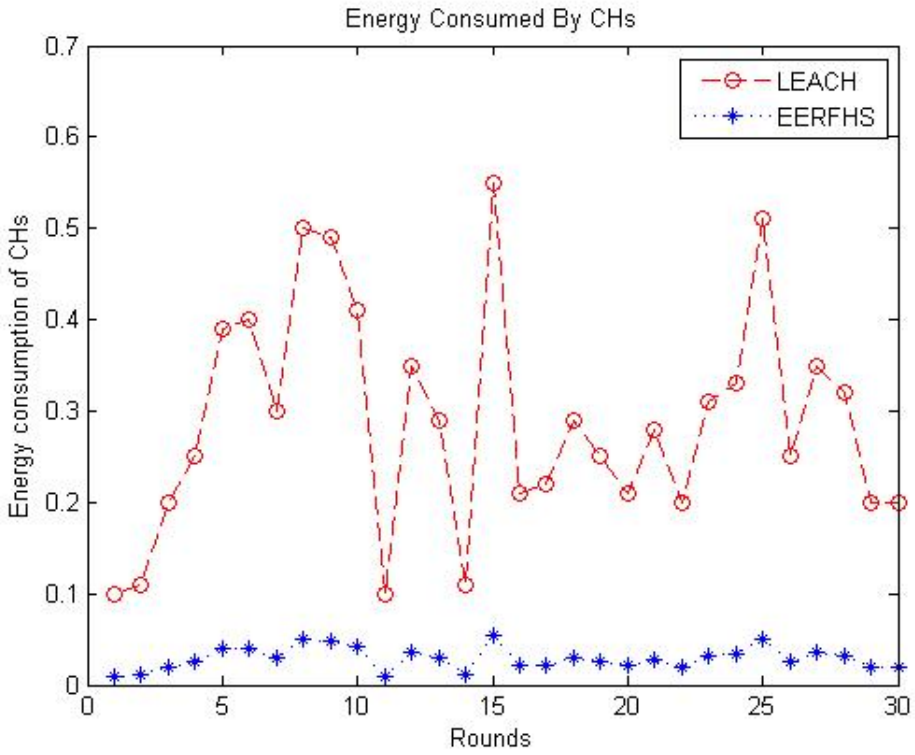

Figure 4.2: Energy Consumption of CHs

4.1.4 Number of Clusters per Rounds

Fig 4.3 shows the cluster distribution in EERFHS and LEACH for 30 rounds. It shows that Clusters formed in EERFHS is much fewer compared to LEACH.

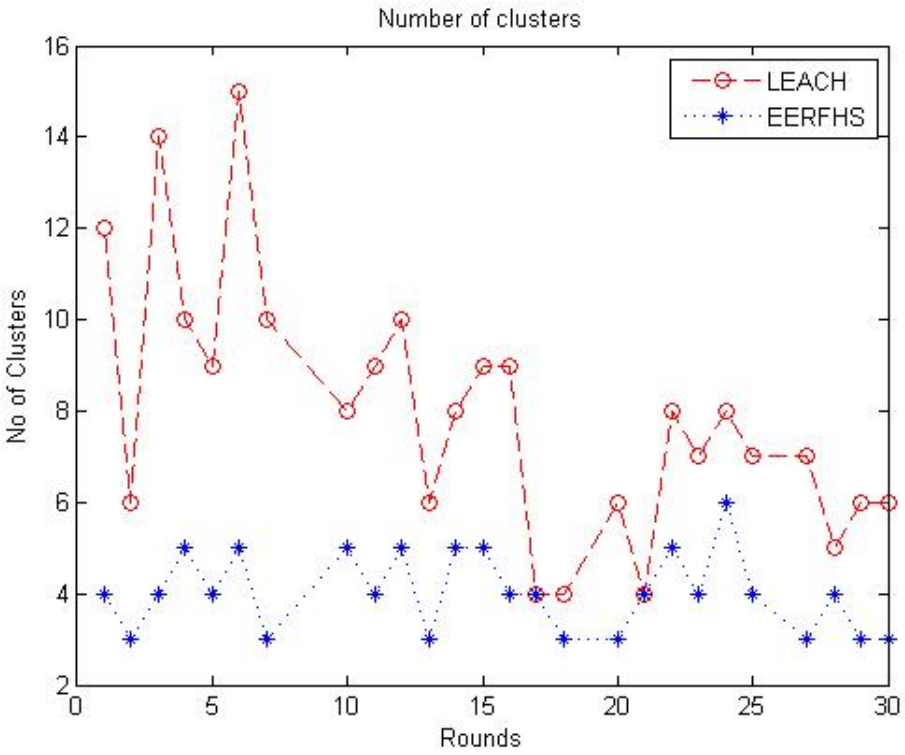

Figure 4.3: Number of Clusters per Round

Chapter 5

Conclusion and Future Work

Chapter 5

Conclusion and Future Work

In this paper, a level based clustering approach protocol has been proposed. The network model based on power levels is being developed. The mathematical formulae for choosing the cluster head are provided. The model developed is simulated in MATLAB.The simulation results of energy consumption of cluster heads, numbers of clusters and network lifetime are provided. It has been observed that the energy consumption for CHs for each round in EERFHS is less than compared to LEACH. For example, after the 20 rounds, the LEACH consumed the about 42 of the initial energy while in EERFHS is about 15. It has been also observed that the clusters formed in EERFHS is fewer than LEACH. Finally, it is concluded that the EERFHS performs better than better than LEACH.

In future research, proposed scheme can be extended to optimize the number of levels to efficiently consume the energy of network and improve the network lifetime,to implement heterogeneous Network.

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