Enhancing Lifetime of Wireless Sensor Nodes in Heterogeneous Environment

Submitted By

Shankar Kumar

16MCEN21

NIRMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
NAAC ACCREDITED 'A' GRADE

DEPARTMENT OF INFORMATION TECHNOLOGY

INSTITUTE OF TECHNOLOGY

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Enhancing Lifetime of Wireless Sensor Nodes in Heterogeneous Environment

Major Project

Submitted in partial fulfillment of the requirements

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Submitted By

Shankar Kumar

(16MCEN21)

Guided By

Dr. Ankit Thakkar

DEPARTMENT OF INFORMATION TECHNOLOGY

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

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Certificate

This is to certify that the major project entitled **"Enhancing Lifetime of Wireless Sensor Nodes in Heterogeneous Environment"** submitted by **Shankar Kumar (Roll No: 16MCEN21)**, towards the partial fulfillment of the requirements for the award of degree of Master of Technology in Computer Science & Engineering (Netwoking Technologies) of Nirma University, Ahmedabad, is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project part-I & part-II, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

Dr. Ankit Thakkar
Guide & Associate Professor,
IT Department,
Institute of Technology,
Nirma University, Ahmedabad.

Dr. Gaurang Raval
Associate Professor,
Coordinator M.Tech - CSE (NT)
Institute of Technology,
Nirma University, Ahmedabad

Dr. Madhuri Bhavsar
Professor and Head,
IT Department,
Institute of Technology,
Nirma University, Ahmedabad.

Dr Alka Mahajan
Director,
Institute of Technology,
Nirma University, Ahmedabad

Statement of Originality

I, **Shankar Kumar**, **16MCEN21**, give undertaking that the Major Project entitled "**Enhancing Lifetime of Wireless Sensor Nodes in Heterogeneous Environment**" submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in **Computer Science & Engineering (Networking Technologies)** of Institute of Technology, Nirma University, Ahmedabad, contains no material that has been awarded for any degree or diploma in any university or school in any territory to the best of my knowledge. It is the original work carried out by me and I give assurance that no attempt of plagiarism has been made.It contains no material that is previously published or written, except where reference has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

Signature of Student

Date:

Place:

Endorsed by

Dr. Ankit Thakkar

(Signature of Guide)

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- Shankar Kumar

16MCEN21

Abstract

The Wireless Sensor Network(WSN) consists of different sensor nodes. Each nodes having a specific amount of energy and deployed randomly in the network. The energy within the node helps in transmission of valuable packets among inter-connected nodes or directly to the Base Station(BS). While transmitting the packet, energy is not properly utilized. For proper utilization of energy, we used various parameters such as routing, probability, throughput and many more. In this paper, two approach is proposed for enhancing the lifetime of sensor nodes. In the first approach, we consider the normal nodes for becoming a part of cluster head(CH) selection. Here the energy and distance is considered as a key parameter. In the second approach, we consider the fitness parameter for enhancing the lifetime of the wireless sensor network. The protocol designed in this paper consider reduction in the various complex task for sensor nodes, enhance network lifetime and much more. Here five layer of network field is implemented which provides better performance. We have also done a comparative and detailed study of a specific protocol with two level of heterogeneity and CH parameter with the help of threshold value and many more.

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Chapter 1

Introduction

The wireless sensor network is an ad-hoc network consisting of sensor nodes. These sensor nodes, having a specific amount of energy and randomly deployed in the network field. The energy within the nodes helps in gathering and transmitting valuable packets within interconnected nodes or BS. These nodes having a specific amount of energy for performing the various computational task; due to which expensive rate of transmission of packets and Quality of Service(QoS) parameter suffer. Hence proper utilization of energy is the key parameter for ideal WSNs. The researcher must also consider the various issue related to data aggregation, data reliability and much more.

With the increase in interesting of the scientist in WSNs from few years in every field which may be CCTV, battlefield surveillance etc, in such types of application which work autonomous nature with the limited lifetime and also validating various task. Some of the properties are taken consideration for deploying some efficient protocol in WSNs.

- **Network architecture**: Without any proper infrastructure for a network, many of the sensor nodes are deployed in a variable environment for gathering information with the help of nearby sensor nodes where the location may be dangerous or in the distant place.

- **Network lifetime**:In a network, replacing or increasing the number of the battery is not feasible for any nodes hence node are designed or programmed in such a way that it prolongs for a long time.

- **Latency**: For a system to be scalable, data which are received and delivered within the network were done within a specific amount of time.

- **Quality**:While monitoring the environment, the redundant information is low as the user only needs the higher level descriptor information.

The network is mainly based on, what is its architecture and also with having ability to gather new data from the sensor nodes which are at random location with its coordinate value. These nodes having specific amount of energy helps in transmitting and receiving the packet. For this clustering technique is deployed in the network which may be Direct Transmission and Minimum Transmission Energy in energy load among nodes are not well balanced. In DT node which is far away was died firstly, since all node directly communicates with Sink. As the transmission power uses up, automatically cost reflects by the use of Minimum Transmission Energy (MTE) when minimum cost routes have been used up by data. Relays could be called up when nodes are near to the sink and relays having a greater probability. As a result, fastly nodes get to die. Sensing process will get biased when monitoring of field stops for sometimes and that whole process comes under DT and MTE. LEACH protocol comes under to resolve the problem of good distribution of energy within the cluster which is done dynamically within a prior better probability. The Cluster Heads gather all the data from the node before it sends to the sink and by giving the chance to CH, the node have to expend some amount of energy in each epoch. In these type of classical approach each node having the same amount of energy doesn't give better performance in case of heterogeneity of networks and for this problem, SEP is introduced which prolong the stability period with reliable feedback from the various application.

Clustering Advantage

- By finding the location of a route at the different interval of the cluster it reduces the dimension of a routing table.
- It avoids the exchange of redundant message among sensing element nodes by limiting the inter-cluster communication information measure.
- To prolong the battery lifetime of individual sensing element nodes.
- Cluster overhead is maintained.
- CH combination information among cluster with reducing the redundant packets.

This paper mainly considers proper utilization of energy. The protocol design in this paper helps in reduction of a various complex computational task. The collection of valuable packets from interconnected node to the CH than to BS become more complex. For reduction of this complex task, fitness parameter is introduced. This fitness function helps in enhancing the lifetime of the wireless sensor network and also finding the optimal probability, which plays an important role in this protocol.

1.1 Objective of study

In wireless sensor network(WSN), nodes a limited amount of energy which is utilized to solve a various technical problem in networking. For enhancing the lifetime of networking, we deals with various approaches such as heterogeneous nature of WSN and fitness parameter. Classical approach and homogeneity nature having some problem which is solved by Heterogeneous nature of WSN and fitness parameter provides optimal solution. This two approach provides better network lifetime, stabilityperiod and optimized QoS parameters and data aggregation.

1.2 Scope

As the era changes, research are done for smartly using of Sensor nodes in Wireless Sensor Network. The heterogeneous nature of WSN and GA are the two approaches done by the author. The HWSN provides better heterogeneity nature of sensor nodes and fitness parameter provides optimal solution.

1.3 Related Work

Here we have studied different protocols which having different heterogeneity structure of network field, the node is randomly deployed in which network may have knowledge of location, The energy is considered as the main consideration for giving heterogeneity in nature or somewhat threshold value is also considered. These common parameters are taken into consideration for the formation of CH which gives better Network lifetime and Throughput with better QoS parameter.

Chapter 2

Literature Survey

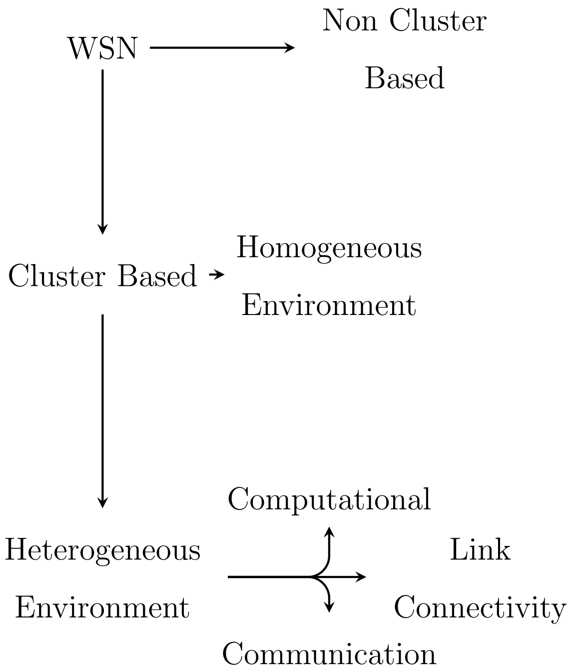
Here we have studied different protocol which having different heterogeneity structure of network field, the node is randomly deployed in which network may have knowledge of location, The energy is considered as the main consideration for giving heterogeneity in nature or somewhat threshold value is also considered. These common parameters are taken into consideration for the formation of CH which gives better Network lifetime and Throughput with better QoS parameter.

2.1 Heterogeneous Wireless Sensor Network

A wireless sensor network consists of different types of sensor node which helps in doing various computation process in different fields like battlefields, medical area, Aerospace, and many more. For this computational work, DT and MTE came across first in which energy was not well balanced hence node dies rapidly after the first node dies, for this LEACH is introduced which gives better performance than DT and MTE, but this protocol having problem when the node having different energy value, the stability period of nodes was reduced. To overcome this problem of heterogeneity nature of node SEP protocol was introduced, which having heterogeneity nature of network field with two different types of nodes. which provides better stability period due to the introduction of advance nodes which having high energy.

2.2 Types of resource for heterogeneity

This is the era for Heterogeneity



Types of heterogeneous cluster [1]

- **Computational heterogeneity:** A heterogeneous node that having powerful micro-processing techniques and memory to do the extra difficult process and future storage.
- **Link heterogeneity:** A heterogeneous node that having huge metric with long transmission than ancient node. A reliable node with high transmission of the node.
- **Energy heterogeneity:** Nodes that unit deployed in sensing field having an occasional battery power so energy heterogeneous devices required enhancing network amount of your time.

2.3 Performance Measure

There are many factor, affect the performance of WSNs.

- **Period of Stability:** The interval of time in-between start of operations and FND.
- **Instability Period:** The interval of time in-between FND and LND.
- **Network lifetime:** The interval of time between start of operation and LND.

- **cluster heads generation per round:** The nodes among the cluster member which might plays a role for sending sink info .
- **Throughput:** The rate of information received at the sink from different cluster heads.

2.4 Survey on Stable Election Protocol

A wireless sensor network consists of different types of sensor node which helps in doing various computation process in different fields like battlefields, medical area, Aerospace, and many more. For this computational work, DT and MTE came across first in which energy was not well balanced hence node dies rapidly after the first node dies, for this LEACH is introduced which gives better performance than DT and MTE, but this protocol having problem when the node having different energy value, the stability period of nodes was reduced. To overcome this problem of heterogeneity nature of node SEP protocol was introduced, which having heterogeneity nature of network field with two different types of nodes. which provides better stability period due to the introduction of advance nodes which having high energy.

2.4.1 SEP

A protocol [2] that provides longer stability amount and better average outturn within the field of HWSN; it's heterogeneous within the sense that election likelihood of CHs is driven by the energy given initially of a node within the network of different nodes using Equation 2.1. During this protocol let "m" be the advance node that is "α" times a lot of energy that different "(1-m)*n" traditional nodes among "n" total nodes within the network. All the nodes are uniformly and at random distributed. Nearly $n(1+m\alpha)$ nodes having energy same as traditional node initial energy and n*P is constant and $n(1+m\alpha)P$ be the common variety of cluster heads per spherical per epoch.

$$P_{nrm} = P_{opt}(1 + m\ \alpha) \tag{2.1}$$

$$P_{adv} = P_{nrm}(1 + \alpha) \tag{2.2}$$

And the threshold that is used for cluster election is defined by

$$T_{(s_{nrm})} = \begin{cases} \left(\dfrac{P_{nrm}}{1 - P_{nrm}\ (r\ mod\ (\dfrac{1}{P_{nrm}})} \right), & if S_{nrm} \in X' \\ 0, & if otherwise, \end{cases} \tag{2.3}$$

where current epoch is "r" and non-cluster heads is a set of G' up to the $\frac{1}{P_{nrm}}$ rounds.

2.4.2 SEPE

This protocol [3], the author utilizes a three-level hierarchical heterogeneous clustering networking device in which the moderate and advanced nodes having more energy in comparison of conventional nodes, whereas the advance and moderate nodes having the higher probability for becoming the cluster heads which can prolong the device network to work.

The initial energy of advance and moderate nodes is outlined by 2.4 2.5

$$E_1 = E_0(1 + a) \tag{2.4}$$

$$E_2 = E_0(1 + b) \tag{2.5}$$

Where $E_0, E_1 and E_2$ are defines the inceptives energy of normal, moderate and advance nodes. Hence total inceptives energy is given by

$$E_t = nE_0(1 + p \times a + k \times b) \tag{2.6}$$

The probability for the network as follows:

$$P_{nrm} = \frac{P_{opt}}{1 + p \times a + k \times b} \tag{2.7}$$

$$P_{mod} = P_{nrm}(1 + a) \tag{2.8}$$

$$P_{adv} = P_{nrm}(1 + b) \tag{2.9}$$

Where $P_{nrm}, P_{mod}, P_{adv}$ are the weighted probability of normal, moderate and advanced nodes, and their threshold is defined by changing the parameter of a weighted probability of 2.3 respectively, hence the network lifetime is extended due to drain rate of energy is less in moderate and advanced nodes.

2.4.3 EM-SEP

Mullah et. al. proposed an approach in [4] for prolonging the stable amount of device network for this protocol having some modification like advance node having a lot of chance for become the cluster heads ;and conjointly thought-about that if there area unit over one node become cluster heads we elect the sole node that having highest energy.

2.4.4 DTRE-SEP

[5] This protocol engages each transmission mechanism and node's residual energy within the network. The nodes directly transmit the info to the sink if its distance is a smaller amount than the cluster head. The cluster head election relies on each weight and residual energy. On the premise of residual energy, if the advance node energy is a smaller amount than any traditional nodes than each having same chance for forming cluster heads.

To transmit m bits of data the energy expands as below

$$E_{NCH} = \begin{cases} P \times E_{ckt} + P \times \epsilon_{fs} \times d_{Tx}^2, & if d_{Tx} < d_{NS} \\ 0, & otherwise, \end{cases} \tag{2.10}$$

Let the nodes square measure uni formally and every which way distributed over the world of "$M \times M$", Within a spherical area the CHs invest some energy is given below

$$E_{CH} = P \times E_{Ckt} \times \frac{n}{C-1} + P \times E_{AD} \times \frac{n}{C+P} \times \epsilon_{fs} \times d_{TX}^2 \tag{2.11}$$

Where C is that the range of clusters. EAD aggregative information and d_{TX} is that the path between the associate CH and sink. The non-CH utilized some energy which is given below,

$$E_{NCH} = \begin{cases} P \times E_{ckt} + P \times \epsilon_{fs} \times d_{Tx}^2, & if d_{Tx} < d_{NS} \\ P \times E_{Ckt} + P \times \epsilon_{mp} \times d_{SK}^4, & if d_{CH} \geq d_{sk}, \end{cases} \tag{2.12}$$

Where d_{CH} and d_{sk} are the distance between every node respective CHs, nearest node to the sink respectively.

2.4.5 A New Stable Election-based Routing Algorithm to Preserve Aliveness and Energy in Fog-supported Wireless Sensor Networks

By maintaining the balance energy consumption and also takes the feature of sensor nodes for better CH selection, [6] helps for Fog-support network stable period also minimization the customization and service cost LocalGrid embedded software which is installed on Fog Nodes which provides standardized and secure communication. It is of two-level hierarchical clustering and for CHs selection which is mainly based on probability which is further divided into different energy level.

$$p_N(r) = max\Big(\frac{p}{(1+m)}; \frac{min\Big(E_{tot}^{res}(r)\Big)\ p}{(1+m)\overline{E_{tot}^{res}(r)}}\Big) \tag{2.13}$$

$$p_A(r) = \frac{2p\overline{E_{tot}^{res}(r)}}{(1+m)E_1} \tag{2.14}$$

Each node takes the any value between 0 and 1 by which threshold value is defined by

$$T_N(r) = \begin{cases} \dfrac{p_N(r)}{1 - p_N(r)\Big(r\ mod\ \dfrac{1}{p_N(r)}\Big)} & if\ N\ \in\ G\prime \\ 0, & otherwise, \end{cases} \tag{2.15}$$

$$T_A(r) = \begin{cases} \dfrac{p_A(r)}{1 - p_A(r)\Big(r\ mod\ \dfrac{1}{p_A(r)}\Big)}, & if\ A\ \in\ G\prime\prime \\ 0, & otherwise, \end{cases} \tag{2.16}$$

The $\overline{E_{tot}^{con}} and \overline{E_{tot}^{res}}$ gives the network stability of [6] by which the stability period and CHs increases .

2.4.6 M-SEP

With the help of two aggregators in opposite side of the sink and change in heterogeneity level from two to nine , this protocol [7] provide large coverage with lower cost which were deployed in sensor nodes with comparison of network lifetime and efficiency of the model in each level. The two aggregators helps in reduction of consumption in energy of each nodes which sends the data to CHs and than to sink and aggregator which are nearer to it. With the collection of different data from aggregators transfer to the sink which posses infinite energy without process is taken place unline the sink nodes with to-fro message traverse between the sink and CHs which are nearer to them. The aggregate device posses large energy which aggregates different CHs information and transfer to the nearest sink. If the amount is less than the threshold T(si), nodes become a CHs for this spherical within the planned [7] change in the brink which is defined by $temp_rand = (p/(1 - p \times mod(r\ ,\ round(\frac{1}{p}))).$ The heterogeneous nodes enhances the network lifetime and stability and works as SEP and also consider optimal CH selection with suggested percentage CH in the network at each round.

2.4.7 Z-SEP: Zonal-Stable Election Protocol

This protocol [8] is deployed in network field. The network field is three different zone with the respect of y-coordinate and energy level which is named as zone 0, Head zone 1 and 2 respectively.

- Zone 0: Randomly deployment of normal nodes which lay in between of 20 to 80 in the y-axis.
- Head zone 1: Randomly deployment of fifty percentile of advance nodes which lay in between of 0 to 20 on the y-axis.
- Head zone 2: Randomly deployment of fifty percentile of advance nodes which lay in between of 80 to 100 on y-axis.

In the network, advance node posses α times more energy than normal nodes, higher energy was required by the corner nodes for communicating with BS and advance node are deployed in head zone 1 and 2. The selected CH broadcast the message to the nodes where nodes judge the CH belong to their spherical or not. Normal nodes (deployed in Zone 0) due to it's lower energy in comparison of an advanced node and cluster head requires large energy for receiving the information from the respective member of cluster nodes and it dies frequently whenever we select it as a cluster head which leads to shortening of stability amount.

2.4.8 FZSEP

In [9], the BS within the network is equipped with a directional antenna having power control ability. With the help of the basic principle of the ZSEP-E and fuzzy logic, we optimized the selection of CHs. With having data from the input parameters (Energy, Density, And Distance) it maps with fizzy logic which helps in making decision and discarding of patterns. As the enhancement of node energy and density, a chance of node to become the Chs is also increased but with greater the distance its chance also decreased. But with a node having the lower energy level, greater density, smaller distance with BS, decrease the chance of becoming CHs. With the help of this protocol, we can enhance the energy saving and network lifetime as compared to ZSEP-E.

- Future Work: Optimize the energy consumption and also QoS parameters.

2.4.9 TSEP

Kashaf et. al. [10] proposed a three-level heterogeneity protocol with reactive in nature and opposes the proactive nature of network which response to the immediate change in a relevant parameter of interest and threshold value helps in CH selection and stability period and network lifetime enhance.

2.4.10 SEP-E (RCH): Enhanced Stable Election Protocol Based on Redundant Cluster Head Selection for HWSNs

In [11] CHs are of two type one is initial and other is redundant and we select the node among these which having high energy and this information was collected by the BS with the help of eq:2.17, 2.18, 2.19, 2.20

$$C_{K_{ICH}} = \frac{K_{ICH}}{K_{ICH} + K_{RCH}} \tag{2.17}$$

$$C_{K_{RCH}} = \frac{K_{RCH}}{K_{ICH} + K_{RCH}} \tag{2.18}$$

$$C_{e_{ICH}} = \frac{E_{curr-ICH}}{E_{curr-ICH} + E_{curr-RCH}} \tag{2.19}$$

$$C_{e_{RCH}} = \frac{E_{curr-RCH}}{E_{curr-ICH} + E_{curr-RCH}} \tag{2.20}$$

for computing C_I *and* C_R

$$C_I = C_{K_{ICH}} \times C_{e_{ICH}} \tag{2.21}$$

$$C_R = C_{K_{RCH}} \times C_{e_{RCH}} \tag{2.22}$$

by comparing C_I *and* C_R

if $C_I \geq C_R$ **then**

In this round CH is Node ICH

else

In this round Node IRCH become cluster head

end if [11]

Within 1000 round the energy consumed by [11] is 14. 5% with a comparison of SEP-E. till the 200 rounds both protocol are going linearly and after that difference is traced. For selecting the reasonable CH [11] consider initial CH and then redundant CH and nodes having higher residual energy and minimum mean distance among CH in each epoch.

2.4.11 DRE-SEP

This [12] protocol provides efficiency of energy, lifetime improvement and protocol stability for WSNs. This is a three-layer protocol which is normal, intermediate and advanced nodes. and their corresponding weight are :

$$pN = \frac{p}{1 + m \quad \alpha + m_0 \quad \beta} \tag{2.23}$$

$$pIN = pN(1 + \beta) \tag{2.24}$$

$$pA = pN(1 + \alpha) \tag{2.25}$$

and there respective threshold values are

$$T(n_N) = \frac{pN}{1 - pN\left(r \ mod \frac{1}{pN}\right)} \frac{D_{avg}}{D_{BS}} \times \left[\frac{E_{cnt}}{E_{max}} + \left(r_s \div \frac{1}{pN}\right)\left(1 - \frac{E_{cnt}}{E_{max}}\right)\right] \tag{2.26}$$

and threshold of $T(n_{IN}) and T(n_A)$ is calculated by replacing pN with pIN and pA in 2.26. For the next round selection of CH is done using threshold which brings data transmission phase enhancement

- The communication between CH and BS is dual-hop rather than direct.
- The data transmit between CH and CMs which are decided with the help of threshold value.

Threshold value provide periodic and communication between CH and BS is dual-hop and throughput value is reduced as data transmission which is a function of threshold parameter and communication is dual-hop.

Advantage

- For threshold decision, we need more computational cost.
- To handle dual-hop communication, we need more processing time at each round.

2.4.12 EDFM

In [13] performance is done by two-time interval:

- The interval of time after the FND.
- FND in the network.

The two different types of CHs in the previous round by using different average energy consumption and energy is forecast to CHs in the next round.

2.4.13 Energy Consumption Rate based Stable Election Protocol (ECRSEP) for WSNs

In every next epoch of [14] protocol, the node having less ECR value was selected for CH in next epoch and the selected CH would not become CH in next every epoch since its ECR value is high among all node. For ensuring "p_{opt}N" CH among nodes with same amount of energy by choosing p to become p_{opt}. This [14] helpful for heterogeneity level of a cluster but not for homogeneous.

In each epoch optimal count of CH has to be express by$\sum_i^N P_i = Np_{opt}$ therefore, p_i is changed into:

$$p_(i) = \begin{cases} \dfrac{p_{opt} \times \dfrac{E(i)-E(r)}{r-1}}{1+\alpha\ m} & if\ S(i)\ is\ the\ normal\ node \\ \dfrac{p_{opt}(1+\alpha)\dfrac{E(i)-E(r)}{r-1}}{1+\alpha\ m} & if\ S(i)\ is\ the\ advance\ node, \end{cases} \tag{2.27}$$

the ECR value was directly correlated with threshold function.

2.4.14 An Efficient Condensed Cluster Stable Election Protocol in Wireless Sensor Networks

This protocol [15] reduces the cluster by merging nearby clusters and whole simulation done with the help of Matlab. For a node to become a cluster head its random value must be less than T(n). If some other CH is present within the circular region, then the node compares its energy to the other CH, and if its energy is less than the older one, then it discards itself from becoming the CH. If its energy is greater than the older one, then the older one is discarded and the node elects itself to be the CH. The CHs broadcast their ID all over the network to allow clusters to form which helps in reduction of the number of clusters and hence minimizes energy dissipation. There is less cluster formation , hence it transmit to the BS which is lesser than LEACH and SEP. For future purpose, the clusters are well separated from each other and redundant information is wiped out. On the basis of the density of nodes, CH is selected among nearby CHs. The concept is that a CH having more number of nodes in its nearby region may neglect the one having very less number of neighboring nodes. We will also research higher level of hierarchies in the network.

2.4.15 An Improved Stable Election based Routing Protocol with Mobile Sink for Wireless Sensor Networks

In [16] With the fraction of an advance node which has additional energy and somewhat residual energy is the main consideration for CH selection for improved sep with non-uniform node distribution. The well-designed network protocol with data collection in an energy efficient by a mobile sink.

Advantage

- For mitigating the hot spot problem,
- Sensor nodes energy balance,
- To reduce the transmission latency,
- To improve network performance by periodically accessing some isolated nodes to the network

MBC utilized a heuristic component that every sensor hub awakens itself one availability before its planned vacancy as per the TDMA plan and backpedals to rest mode after now is the ideal time slot. To demonstrate a sensor hub's condition, an element of position, remaining vitality, beginning vitality, and correspondence see that has been mulled over, where the position is (x(i,n),y(i. n)) and lingering vitality of e(i,n), underlying vitality is E(i,n), and transmission go from Ri.

MSE convention demonstrated promising execution in vitality adjusting and arrange lifetime dragging out. In any case, the direction in our proposed organize is static, with the hub bites the dust or topology changes, the pre-found settled direction might be unsatisfactory constantly.

2.4.16 HSEP: Heterogeneity-aware Hierarchical Stable Election Protocol for WSNs

By reducing data transmission cost in BS from CH for prolonging the network lifetime and stability period and with the property of heterogeneity CH is done by comparing the initial energy of the node with other node energy which helps in minimizing the transmission cost of energy by selecting the secondary CHs which are selected using probability function among existing primary CHs were the strategy in [17] protocol.

2.4.17 FSEP-E: Enhanced Stable Election Protocol based on Fuzzy Logic for Cluster Head Selection in WSNs

This is the protocol [18] which are used to improve the SEP-E protocol by using the concept of fuzzy expert system and includes heterogeneity proximity threshold and node density to the base station. For a real-time scenario, trapezoidal membership function and Gaussian function are used with a fuzzy variable of low medium and high for normal, intermediate and advance node respectively which are transformed into a single crisp number with 'centroid' used in defuzzification.

2.4.18 Improvement of the SEP protocol based on community structure of node degree

In [19] network Node is established with the help of grid Deployment model, the connection established by setting up the community threshold. During the formation of Cluster Heads, the community is constructed by node degree and node's residual energy and node degree is added. The whole network model is well-divided into four equal areas. The advanced node is deployed in the center of the geometric center of the area normal nodes are randomly deployed. The residual energy and degree of a node are introduced in cluster selection mechanism. The formula is:

$$T(S_{nrm}) = \frac{P_{nrm} \times H}{1 - P_{nrm}\left(r \ mod \ \frac{1}{P_{nrm}}\right)} \tag{2.28}$$

$$T(S_{adv}) = \frac{P_{adv} \times H}{1 - P_{adv}\left(r \ mod \ \frac{1}{P_{adv}}\right)} \tag{2.29}$$

here H is defined by

$$H(r) = \alpha \frac{E_i(r)}{E_{max}(r)} + \beta \frac{k_i(r)}{k_{max}(r)} \tag{2.30}$$

where $\alpha \ and \ \beta$ are adjustement function and $E_i(r)$ and $E_{max}(r)$ are residual and maximum residual energy , $k_i(r)$, $k_{max}(r)$ are node degree and maximum degree of the nodes in "r" round. The simulation is carried out by Matlab simulation with 100×100 m.

2.4.19 BOKHARI-SEPFL Routing Protocol based on Fuzzy Logic for WSNs

For improving the lifetime and throughput of wireless sensor network [20] introduced fuzzy logic function which is mainly based on three variable i. e. level of battery with low,medium & high , Distance with Near Medium and fair and density of node with sparsely , medium and density along with threshold function used in the [2] protocol which helps in enhancing the process of CH with membership function. In [20] procedure starting with calculating the level of battery and density and distance of nodes from the base station and by considering fuzzy rule which is taken in getting threshold function value (2.32 & 2.31) which are stored separately.

$$T_N(r) = \begin{cases} \frac{p_N(r)}{1 - p_N(r)(r \ mod \ \frac{1}{p_N(r)})}, & if \ N \in G' \\ 0, & otherwise, \end{cases} \tag{2.31}$$

$$T_A(r) = \begin{cases} \frac{p_A(r)}{1 - p_A(r)(r \ mod \ \frac{1}{p_A(r)})}, & \text{if } A \in G'' \\ 0, & \text{otherwise,} \end{cases} \tag{2.32}$$

The CHs node is selected by using value obtain from probability which is in a fuzzy logic system and the threshold equation. The probability of each epoch are sorted and nodes which having high value is selected as a CHS. In order to prolong the lifetime of network and enhancement of efficiency, [20] consider threshold function and all the property of a node. The lifetime of the network has been extended by 73.2% and 42.4%; the throughput of the network to be improved by 68.54% and 33.4%; in comparison with SEP and SEP-E protocol.

2.4.20 An Improved Scheme of SEP in Heterogeneous Wireless Sensor Networks

By location-aware and data communication in the region of high SNR and location of the sink node is out os the network field with enough energy and ability for controlling the transmission data. [21] was done in three phase which may be cluster formation phase, virtual cluster head and data transmission phase and in the network load is well balanced during CH formation by assuming initial energy of each node be $(1 + \partial_i)E_0$ and probability function in 2.33 and an optimal probability is calculated by 2.34.

$$p(s_i) = \frac{p_{opt} \times N(1 + \partial_i)}{N + \sum_{i=1}^{N} \partial_i} \tag{2.33}$$

$$p_{opt} = \frac{k_{opt}}{N} = \sqrt{\frac{N}{2\pi}} \times \frac{M}{d_{toBS} \times N} = \sqrt{\frac{1}{2\pi N}} \times \frac{2}{0.765} \tag{2.34}$$

2.4.21 CHATSEP: Critical Heterogeneous Adaptive Threshold Sensitive Stable Election Protocol

With reactive nature of protocol [22] of heterogeneity level of three with critical information transmission which provides highest priority to any information and whenever there is no transmission to BS, its adaptive nature provides the information about network status in each epoch done by Adaptive Meter(AM).

2.4.22 E-CHATSEP: Enhanced CHATSEP for Clustered Heterogeneous Wireless Sensor Networks

This [23] is adaptive nature of protocol which sends information of network status to BS. By considering an energy factor and distance parameter for determining the threshold value for new enhanced CH election for prolonging the stable period of the sensor node with the use of first-order radio energy model during the whole process. Optimal number of CHs is calculated by 2.35

$$k = \frac{\sqrt{3} \times M}{2 \times r^2 \times \pi^2} \tag{2.35}$$

The threshold is defined by 2.36

$$T(n) = \frac{E_i \times k}{E_{tot} + D} \tag{2.36}$$

For CH election among sensor nodes the leftover battery and spatial separation for threshold function which makes [23] better than [22].

2.4.23 Life Time Enhancement of Sensor Network by using concept of SEP & LEACH(LEACH-P)

SEP is mainly based on weighted election probability and residual energy for CH selection, embedded with LEACH for increasing the first node dead period with the help of reliable sensor network. The stability period of LEACH is 8 times of DT, MTE and network lifetime is 3 times of MTE, DT.

2.4.24 Multi-zonal approach Clustering based on Stable Election Protocol in Heterogeneous Wireless Sensor Networks

This is a protocol which mainly distributes in multiple-zonal approach based on [2] protocol; For energy consumption during data communication having three zones of same vertex point which were the closest point with respect to BS. It [24] is mainly depended on the dimension of the network area with location of BS. It starts from the vertex which is nearest point and top of a triangle. The size of the field is $100 \times 100m$ with BS at (50,50). The vertex point are randomly distributed with node(1 and 3) far from the BS with distance less than d_0 and uses energy less than other cluster head in every triangle which are distributed in hierarchical clustering where data is transmitted from CH to BS after collecting the information among members which are calculated by

$$E_{T_x=f_s(k,d)=K\times(E_{elec}+E_{fs}\times d^2)} \; ifd < d_0 \tag{2.37}$$

It provides better instability and also extends the network lifetime.

2.4.25 Optimal Number of Cluster Heads For Random Topology WSNs using the Stable Election Protocol

In this [25] protocol, an author uses TinyOS for validating the performance of SEP protocol, and simulate the heterogeneous clustered WSN in a field of $70m \times 70\ m$ with 25, 50, 75, ... , 500 sensor nodes randomly, the main goal is to find the optimal CHs for each Network Lifetime and then an optimal probability is driven out for CH selection. The optimal number of CH evolves is $\sqrt{\frac{2n}{\Pi}}$e There is possibility, for calculating the performance of a routing protocol WSNs we can find "delivery ratio and end to end delay"

2.4.26 New Hierarchical Stable Election Protocol for Wireless Sensor Networks

In this [26] protocol, author use NS2 simulator and compare with a parameter like consumption of energy, a fraction of packet delivered, residual of energy, a delay between End to End communication and a number of dead nodes.

2.4.27 Improving the Stable Period of WSN using Dynamic Stable Leach Election Protocol

In this [27] protocol, the author used three level of hierarchical heterogeneous clustering network. Here cluster heads are elected at each round with respect to the threshold function which is defined by

$$T(s) = \begin{cases} \dfrac{p_{opt}}{1 - p_{opt}\ (r\ mod\ \dfrac{1}{p_{opt}})}, & if s \in G' \\ 0, & otherwise \end{cases} \tag{2.38}$$

The well distribution and well balance of network among nodes of the network without changing the value of spatial energy but there is a chance of changing the total initial energy.

2.4.28 MSEP-E: Enhanced Stable Election Protocol with Multihop Communication

In [28] protocol, with the different probability weight, CH was selected periodically by considering the initial energy of a node and the far away CH from sink node communicate via another Ch which were near to sink node. The total initial energy of system was enhance by $(1 + m \times \alpha + m_0 \times \beta)$. In the entire network, energy is well balanced which enhance the network lifetime and stability of WSN.

2.4.29 Fuzzy Logic Approach to improving Stable Election Protocol for Clustered heterogeneous wireless sensor networks

In [29], a Fuzzy system is used for improving SEP protocol with CH selection by considering the initial weighted energy among node in a network and also provide the larger round for first node dead as well as lesser the network instability period with an increased lifetime of the sensor nodes with a large value of extra energy. Energy level and a distance between BS and non-CH node are mainly of two types. Low, medium, high is a parameter of energy level; close, medium, far are a parameter of distance are two linguistic variables. Triangle and trapezoidal membership function are used which gives more determining degree. The result is aggregate in each rule which is obtained by chance value which is called defuzzification which is a centroid and gives the area center of the area under the fuzzy set, This change value is given by

$$chance(i,r) = \frac{\sum_{j=1}^{n} u(x_j)\ x_j}{\sum_{j=1}^{n} u(x_j)} \tag{2.39}$$

IF-THEN rule is used in every epoch by which sensor node calculate the chance to become the CHs. If maximum chance value is less than the node is elected as a CH, broadcasting of this message to all other nodes among cluster and nodes having this message for calculate the path between the CH and itself broadcast and join message with nearer CHs helps in formation of cluster which was last for $\frac{1}{P_{adv}}$ & $\frac{1}{P_{nrm}}$ with threshold of

$$T(S_{adv}) = \begin{cases} \dfrac{P_{adv}}{1 - Padv\left(r\ mod\ \dfrac{1}{P_{adv}}\right)} & if\ S_{adv} \in G' \\ 0 & otherwise \end{cases} \tag{2.40}$$

$$T(S_{nrm}) = \begin{cases} \dfrac{P_{nrm}}{1 - Pnrm\left(r\ mod\ \dfrac{1}{P_{nrm}}\right)} & if\ S_{adv} \in G'' \\ 0 & otherwise \end{cases} \tag{2.41}$$

The network lifetime is enhanced about 67.36% *and* 54% with respect to SEP protocol for $\alpha = 1$ *and* 3 respectively hence with an increase in value, network lifetime also increases. This protocol enhances its stability by achieving the prototype of node join.

2.4.30 Energy Level Based Stable Election Protocol in Wireless Sensor Network

This [30] routing protocol was reactive in nature with heterogeneity level of three which is based on energy residual level which helps in estimating the sensor nodes which combine with the best feature TSEP protocol and also provides a mechanism for periodical data packet gathering in WSN. The cluster is formed within the radii of R_{ci} is

$$R_{ci} = \left(1 - c\frac{d_i - d_{min}}{d_{max} - d_{min}}\right) R_{max} \tag{2.42}$$

and respective threshold are defines as

$$T_{nor} = \begin{cases} \dfrac{P_{nor}}{1 - P_{nor}\left(r \ mod \ \dfrac{1}{P_{nor}}\right)} \times \dfrac{E_{current}}{E_{initial}} & if \ P_{nor} \ \in \ G' \\ 0 & otherwise \end{cases} \tag{2.43}$$

$$T_{adv} = \begin{cases} \dfrac{P_{adv}}{1 - P_{adv}\left(r \ mod \ \dfrac{1}{P_{adv}}\right)} \times \dfrac{E_{current}}{E_{initial}} & if \ P_{adv} \ \in \ G''' \\ 0 & otherwise \end{cases} \tag{2.44}$$

and optimal number of CH per epoch was

$$n(1 - m - b)P_{nor} + n \times b \times P_{int} + n \times m \times P_{adv} = n \times P_{opt} \tag{2.45}$$

Advantage

1. perform better in small and large geographical area.
2. The energy consumption by the sensor nodes is well balanced as well as enhancing the network lifetime.
3. It is applicable for time critical application.

Limitation

1. if a threshold value is not reached, information or data from the nodes are not received by the base station even if all the node are dead in the network.

2. not applicable to the system where sensed data is required frequently and continuously.

2.4.31 An Energy Efficient Stable Election-Based Routing Algorithm for Wireless Sensor Networks

In [31] protocol having distribution of nodes in a non-uniform distribution in which SEP employs mobile of sink node and additional energy with residual energy helps in CHs formation with threshold value of

$$T(n) = \begin{cases} \dfrac{P}{1 - P\Big(r\ mod\ \dfrac{1}{p}\Big)} & if n\ \in\ G, \\ 0 & otherwise, \end{cases} \tag{2.46}$$

The total energy of network is calculated by

$$N(1-m)E_0 + N \times m \times E_0(1+\alpha) = N \times E_0 \times (1 + \alpha\ m) \tag{2.47}$$

The weighted probability for normal and advance nodes are

$$P_{nrm} = \frac{P_{opt}}{1 + \alpha \times m} \times \frac{E_{residual}}{E_0} \tag{2.48}$$

$$P_{adv} = \frac{P_{opt}}{1 + \alpha \times m} \times (1+\alpha) \times \frac{E_{residual}}{E_0} \tag{2.49}$$

and their threshold is defined as

$$T(s_{nrm}) = \begin{cases} \dfrac{P_{nrm}}{1 - P_{nrm}\Big(r \ mod \ \dfrac{1}{P_{nrm}}\Big)} & if \ n \in \ G' \\ 0 & otherwise \end{cases} \tag{2.50}$$

$$T(s_{adv}) = \begin{cases} \dfrac{P_{adv}}{1 - p_{adv}\Big(r \ mod \ \dfrac{1}{P_{adv}}\Big)} & if \ n \in G'' \\ 0 & otherwise \end{cases} \tag{2.51}$$

[31] having better throughput than LEACH and [2] which is completely drain-out within 500 and 2500 round with 5000 round which is mostly 4 times and 2 times larger respectively. Whenever any node in the network dies or any change in topology there is a chance of unsuitability of pre-located fixed trajectory for making network static.

2.4.32 A Novel Energy-Efficient Stable Clustering Approach for Wireless Sensor Networks

This [32] protocol which helps in better CH selection which results in better stability period, consumption of energy, a lifetime of the network . For communication of information [32] uses higher capability , functionality. With the help of mutation, selection and crossover operators used in [32] with an initial population. The vector $V_{i,G}$ is defined during mutation phase by:

$$V_{i,G} = X_{r1,G} + F(X_{r2,G} - X_{r3,G}), r_1 \neq r_2 \neq r_3 \neq i \tag{2.52}$$

and crossover operator $U_{i,G}$ generated a trail vector as:

$$U_{ji,G} = \begin{cases} V_{ji,G}, & if \ rand(j) \leq CRorj = j_{rand} \\ X_{ji,G}, & otherwise \end{cases} \tag{2.53}$$

and CR is given in the range [0,1]. and selection operation is given by:

$$X_{i,G+1} = \begin{cases} U_{i,G}, & if \ (f(U_{i,G}) < f(X_{i,G})) \\ X_{i,G}, & otherwise \end{cases} \tag{2.54}$$

With 0 to $200°F$ in a different zone by considering $50°F$ and $2°F$ of hard and soft threshold with 0. 5 as a CR to analyze the homogeneous and heterogeneous protocol setup in [32]. The cluster size is not set properly and distribution of node is uniform across the network using the objective function concerned with the quality of cluster which has a function of separation and cohesion. Consumption of energy among the similar size of a cluster is fairly distributed. With the present energy, initial population is driven by

$$X_i(j) = \begin{cases} 1, & if(rand \geq p \ and \ E(node_j) \leq E_{avg}(r)) \\ 0, & otherwise \end{cases} \tag{2.55}$$

U_i and V_i as a trail and mutual vector with sensor nodes having residual of energy above-average energy within the network which is mathematically represented as

$$U_i(j) = \begin{cases} V_i(j), & if(rand \geq p \ andE(node_j) \leq E_{avg}(r)) \\ X_i(j), & otherwise \end{cases} \tag{2.56}$$

Energy is an imbalance between different nodes and more effective by improving the stability period also minimize the energy variance of the network by balancing the load, efficiency of energy and stability period. The multi-objective optimization algorithm for providing higher network stability periods.

2.4.33 SKIP: A novel self-guided adaptive clustering approach to prolong lifetime of wireless sensor networks

In this [33] protocol every node take part in CH election process which is based on residual energy, but not considered in-network lifetime, to overcome this problem some changes are done in [2], and [3] threshold value $T(n^*)$ which is given by

$$T(n^*_{skip}) = \begin{cases} T(n^*) \times \ Er_i & if \in G \\ 0 & otherwise \end{cases} \tag{2.57}$$

this threshold value reduces the node drain rate in each epoch where Er_i is defined by

$$Er_i = \left(\frac{E_{i\ current}}{E_{i\ init}}\right)^{\frac{1}{1+ESC_i}} \tag{2.58}$$

ESC_i is the controlling parameter of a node i that increases/reduces threshold value of a node over a period of time, and defined by

$$ESC_i = \begin{cases} ESClast_i + \dfrac{E_{i\ init}}{E_{i\ current}} & if((i \in\ CHlastANDMmbri < Th)or(i \in\ CHlast)) \\ 0 & if i \in CHlastANDMmbr \geq\ TH \end{cases} \tag{2.59}$$

where $ESClast_i$ is the maximum value of ESC where a node i is not elected as CH. It is tested in First order radio energy model and simulation is done by Matlab in which energy dissipates as

$$E_{Tx} = \begin{cases} l \times E_{elect} + l \times \epsilon_{fs} d^2 & if d < d_0 \\ l \times E_{elect} + l \times \epsilon_{mp} d^4 & otherwise \end{cases} \tag{2.60}$$

2.4.34 Effect of Heterogeneous Nodes Location on the Performance of Clustering Algorithms for Wireless Sensor Networks

This [34] protocol is based on analyzing within the location of the heterogeneous nodes by considering clustering algorithm performance. In each epoch the clustering algorithm is established in the transmission of data is done into a different frame which is divided into the time slot which is occupied by each member node in each frame , data is transferred from BS from CH which results in inter-cluster communication distance which is defined by $\sum_{i=1}^{N} Dist(i, CH)$ where member nodes are N and distance of nodes from CH from I with a function of $Dist(i, CH)$. Heterogeneous clustering provides the heterogeneous nodes over normal nodes for CH election and also depends on its position. It is simulated by Matlab using 100 nodes over an area of $100 \times 100\ m^2$ for generating the effect of the position of heterogeneous nodes on the performance of clustering algorithm. This protocol is simulated with [2] and DEEC protocol for finding the best location. In a best case, a network is better to load balance than the other scenarios so the lifetime of the network gets extended.

2.4.35 Design and Development of Energy Efficient Routing Protocol for Heterogeneous Wireless Sensor Networks

In this [35] protocol with increasing the stability period and lifetime of a network by minimizing the consumption of energy, average residual energy is used for selecting CH. BS is far away from the network in which all nodes are randomly deployed due to unequal consumption of energy with different residual energy by which nodes are coined as of two types high energy node and low energy node. Each low energy node becomes cluster heads exactly once whereas high energy node becomes CH $\overline{E}_{hn}(r)/\overline{E}_{ln}(r)$ times at every

$$\frac{1}{P_{opt}}\Big(\frac{E_{hn}(r)\times\ hn+\overline{E_{ln}}(r)\times ln}{(hn+ln)\times\overline{En_{nln}}(r)}\Big), round\ per\ epoch \tag{2.61}$$

Hence, the probability for lower and higher energy nodes to become a CH are,

$$P_{ln}=\frac{P_{opt}\times((hn+ln)\times\overline{E}_{ln}(r))}{\overline{E}_{hn}(r)\times hn+\overline{E}_{ln}(r)\times ln} \tag{2.62}$$

$$P_{hn}=\frac{P_{opt}\times((hn+ln)\times\overline{E}_{ln}(r))}{\overline{E}_{hn}(r)\times hn+\overline{E}_{ln}(r)\times ln}\times\frac{\overline{E}_{hn}(r)}{\overline{E}_{ln}(r)} \tag{2.63}$$

To ensure CH is elected from the nodes, whose residual energy is more or equal to the system average residual energy, we have taken threshold level as a consideration is given below

$$T_{ln}=\begin{cases}\dfrac{P_{ln}}{1-P_{ln}\times(r\ mod\dfrac{1}{p_{ln}})}, & if ln\in\ G'\\ 0, & otherwise\end{cases} \tag{2.64}$$

$$T_{hn}=\begin{cases}\dfrac{P_{hn}}{1-P_{hn}\times(r\ mod\dfrac{1}{p_{hn}})}, & if hn\in\ G''\\ 0, & otherwise\end{cases} \tag{2.65}$$

Once the CH has selected then it broadcast a message, In each current round, a node is decided to which it belongs and thus CH is formed. The extra energy is utilized effectively for increasing network lifetime, over a long time nodes having an unequal distribution of energy inhomogeneous network which is also coined as heterogeneous. There is a good distribution of CH in each round and give a report to BS hence increase in throughput and helps in reduction of data redundancy by transmitting concise and important data.

2.4.36 EECHE: Energy-Efficient Cluster Head Election Protocol for Heterogeneous Wireless Sensor Networks

In [36] by using a technique of clustering the sensor nodes we can enhance the efficiency of energy lifetime and stability of network and also having an ability for prolonging the stability over existing protocol in BS is positioned at the centre and non CH nodes transmit data to CH which are aggregated and transmitted to distant BS with having responsible for coordinate the transmission of data in their cluster with type 1,2 & 3 nodes having α & β fraction of energy enhance type 1 to type 2 & 3 nodes which are responsible for CH formation and with E_0 & E_1 & E_2 . Each type of nodes having its own initial energy which is defined by

$$E_2 = E_0(1 + \beta) \tag{2.66}$$

$$E_1 = E_0(1 + \alpha) \tag{2.67}$$

The new heterogeneous network having total initial energy which was setup as

$$Q = \alpha - p \times (\alpha - \beta) \tag{2.68}$$

$$E_i = n.E_0(1 + m \times Q) \tag{2.69}$$

$$N_e = (1 + m \times Q)/P_{opt} \qquad , be\ new\ epoch \tag{2.70}$$

In each epoch CH baverage value is defined by $n \cdot (1 + m \cdot Q)$ with probability of

$$P_1 = \frac{p_{opt}}{1 + m \times Q} \tag{2.71}$$

$$P_2 = P_1 \times (1 + \alpha) \tag{2.72}$$

$$P_3 = P_1 \times (1 + \beta) \tag{2.73}$$

for electing the CH we have to consider the threshold which are defined by

$$T(S_1) = \begin{cases} \dfrac{P_1}{1 - P_1 \times \left(r \ mod \ \dfrac{1}{P_1}\right)} & S_1 \in G \\ 0 & Otherwise \end{cases} \tag{2.74}$$

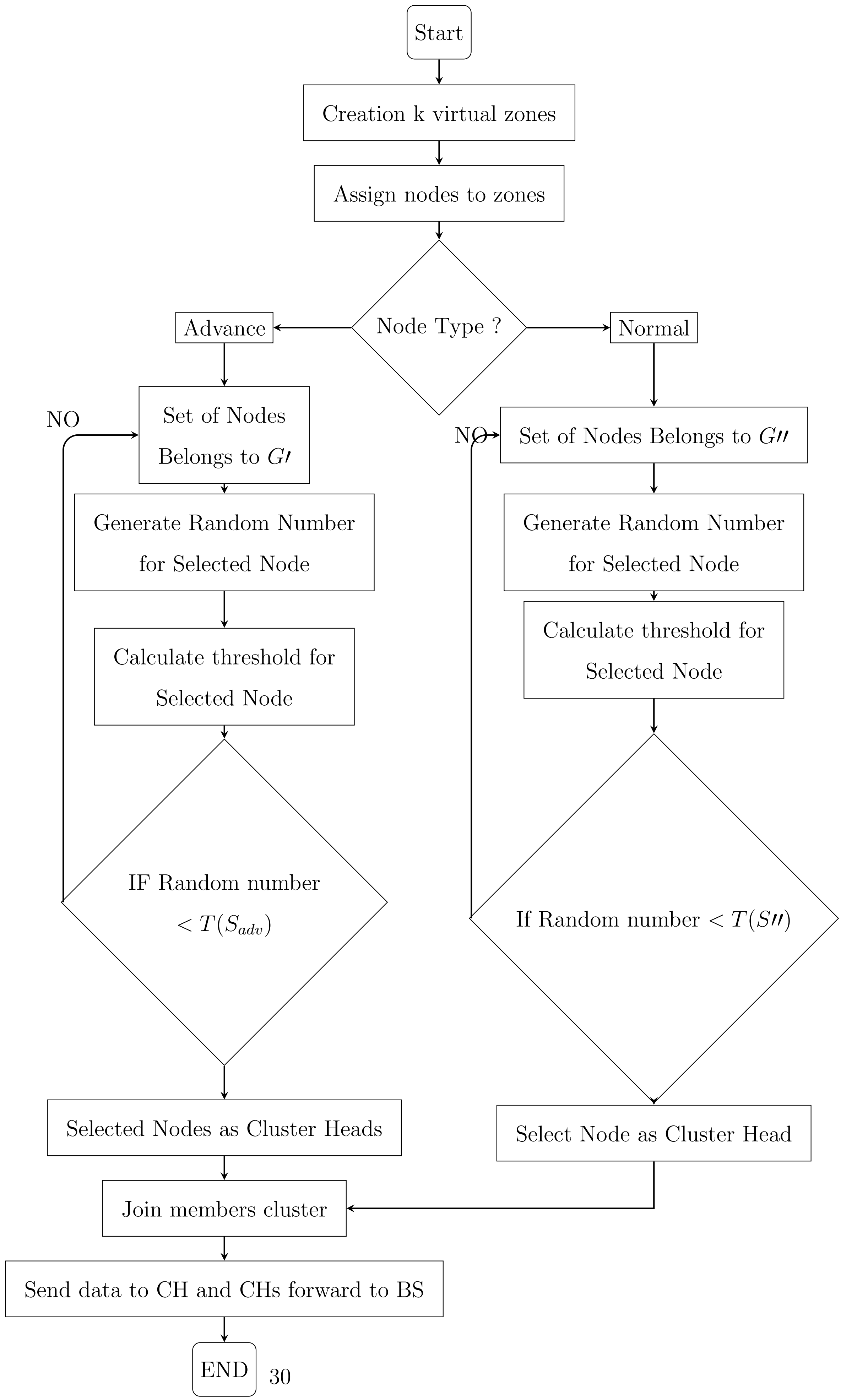
Similarly for $T(S_2)$ *and* $T(S_3)$ for type 2 & type 3 nodes. this protocol simulates the result with the energy of this network is decreased and gives better performance.

2.4.37 SEPFL routing protocol based on fuzzy logic control to extend the lifetime and throughput of the wireless sensor network

This [37] uses the fuzzy logic in which input parameter is level of a battery, density of node and distance between node and CH with membership function of three level and probability level which are derived from the fuzzy system was used for selecting optimal cluster heads which provide the better lifetime of the network. The whole procedure is done in some steps

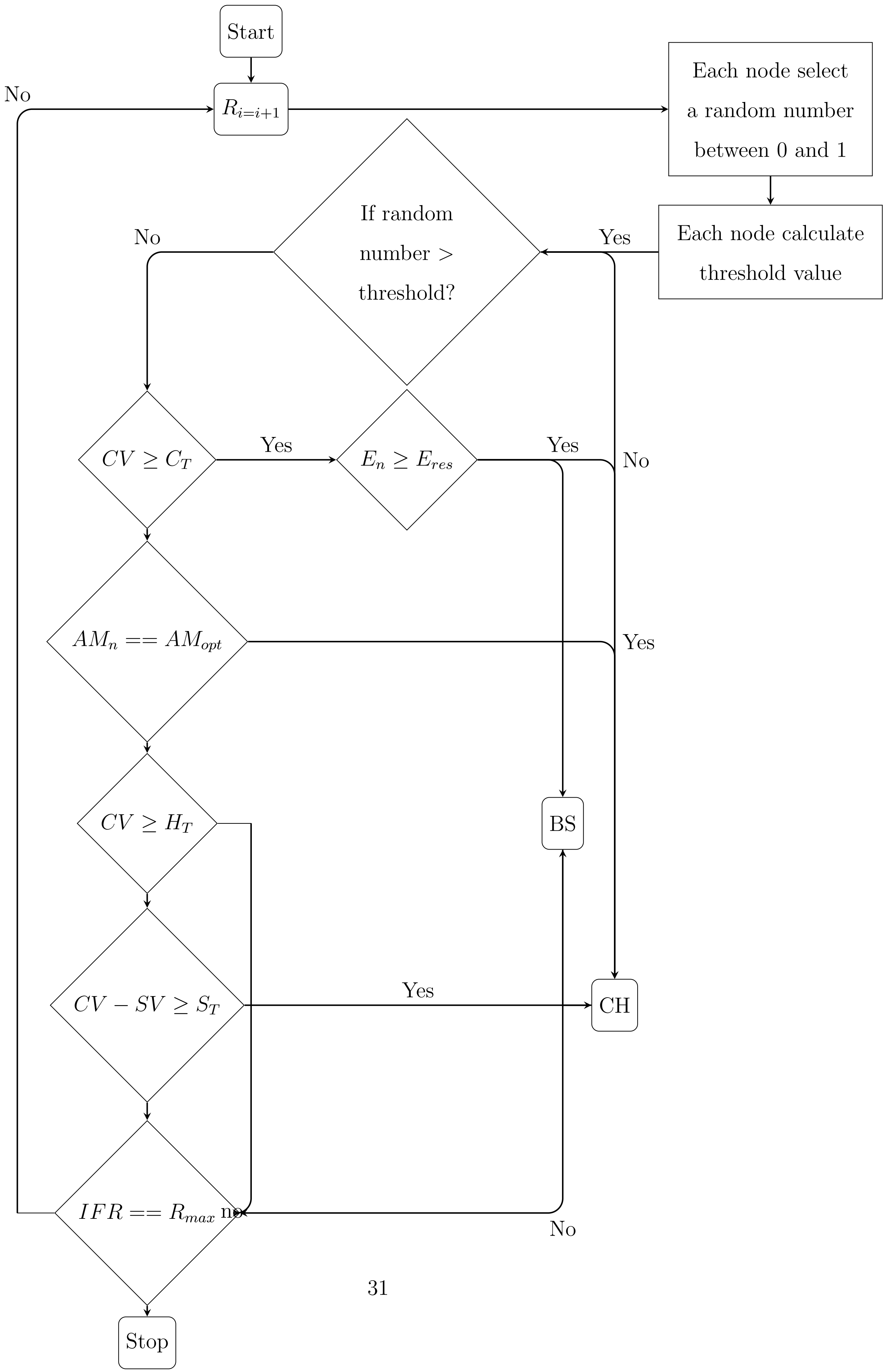
1. Level of battery, density of node, and between every node and BS was calculated,
2. With fuzzy rule probability was calculated, store it in another variable.
3. Threshold value was computed for each node has been stored in the separate variable.
4. For optimal CH selection, two variant probability derived from a fuzzy logic system.
5. Weighted probability is derived by using the mean value of all previous probability and sorting algorithm is applied in each.
6. Node having high probability is elected as the CH.

For prolong the lifetime of a network with enhanced efficiency, CH is selected optimally by old threshold function with each node's properties. [37] was simulated on Matlab with 100 nodes within an area if 100×100 m^2 with first order energy model, which prolong the network lifetime by 73.2% and 42.4% and throughput by 68. 54% and 33.4% with a comparison of sep and sep-e protocol.



Flowchart of cluster formation process of the multi-zonal sep [24]

Flowchart of E-CHATSEP [23] operation



Paper	**Single/ Multi hop**	**Output Parameter**	**Level of Heterogeneity**	**Application Specific**	**CH parameter**	**Network Field**	**simulator**	**Energy Model**	**Load Balancing**	**Security Considerations**
[2]	single	stability period	2	No	Threshold	100 × 100m	Matlab	First order radio model	No	No
[3]	Multi	Throughput	3	No	Threshold	100 × 100 m^2	Matlab	First order radio model	No	No
[4]	single	Stability period and throughput	2	No	Base Station	100 × 100m^2	Matlab	First order radio model	No	No
[5]	Single	Stability Period	2	No	Energy Expansion	100 × 100 m^2	Matlab	First order radio model	No	No
[38]	Single	Stability period and throughput	2	Fog Computing	Probability	100 × 100m^2	Matlab	First order radio model	Network	NA
[6]	single	stability and network lifetime	2	fog computing	Threshold	100 × 100m^2	Matlab	First order radio model	No	No

Paper	**Single/ Multi hop**	**Output Parameter**	**Level of Heterogeneity**	**Application Specific**	**CH parameter**	**Net work Field**	**simulator**	**Energy Model**	**Load Balancing**	**Security Consideration**
[7]	single	Stability period and efficiency of transmission and makes the wireless sensor network very efficient	2 to 9	NA	probability	100 × 100	Matlab	First order radio model	NA	NA
[8]	Single	Stability and throughput	2	NA	Threshold	$100 \times 100m^2$	Matlab	first order radio model	No	No

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[9]	Single	energy consumption and network lifetime	3	NA	fuzzy system	$100 \times 100m^2$	Matlab	first order radio model	No	No
[10]	Single	stability period and network life	3	NA	Threshold	$100 \times 100m^2$	Matlab	first order radio model	No	No
[11]	Single	Network lifetime	3	NA	Probability	$100 \times 100m^2$	Matlab	first order radio model	No	No
[12]	Dual	Network Lifetime and throughput	3	time critical applications	Threshold	$100 \times 100m^2$	Matlab	first order radio model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[13]	Single	Stability and Normal stability period	2	NA	Energy	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA
[14]	Single	Network lifetime	2	NA	energy consumption rate	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA
[15]	multi	network lifetime and reduction in redundant information	2	NA	Threshold	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[16]	Dual	energy balancing and network lifetime prolonging	2	Mobile sink	Threshold	$200 \times 200\ m^2$	Matlab	first order radio model	NA	NA
[17]	Dual	stability period and network lifetime	2	NA	Probability	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA
[18]	single	Network lifetime	2	fuzzy application	fuzzy file and sensor node parameter	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[19]	Multi	Optimizing the cluster selection mechanism	2	NA	residual energy and node degree	100 × 100 m^2	Matlab	first order radio model	Energy Consumption	NA
[20]	single	Network Lifetime, Residual energy, Throughput	2	fuzzylogic	Battery level, Distance, Node Density	100 × 100 m^2	Matlab	First order radio model	NA	NA
[21]	multi	Stability period and Throughput	2	NA	prob ability	100 × 100 m^2	Matlab	First order radio model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[22]	Single	stability period, network lifetime and throughput	3	temperature sensing	Threshold	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA
[23]	Single	Residual Energy	3	Temperature sensing	distance	$100 \times 100\ m^2$	Matlab	First order radio model	NA	NA
[39]	single	stability period, Average energy	2	NA	NA	$100 \times 100\ m^2$	Matlab	First order radio model	NA	NA
[24]	Single	network lifetime and the stability period	2	NA	Threshold	$100 \times 100\ m^2$	Matlab	First order radio model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[25]	Single	Optimal Number of elected CH	2	BA	energy	70 $\times$ 70 m^2	TinyOS		NA	NA
[26]	Single	Energy consumed and Stability period	2	NA	Probability	1000 $\times$ 1000 m^2	NS2		NA	NA
[27]		increasing network lifetime	3	NA	Threshold	100 $\times$ 100 m^2	Matlab	first order radio model	NA	NA
[28]	Multi	Stability period and residual energy	3	NA	distance	100 $\times$ 100 m^2	Matlab	first order radio model	NA	NA
[29]	Single	Network lifetime	2	NA	Threshold	100 $\times$ 100 m^2	Matlab	First order radio model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[30]	Single	Energy efficient with greater network lifetime	3	NA	Energy	$100 \times 100\ m^2$	Matlab	first order radio model	NA	NA
[31]	Single	Network lifetime and throughput	2	NA	Distance	$200 \times 200\ m^2$	Matlab	first order radio energy model	NA	NA
[32]	dual	Energy variance	3	which required complete coverage of network	NA	$100 \times 100\ m^2$	Matlab	first order radio energy model	yes	NA
[33]	Single	Stability period	2,3	NA	Energy	$100 \times 100\ m^2$	Matlab	first order radio energy model	NA	NA

Paper	Single/ Multi hop	Output Parameter	Level of Heterogeneity	Application Specific	CH parameter	Network Field	simulator	Energy Model	Load Balancing	Security Consideration
[34]	Single	Location of heterogeneous node	2	NA	distance	$100 \times 100\, m^2$	Matlab	first order radio energy model	network in best case	NA
[35]	Single	throughput and data redundancy	2	NA	Energy	$100 \times 100\, m^2$	Matlab	first order radio energy model	NA	NA
[36]	Single	stability and throughput	3	NA	Threshold	$100 \times 100\, m^2$	Matlab	first order radio energy model	net work	NA
[37]	Single	Network lifetime & throughput	2	NA	threshold with battery level, node density and distance to BS	$100 \times 100\, m^2$	Matlab	first order energy model	NA	NA

Table 2.1: Survey

2.5 Survey on Machine Learning Tools in WSNs

With The idea of Genetic and Darwinism, John Holland invented Genetic Algorithm. This algorithm is also referred as adaptive heuristic search algorithm for solving an optimization problem. Fitness survival parameter is defined by Charles Darwin, which is accepted as a basic approach for GA. This algorithm provides optimization and robust technique.

Abo-Zahhad et. al. used this algorithm for improving the stability period of WSNs. This approach is used for finding the optimal number of CH and their location based on consumption of energy of sensor nodes after deploying GA. The simulation results show improvement of network lifetime and stability period in both homogeneous and heterogeneous cases.

Hussain et. al. [40] used GA in HCR protocol for creating energy-efficient cluster during transmission. This approach is used for identifies the suitable cluster heads for the network. By using the minimum distance strategy BS assign member nodes to each CH and broadcast the important information. This information consists of No of CH, Member associated with it and number of transmission for this configuration. This information helps him to create the Cluster formation phase. The nodes transmit the info to their respective CH with the transmission number. The simulation result shows enhancement of network lifetime.

Im et. al. [41], for selection of better population size GA is used as a tournament selection or a roulette selection. The heuristic rule is used with Fuzzy selection system for finding optimal solution efficiently. The simulation result shows better performance by heuristic information implemented in a fuzzy logic system.

Tsai et. al. [42], applied an HTGA by combining traditional GA with the Taguachi method. This approach is effectively applied for solving the multiparameter and multicriteria optimization problem of designing the digital low-pass(LP), high-pass(HP), bandpass(BP), and bandstop(BS) filters. The merit of proposed HTGA approach with the merit of convergence of packet is fast, robustness in nature.

Liu et. al. [43], propose a genetic algorithm-based with an optimal probability prediction to achieve good performance in terms of the network in a wireless sensor network. The protocol is evaluated using first-order radio model. The optimal probability is calculated by the GA by searching the solution space through an evolutionary optimization process incorporating probabilistic transitions and non-deterministic rules. The selection, crossover and mutation operation is performed for finding P_{opt}, the BS broadcast the value of P_{opt} to all nodes. This optimal probability is mainly based on BS. This probability provides better network lifetime in respect of LEACH.

2.6 Gaps in survey

While survey on SEP and Machine learning on HWSN we face some problem

1. Due to some problem with probabilistic selection clustering algorithm is defined by priori probability which used to determine the individual cluster head .
2. Lacking of diverse CH parameter.
3. Consumption of energy is unbalance.

To overcome this protocol we discuss about two heuristic approach for enhancing the lifetime of Wireless Sensor Network. This aproach not only enhance the network but also permits the normal nodes for a part of CH selection. In setup phase network is deployed using 5 zones in which the advance nodes and normal nodes are randomly deployed. Than the normal nodes whose energy is more than the minimum energy of advanced nodes in the network takes part in Ch selection phase. These nodes having some initial energy and optimal probability defined for it. While designing the approaches for enhancing lifetime we think for these problem.

2.6.1 System Model

The approach 1 and 2 are modeled by using five zones network field as shown in figure 2.1. Here sensor nodes of n which are randomly deployed in M×M area. While deploying network field we take some assumption.

- Heterogenety nature of nature field.
- The distance is measured on the basis of Wireless radio signal power.
- Once deployed, all nodes are stationary.
- Base Station(BS) is located at the centre of WSNs.

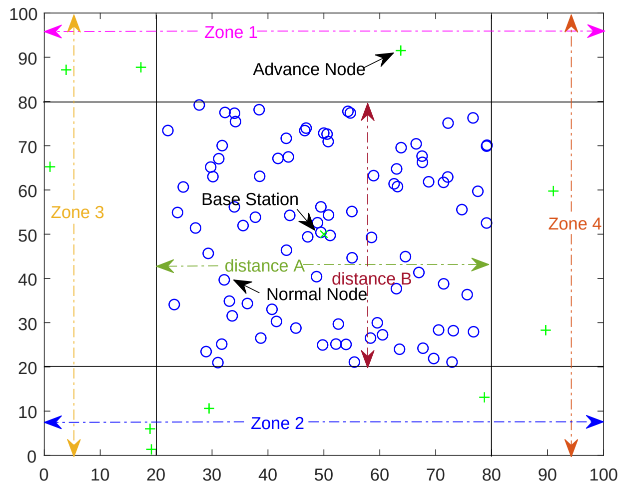


Figure 2.1: Network Model

2.6.2 Simulation Parameter

The simulation parameter used for enhancing this protocol is defined in Table 2.2

Parameter name	**Value**
Node Deployment Area(A)	$200 \times 200\ m^2$ & $300 \times 300\ m^2$
Number of Nodes(n)	100,200 & 500
Initial Energy/Node(E_0)	0. 5J & 1J
Energy factor(α)	2,3 & 4
Simulation Time(r)	Till death of a last node
Sink Position(sink(x,y))	centre
Packet Size(l)	4000 bits
Control Packet Size(K)	200 bits
Transmission Energy($E_{TX-elect}$)	50 nJ/bit
Reception Energy($E_{RX-elect}$)	50 nJ/bit
Amplification energy for short distance (E_{fs})	10 pJ/bit/m^2
Amplification energy for long distance (E_{amp})	0. 013 pJ/bit/m^4
Data Aggregation Energy(E_{DA})	5nJ/bit/message
Threshold Distance(d_o)	$\sqrt{\frac{E_{fs}}{E_{amp}}}$ m
Probability (P_{opt})	0.1
Simulation Runs	Each protocol runs twenty five times for a given n and E_0

Table 2.2: Parameters used for simulations

Chapter 3

FAME

Optimal number of cluster cannot be guarantee of ZSEP. In ZSEP protocol only 2 CH are formed during whole simulation. The cluster formation during every simulation by taking only advance nodes in every $\frac{1}{P}$ adv round. In this approach , the normal nodes are also take part in CH selection.

3.1 Selection of Cluster Heads

If we assume n number of nodes in which "m" fraction of nodes are advance nodes with P_{opt}. These advance nodes having higher energy than normal nodes by α times. Than advance nodes by m×n. With the help of P_{nrm} probability, CH is selectted for each nodes. Once the normal nodes can selected for CH, it cannot goes for next round.
The weighted probabity of normal nodes to become CH is given by

$$P_{nrm} = \frac{P_{opt}}{1 + (\alpha \times m)} \tag{3.1}$$

The weighted probability of advance nodes to become CH is given by

$$P_{adv} = \frac{P_{opt} \times (1 + \alpha)}{1 + (1 + (\alpha \times m))} \tag{3.2}$$

The threshold value for normal and advance node are coined by eq2.50.

3.2 Calculation of distance(d)

Within a square regin of M dimention by considering P_{opt} within the r round. The distance between node and base station is given by

$$d = \sqrt{(loc\_BS\_x - loc\_n\_x)^2 + (loc\_BS\_y - loc\_n\_y)^2} \tag{3.3}$$

Energy dissipating by normal and advance node can be calculated by considering distance "d"

$$E = \begin{cases} E - ((E_{TX} + E_{DA}) \times l + E_{mp} \times l \times (dis^4)) & ifdis > d \\ E - ((E_{TX} + E_{DA}) \times l + E_{fs} \times l \times (dis^2)) & ifdis \leq d \end{cases} \tag{3.4}$$

In this protool, the source will meaure the distance between itself and base station by eq3.3, if distance is less than 0.5×d it will directly transmit the packet or else if the distance is more than 0.5×d it will transmit packet through Cluster Head.

3.3 Overhead

The energy expended during the transmitting and receiving the data to sensor nodes by advance nodes is defined by

$$OH = \begin{cases} OH - ((E_{TX}) \times l + E_{mp} \times l \times (dis^4)) & ifdis > d \\ OH - ((E_{TX}) \times l + E_{fs} \times l \times (dis^2)) & ifdis \leq d \end{cases} \tag{3.5}$$

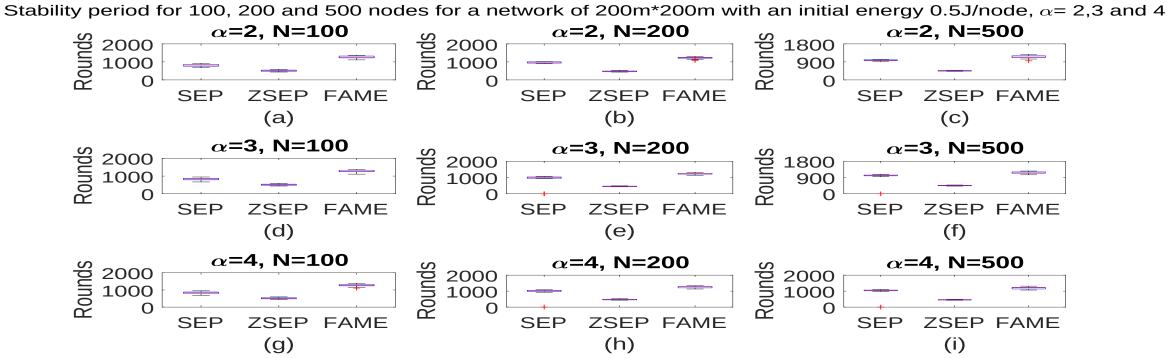
and for normal nodes it is calculated as

$$OH = OH + (E_{RX} \times CONTROL\_PKT\_SIZE) \tag{3.6}$$

3.4 Simulation and Result

The whole simulation is done by MATLAB and first order radio energy model is used. The node may vary from (100, 200 & 500) with initial energy of (0.5,1)j, the energy factor is (2,3 & 4) in a network field of ($200 \times 200m^2$ & $300 \times 300m^2$).The figures 3.1a, 3.1b, 3.1c & 3.1d of figure 3.1 shows comparative study of SEP, ZSEP and proposed protocol.

The figure 3.1a & 3.2a shows the comparision with $200 \times 200m^2$ network field with energy factor of 2,3 & 4 with initial energy of 0.5J. The figure 3.1b & 3.2b shows the comparision with $200 \times 200m^2$ network field with energy factor of 2,3 & 4 with initial energy of 1J. The figure 3.1c & 3.2c shows the comparision with $300 \times 300m^2$ network field with energy factor of 2,3 & 4 with initial energy of 0.5J. The figure 3.1d & 3.2d shows the comparision with $300 \times 300m^2$ network field with energy factor of 2,3 & 4 with initial energy of 1J . The stability period is enhanced as the network field size and energy factor with number of nodes increases. The proposed approach 1 enhance the network lifetime 1.5 times of SEP protocol and 8 times of ZSEP protocol. The instability period of proposed approach shown in figure 3.2. This figure shows proposed approach is reduced by average 0.6 times of ZSEP protocol and 0.19 times of SEP protocol.



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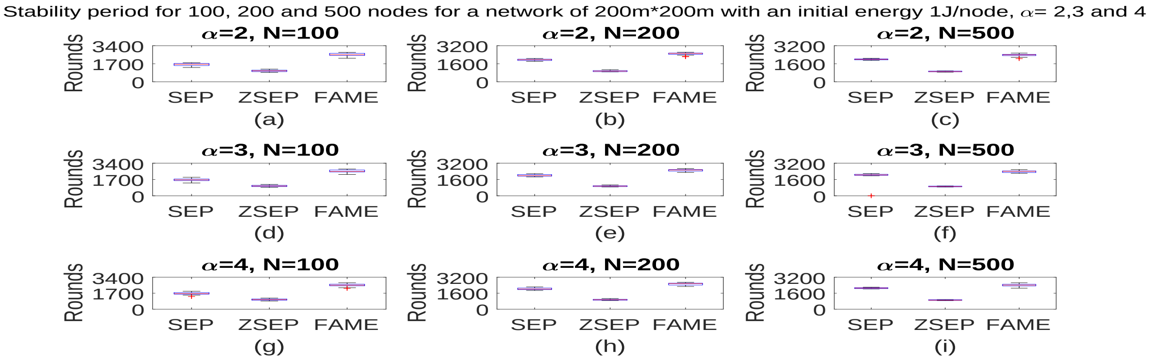

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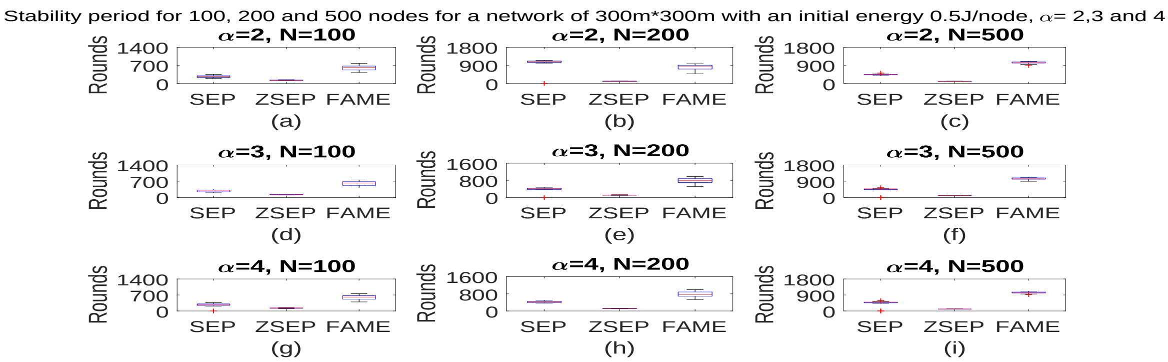

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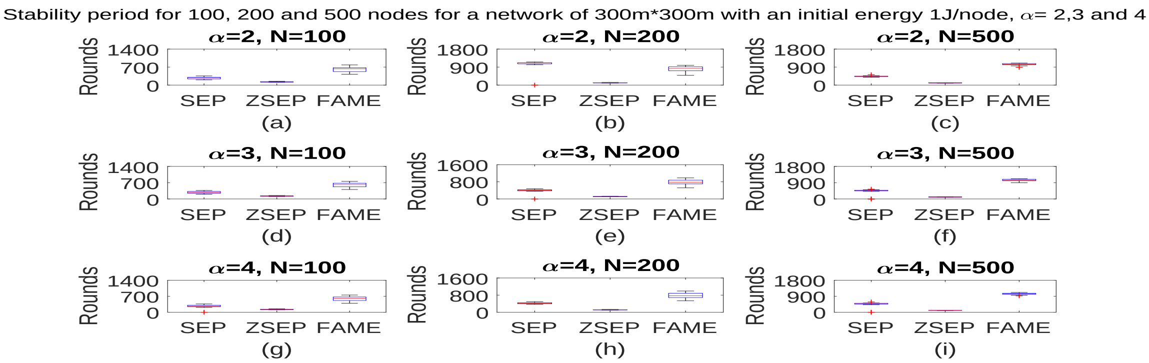
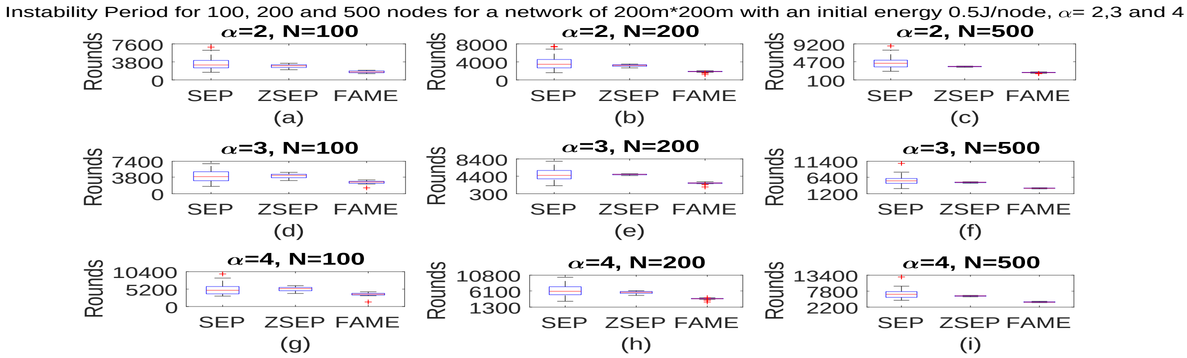
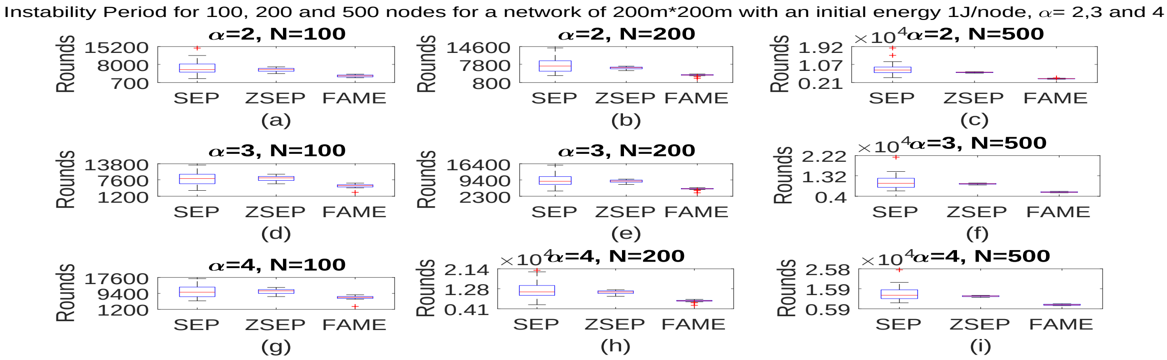


(d)

Figure 3.1: Stability Period



(a)



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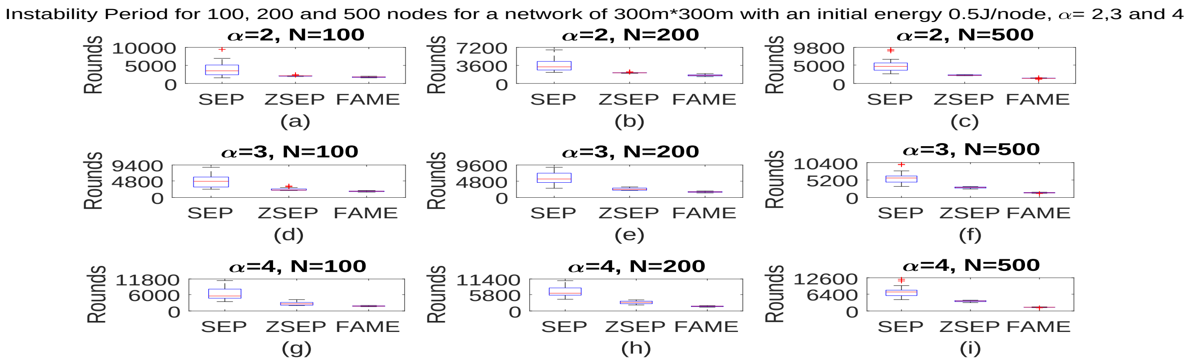

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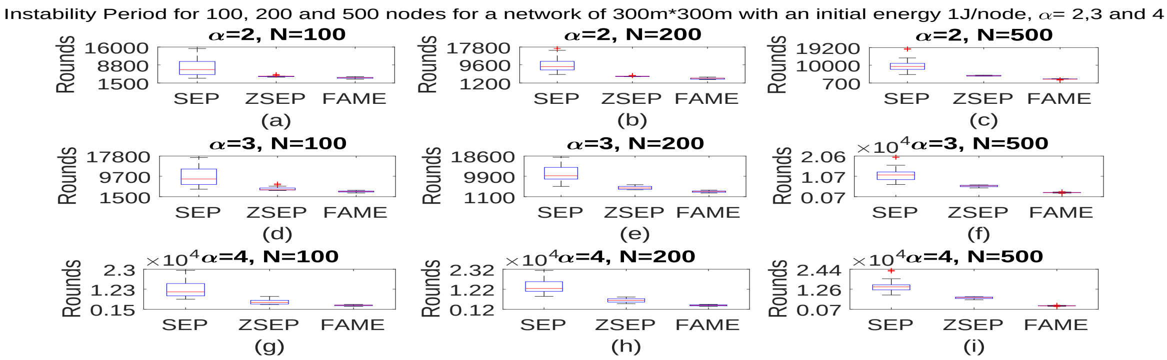


(d)

Figure 3.2: Instability Period

Chapter 4

FCH: Fitness based Cluster Head Election

This fitness parameter is the basic and important parameter for the GA. This parameter helps us for maintaining the utilization of energy and formation of CH. Here we consider the proper utilization of energy by considering the distance to the BS which is given in equation (4.1)

$$F = \left(P \times \frac{RE}{avg}\right) + \left(\frac{distance}{avg\_distance}\right) \tag{4.1}$$

where F is the fitness function, RE is the residual energy, avg is the average energy of the network. The "distance" is the maximum distance and "avg_distance" the avg of the distance of a specific type of nodes.

4.1 Selection of Cluster Heads

If we assume n number of nodes in which "m" fraction of nodes are advance nodes with P_{opt}. These advance nodes having higher energy than normal nodes by α times. Then advance nodes be m×n. The normal nodes be (1-m)×n.
As we know the probability for normal nodes is existing protocol is ,

$$P_{nrm} = \frac{P_{opt}}{1 + (\alpha \times m)} \tag{4.2}$$

With the help of this probability we used to find Fitness parameter for normal nodes

$$F_{nrm} = \left(P_{nrm} \times \frac{RE}{avg}\right) + \left(\frac{distance\_n}{opt\_distance\_n}\right) \tag{4.3}$$

Here distance_n is the maximum distance to the base station from the alive normal nodes in each round and opt_distance_n is the normalized distance of allive nodes in each round. This fitness parameter is gone through the nomalization technique , first normalization we calculate by,

$$F_{nrm1} = \frac{F_{nrm}}{max(F_{nrm})} \tag{4.4}$$

and secound normalization is defined by,

$$F_{nrm2} = \frac{F_{nrm1} - min(F_{nrm1})}{maxF_{nrm1} - minF_{nrm1}} \tag{4.5}$$

The new probability of normal nodes become,

$$P_{newnrm} = max(P_{nrm}, F_{nrm2}) \tag{4.6}$$

The probability measure for advance nodes is define by P_{newadv} using same process done for normal nodes equation (4.6). For selection of optimal CH among different cluster, we used throughput parameter defined in equation (4.7), (4.8) for normal and advance nodes.

$$T_{(s_{nrm})} = \begin{cases} \left(\dfrac{P_{newnrm}}{1 - P_{newnrm} * (r * mod(\dfrac{1}{P_{newnrm}})} \times \left(\dfrac{RE}{avg \times p} \right) \right), & ifS_{nrm} \in X' \\ 0, & ifotherwise, \end{cases} \tag{4.7}$$

$$T_{(s_{adv})} = \begin{cases} \left(\dfrac{P_{newadv}}{1 - P_{newadv} * (r * mod(\dfrac{1}{P_{newadv}})} \times \left(\dfrac{RE}{avg \times p} \right) \right), & ifS_{adv} \in X'' \\ 0, & ifotherwise, \end{cases} \tag{4.8}$$

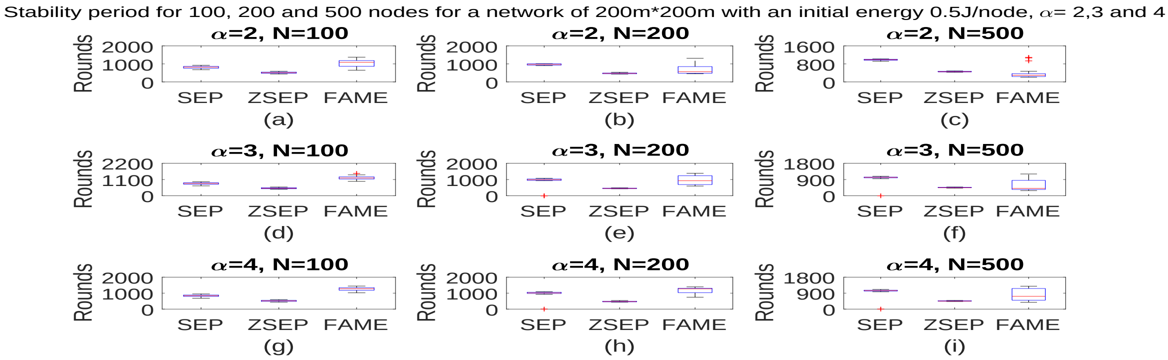
4.2 Calculation of distance(d)

The distance calculated from the network of each alive nodes by eq:3.3, the optimal distance is calculated by

$$opt\_distance\_n = \frac{dist_i}{sum\_distance} \tag{4.9}$$

4.3 Simulation Result

The whole simulation is done by MATLAB and first order radio energy model is used. The node may vary from (100, 200 & 500) with initial energy of (0.5,1)j, the energy factor is (2,3 & 4) in a network field of ($200 \times 200m^2$ & $300 \times 300m^2$). The figures 3.1a, 4.1b, 4.1c & 4.1d of figure 4.1 shows comparative study of SEP, ZSEP and proposed protocol. The figure 4.1a & 4.2a shows the comparision with $200 \times 200m^2$ network field with energy factor of 2,3 & 4 with initial energy of 0.5J. The figure 4.1b & 4.2b shows the comparision with $200 \times 200m^2$ network field with energy factor of 2,3 & 4 with initial energy of 1J. The figure 4.1c & 4.2c shows the comparision with $300 \times 300m^2$ network field with energy factor of 2,3 & 4 with initial energy of 0.5J. The figure 4.1d & 3.2d shows the comparision with $300 \times 300m^2$ network field with energy factor of 2,3 & 4 with initial energy of 1J . The stability period is enhanced as the network field size and energy factor with number of nodes increases. The proposed approach 1 and 2 enhance the network lifetime 2 times of SEP protocol and 9 times of ZSEP protocol. The instability period of proposed approach shown in figure 4.2. This figure shows proposed approach is reduced by average 0.5 times of zsep protocol and 0.2 times of SEP protocol.



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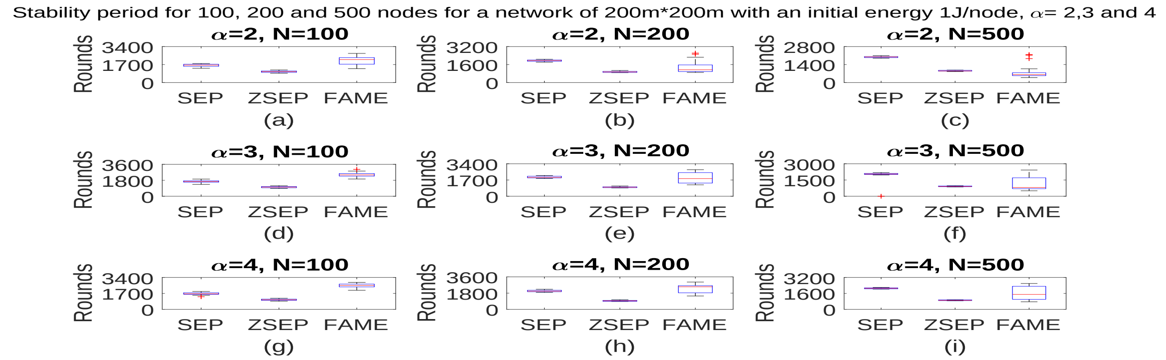

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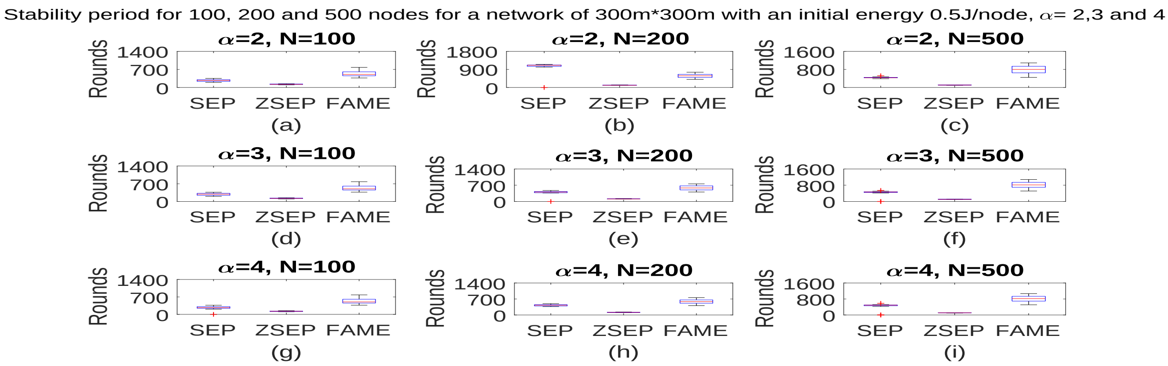

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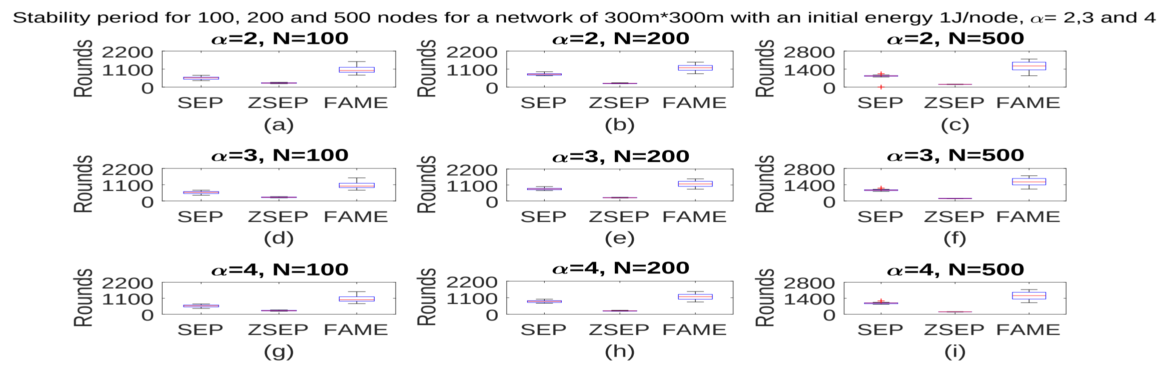
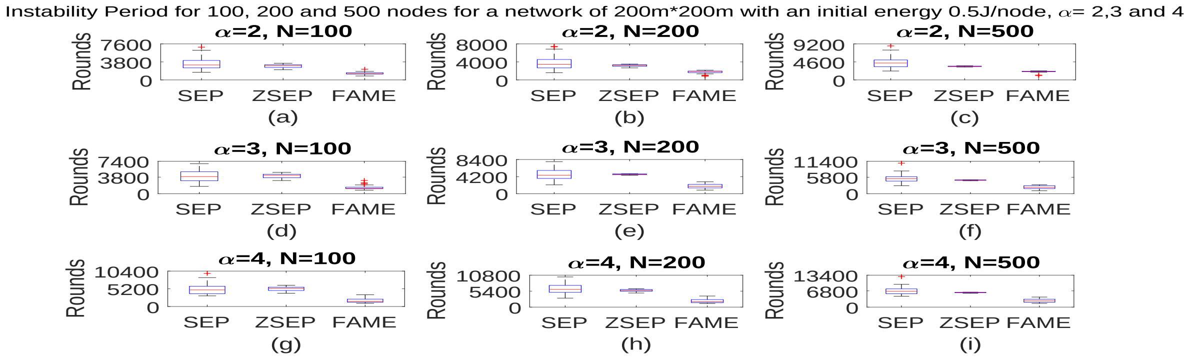


(d)

Figure 4.1: First Node Death



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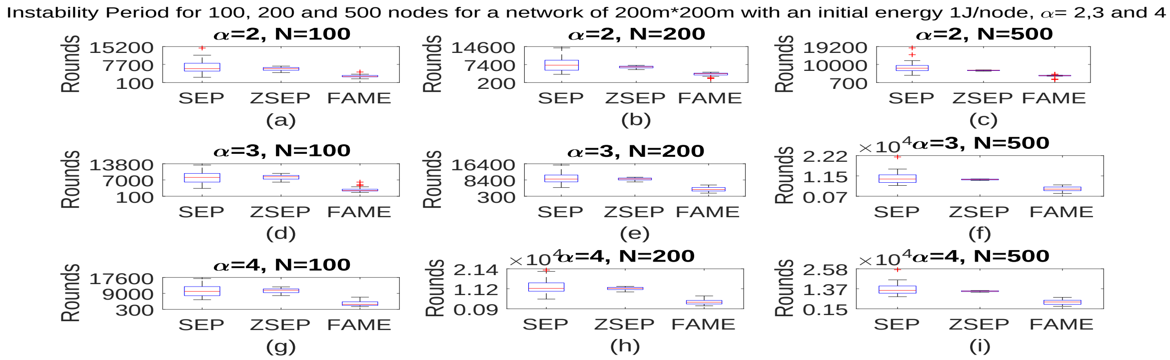

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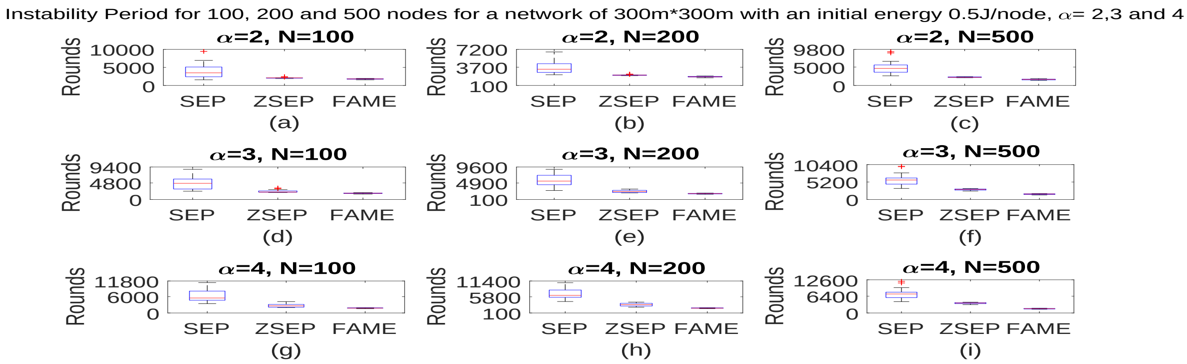

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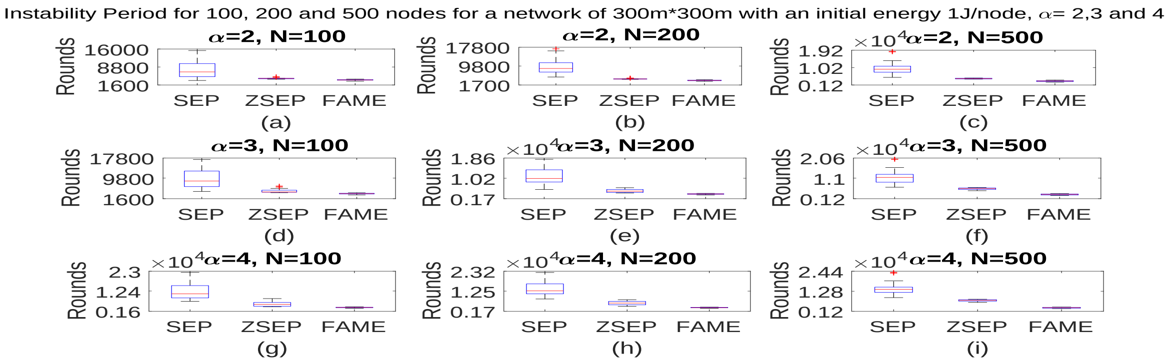

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Figure 4.2: Instability Period

Chapter 5

Conclusion

The two heuristic approaches shown here is used for enhancing the lifetime of the protocol. Here the energy, as well as the distance parameter, are considered as a key parameter for HWSNs. The energy is well utilized by the network model. The simulation done for this protocol shows that the stability period of the whole network are far better than the SEP and ZSEP protocol. The instability period is also reduced. In future, we like to integrate with the distance routing protocol for increasing the QoS parameter.

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