Optimizing Cluster Head Selection in Hierarchical Clustered Sensor Network Using Genetic Algorithm

Thesis submitted in partial fulfilment of the requirements for the award of degree of

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Submitted By

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CERTIFICATE

I hereby certify that the work which is being presented in the thesis entitled, **"Optimizing *Cluster Head Selection in Hierarchical Clustered Sensor Network Using Genetic Algorithm*"**, in partial fulfillment of the requirements for the award of degree of Master of Technology in *Computer Applications* submitted in Computer Science and Engineering Department of Thapar Institute of Engineering and Technology, Patiala, is an authentic record of my own work carried out under the supervision of ***Dr. Sharad Saxena*** and refers other researcher's work which are duly listed in the reference section.

The matter presented in the thesis has not been submitted for award of any other degree of this or any other University.

Nitika

(Nitika Garg)

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

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ABSTRACT

Wireless sensor network is the network containing various sensor nodes. Their sole purpose is to aggregate the data from the physical environment and transmit it to the Base Station (BS). This communication will take place wirelessly. Each node has small asset regarding power and bandwidth. Wireless Sensor Network (WSN) applications have expanded for example, ecological detecting, region observing, air contamination checking, machine wellbeing checking, etc. So because of limited battery power, it becomes very important to save the power of these nodes to extend the network lifetime as it is extremely hard to replace batteries.

Clustering is a mechanism to extend the lifetime of the WSN. Hierarchical based routing protocols are used to route the traffic from source to the destination via Cluster Head (CH). This sort of routing convention sub-partition the WSN into small clusters and build a hierarchy of nodes.

Type-2 fuzzy logic, that follows certain rules, is used to select one node to be the CH so that network life time can be enhanced compare to the simple leach where CH is chosen based on single parameter like remaining energy. Type-2 Fuzzy based system has taken three parameters like density, residual energy and distance for cluster head selection. In proposed work, Genetic based approach has been used. This approach uses selection; crossover and mutation based system so that optimized result can be generated in terms of selection of the most superior sensor node to become a CH. Various performance analysis like dead nodes count, alive nodes count and residual energy have been evaluated. An improvement in case of Genetic based approach as compared to Type-2 Fuzzy based selection criteria and comparison has been observed on different network topologies.

.

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LIST OF ABBREVIATIONS

WSN	Wireless Sensor Network
CH	Cluster Head
GA	Genetic Algorithm
BS	Base Station
QOS	Quality of Service
TDMA	Time Division Multiple Access
MCH	Master Cluster Head
LEACH	Low-Energy Adaptive Clustering Hierarchy
HEED	Hybrid Energy-Efficient Distributed Clustering
TEEN	Threshold Sensitive Energy Efficient Sensor Network
APTEEN	Adaptive Threshold Sensitive Energy Efficient Sensor Network
PEGASIS	Power-Efficient Gathering in Sensor Information Systems
IE	Initial Energy
RE	Remaining Energy
CE	Consumed Energy
N	Number of Nodes
DNC	Dead Nodes Count
ANC	Alive Nodes Count
AN	Alive Nodes
DN	Dead Nodes

Chapter 1

Introduction

This section gives introduction about Wireless Sensor Network (WSN), its advantages and the characteristics. Discussion on how clustering is done in WSN, its objectives and various advantages of clustering. A brief summary on Type-2 Fuzzy Logic and Genetic Algorithm is given in this section.

1.1 Wireless Sensor Network

Wireless sensor network comprises vast number of little, less energy, minimal effort sensor nodes with restricted memory, computational, and correspondence assets and a Base Station (BS). These nodes consistently screen ecological surroundings, gather full data about the environmental condition in which they are introduced, and at that point transmits the gathered information to the BS. The BS has an expansive repository and huge information handling abilities. It paths the information it gets from sensor nodes to the server from where end-client can get to them [1].

WSN has leverage of being worked unattended in nature where non-stop human observing is unsafe, wasteful or unusable. Sensor nodes keep running on batteries and as the nodes are deployed their batteries can't be replaced, thus have small life expectancy. Wireless sensor network is shown in Figure 1.1.

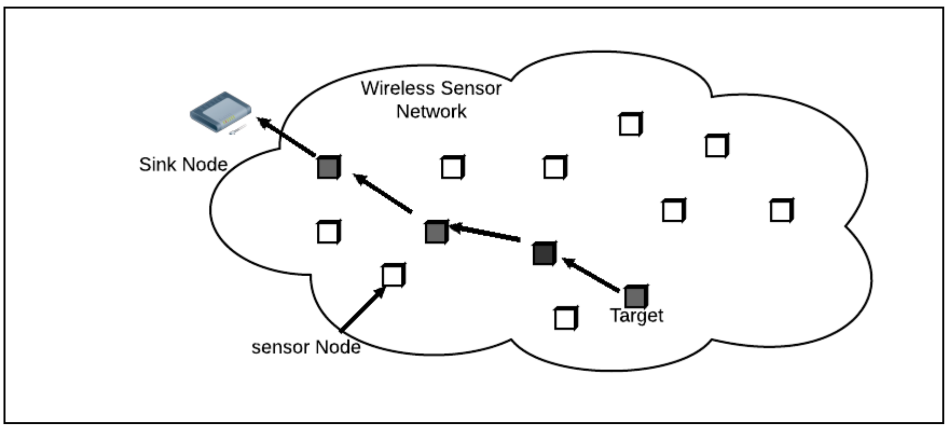

Fig. 1.1 Wireless Network Containing Sensor Nodes [2]

There are various uses of WSN that includes environment applications and health applications like forest fire detection in perspective of temperature information it gets from considerable number of dispersed sensor nodes, landslide detection, following and checking specialists and patients, and natural disaster [2]. They are also applied in military applications like zone observation, fight harm evaluation, and so forth [3]. Home applications include home automation, smart environments.

Characteristics of WSN:

- Restricted computational limit.
- Restricted vitality assets.
- Scalability.
- Restricted memory limits.
- Ease of use.
- More risk of breakdown of nodes due to unattended condition and low power.
- More thickly deployment of nodes [4].

Advantages of WSN:

- **Flexible:** Wireless sensor networks are flexible as they can easily adapt to any kind of changes.
- **Improved Lifetime:** In WSN, the nodes are assembled together into different clusters. So only one node from their respective cluster can take the responsibility of passing information to the BS instead of all the nodes participating in communication, thus upgrades the lifetime of the system [5].
- **Cost:** Cost of implementation is less.
- **Robustness to Withstand Rough Environmental Conditions:** Ideal for the hostile environment, for example, over the ocean, mountains, country territories or profound woods. .
- **Fault Tolerance:** In WSN, various sensor nodes are deployed near each other. They are able to overcome node failures, by simply using another routing path.

Disadvantages of WSN:

- Short lifespan.
- Restricted energy of nodes.
- Speed of communication is less.
- Low bandwidth.
- Slow access time.
- Limited processing.

1.2 Clustering in WSN

Network lifetime is one of the crucial concerns in WSNs. As senor node has constrained battery control and due to its presence in unattended and harsh area makes it difficult to energize the batteries, so it becomes very crucial to increase life expectancy of the network. To cope up with this issue and to upgrade life of the system, clustering of the sensor nodes is done. Clustering is a way towards combining various sensor nodes into different gatherings that are known as clusters and one node known as the CH is chosen from every cluster based on some mechanism [6]. This node known to be cluster head is in charge of communicating information on behalf of all sensor nodes present in that cluster to the BS as shown in Figure 1.2.

All senor nodes in a cluster will sense the surroundings and collects all the sensed data. These nodes as opposed to passing information individually to the BS pass it to its CH. This will gather and combine all information from the sensor nodes and pass it to the base station through single hopping or by multi-hopping. The BS then passes the meaningful information to end users. As lot of power is taken up in transmitting and receiving of data, because of clustering it takes only one node to transmit information to BS thereby saving the vitality of a node. Hence, lifetime of the network increases.

There are various types of clustering techniques. These includes Event-to-Sink Directed clustering, Load Balanced clustering scheme, K-means clustering, Low-Energy Adaptive clustering, Hybrid Energy Efficient Distributed Clustering, Weight Based clustering, Hierarchical clustering. We have used hierarchical clustering approach as discussed in the following section.

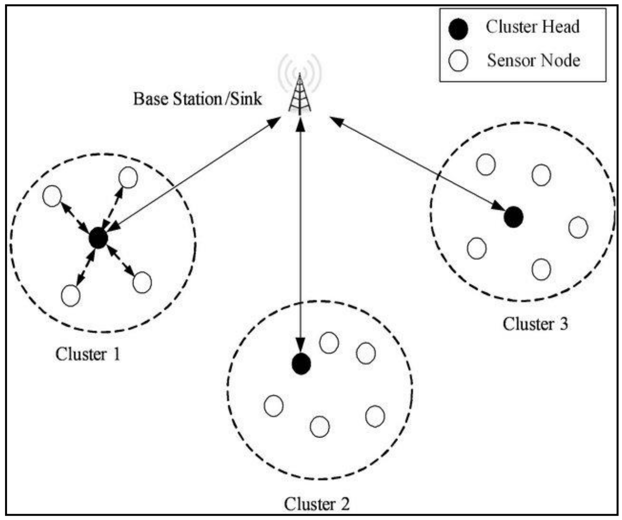

Fig. 1.2 Clustering in WSN

Advantages and Objectives of Clustering:

- **Scalability:** In WSNs we can add any number of sensor nodes when required.
- **Fault Tolerance:** Re-clustering can be done in case any node goes out of energy i.e. node failure.
- **Quality of Service:** Non excess and quality information is conveyed to the end client through grouping at exact time.
- **Load Balancing:** The sensor nodes are uniformly distributed to frame groups. These equivalent estimated cluster heads helps in adjusting the load among nodes and anticipates untimely vitality depletion.
- **Less Energy Consumption:** By aggregating data, we can significantly decrease transmission of information and spare vitality. Additionally, grouping with intra-cluster and between group correspondences decrease quantity of sensor nodes

playing out an assignment of large separation interchanges, in this manner permitting less vitality utilization for the whole system. Also, just cluster heads play out the assignment of information transference in clustering routing mechanism that will spare lot of vitality utilization.

- **Fewer Loads:** Since sensors may produce repetitive information, information collection or combination has risen as a critical precept and target in WSNs. The primary thought of information collection or combination is to consolidate information from various sources to dispense with excess information transferences, and give a rich and multi-dimensional perspective of objectives that are observed. For grouping topology, nodes just passes information to cluster heads and information gathering is done at the cluster heads that will drastically lessen transfer of information and spare vitality.
- **Data Aggregation/Fusion:** All the nodes scatter collected data towards their corresponding cluster heads. They at that point do information assembling and wipe out excess data and pass just significant information to BS. Along these lines information gathering helps in lessening the vitality utilization [8].
- **Robustness:** Clustering makes it more helpful to organize topology and reacting to arrange change involving node expanding, node portability and unexpected disappointments, and so forth. A grouping plan just require adapting to the progressions inside individual clusters, subsequently the whole system is stronger and more advantageous for administration. Remembering the ultimate objective to share cluster head duty, cluster heads are turned among the entire sensor nodes to avoid the single point failures.

1.3 Hierarchical Clustering

In hierarchical based clustering choosing the cluster heads in WSNs is the main level and second level includes the information transfer from sensor nodes to a BS by means of cluster heads shown in Figure 1.4. A broad number of groups will cover zone with minimal size clusters and few number of clusters will deplete CH by huge measure of messages to be transmit from group individuals. To accomplish network scalability, high vitality efficiency and drag out system lifetime in substantial scale wireless sensor networks, sensor nodes are frequently gathered into non-covering groups called clustering process in WSN [10].

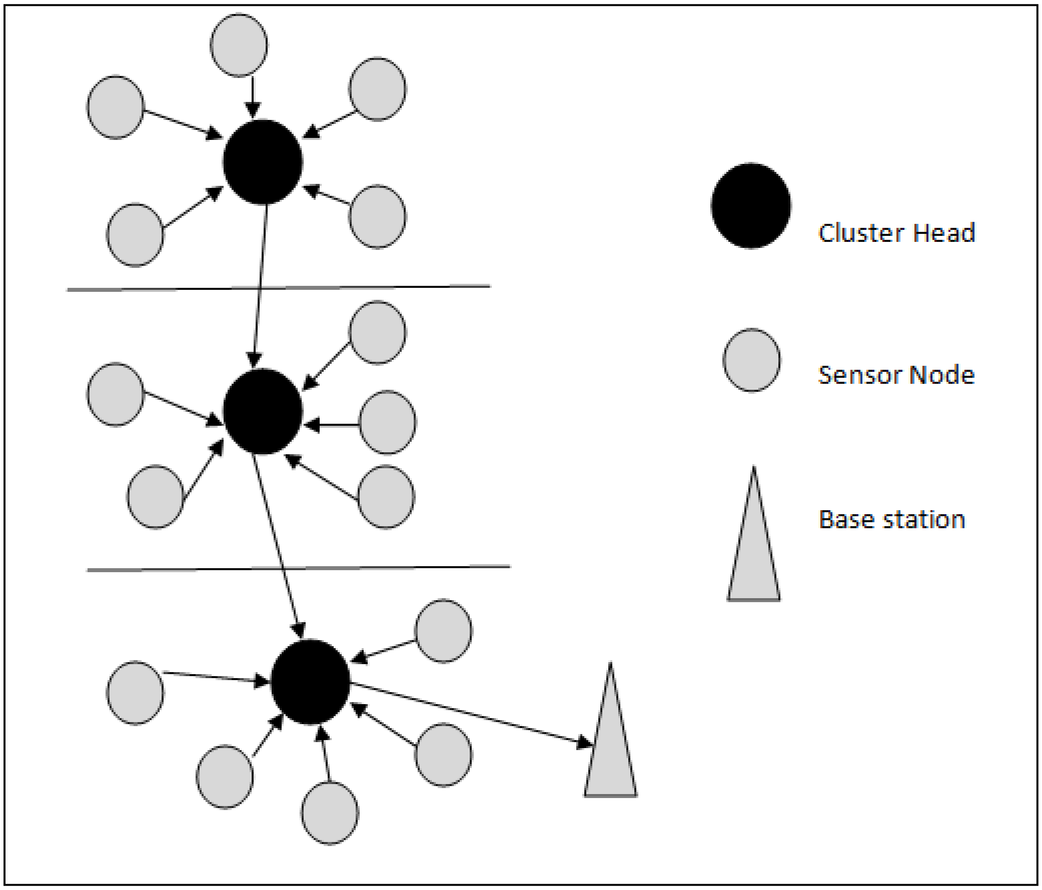

Fig. 1.3 Hierarchical Clustering in WSN

1.4 Fuzzy Type-2 Logic Systems

The idea of data is associated with idea of vulnerability. The most basic part with the association is vulnerability engaged with any critical thinking circumstance is a consequence of few data insufficiency that might be inadequate, loose, not completely dependable, dubious, opposing, or insufficient in some other way. Vulnerability might be seen as a property of data. The basic structure of fuzzy thinking permits taking care of quite a bit of vulnerability and fuzzy frameworks could utilize Type-1 sets that speak to vulnerability by number in the range [0, 1]. At the point the element is indeterminate, it becomes hard to decide its correct connection value, and obviously Type-1 fuzzy sets bode well. In any case, it isn't sensible utilizing exact membership function for something that is not certain, so for the situation we required is other kind of fuzzy sets, those that can deal with these vulnerabilities, the supposed Type-2 fuzzy sets. A measure of vulnerability in framework could be diminished by utilizing this logic since it provides good capacities dealing with linguistic vulnerabilities demonstrating unclearness and inconsistency of data. Type-2 fuzzy inference mechanism is shown in Figure 1.5.

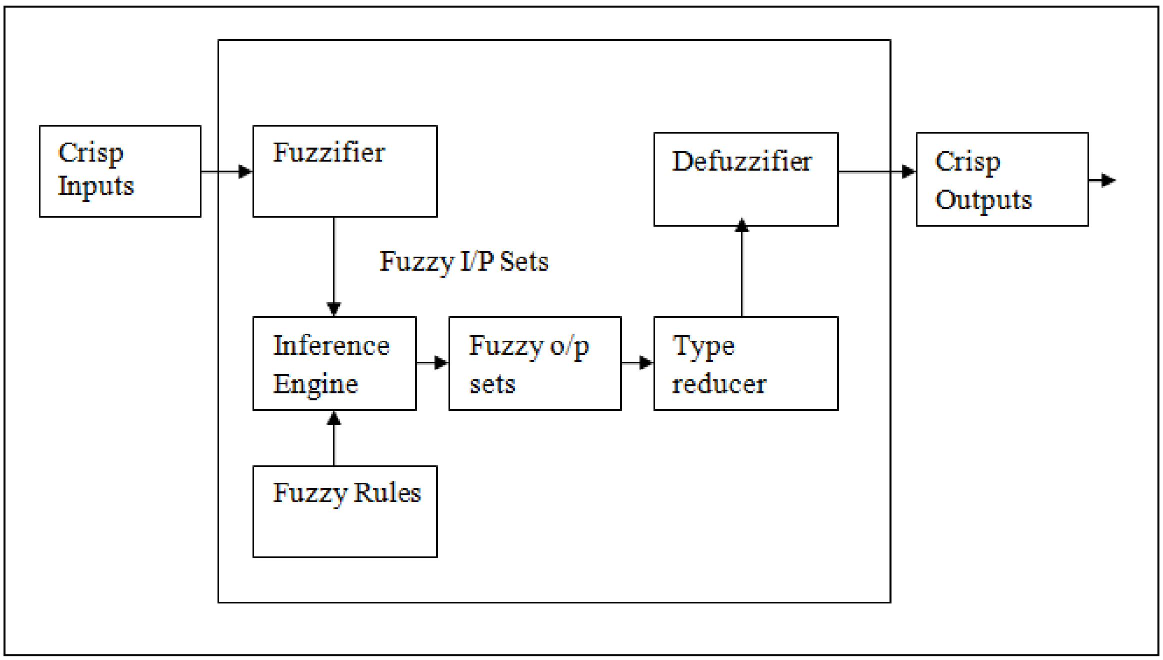

Fig. 1.4 Type-2 Fuzzy Inference Mechanism [11]

- **Fuzzifier:** In this block the fuzzy sets are generated from crisp inputs. Three sorts of fuzzifiers are conceivable in interim Type-2 fuzzy logic system. At the point when estimations are :
  - Perfect and displayed as fresh set;
  - Noisy, yet commotion is motionless, they are demonstrated as a Type-1 fuzzy set.
  - Noisy, yet commotion is in motion, they are demonstrated as interval Type-2 fuzzy set.

- **Rules:** Standards, that are either given by subject specialists or are extricated from numerical information, are communicated as a collection of IF-THEN explanations.
- **Inference:** The Inference block maps resultant input fuzzy sets into output fuzzy sets after estimations are fuzzified. This is refined by initially measuring each rule with fuzzy set theory, and by then utilizing the arithmetic of fuzzy sets to build up the yield of each rule, with the assistance of an inference system. In the event that there are M rules then the fuzzy input sets to the Inference block will initiate just a subset of those rules, where the subset contain no less than one rule and usually way less than M rules. Thus, at the yield of the Inference block, there will be at least one fired-rule fuzzy output sets.
- **Type Reducer:** It produces a Type-1 fuzzy set output, which is changed over in a numeric yield through running the defuzzifier [12-14].
- **Defuzzifier:** An average of two end-points of the interval set is the defuzzified output.

Disadvantages:

- Membership function estimation is hard.
- Hard to make a model from a fuzzy logic.
- Wants further fine-tuning and simulation before operational.

1.5 Genetic Algorithm

Genetic Algorithms are search algorithms inspired by system of natural selection. It is a biological procedure such that fittest individuals are likely to become the victors in the contending domain. Here, Genetic Algorithm utilizes an immediate relationship of such normal development. It considers that possible arrangement of an issue is an individual and can be expressed by an arrangement of parameters. Parameters are viewed as the genes of chromosome and can be organized by string of values in binary figure. To mirror the level of "goodness" of the chromosome, a positive value called as fitness value is utilized for tackling the issue, and this value is firmly identified with its objective value [15].

All through a Genetic evolution, a stronger solution tends to defer great quality offspring, which implies an improved outcome for an issue. In reasonable utilization of GA, population collection of chromosomes must be introduced and can be arbitrarily place at first. From one issue to the other, there is a variation in the size of the population. In every round of Genetic action, from the present population a fresh generation is formed from chromosomes. This must be fruitful if a gathering of those chromosomes, for the most part called "parents" are chosen through a particular selection mechanism. The genes of the parents are to be blended and recombined for the creation of offspring in next generation. It is likely that from this procedure of development, the “superior” chromosome will make a bigger number of offspring, and thus has a high ability of existing in the succeeding generation. Genetic Algorithm procedure is shown in Figure 1.6.

Genetic Algorithm Procedure:

- An initial population of individuals is selected.
- Calculation of the value from fitness function of each chromosome present in that initial population.
- Repeat this process until end condition. (Time restrain, adequate fitness accomplished, etc.)
- Then best-fit individuals are selected for reproduction process.
- Crossover and mutation operations are performed on these individuals to give birth to offspring.
- Assess the individual fitness value of new individuals.
- Replace less fit population with the new generated individuals [16].

Steps of Genetic Algorithm:

- **Population:** Population is defined as a collection of chromosomes i.e. possible solutions. A chromosome is made of genes that mirror the parameters that are to be optimized. In this manner, every individual chromosome represents a conceivable answer for the optimization issue. A measurement of the Genetic Algorithm alludes to a measurement of the search space which is equal to the quantity of gene in each solution. The range of population should not be either too large or should be too small. Because if the size of the initial population is too large, it can lead slowing down of Genetic Algorithm, and if the size of initial population is too small, it will not have a good mating pool.

- **Fitness Function:** The performance of each chromosome is calculated through the fitness function present in the population. The function must be selected with mind as it is the only main connection between the Genetic Algorithm and the application itself. The fitness function must reflect the application suitably to minimize the parameters.
- **Crossover:** The selection operator chooses two parents from the population and then two offspring are computed through crossover operation. The new generation is made after mutation operator by these offspring. Crossover is the Genetic Algorithms primary local search routine. A likelihood of crossover is foreordained before the calculation is begun which administers whether each parent combine is crossed-over or reproduced. Generation brings about the posterity match being precisely equivalent to the parent combine. The crossover activity changes over the parent match to binary notation and swaps bits after a haphazardly chose crossover point to frame the posterity combine.

Indiv1	1	0	0	1	**1**	**1**	**0**	**0**
Indiv2	0	0	1	0	**1**	**1**	**0**	**1**
Child1	1	0	0	1	**1**	**1**	**0**	**1**
Child2	0	0	1	0	**1**	**1**	**0**	**0**

- **Mutation:** Mutations are worldwide inquiries. A likelihood of mutation is again foreordained before the calculation is begun which is connected to every individual piece of every posterity chromosome to decide whether it is to be altered.

Before	1	0	**1**	0	1	1	0	0
After	1	0	**0**	0	1	1	0	0

- **Selection:** By depending on the values generated from the fitness function, this operator selects good chromosomes and temporary population is produces which is known as the mating pool. Roulette wheel, ranking, tournament selection, random selections are some of the common schemes used for selection mechanism. This operator is in charge of convergence of the algorithm.

Advantages of Genetic Algorithm:

- Gives a solution that shows signs of improvement with time.
- It's a best suited algorithm in case of noisy surroundings.
- Genetic algorithm is inherently parallel and effectively appropriated.
- Used to solve optimization problems.
- Simple technique to comprehend and helpfully exchange to existing simulations and models.

Flowchart:

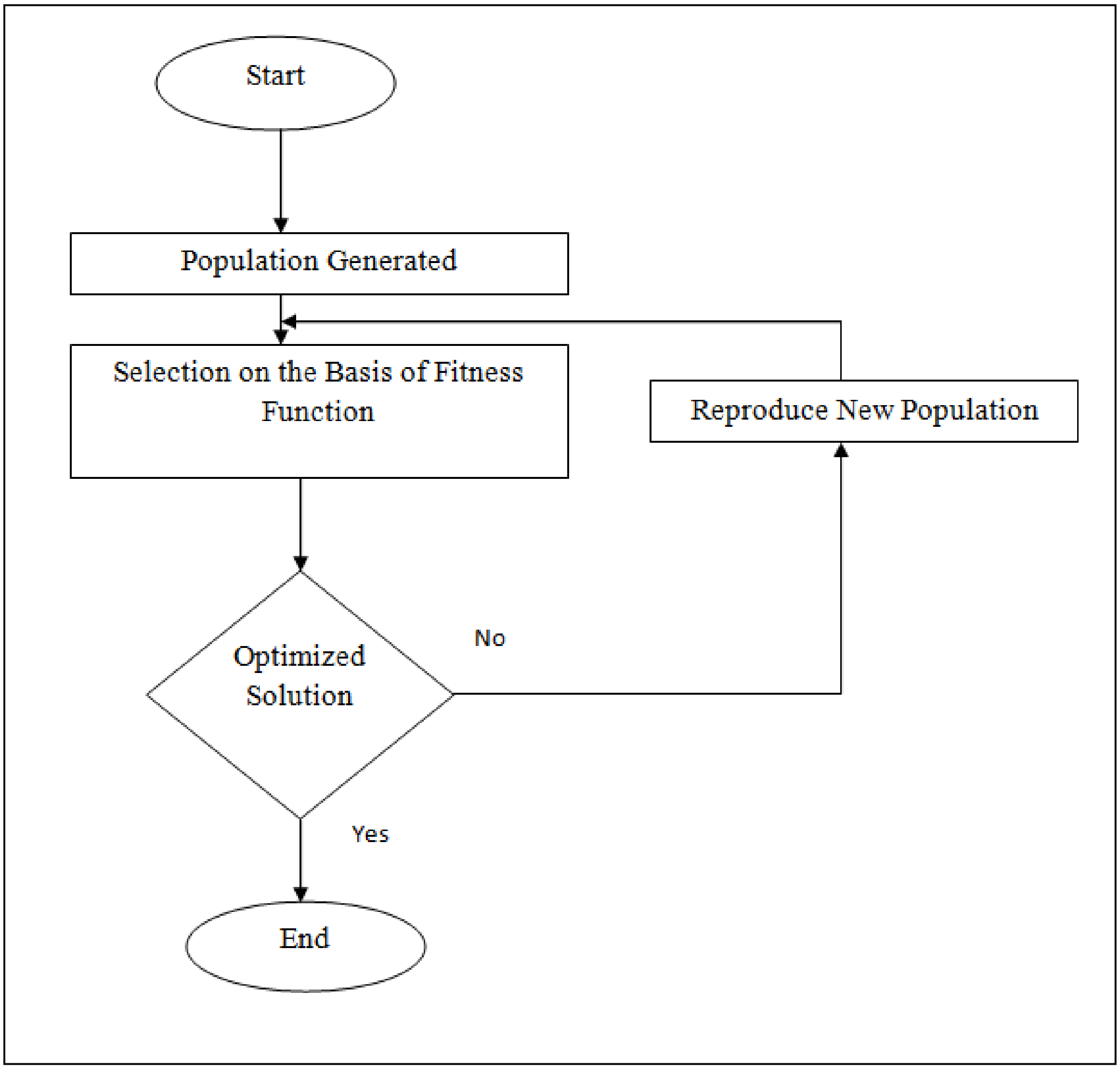

Fig. 1.5 Flowchart of Genetic Algorithm

1.6 Thesis Organization

The objective of thesis is to upgrade the life of the WSN by conserving battery energy and adjusting the power utilization of sensor nodes. The layout of thesis is discussed below:

In Chapter 1, introduction about wireless sensor networks, its advantages, and characteristics, clustering approach, Type-2 Fuzzy Logic and Genetic Algorithm is given. A literature review of the important papers has been discussed in Chapter 2. In Chapter 3, problem statement is given. A proposed framework for clustering of sensors and cluster head selection in WSN has been presented in Chapter 4. Chapter 5, demonstrates the simulation outcomes accomplished. Chapter 6, discusses conclusion and future work.

Chapter 2

Literature Review

The different methods and techniques for clustering of sensors are discussed to amplify the lifespan of a network. This survey includes theoretical review on Fuzzy Logic, Genetic Algorithm and other techniques on the basis of which cluster head is selected. A brief summary of various clustering routing protocols is also carried out in this section. The block diagram of different clustering approaches is shown in Figure 2.1.

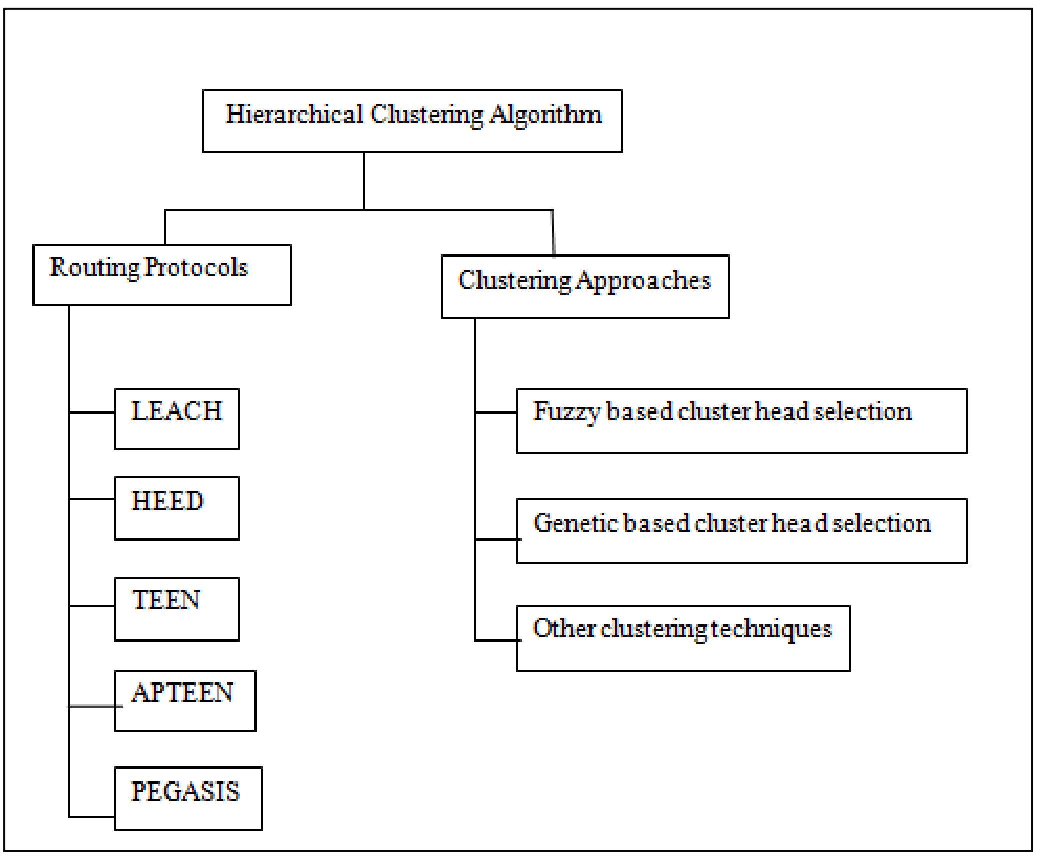

Fig. 2.1 Routing Protocols and Clustering Approaches for Hierarchical Clustering

2.1 Hierarchical Clustering Routing Protocols

In this section, various hierarchical clustering routing protocols are discussed that are given below.

2.1.1 LEACH

The present enthusiasm for WSNs has prompted the development of numerous application arranged protocols of which LEACH is the most yearning and broadly utilized protocol. This protocol could be portrayed mix of a group based design and multi hopping directing. The terminology group based could be clarified through way that nodes utilizing the LEACH protocol capacities depend on CHs and cluster individuals. Multi-hop routing is utilized for inter-cluster correspondence with CHs and BSs. Experimental outcomes proved that energy consumption is less with multi-hop routing as compared to direct communication [17-19].

In wireless sensor networks, sensors sense information, aggregate it, afterward pass data to BS from a remote zone utilizing the radio transmission scheme as correspondence medium. Information which is accumulated by sensors is sent to the BS. Amid this procedure a great deal of risky issues happens, for example, information crash and the information aggregation. LEACH is well suited to lessen the data collection issues by compressing the information that is gathered by the CH before sending to the BS. All sensors shape a self-composed system by sharing the part of a CH at minimum once. CH is significantly in charge of passing the data that is accumulated by the sensors to the BS. It tries to adjust the vitality dispersal inside the network and upgrades the network's life time by enhancing the life time of the sensors. The tasks that are done in this protocol are isolated in 4 phases that are discussed below. The topology of LEACH is shown in Figure 2.2.

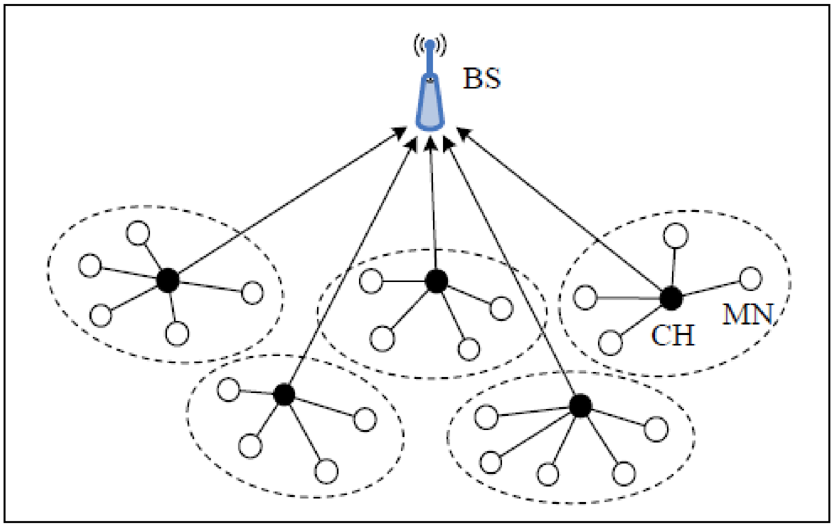

Fig. 2.2 LEACH Topology [9]

1. Advertisement Phase

At first, when clusters are being made, for current round, every sensor node chooses whether or not to become a CH. The choice relies upon the planned percentage of cluster heads (decided from the earlier) and on the count the node became a CH until now. The choice is made by the sensor node n picking an irregular number in interval 0 and 1. If the number is not as much as an edge T (n), node turns into CH in the same round. The limit is set as shown in Equation 2.1.

$$T(n) = \begin{cases} \frac{P}{1-\left(r \bmod \frac{1}{P}\right)} & if\ n\ \in G \\ 0 & otherwise \end{cases} \qquad (2.1)$$

where P denotes an estimated percentage of CHs for current round r and an arrangement of sensor nodes that does not became CH in last (1/P) rounds is denoted by G. Utilizing this limit, every sensor node will be a CH sooner or later inside 1/P rounds.

2. Set-up Phase

After every node has chosen to which group it has a place, it must educate the group head node i.e. the CH to be an individual from the cluster. Every node transfers the data back to the CH utilizing a CSMA MAC protocol. Amid, all CH nodes should make their beneficiaries on.

3. Schedule Creation

All the messages from the sensor nodes that might want to be incorporated into the cluster will be received by the CHs. In view of quantity of nodes in a group, the CH makes a TDMA plan informing every sensor node when to start transmission. Then calendar is communicated back to the nodes in the group.

4. Steady Phase

Information exchange starts after TDMA plan set up and after the clusters are being made. Accepting nodes dependably have information to pass; they pass it between their apportioned transmission time to the CH. This communication utilizes an insignificant measure of vitality. The radio of each non CH node is killed until the nodes designated transmission time, in this manner limiting vitality dispersal in these nodes.

2.1.2 HEED

Heed protocol was proposed by Younis and Fahmy. It stands for Hybrid Energy-Efficient Distributed clustering algorithm. It's not same as LEACH in the way of cluster head race; HEED doesn't choose cluster heads arbitrarily. The way of cluster formation is done in view of the hybrid of 2 parameters. One relies upon the leftover vitality of a node, and second parameter is the intra-cluster correspondence cost. Chosen cluster heads have generally more normal remaining vitality contrasted with other cluster member nodes. Furthermore, one of the primary objectives of HEED is to get an even distributed cluster heads all through the systems. Additionally, in spite of the wonders that two nodes, inside each other's correspondence go, move toward becoming cluster heads together, yet the likelihood of this wonders is little in HEED.

CHs are intermittently chosen in light of two essential parameters: remaining power and intra-cluster correspondence cost of applicant nodes. At first, proportion of cluster heads amid all sensor nodes, C_{prob}, is set to expect that ideal rate can't be registered from the earlier [20].

The likelihood that a node turns into a cluster head is given in Equation 2.2.

$$CH_{prob} = C_{prob} \frac{E_{residual}}{E_{max}} \tag{2.2}$$

where $E_{residual}$ denotes evaluated present vitality of a node, and E_{max} is the most extreme vitality that is commonly indistinguishable from all nodes present in the network. An estimation of CH_{prob}, isn't permitted to fall beneath a specific limit that is chosen corresponding to E_{max}. A short time later, every node experiences a few emphases until the point when it finds the cluster head. In the event that it gets notification from no CH, node chooses itself to be a CH and passes a declaration message to its neighbours. Every node doubles its CH_{prob} value for every sensor node and then goes to the next iteration until its CH_{prob} achieves 1. Accordingly, there are 2 sort of status that sensor node could report to its neighbors: tentative status and final status. On the off chance that its CH_{prob} is under 1, the node turns into a tentative cluster head and can adjust its status to a general node at a later cycle in the event that it find a lesser price CH. In the event that it's CH_{prob} has achieved 1, the node for all time turns into a CH. In HEED, each node chooses the minimum correspondence cost cluster head keeping in mind the end goal to go along with it. Then again, cluster heads pass the collected information to base station in multi hopping mold as opposed to single-jump form of LEACH.

There are few advantages of this HEED protocol which are: (1) It is a completely distributed strategy that advantages from the utilization of the two vital parameters for cluster head decision; (2) Interactions in multi-bounce form amongst cluster heads and base station advance further vitality protection and versatility conversely with the single-jump mold straightforwardly from CHs to the BS, in the LEACH protocol.

2.1.3 TEEN

The fundamental objective of this hierarchical protocol is to adapt to rapid variations in detected qualities, for example, temperature. The nodes sense their condition ceaselessly; however the power utilization can possibly be significantly less in this algorithm than that in the proactive system, on the grounds that information transmission is done less as often as possible. Two level clustering in TEEN is shown in Figure 2.3.

There are 2 thresholds in this protocol namely hard and soft threshold. The soft threshold is an absolute value of the attribute beyond which, the node detecting this value should make its transmitter on and answer to its cluster head. The hard threshold is slight modification in assessment of the calculated property which triggers the node to make its transmitter on and transfer [21].

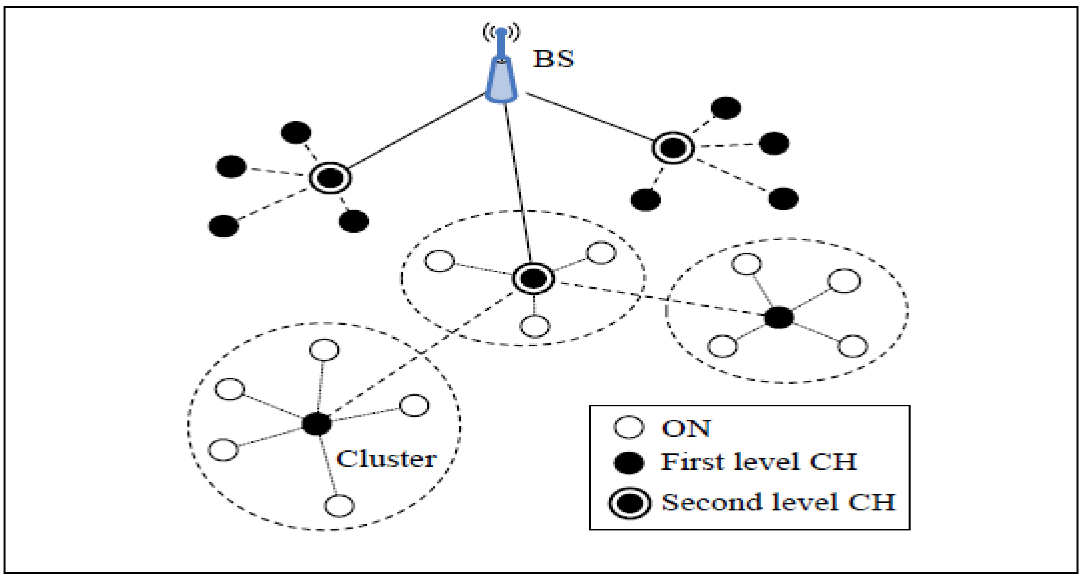

Fig. 2.3 Two-level Clustering in TEEN [9]

These threshold values are sent to the cluster members by their CH. The hard threshold make effort to lessen information interchanges by enabling the nodes to transfer data just when the detected property is in scope of intrigue. The soft threshold additionally decreases information exchanges that may have generally happened when there is next to zero variation in detected attributes.

2.1.4 APTEEN

APTEEN is augmentation to TEEN and goes for both transmitting discontinuous information and responding to time basic occasions. It is a hybrid protocol that progressions the periodicity or limit values utilized as a part of TEEN as per the prerequisite of clients and the sort of the application. APTEEN depends on an inquiry framework which permits three kinds of inquiries: historical, on-time, and tireless that could be utilized as part of a hybrid system. Besides, Quality of service prerequisites are presented for the on-time questions and least postponement is accomplished by a TDMA plan with a unique schedule vacancy task way.

In APTEEN [22], cluster heads communicate the accompanying four parameters: (i) Properties (a) - an arrangement of physical parameters that the client is occupied with getting data around; (ii) Thresholds - hard and soft; (iii) Schedule – time division multiple access plan, allotting a period to every sensor node; (iv) Count time - the most extreme era amid 2 progressive reports sent by a node.

The component of APTEEN is to change amongst proactive and receptive mode to send information. Only the node whose value is at or past the hard threshold value is allowed to transmit. In this protocol the member nodes of the group pass information to CH which combines data and transmits the amassed information to the BS. Amid the procedure of information aggregation, it is accepted that the information got from comparing cluster nodes are adequately associated, in this way it decreases excess information to be transferred to BS. Besides, an adjusted TDMA plan is utilized to actualize this hybrid arrange by allocating every node in the group a transmission space.

APTEEN time line is shown below in Figure 2.4.

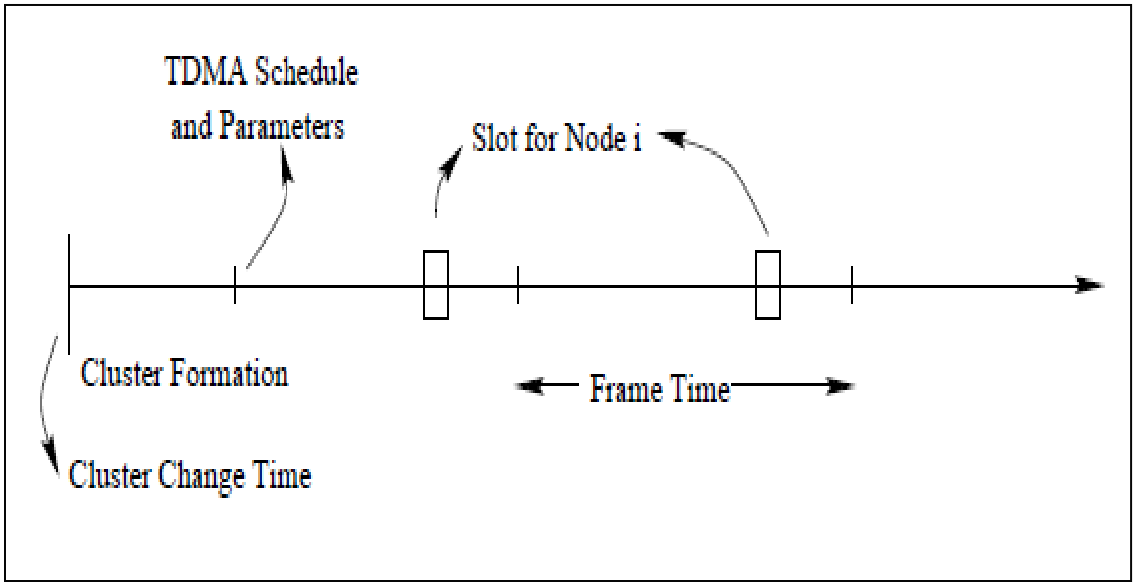

Fig. 2.4 APTEEN Time Line [9]

2.1.5 PEGASIS

The fundamental thought of this protocol is for every node to just speak with their nearby neighbours and alternate being a pioneer for transmitting to a sink. Positions of nodes are irregular; every node has ability of detecting information location, information combination. Power load is disseminated uniformly amongst the nodes in the network.

In this protocol [23], the nodes are sorted out to shape a chain, that can be allocated by the base station and communicate to all nodes by greedy algorithm. In the event that the chain is framed by the nodes themselves, they would first be able to get area information of the nodes and locally measure the chain utilizing a similar algorithm. The chain development is initiated from the uttermost node from the base station and the nearest neighbour to this node will be the following node on the chain. At the point when nodes on the chain die, the chain will remake in similar way to sidestep the dead node.

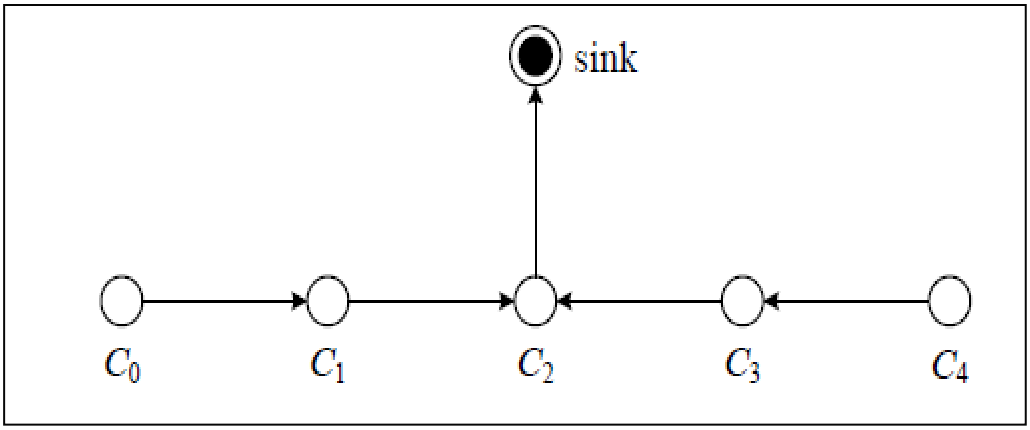

Fig. 2.5 The Token Passing Scheme in PEGASIS [17]

In each round, every node gets information from one neighbour, wire the information with its own, and transfers to the next neighbour in the chain. By going in this manner, the intertwined information in the long run is passed to the base station by the pioneer at an arbitrary location in the chain. On the other hand, in every cycle, a token passing methodology started by pioneer is utilized for starting the information broadcast from the end of a chain. The plan of information diffusion is shown in the Figure 2.5. If node C_2 is a pioneer, it will send the token along the bind to sensor node C_0. At that point, sensor node C_0 will send its information to node C_2. After C_2 gets information from node C_1, it will pass the token to C_4, and C_4 will send its information to C_2 with information combination occurring along the chain.

The summary of hierarchical clustering routing protocols is given in Table 2.1.

Table 2.1 Summarized Literature Survey on Hierarchical Clustering Routing Protocols

Protocol	**Advantages**	**Disadvantages**
LEACH	• Increase in lifespan • Highly scalable • Throughput is more	• Hot spot problem • Energy efficiency is very low.
HEED	• Less cost of communication • High cluster stability	• Unsuitable for the requirements of wireless sensor network.

TEEN	• High cluster stability • Very high energy efficiency	• Not for applications where periodic reports are needed.
APTEEN	• Energy dissipation is less and network lifetime is more as compared to LEACH and TEEN	• Very low cluster stability • Less scalability.
PEGASIS	• Increase in network lifetime as compared to LEACH. • Avoids lot of clustering.	• Considers every node to have equal energy which is not possible. • Delivery delay is very large.

2.2 Fuzzy Based Cluster Head Selection

In [11] Nayak et al. projected a proficient method for selecting CH from each cluster. The entire sensor organize field is isolated in levels i.e. clusters of equal sizes such that all these clusters are numbered sequentially. Type-2 Fuzzy Logic is used for selection of cluster heads. This logic is a decision making algorithm that handles uncertainties way better than type-1 fuzzy rule. This method was suggested to overcome the burden on cluster head so that with this technique an efficient cluster head could be selected. Residual power, distance to BS and concentration were the three fuzzy descriptors that were considered for selecting CH. Based on these parameters a proficient CH is chosen from each cluster. The cluster head from first cluster will pass the aggregated information to the CH of second cluster and so on till the last level. The cluster head of the last level will convey information to BS. A stand by CH is used in case of CH failure as well as multi hop communication was made. It was observed that Type-2 Fuzzy Logic provided more scalability and improved network life when contrasted with leach and Type-1 Fuzzy.

An efficient CH determination technique was conveyed by Nayak et al. in [24]. The concept based on fuzzy logic was utilized for selecting the super CH. In this effort 3 fuzzy parameters i.e. remaining power, concentration and mobility of the base station have been taken for choosing the super CH. A super CH is the CH that is chosen from all the CHs. All the CH instead of passing information to the BS, only one cluster head known as super CH will be send the whole information to the BS. With this technique, energy consumption will be less as retaining the energy of the nodes in WSNs is a challenging issue. To choose the opportunity to be the super CH, the fuzzy inference engine is used. Performance parameters like first node dies, half node alive were calculated. It was observed this proposed technique provides better lifetime and scalability as compared to LEACH.

In [25] Bagci et al. presented an EAUCF algorithm. As chances of CH which is nearer to BS to become dead prior is more, so this unequal clustering technique was introduced. This EAUCF algorithm solves this problem of hot spots. EAUCF intends to diminish intra-cluster effort of CH that is either near the BS or have less residual power control. EAUCF expects to disseminate workload among all sensor nodes equitably. Remembering the ultimate objective to accomplish this goal, it for the most part centers on relegating suitable cluster head rivalry reaches to the sensor nodes. Various clustering algorithms were compared with this proposed technique; it was observed that this technique performs far better than previously designed techniques. As an outcome of observations, it is winded up that the proposed algorithm is firm and power-effective for WSN. EAUCF is intended for WSN having immobile nodes.

Sharma et al. proposed in [26] a uniform algorithm known as F-MCHEL. In this algorithm cluster heads are chosen using fuzzy logic. Two fuzzy descriptors such as power and distance were used. Out of all the cluster heads, one master cluster head (MCH) is chosen. This MCH is selected on an account of power, i.e. cluster head with maximum remaining power is chosen as the MCH. All the CHs instead of sending information to the BS, simply one CH known as MCH send whole information to BS. With this technique, power consumption becomes less as saving the battery energy of the nodes in wireless networks is a challenging issue. Reenactment comes about on MATLAB demonstrates that the proposed protocol gives higher vitality productivity, better stability interval and lower unsteadiness period when contrasted with LEACH protocol regardless of overhead of decision of master CH. Results got demonstrate that a suitable master cluster head decision radically lessen vitality utilization and improve the lifespan of the network. F-MCHEL is augmentation of CHEF that brings about more strength of various hierarchical systems when contrasted with LEACH and CHEF.

Lee et al. in [27] used a fuzzy rule based technique for WSNs in light of LEACH design with expansion to the vitality predication. Primary goal of this approach is to draw out the life scope of the WSN by equitably appropriating the workload. To accomplish an objective, author has generally centered on choosing appropriate cluster heads from existent sensor nodes. The simulation outcomes demonstrate suggested LEACH-ERE is effective than another disseminated techniques. In the research, suggested approach is intended for the WSN that contain immobile nodes. It’s trusted that procedure displayed in this work additionally connect to extensive scale WSNs.

Taheri et al in [28] projected an ECPF protocol. Here the CH procedure exits with steady range of rounds. In this work the main parameter is residual energy for selecting the cluster heads via a non-probabilistic fashion. Then from the set of neighboring selected cluster heads, one CH chosen by applying fuzzy rule to calculate fitness of the node. Whereas another nodes that are not CHs goes to interface with CHs having slightest fuzzy price in its locality. Simulation consequences reveal this technique showed good results in phrases of enhancing community lifespan and preserving power than other techniques. Therefore, on demand clustering, cluster head selection and applying fuzzy logic are the three approaches the author has used. This protocol can be enhanced to meet the requirement of quality of service in WSNs along with insurance protection, because total insurance of the observed place over lengthy time interval is a remarkable issue.

The summary on clustering based on Fuzzy Logic is given in Table 2.2.

Table 2.2 Summarized Literature Survey on Clustering Based on Fuzzy Logic

Year	Title	Authors	Proposed work
2017	Energy efficient clustering algorithm for multi-hop wireless sensor network using Type-2 fuzzy logic	Nayak et al.	• Used Type-2 fuzzy rule for cluster head choice. • Sensing field is arranged into levels. • Multi-hop communication is done.
2015	A fuzzy logic based clustering algorithm for WSN to extend the network lifetime	Nayak et al.	• A super CH among all CHs is chosen. • Used 3 parameter i.e. rem. power, mobility, centrality.
2013	An energy aware fuzzy approach to unequal clustering in wireless sensor networks	Bagci et al.	• EAUCF algo is used to solve hot spot issue. • To handle uncertainties fuzzy rule is used. • Workload evenly distributed
2012	F-MCHEL: fuzzy based master cluster head election leach protocol in wireless sensor network	Sharma et al.	• MCH is chosen from all elected CHs. • Fuzzy logic based homogeneous procedure is used.
2012	Fuzzy logic based clustering approach for wireless sensor networks using energy predication	Lee et al.	• Planned LEACH-ERE technique for clustering. • Expected remaining power is used for CH election.

2012	An energy aware distributed clustering protocol in wireless sensor networks using fuzzy logic	Taheri et al.	• Fuzzy rule • Clustering on demand • Electing CH using leftover power.

2.3 Genetic Based Cluster Head Selection

Deshmukh et al. in [29] proposed a grouping routing protocol for vitality proficiency and also load adjusting of the WSN. The proposed framework use Genetic Algorithm for vitality proficient bunching of sensor nodes and choice of ideal way for routing with better network lifetime and lesser vitality utilization. It likewise indicates how vitality productivity can be expanded so that we can make the sink versatile. In this work, authors have clarified ML-LEACH protocol. To start with they profoundly considered LEACH and LEACH-SAGA protocols, and discovered deficiencies of them. At that point the ML-LEACH protocol was build up to beat those inadequacies. ML-LEACH uses Genetic Algorithm for grouping, here sink area is dynamic, which gets changed with new group head areas, bringing about lessening the correspondence cost, in this way expanding the vitality effectiveness of the network. In this way ML-LEACH protocol expands vitality proficiency, do the better vitality and load adjusting and subsequently expanding the life time of the WSN.

Kaur et al. in [30] looks at the contending issues of vitality utilization effectiveness in WSN. For this reason, an adjusted Genetic Algorithm in the choice of Cluster Head was proposed such that its vitality is utilized consistently with load adjusting among groups for deferred deterioration of network. WSNs are recreated utilizing a MATLAB programming and power utilization calculations consider all parts of energy utilization in the task of the node. Simulating schemes conspires on a similar system framework, same introductory power sources, and steering protocol, an expansion of general framework lifetime is illustrated. The execution of GA cluster based routing protocol indicates upgrades in lifetime.

Ma et al. in [31] proposed another power-effective collaborative communication system. This system depends on the Genetic Algorithm. He suggested calculation will fit for deciding whether the sensor nodes can be a CH. At that point Genetic Algorithm would shift through a few nodes from these impermanent CHs to get the last and final CHs. Observation demonstrates that suggested calculation can distribute vitality to every node of WSN and delay demise of a primary node. This way, the lifespan of wireless sensor network is successfully drawn out.

Pal et al. in [32] provides a load balanced approach network by performing clustering. Clustering of sensors is a proficient method for extending the lifespan of network. With clustering, problem of scalability and energy depletion is addressed. In this work, author has done cluster head selection using Genetic Algorithm. Calculations have proved that selecting cluster head with Genetic Algorithm provides better outcomes as contrasted with another existing traditional algorithm for lifetime improvement of a network. In this work remaining energy and inter-cluster as well as intra-cluster distance is used for cluster head selection. This proposed scheme is for centralized clustering algorithms and it also improves the quantity of CHs for a round. Comparison of this technique has been done with LEACH and LEACH-C.

Norouzi et al. in [33] conducted a survey on various operational stages of wireless sensor networks. Theses stages include sensor node placement, system area coverage, clustering, data gathering, and routing. Various limitations were found out to find out the best optimized parameters for the network system. At long last, utilizing Genetic Algorithm works well with optimum formula and the protocols were optimized. The consequences of recreations in JPAC, MATLAB, and NS were contrasted. It is likewise perceptible that the charts acquired from the observations demonstrated a change in vitality utilization parameters and lifetime of the network; this implies more perfect WSNs.

Maheshwari et al. in [34] considered that routing is essential to enhance the lifespan of network. Advance Hybrid Multi-hop Routing Network (AHYMN) techniques were proposed. Choice of CH depends on power line in sensor node. They actualized the HYMN techniques with Genetic calculation to collect the information in sensor arrangement. Another strategy which depends on AHYMN approach and GA is spoken to pick CH in WSN. Accordingly, it’s speedier and furthermore precise to recognize node with more vitality and to choose the CH. In addition, system uses nodes with heterogeneous attributes. A portion of varied nodes is: extended lifespan of networks, increment in system dependability and diminishing information transfer interruption.

Rana et al. in [35] proposed a coordinated technique of CH choice furthermore; routing in 2-level WSN utilizing Genetic Algorithm based CH choice with A-Star approach based routing strategy to broaden existence of wireless sensor network. The method prompts noteworthy changes in the system lifetime over other strategies. This strategy was compared with many other existing routing protocols and various CH selection mechanisms. Current CH selection according to current routing and routing schedule selection with the thought of CH chosen helps in searching for the best combinations. Performance results clearly prove that the conveyed method significantly enhances the network lifespan for different sizes of the networks.

Karimi et al. in [36] provided GP Leach and HS Leach algorithms. It enhanced vitality utilization by dividing network and utilizing evolutionary procedures for upgrading CH choice taking WSN nodes position data as well as leftover vitality. Observations were taken in MATLAB demonstrates that the suggested calculations are more productive and expanded the lifespan of a network. In suggested techniques the quantity of CHs in every round is steady that helps in making the vitality utilization in each round stable. They analyzed calculations with two different protocols, Leach and P-Leach. Recreation comes about passed on that GP-Leach is proficient than Leach.

Liu et al. in [37] proposed GA based protocol with an ideal likelihood forecast to accomplish great execution as far as lifespan of network in WSN. The suggested GA-construct algorithm LEACH-GA fundamentally have set up and steady stages for every round in the protocol and extra planning stage prior to the start of the primary round. In the time of planning stage, all the sensor nodes at first do CH choice procedure and afterward pass their messages with status of being an applicant CH or not, sensor node identities, and land positions to BS. As the BS got the messages from nodes, it at that point looks for an ideal likelihood of nodes being cluster heads by means of a Genetic Algorithm by limiting an aggregate vitality utilization needed for finishing one round in the sensing field. From that point, BS communicates a commercial message with the ideal estimation of likelihood to all nodes with a specific end goal to frame groups in an accompanying set up stage. Planning stage is executed just one time before set up period of a primary round. Observations illustrate that suggested algorithm adequately creates ideal vitality utilization for the WSNs and bringing about an extension of lifetime for the system.

The summary on clustering based on Genetic Algorithm is given in Table 2.3.

Table 2.3 Summarized Literature Survey on Clustering Based on Genetic Algorithm

Year	Title	Authors	Proposed work
2016	Clustering routing protocol for energy efficiency of wireless sensor network using Genetic algorithm	Deshmukh et al.	• GA for power-effective grouping of sensor hubs. • Mobile BS that gets changed according to other CH positions.
2015	GA based balanced clustering approach for energy efficiency in WSN	Kaur et al.	• CH choice by seeing how vitality is utilized consistently with load adjustment among clusters for postponed breaking down of system.
2015	Energy-efficient collaborative communication for optimization cluster heads selection based on Genetic algorithms in wireless sensor networks	Ma et al.	• GA dependent power-efficient approach to make CH election optimized. • Algo to decide whether node is efficient for becoming CH or not.
2015	Cluster head selection optimization based on Genetic algorithm to prolong lifetime of wireless sensor networks	Pal et al.	• Centralized CH choice based on Genetic algo. for optimization • Residual power for

			choosing CH
2014	Genetic algorithm application in optimization of wireless sensor networks	Norouzi et al.	• Generated improved fitness function tweaked for each operational phase of WSN for CH election.
2014	Cluster head selection based on Genetic algorithm using AHYMN approaches in WSN	Maheswari et al.	• CH choice depends on Genetic and HYMN techniques.
2013	Synthesized cluster head selection and routing for two tier wireless sensor network	Rana et al.	• CH election via Genetic algo. • For routinh A-star algo is considered.
2012	Optimizing cluster head selection in wireless sensor networks using Genetic algorithm and harmony search algorithm	Karimi et al.	• Suggested GP-Leach and HS-Leach algo. • Nodes's location info and remaining power are taken into account
2011	Leach GA: Genetic algorithm based energy efficient adaptive clustering protocol for wireless sensor networks	Liu et al.	• GA-based versatile grouping protocol to decide the ideal thresholding likelihood or cluster development in WSNs. • Utilizes a planning stage before the set-up period of main round to assemble data about hub status, ID, position.

2.4 Other Clustering Techniques

Jan et al. in [38] features and talks about the challenges for cluster based plans, the imperative group development parameters, and arrangement of hierarchical clustering protocols. In addition, existing cluster based and network based methods are assessed by considering certain parameters to help clients in choosing fitting strategy. Besides, a point by point synopsis of these protocols is given, their points of interest, drawbacks, and materialness specifically cases.

Anjali et al. in [39] proposed a protocol named as DAPTEEN. This is based on hierarchical TEEN and APTEEN protocols for expelling excess information and subsequently to improve power productivity. Essentialness adequacy is achieved by lessening the transference of tedious data by sensor center points to head. Diminishing tedious data transmission is proficient by using partition as edge parameter. During start of partition parameter, center points pass data. Center points inside the extent of above said edge pass the data to CH i.e. the similar data detected in excess of one center point inside degree is sent only one time. Reenactment happened show Average Balance imperativeness improved in DAPTEEN when diverged from APTEEN.

Singh et al. in [40] gave an overview of directing protocols for Wireless Sensor Network and also look at their qualities and confinements. In this paper, author overviewed an example of directing protocols by considering a few arrangement criteria, including area data, organize layering and in-arrange handling, information centricity, way excess, arrange flow, quality of service prerequisites, and system heterogeneity.

Heinzelman et al. in [41] took a gander at communication protocols that can make basic impact on the general power dispersal of these frameworks. Filter uses confined synchronization to empower adaptability and power for dynamic systems, consolidates information combination into the directing protocol to diminish the quantity of data that must be transmitted to BS.

Ding et al. in [42] proposed RDICMR algorithm. The suggested approach spares a great deal of vitality during the time spent making groups and information transference expands measure of information exchange and drags out life time of a system. This kind of system has dynamic cluster determination. The goal is that randomly only one sensor node is picked as cluster head whereas cluster will have arbitrary number of sensor nodes. This spares energy for readiness of the cluster and also for cluster head determination. The simulation observations prove that life of the network, remaining energy, measure of data transmission is more as contrasted with other current algorithms.

The summary on other clustering techniques is given in Table 2.4.

Table 2.4 Summarized Literature Survey on Other Clustering Techniques

Year	**Title**	**Authors**	**Proposed work**
2017	Energy efficient hierarchical clustering approaches in wireless sensor networks: a survey	Jan et al.	• Features and talks about the challenges depending on clusters, an imperative cluster development parameters and arrangement of various leveled grouping protocols.
2015	Distance adaptive threshold sensitive energy efficient sensor network protocol in WSN	Anjali et al.	• DAPTEEN is used for evacuating information repetition and consequently to upgrade vitality proficiency.
2010	Routing protocols in wireless sensor networks – a survey	Singh at al.	• Presented a review on routing protocols for WSN • Compared their pros and cons.
2000	Energy-efficient communication protocol for wireless micro sensor networks	Heinzelman et al.	• Discussed various hierarchical communication protocols and discussed LEACH in detail.

Chapter 3

Problem Statement

In this chapter, problem statement, research gaps and research objectives are given.

3.1 Problem Statement

Research on WSN has expanded excessively consistently. Sensor nodes are deployed to work unsupervised in remote conditions. WSNs are profoundly asset obliged with constrained power, transfer speed, handling abilities and computational capacities. So because of limited battery power, it becomes very necessary to save power of these nodes to improve the system duration as it is extremely hard to replace these batteries. Expanding system maintainability and lifetime are the key issues for the contemporary examinations in sensor space. Regularly, power exhaustion is profoundly commanded by radio transmission. The energy exhaustion of radio correspondence is straightforwardly identified with any transmission in the system. Clustering is a mechanism to progress the duration of WSN. Clustering procedure lessen the quantity of radio transmissions and builds sensor network lifetime. Subsequently, clustering method can, effectively, increment lifetime of different sensor applications, for example, robot control, ecological control, workplaces, savvy homes, producing conditions, body territory systems, and submerged sensor systems.

3.2 Research Gaps

A lot of study has been done in the area of clustering in WSN but still some exploration holes were seen which are discussed below:

- In [11] Type-2 Fuzzy Logic is used for cluster head selection, where three fuzzy descriptors were used. Because of large number of rules creation, it becomes very time consuming process for CH selection .
- Fuzzy rule only finds local optimum solution which does not give accurate results [24, 25 and 27].
- The approach in [19, 20, 21, 22] is limited to single clustering deployment model.
- Genetic Algorithm is used for CH selection which finds global optimum solution but has not considered node density for selecting cluster head [33, 34].
- A comparison of optimization technique with decision making methodology is required.

3.3 Research Objectives

- To study the different hierarchical clustering approaches and the parameters which effect the lifetime of sensor network.
- To select cluster head using Genetic Algorithm in hierarchical clustering by considering different parameters.
- To compare the performance of proposed method with existing research.

Chapter 4

Proposed Genetic Based Cluster Head Selection Method

In this chapter, we discussed about the Genetic Algorithm that we have used for cluster head selection. The parameters considered for fitness function are discussed below. The proposed deployment models with their algorithms and the energy model used in our work has been discussed.

4.1 PROPOSED GENETIC ALGORITHM

- **Population:** Population is consisting of the network solutions. Higher is the population size the higher is the precision of the Genetic Algorithm. Beginning population is haphazardly selected.
- **Fitness Function:** Every Individual's fitness value is calculated depending on this fitness function as given in Equation 4.1. Various variable parameters are being used for the function, such as:
  i. Remaining Energy (RE).
  ii. Concentration or Density (C)
  iii. Distance among sensor node to the CH and then CH to the BS (D).

$$Fitness\ Function = RE + (N - C) + D/N \qquad (4.1)$$

where count of sensor nodes is denoted by N.

- **Selection:** Selecting nodes from existing population for generating new population.
- **Crossover:** Crossover rate of 2 chromosomes is used with specific probability rate.
- **Mutation:** This operator is adjusted on each particular bit of the chromosome with likelihood rate of mutation rate. Each bit will be changed to 1 from 0 and from 0 to 1.

The flow of Genetic Algorithm is shown in Figure 4.1.

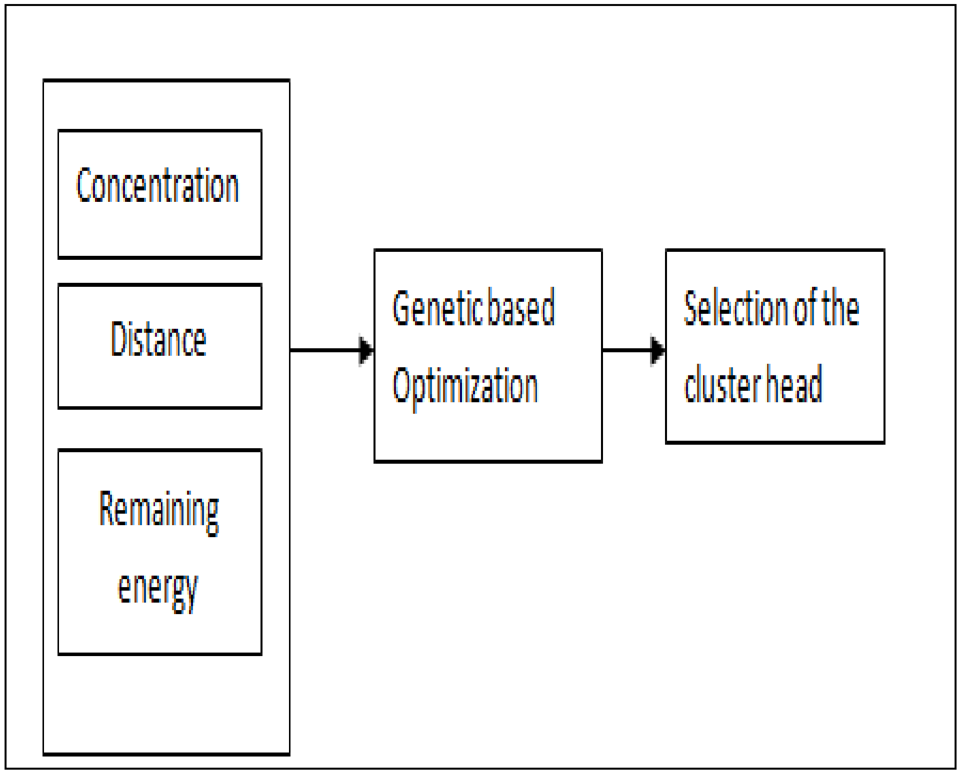

Fig. 4.1 Flowchart of Proposed Model

4.2 DEPLOYMENT MODELS

We have worked on two different deployment models. One with fixed number of nodes and other with random number of nodes as discussed below.

4.2.1 Topology with Fixed Number of Nodes.

i. Subdivide the network area of size M*M in N number of clusters.

ii. Distribute the nodes randomly in whole network such that each cluster should have equal number of nodes as shown in Figure 4.2.

iii. Based on Genetic model select one node to be the optimal for being a cluster head from each cluster. The set parameters for Genetic will be concentration, residual energy and distance.

iv. Transfer the information from sensor nodes to the CH where data will be aggregated.

v. Distance to BS and distance to other CH present inside another cluster is calculated. Data will be transmitted through the distance which will be less.

vi. BS will aggregate whole data and send it to the end users.

Algorithm: 1 Clustering of Sensors with Equal Distribution of Nodes in Each Cluster.

Test case set S=θ

Distribute equal no. of nodes randomly in each cluster of network.

For each coverage C do

Find start node $S_n = N_s$

Generate initial population

Compute fitness = RE+ (N-C) + D/N

Repeat until stop condition

for (i=0; i<|N*s*|/2; i++) do

Select two parents in the population

for ($Parent_1$, $Parent_2 \in$ Parents)

Generate two offspring by crossover operation between two parents

$Child_1$, $Child_2$ ← crossover ($Parent_1$, $Parent_2$, $P_{crossover}$)

If a new offspring satisfy the coverage, C then

S=S U (∑ of the offspring)

Break

End if

End for

End for

Mutate some offspring in the new generation list

Children ← mutate ($Child_1$, $P_{mutation}$)

Children ← mutate ($Child_2$, $P_{mutation}$)

Until satisfy C or reach maximum iteration

End for

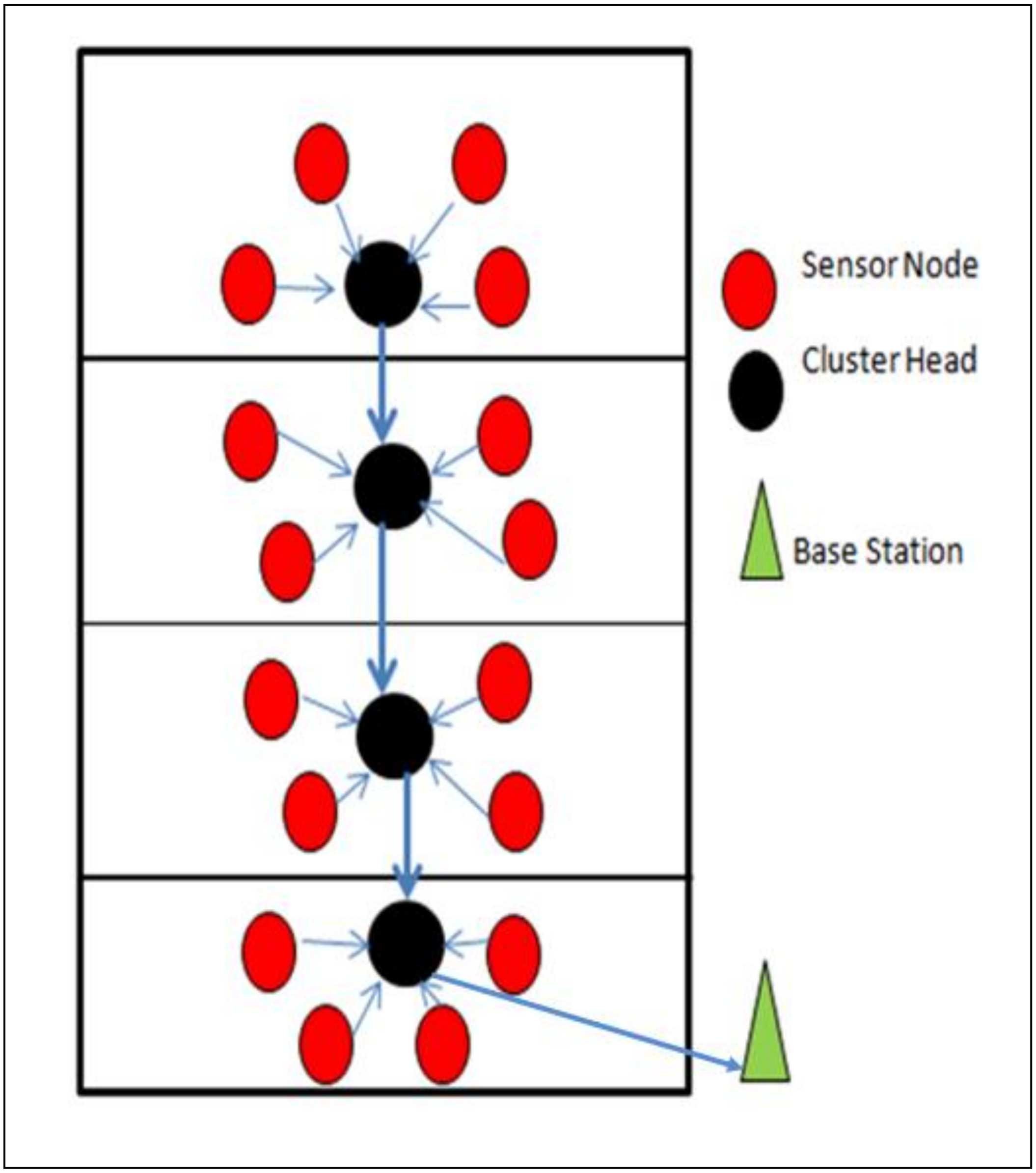

Fig. 4.2 Multi-hop Clustering Containing Equal Number of Nodes Inside Every Cluster

4.2.2 Topology with Random Number of Nodes.

i. Subdivide network area of size M*M in N clusters.
ii. Distribute the nodes randomly in the whole network such that each cluster can have any random number of nodes as shown in Figure 4.3.
iii. Based on Genetic model select one node to be the optimal for being a cluster head. The set parameters for Genetic will be concentration, residual energy and distance.

iv. Send the data from sensor nodes to the CH. At CH data will be aggregated.

v. Distance to BS and distance to other CH present inside another cluster is calculated. Data will be transmitted through the distance which will be less.

vi. BS will aggregate whole data and send it to the end users.

Algorithm: 2 Clustering of Sensors with Random Distribution of Nodes in Each Cluster.

```
Test case set S=θ
    Distribute any no. of nodes randomly in each cluster of network.
    For each coverage C, do
        Find start node Sn = Ns
        Generate initial population
        Compute fitness = RE+ (N-C) + D/N
        Repeat until stop condition
                for (i=0; i<|Ns|/2; i++) do
                 Select two parents in the population
                        for ( Parent1, Parent2 ϵ Parents)
                            Generate two offspring by crossover operation between two parents
                            Child1, Child2 ← crossover (Parent1, Parent2, Pcrossover)
                                        If a new offspring satisfy the coverage, C then
                                        S=S U (∑ of the offspring)
                                        Break
                                        End if
                        End for
                End for
        Mutate some offspring in the new generation list
        Children ← mutate (Child1, Pmutation)
        Children ← mutate (Child2, Pmutation)
        Until satisfy C or reach maximum iteration
     End for
```

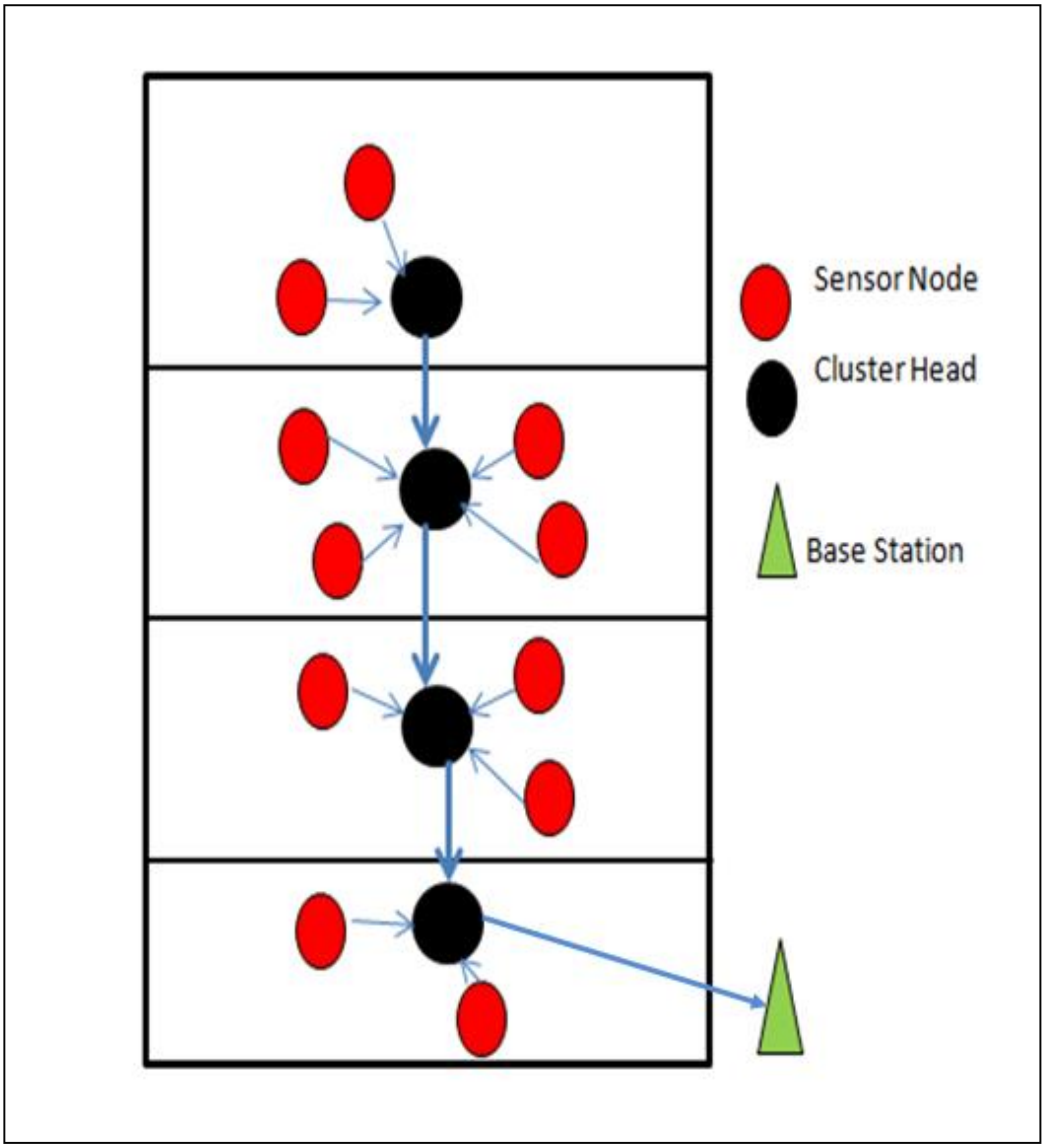

Fig. 4.3 Multi-hop Clustering Containing Random Number of Nodes within Each Cluster

4.3 Energy Model

Sensor nodes are being scattered within a space. The total network area will be sub divided into smaller parts. Each small part is denoted as cluster. Based on various parameters the cluster head will be chosen. Each time the sensor node passes information to the CH. This information will be received by the cluster head which will in turn send this information to either second level CH or to the BS. Each sensor node and the BS are situated in light of battery control. The transmitter dissipates energy to run the radio electronics. Energy model used is shown in Figure 4.4. Power utilization for forwarding l bits to the distance d is given in Equation 4.2.

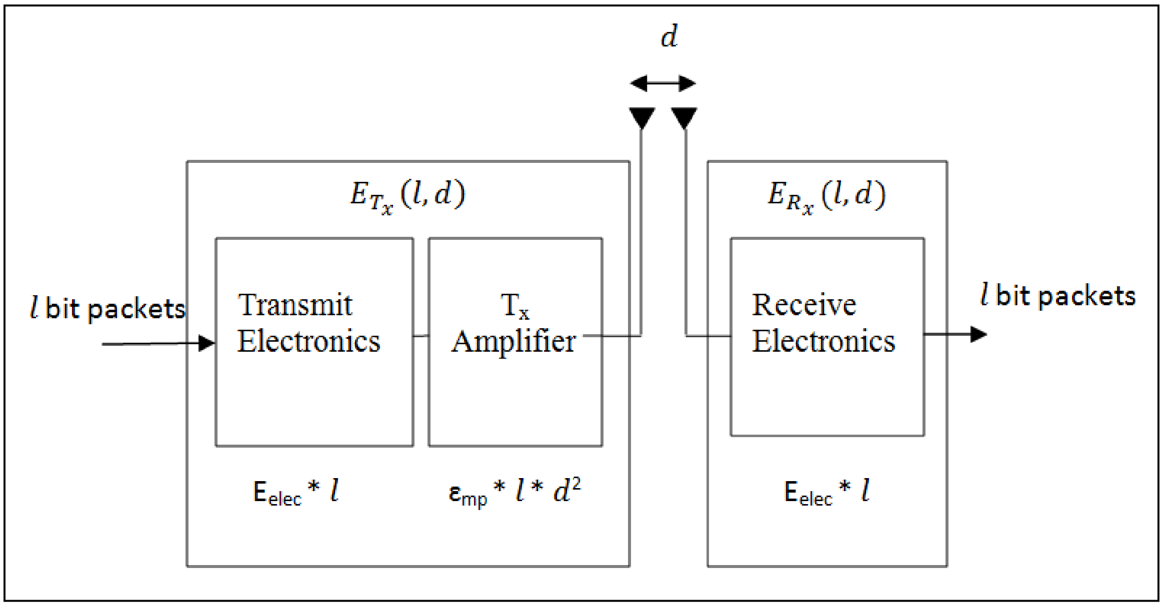

Fig. 4.4 Energy Diagram [11]

$$E_{T_x}(l,d) = E_{T_{x-elec}}(l) + E_{T_{x-amp}}(l,d)$$

$$= \begin{cases} l * E_{elec} + l * \varepsilon_{fs} * d^2 & if \ d < d_0 \\ l * E_{elec} + l * \varepsilon_{mp} * d^4 & if \ d \geq d_0 \end{cases} \tag{4.2}$$

E_{elec} denotes the energy dissipation by the transmitter and receiver for transmitting per bit. ε_{fs} and ε_{mp} are features of transmitter amplifier. As the distance between transmitter and receiver is less than threshold value d_0, power loss is d^2, otherwise it is d^4. E_{R_x} represents amount of power utilization to receive l bit of data as shown in Equation 4.3. d_0 is the ratio of ε_{fs} and ε_{mp} as shown in Equation 4.4.

$$E_{R_x}(l) = E_{elec} * l \tag{4.3}$$

$$d_0 = \sqrt{\varepsilon_{fs}/\epsilon_{mp}} \tag{4.4}$$

Chapter 5

Implementation and Results

Based on parameters taken for simulations, both Type-2 fuzzy and proposed Genetic Algorithm are being implemented in MATLAB [43] for identifying the based parameters like residual energy, alive node, and dead nodes count.

5.1 Simulation Assumptions

The sensor nodes are designed to be deployed consistently to supervise the surroundings regularly in proposed model.

- Every sensor node as well as BS is taken as static.
- Equal initial energy is given to all the nodes i.e. the sensor system is treated as homogeneous.
- Separation between BS and the sensor node is processed in view of Euclidean distance.
- The nodes are treated as dead only when their power is depleted.
- Cluster head is chosen based on Genetic Algorithm.

5.2 Simulation Parameters

Table 5.1 Simulation Parameters

Parameter Name	**Parameter Value**
Area	100m X 100m
Sink position	50m X 50m
Number of nodes (N)	150
E_{mp}	0.0013pJ/bit/m^4
E_{fs}	10pJ/bit/m^2
Initial Energy(IE)	0.5J
Transmission Power	50nJ/bit
Receiving Power	50nJ/bit
Number of clusters	8
Node Distribution	Random, Uniform

5.3 Performance Parameters

We have evaluated the performance of our work through the following parameters:

1. Remaining Energy (RE).
2. Dead Nodes Count (DNC).

3. Alive Nodes Count (ANC).

Remaining Energy (RE): It's an amount of energy being left while making the communication between source node, then to CH and lastly to BS. On each communication, there will be receiving energy, transmission energy, and aggregating energy, etc. utilized. Remaining energy can be calculated by subtracting energy consumed (CE) during the communication from the total initial energy (IE) of nodes as shown in following Equation 5.1.

$$RE=IE - CE \tag{5.1}$$

Dead Nodes Count (DNC): As the sensors have restricted power and it's next to impossible to replace or recharge their batteries so these sensor nodes become dead i.e. their energy gets totally consumed while making communication. So dead node count is number of nodes that have been dead while their energy becomes zero and their activity has been dormant. Dead nodes can be counted by subtracting alive nodes (AN) (having some power for communication) from the total number of nodes present as shown in Equation 5.2.

$$DNC= N - AN \tag{5.2}$$

Alive Nodes Count (ANC): It is the count of number of nodes that still have some energy for communications. It is calculated by subtracting the dead nodes (DN) from total count of nodes as given in an Equation 5.3.

$$ANC= N-DN \tag{5.3}$$

5.4 Results

Results have been carried out by comparing Type-2 Fuzzy Logic with Genetic Algorithm. Comparison is also made between topology with fixed number of nodes and topology with random number of nodes.

5.4.1 Topology with Fixed Number of Nodes

In fixed topology, the network area of 100x100 is split in eight clusters. These clusters are of equal sizes where each cluster will have equal number of sensor nodes. The sensor nodes are randomly deployed within a network but each group will have equal number of nodes.

In this scenario, total 150 sensor nodes are deployed in system range, so each cluster will have 15 number of nodes whereas there will be few more number of nodes in a cluster closer to the BS as more power is utilized for communicating bulk amount of data from CHs to the BS as shown in Figure 5.1.

In each cluster, CH will be selected. All the nodes will sense data and pass it to their own CHs. The CH will pass information to the other CH in second cluster and then to BS.

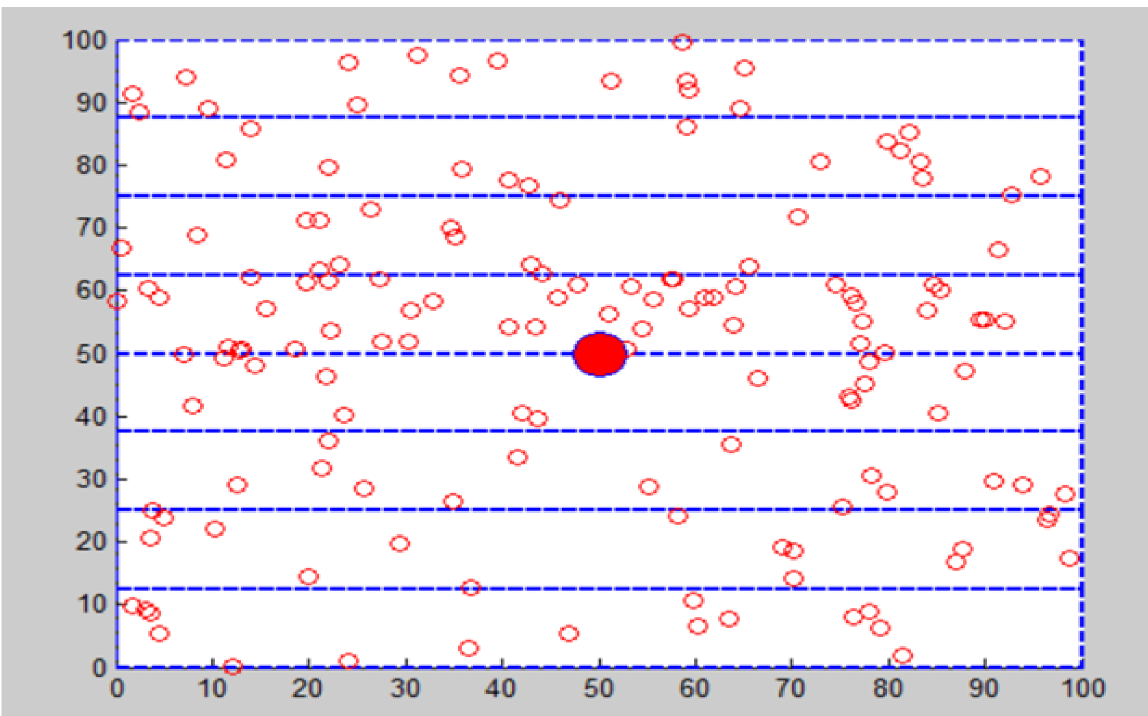

Fig. 5.1 Fixed Topology with Node Distribution

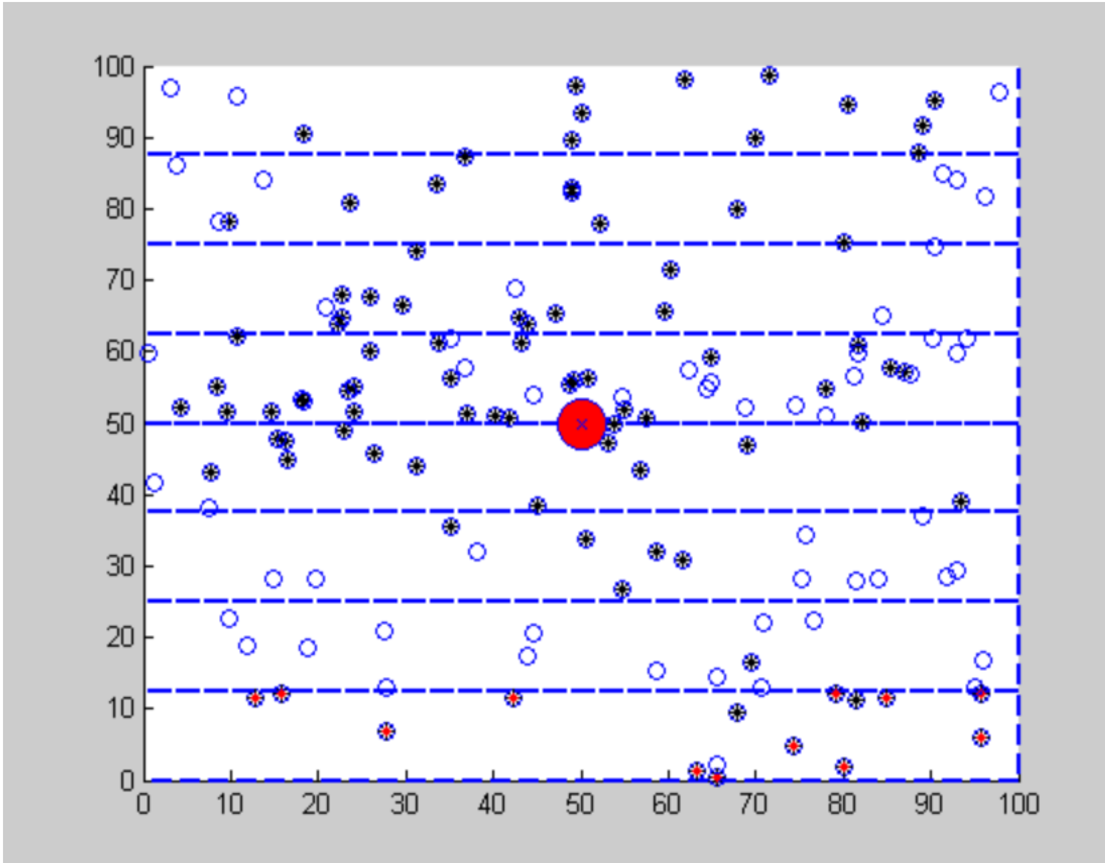

Fig. 5.2 Fixed Topology with Cluster Head Selection

Figure 5.2 is the screenshot after performing 1500 iterations. The network is leveled into groups and the CHs are chosen. The filled circles represent cluster heads and empty circles represent sensor nodes.

5.4.1.1 Comparison of Proposed Genetic Algorithm with Existing Type-2 Fuzzy Logic Algorithm Where Each Cluster Have Fixed Number of Nodes (Fixed Topology).

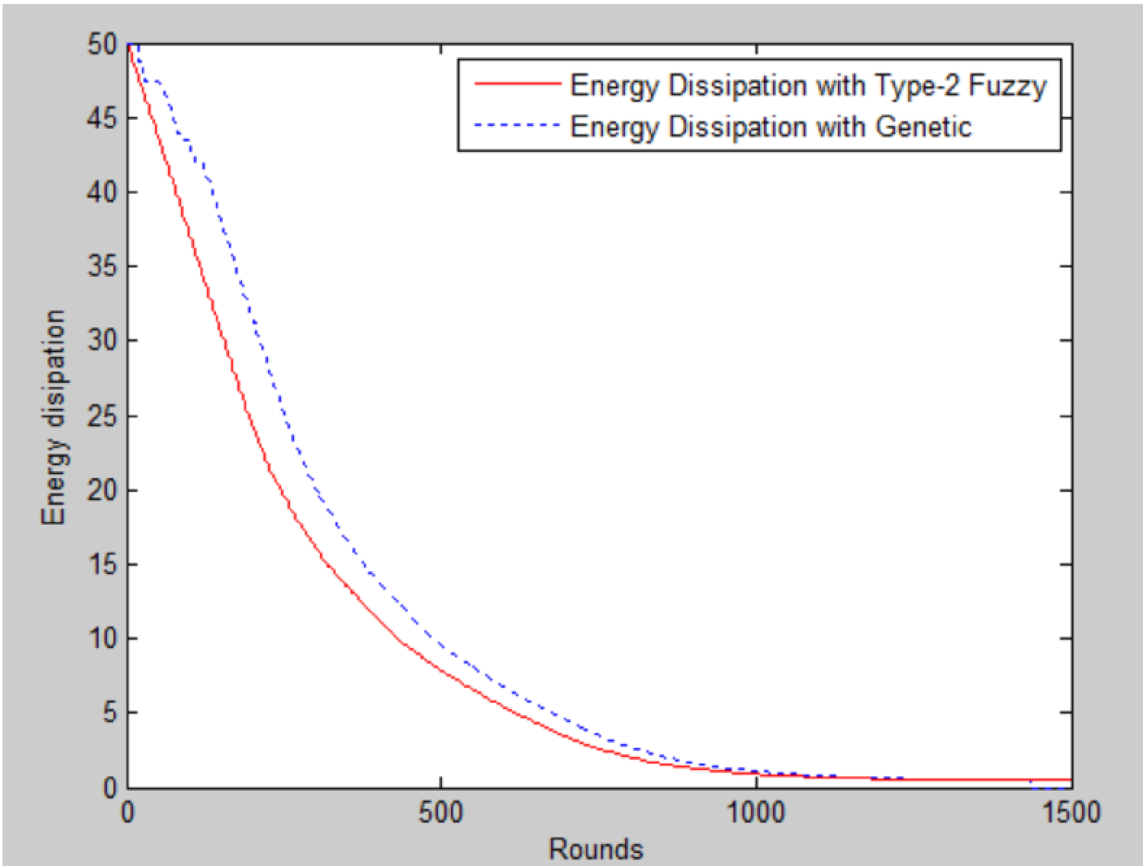

Fig. 5.3 Energy Dissipation for Type-2 Fuzzy and Genetic

Figure 5.3 shows comparison between Type-2 Fuzzy and proposed Genetic Algorithm on the basis of energy dissipation. As it can be observed from the graph there is an improvement in case of proposed Genetic Algorithm over existing Type-2 Fuzzy rule. In case of former energy starts depleting faster as compared to the proposed work. More residual energy will remain in case of Genetic based approach that means more residual energy will lead to more duration of nodes belonging to network.

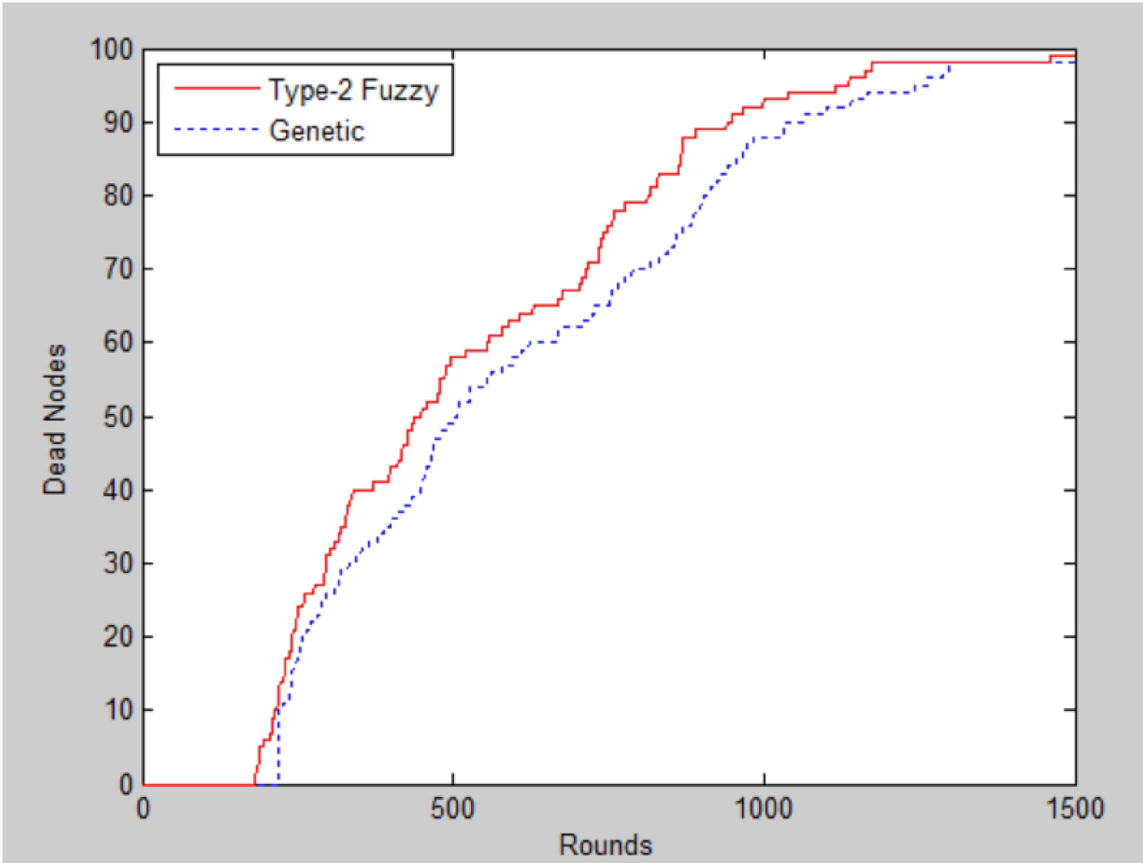

Fig. 5.4 Dead Node Count for Type-2 Fuzzy and Genetic

Figure 5.4 shows dead node count comparison between Type-2 Fuzzy and proposed Genetic Algorithm. In case of former, the sensor nodes start becoming dead (i.e. their energy gets completely exhausted) earlier as compared to proposed Genetic algorithm.

At the end of 1500 iterations, less number of nodes will become dead in the proposed work that undergoes rise in lifespan of sensor system.

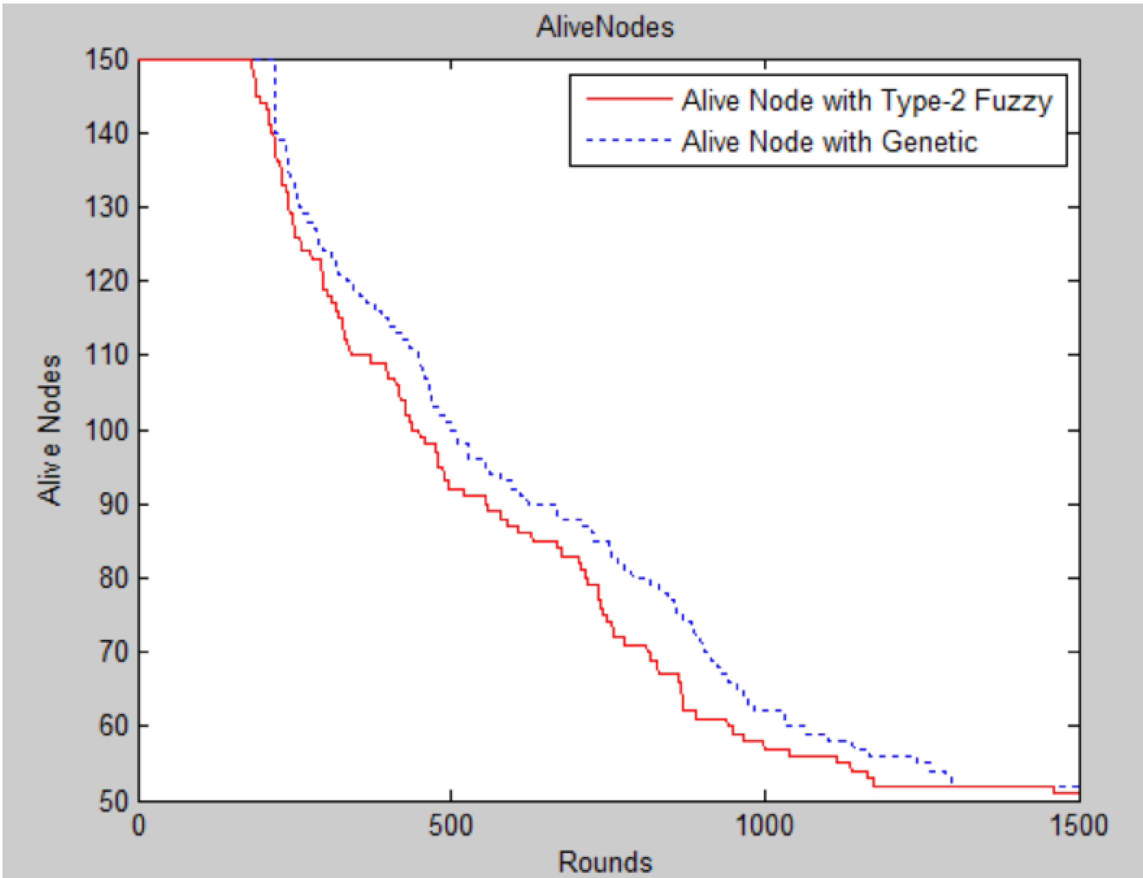

Fig. 5.5 Alive Node Count for Type-2 Fuzzy and Genetic

Figure 5.5 shows alive node count comparison between Type-2 Fuzzy and proposed Genetic algorithm. In case of former, the sensor nodes start becoming dead (i.e. their energy gets completely exhausted) earlier as compared to proposed Genetic Algorithm.

At the end of 1500 iterations, more count of nodes will be alive in proposed work that undergoes rise in lifespan of sensor system.

5.4.2 Topology with Random Number of Nodes

In random topology, the network area of 100x100 is split in eight clusters. These clusters are of equal sizes such that each cluster will not have equal count of sensor nodes. These sensor nodes are randomly deployed within a network.

In this scenario, total 150 nodes are deployed in network range, where each cluster can have any number of nodes i.e. the number of nodes for each cluster is not fixed as shown in Figure 5.6.

In each group, CH will be selected. All nodes will sense data and pass it to their own CHs. The CH will pass information to other CH in second cluster and then to BS.

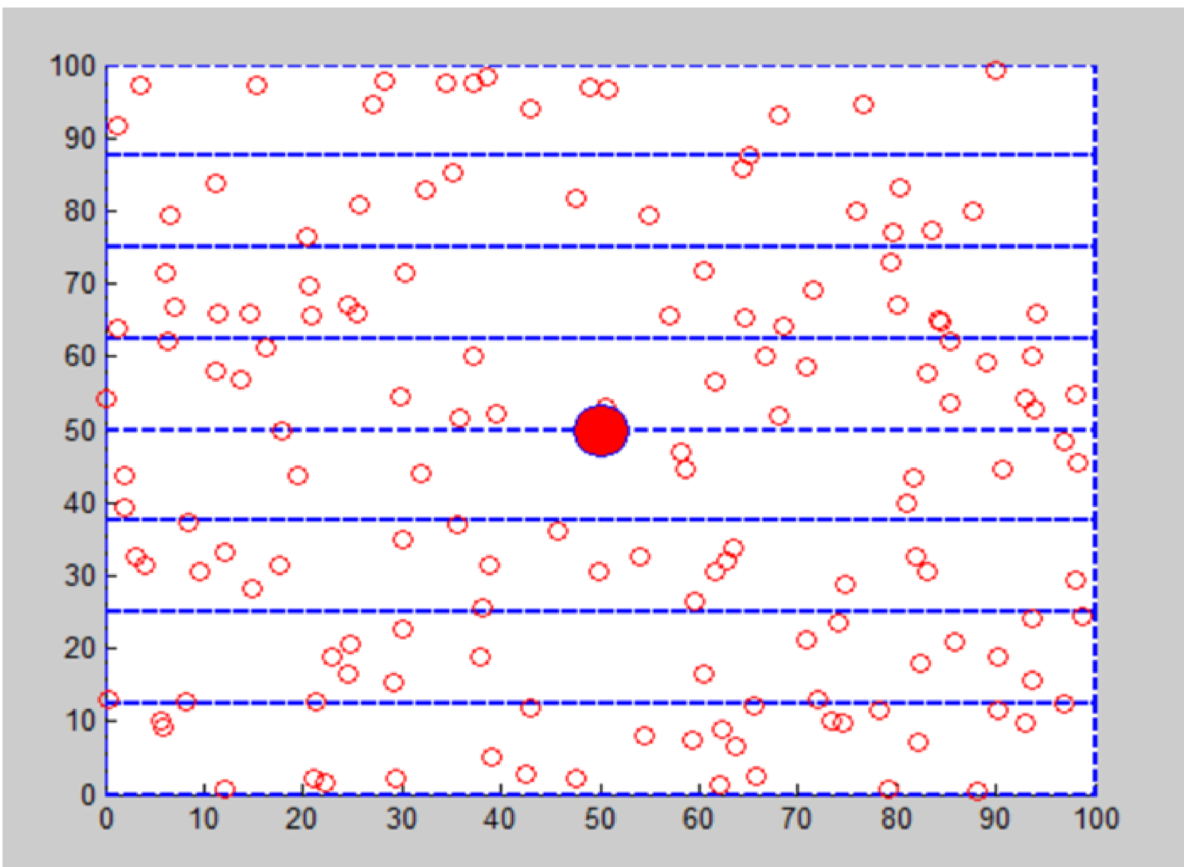

Fig. 5.6 Random Topology with Random Distribution of Nodes

5.4.2.1 Comparison of Fixed Topology (F) with Random Topology (R) Where Cluster Head Selection is Done By Proposed Genetic Algorithm.

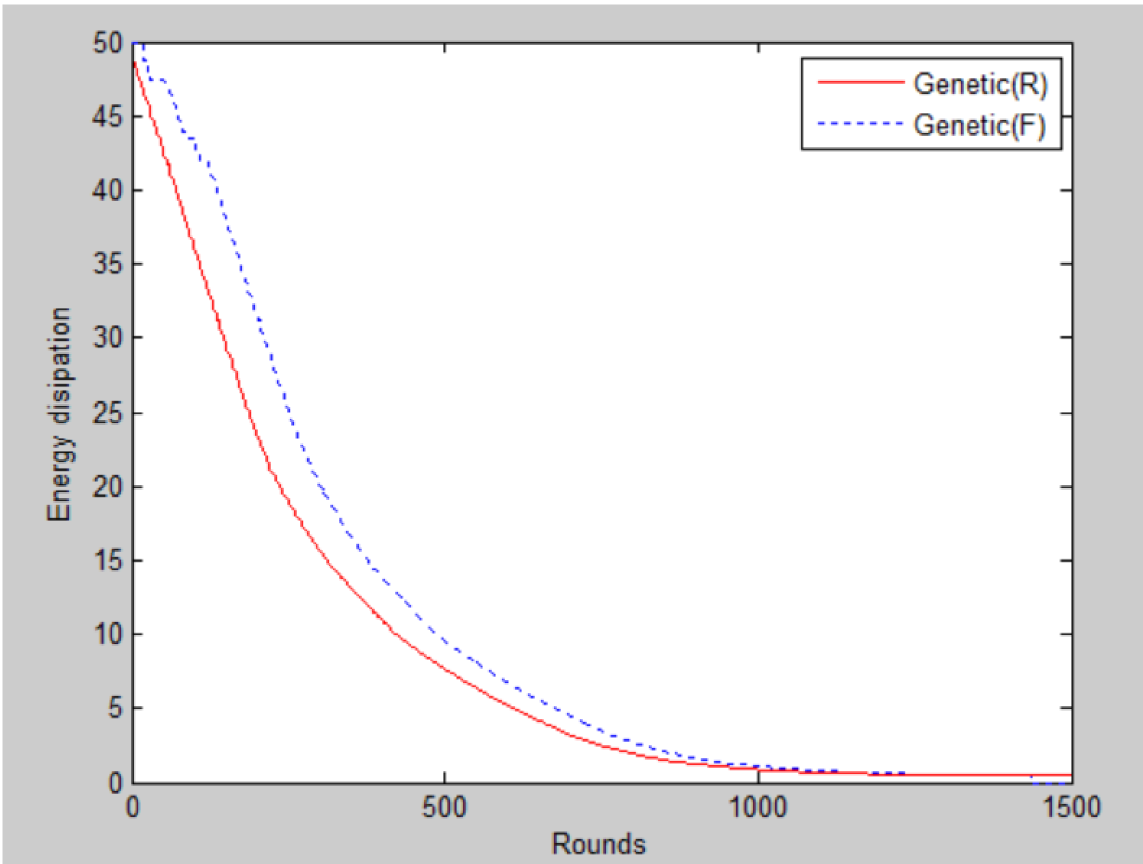

Fig. 5.7 Energy Dissipation

Figure 5.7 shows energy dissipation comparison between fixed topology and random topology. The CH is selected by proposed Genetic Algorithm in both the topologies. As it can be observed from the graph there is an improvement in case of fixed topology (where each cluster will have equal number of sensor nodes) over random topology (where each cluster can have any random number of sensor nodes). In case of random topology, energy starts depleting faster as compared to the fixed topology. More residual energy will remain in case of fixed topology based approach that means more residual energy will lead to more existence of nodes belonging to a network.

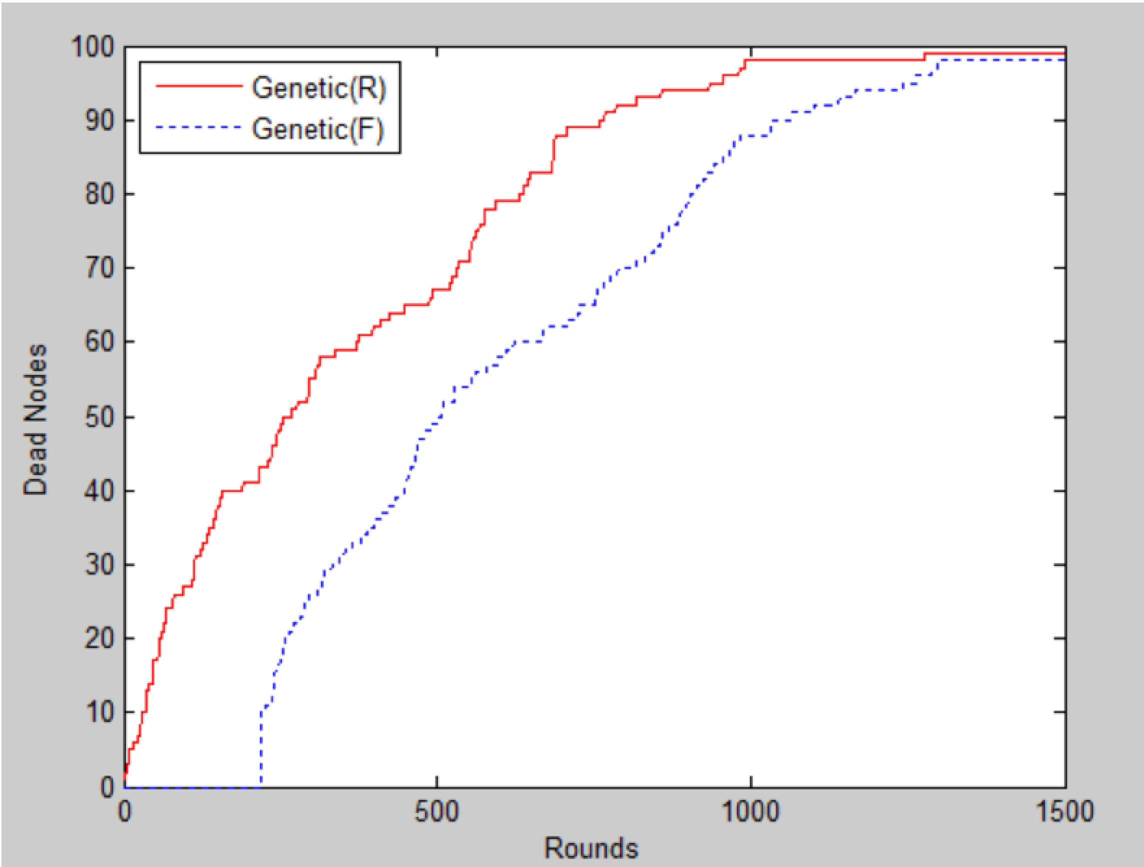

Fig. 5.8 Dead Node Count

Figure 5.8 shows dead node count comparison between fixed topology and random topology. In case of random topology, the sensor nodes start becoming dead (i.e. their energy gets completely exhausted) earlier as compared to fixed topology. The CH is selected by proposed Genetic Algorithm in both the topologies.

At the end of 1500 iterations, less number of nodes will become dead in case of fixed topology that undergoes rise in the lifespan of the sensor network.

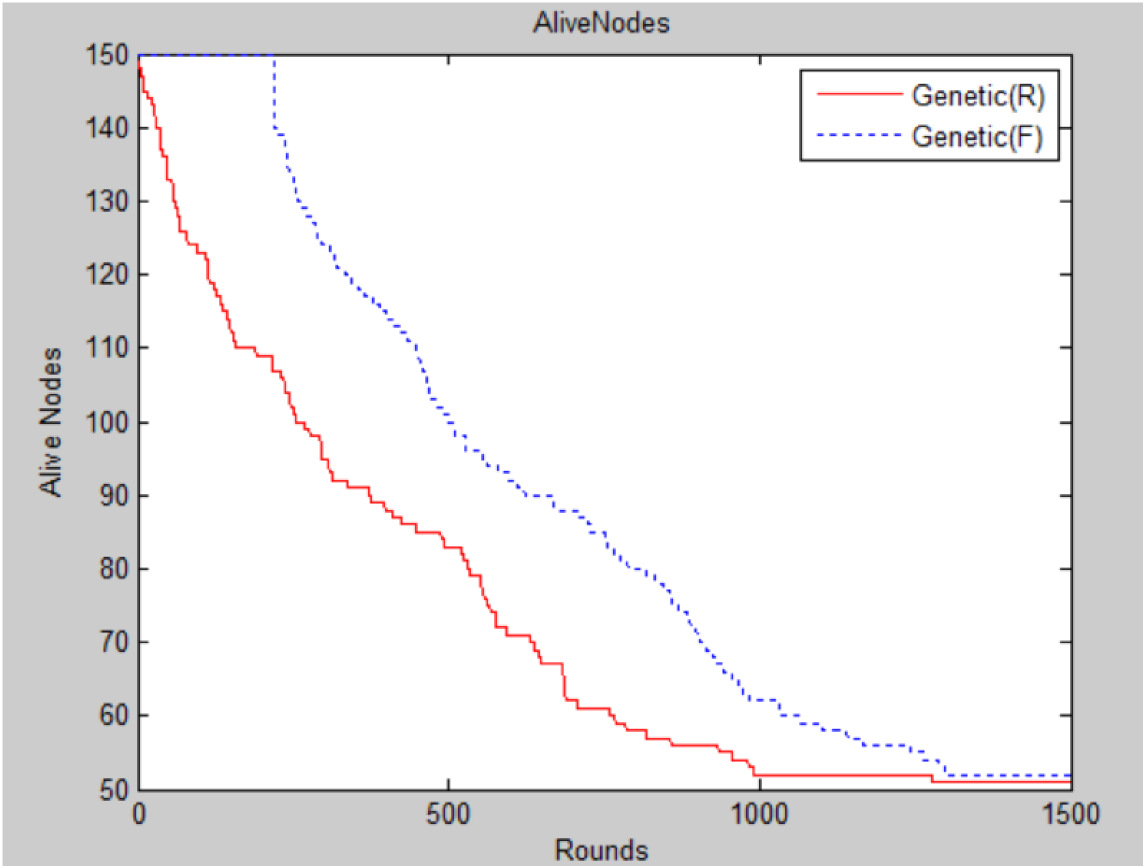

Fig. 5.9 Alive Node Count

Figure 5.9 shows alive node count comparison between fixed topology and random topology. In case of random topology, the sensor nodes start becoming dead (i.e. their energy gets completely exhausted) earlier as compared to proposed Genetic Algorithm. The CH is chosen by proposed Genetic Algorithm in both the topologies.

At the end of 1500 iterations, more number of nodes will remain alive in the fixed topology that undergoes rise in the lifespan of the sensor network.

Chapter 6

Conclusion and Future Work

Conclusion

Various hierarchical routing protocols TEEN, APTEEN and so forth are productivity based directing protocols. These protocols are to sub divide the system into small clusters. Based on left over energy the cluster head is chosen. The thresholding of time is performed so that there is less number of transmissions and receptions. In current research Genetic based technique is used for identifying the cluster head. This cluster head model depends on different parameters like remaining energy, concentration and distance. These parameters optimize the cluster head selection such that best node can be chosen which can serve as CH of any of the level. Levels are decided based on distance from the cluster head. Various performance parameters like residual energy, alive nodes, and dead nodes count has been evaluated for both Genetic and Fuzzy. All the performance parameters have shown the better performance, in nutshell better life time.

Future Work

In future this work can be further extended by considering mobile sink and multiple mobile sinks.

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APPENDIX

Plagiarism Report

ORIGINALITY REPORT

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