Improving energy efficiency in WSN using Discriminant Analysis on dynamic multi-hop clustering

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Abstract:- Dynamic Wireless Sensor Networks have a broad scope of utilizations however they are vanquished with numerous testing issues and entanglements that should be tended to. The vitality utilization of the hubs and the expansion of the system lifetime are the centre difficulties and the most critical elements of the steering convention with a specific end goal to make it appropriate, viable and productive for WSNs. As the sensor hubs are fundamentally battery fuelled gadgets, so the top concern is dependably to how to lessen the vitality usage to amplify its lifetime. In the previous couple of years WSNs has picked up a lot of consideration from both the exploration community and the genuine clients. The analysts likewise proposed a wide range of vitality effective directing conventions to accomplish the craved system operations. In this paper there is an endeavor to give a wide examination of the directing conventions in WSNs concentrating on the hierarchical or grouping based steering conventions. Additionally, extricating the qualities and shortcomings of every convention, giving a correlation among them, including a few measurements like adaptability, versatility, power use, heartiness and so on to make it justifiable and easy to choose the most reasonable one according to the prerequisite of the system.

Keywords– *Wireless Sensor Network, Energy Efficiency, Adaptability, Sensors.*

I. Introduction

Wireless Sensor Networks (WSNs) got a sensational variety getting headway innovations furthermore giving chances to powerful utilization of assets in basic situations [1]. WSNs are fundamentally the accumulation of remote n tributes having constrained vitality abilities, are conveyed arbitrarily over a powerfully evolving climate, might be versatile or stationary, for watching physical marvels like dampness, temperature, wellbeing observing, vibrations, seismic occasions and so forth [2].

The WSNs might be utilized as a part of the assortment of ordinary life exercises or administrations. For instance its regular use is for checking like in Military to distinguish foe interruption or checking the air contamination or to be utilized for woods fire recognition to control when a flame has begun. Furthermore, a vital zone of utilization is the social insurance part. Also, the utilization of WSNs on agribusiness may advantage the business liberates the agriculturist from the support and wiring in a troublesome domain. A sensor hub is normally a ultra-little restricted force gadget that comprises of four fundamental segments. In the first place is the detecting part for information obtaining, then the control framework for the neighborhood information handling and memory operations (stockpiling), then a correspondence subsystem for transmission and gathering of information from other connected gadgets lastly a force source that supplies the required vitality for performing the coveted errands [3][4]. This force source ordinarily involves a battery with restricted vitality so if a basic hub quits working then it's a major and genuine convention disappointment. The primary concern is that it could be difficult to energize the battery in light of the fact that the hubs are sent and spread haphazardly in a threatening domain or whatever other region of interest, for example, unapproachable zones or the fiasco areas for getting the required data. So to satisfy the situation prerequisites the sensor hubs ought to have enough and delayed life time, even now and again up to a while or years can be required. So the inquiry emerges that "how to stretch the lifetime of the hub for such a long term" [4].

It is likewise conceivable to utilize the vitality from the outside environment e.g. utilizing the sun based cells as a force source [5]. In any case, use partner a non-stop conduct is generally seen from the outer force sources so some vitality support is likewise required. Whatever is the circumstance; vitality is a genuine asset and ought to be utilized painstakingly. Grouping based directing conventions which are intended for the vitality productivity of a system are equipped for information accumulation. Deferral can be effectively lessened in light of the fact that within a bunch the limited calculations can work without the hold up of the control messages. So as contrasted and the brought together ones the restricted calculations can accomplish more strength and throughput. In grouping certain hubs are chosen as Cluster Heads (CHs) which needed to spent more vitality than rest of the hubs for a particular time allotment. The data from the sensor hubs is quickened to CHs and after that these CHs are dependable to handover the data to the base station (BS) which is set far separated from the field. Numerous bunch based conventions like LEACH [6][7], LEACH-C, PEGASIS , TEEN, APTEEN VGA[8] so on are proposed which edify the effective utilization of vitality in remote sensor systems.

This paper is organized as takes after: The literature survey is done to edifies the related work in the overviews of directing

conventions in WSNs. Afterwards, the Network Lifetime is characterized and the key idea driving any procedure utilized for vitality effective directing. The objective of paper is to comprehend the wellsprings of vitality waste in WSNs. In this, we portrayed and thought about various bunching conventions plans and demonstrating a portion of the focal points and detriments of them.

II. LITERATURE SURVEY

A colossal number of current works and endeavors are on the go, for the headway of directing conventions in WSNs. These steering conventions are grounded on the application needs and the structure of the system. Be that as it may, there are some issues that must be thought about while mounting the directing conventions for WSNs. The most critical and sparkling element is the vitality effectiveness of the sensors that straightforwardly impact the lifetime of the system. There are various studies and Journals on steering conventions in WSNs and an exertion is done to display beneath and talk about the dissimilarities between them. In overview [9], the creators clarified exhaustively the configuration issues and systems for the WSNs. They characterize the "physical requirements of sensor hubs" and the "proposed conventions" securing all layers of the system stack. Other than that the potential uses of sensor systems are likewise examined. In any case, the rundown of talked about conventions in the paper can't give the complete picture and the extent of the review. My overview is more devoted to the vitality proficiency of WSNs giving the grouping of the current steering progressive conventions. I additionally examined various officially created vitality productive steering progressive conventions and give rules to the peruses to choose the most appropriate convention for their system.

The study Mohamed Elhoseny et al “K-Coverage Model based on Genetic Algorithm to extend WSN lifetime”[10] in this, classical target coverage methods often assume that the environment was perfectly known, and each target was covered by only one sensor. Such algorithms, however was inflexible especially if a sensor died, i.e. run out of energy; and hence, a target may need to be covered by more than one sensor which is known as K-coverage problem. K-coverage problem was time and energy consuming process, and the organization between sensors was required all the time. To address this problem, this paper proposes a K-coverage model based on Genetic Algorithm (GA) to extend a WSN lifetime. In the search for the optimum active cover, different factors such as targets’ positions, the expected consumed energy, and coverage range of each sensor; are taken into account. A set of experiments were conducted using different K-coverage cases. Compared to some state-of-the-art methods, the proposed model improved the WSN’s performance regarding to the amount of the consumed energy, the network lifetime, and the required time to switch between different covers.

The Al-Karaki & Kamal’s [11], is a study on "directing conventions in WSNs" exhibited in 2004. Level, various leveled, and area based directing conventions are the three steering systems arranged in this review in light of the structure of the system. These conventions are further grouped into "multipath-based, inquiry based, arrangement based, and QoS-based steering methods". In complete it presents 27 directing conventions. Moreover, this paper shows a fine number of vitality productive steering conventions which have been built up for WSNs. Challenges in directing are additionally displayed and Design Issues are likewise said in the paper. On the other side, in my work I focused on the vitality proficiency issues in WSNs. I give some points of interest and examinations on vitality proficient conventions that may help scientists on their work to some degree.

In Anastasi, Conti, Di Francesco, & Passarella[12], the creators show a review that is centered on the vitality utilization in light of the equipment segments of a run of the mill sensor hub (2009). They convey the sensor hub into four key segments: "a detecting subsystem including one or more sens ors for information securing, a handling subsystem including a miniaturized scale controller and memory for nearby information preparing, a radio subsystem for remote information correspondence and a force supply unit". The paper is focused on the clarification of the attributes and advantages of the scientific categorization of the vitality preservation plans. The conventions are ordered into "obligation cycling, information driven and portability based". In the following conventions, more subtle elements and discourse are exhibited of this grouping. Additionally, diverse ways to deal with vitality administration are given and highlighted. They presume that "the examining stage may require quite a while particularly contrasted with the time required for interchanges".

In review Ehsan & Hamdaoui paper [13], some vitality productive directing strategies for "Remote Multimedia Sensor Networks (WMSNs)" are displayed in 2011. The creators additionally centered around the execution matters of every procedure. The configuration undertakings of directing conventions for WMSNs are additionally highlighted in the paper. Besides, scientific categorization of current directing conventions for WMSNs i s likewise introduced. This review paper talks about few issues on vitality effectiveness. However, there are better than average number of studies for "sensor arranges, or directing and MAC calculations for WSNs, yet this paper gives a brief review underscoring on the vitality effective steering progressive conventions in WSNs. My study is centered around the vitality proficient grouping conventions in WSNs that can give a few headings to the readers. In addition, I additionally examined the qualities and shortcomings of every bunching convention making an examination between them including a few measurements[14].

III. TECHNIQUES USED

A. LEACH Protocol(Low Energy Adaptive Clustering Hierarchy):

LEACH is a protocol in which most nodes transmit to cluster heads, and the cluster heads aggregate and compress the data and forward it to the base station (sink). LEACH divides the entire network into several clusters, which are designed by using leach coordination and control. This will not only reduce the amount of data to be transmitted to the sink, but also to make routing and data distribution more extensible in robust. Leach chooses arbitrarily the nodes CH cluster heads also allocate function to dissimilar nodes by utilizing round robin strategy to make sure fair energy indulgence among nodes. As to reduce the amount of the data sent to the base station, Ch-cluster head summative the data composed of member node linked with their own cluster also on the summative packet to a base station[15]. This algorithm works in two phase :

- 1st Phase :
  In set-up phase every node takes decision regarding to be the cluster head or not be the cluster head. This conclusion is based on the planned percentage of the Cluster Head(CH) to a network end cluster node have turn into the cluster head meant for the number of times. Sensor node would convert into the cluster head if number was greater than the following threshold

$$T(n) = \frac{P}{1 - P \times \left(r \bmod \frac{1}{P} \right)} \qquad \forall n \in G$$

$$T(n) = 0 \qquad \forall n \notin G$$

  Here P is a preferred percentage of the CHs, is a current round, and also is a set of nodes which are not elected as a CHs in last 1/p round.
- 2nd Phase :
  This is the steady state phase here data is send to Base Station using TDMA.

B. MGEAR-Protocol

In this section, we present detail of our proposed protocol. Sensor nodes have too much sensed data for BS to process. Therefore, an automatic method of combining or Aggregating the data into a small set of momentous information is required [16]. The process of data aggregation also termed as data fusion. In order to improve network lifetime and throughput, we deploy a gateway node at the centre of the network field. Function of gateway node is to collect data from CHs and from nodes near gateway, aggregation and sending to BS. Our results ensure that network lifetime and energy consumption improved with the expense of adding gateway node. We add rechargeable gateway node because it is on ground fact that the recharging of gateway node is much cheaper than the price of sensor node.

A. **Initial Phase:** In M-GEAR, we use homogenous sensor nodes that are dispersed randomly in network area. The BS broadcast a HELLO packet. In response, the sensor nodes forward their location to BS. The BS calculates the distance of each node and save all information of the sensor nodes into the node data table. The node data table consists of distinctive node ID, residual energy of node, location of node and its distance to the BS and gateway node.

B. **Setup Phase:** In this section, we divide the network field into logical regions based on the location of the node in the network. BS divide the nodes into four different logical regions[17]. Nodes in region-one use direct communication and transmit their data directly to BS as the distance of these nodes from BS is very short. Similarly nodes near gateway form region-two and send their data directly to gateway which aggregates data and forward to BS. These two regions are referred to as non clustered regions. All the nodes away from the gateway node and BS are divided into two equal half regions. We call them clustered regions. Sensor nodes in each clustered region organize themselves into small groups known as clusters. C. CH Selection Initially BS divides the network into regions. CHs are elected in each region separately. Let ri represent the number of rounds to be a CH for the node S i. Each node elect itself as a CH once every r i = 1/p rounds. At the start of first round all nodes in both regions has equal energy level and has equal chance to become CH. After that CH is selected on the basis of the remaining energy of sensor node and with a probability p alike LEACH. in each round, it is required to have n x p CHs. A node can become CH only once in an epoch and the nodes not elected as CH in the current round feel right to the set C. The probability of a node to (belongs to set C) elect as CH increases in each round. It is required to uphold balanced number of CHs. At the start of each round, a node Si belongs to set C autonomously choose a random number between 0 to 1. If the generated random number for node Si is less than a predefined threshold T(s) value then the node becomes CH in the current round. The threshold value can be found as:

T (S) = p 1−p×(rmod(1/p)) if s ∈ C 0 otherwise

where P = the desired percentage of CHs and r = the current round, C = set of nodes not elected as CH in current round. After electing CHs in each region, CHs inform their role to neighbor nodes. CHs broadcast a control packet using a CSMA MAC protocol. Upon received control packet from CH, each node transmits acknowledge packet. Node who find nearest CH, becomes member of that CH.

C. GENETIC ALGORITHM

A **genetic algorithm** is a search heuristic that is inspired by Charles Darwin's theory of natural evolution. This algorithm reflects the process of natural [18]selection where the fittest individuals are selected for reproduction in order to produce offspring of the next generation as shown in fig 3.

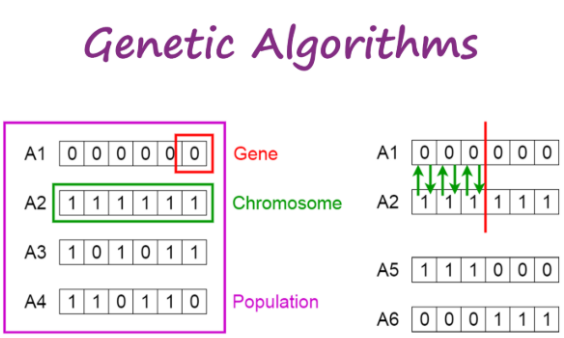


Fig 1: Introduction to Genetic Algorithm

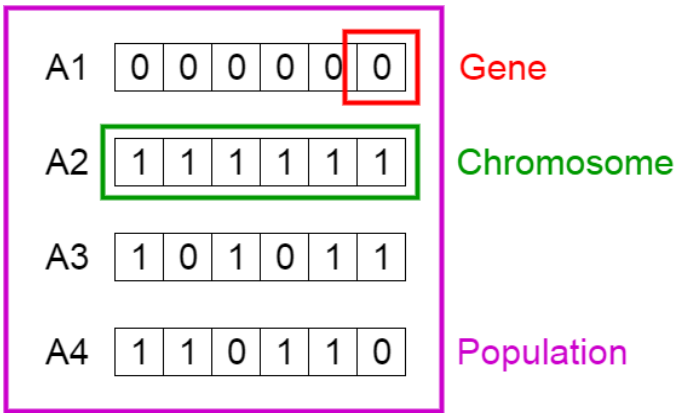


Fig 2: Population, Chromosomes and Genes

IV. Notion of Natural Selection

The process of natural selection starts with the selection of fittest individuals from a population. They produce offspring which inherit the characteristics of the parents and will be added to the next generation. If parents have better fitness, their offspring will be better than parents and have a better chance at surviving[19][20]. This process keeps on iterating and at the end, a generation with the fittest individuals will be found. This notion can be applied for a search problem. We consider a set of solutions for a problem and select the set of best ones out of them. Five phases are considered in a genetic algorithm.

A. Initial population

B. Fitness function

C. Selection

D. Crossover

E. Mutation

The process begins with a set of individuals which is called a **Population**. Each individual is a solution to the problem you want to solve. An individual is characterized by a set of parameters (variables) known as **Genes**. Genes are joined into a string to form a **Chromosome** (solution).

In a genetic algorithm, the set of genes of an individual is represented using a string, in terms of an alphabet. Usually, binary values are used (string of 1s and 0s). We say that we encode the genes in a chromosome.

V. Fitness Function

The **fitness function** determines how fit an individual is (the ability of an individual to compete with other individuals). It gives a **fitness score** to each individual. The probability that an individual will be selected for reproduction is based on its fitness score.

Selection

The idea of **selection** phase is to select the fittest individuals and let them pass their genes to the next generation. Two pairs of individuals (**parents**) are selected based on their fitness scores. Individuals with high fitness have more chance to be selected for reproduction.

Crossover

Crossover is the most significant phase in a genetic algorithm. For each pair of parents to be mated, a **crossover point** is chosen at random from within the genes.

For example, consider the crossover point to be 3 as shown below.

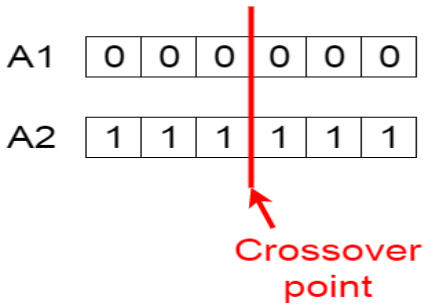
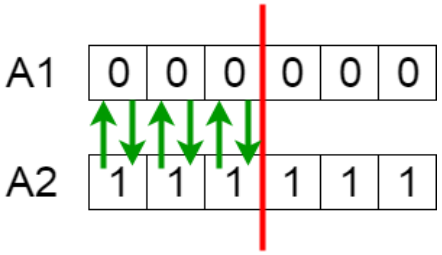


Fig 3: Crossover point



Exchanging genes among parents

The new offspring are added to the population.

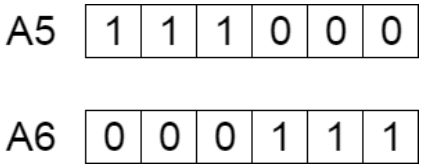


Fig 4: New offspring

VI. Mutation

In certain new offspring formed, some of their genes can be subjected to a **mutation** with a low random probability. This implies that some of the bits in the bit string can be flipped.

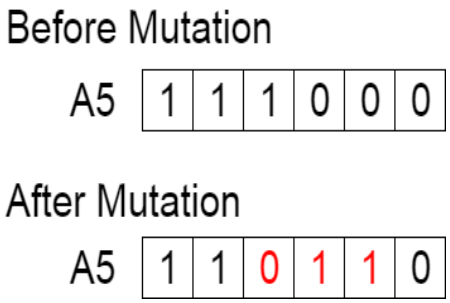


Fig 5: Mutation: Before and After

Mutation occurs to maintain diversity within the population and prevent premature convergence.

Termination

The algorithm terminates if the population has converged (does not produce offspring which are significantly different from the previous generation). Then it is said that the genetic algorithm has provided a set of solutions to our problem.

4. Linear Discriminant Analysis

The term linear discriminant analysis (LDA) refers to two distinct but related methods. The first is classifier design. Given a number of variables as the data representation, each class is modelled as Gaussian (with a covariance matrix and a mean vector).[21] Observations are now classified to the class of the nearest mean vector according to Mahalanobis distance. The decision surfaces between classes become linear if the classes have a shared covariance matrix. In this case the decision surfaces are called Fisher discriminants, and the procedure of constructing them is called Linear Discriminant Analysis. The second use of the term LDA refers to a discriminative feature transform that is optimal for certain cases . This is what we denote by LDA throughout this paper. In the basic formulation, LDA finds eigenvectors of matrix T = S1 w Sb. Here Sb is the between-class covariance matrix, that is, the covariance matrix of class means. Sw denotes the within-class covariance matrix, that is equal to the sum of covariance matrices computed for each class separately. S1 w captures the compactness of each class, and Sb represents the separation of the class means. Thus T captures both. The eigenvectors corresponding to largest eigenvalues of T form the rows of the transform matrix W, and new discriminative features y are derived from the original ones x simply by y = Wx. The relation to LDA as a classifier design is that these eigenvectors span the same space as directions orthogonal to the decision surfaces of Fisher discriminants. The straightforward algebraic way of deriving the LDA transform matrix is both a strength and a weakness of the method. Since LDA makes use of only second-order statistical information, covariances, it is optimal for data where each class has a unimodal Gaussian density with we separated means and similar covariances. Large deviations from these assumptions may result in sub-optimal features. Also the maximum rank of Sb in this formulation is N 1, where N is the number of different classes. Thus basic LDA cannot produce more than N 1 features. This is, however, simple to remedy by projecting the data onto a subspace orthogonal to the computed eigenvectors, and repeating the LDA analysis in this space [24]. Further extensions to LDA exist. For example, Heteroscedastic Discriminant Analysis (HDA) allows the classes have different covariances [21]. However, simple linear algebra is no longer sufficient to compute the solution. One must resort to iterative optimization methods. Same applies to methods that further relax the Gaussianity assumptions of the classes [26, 28]. The following section discusses why LDA and the assumptions behind it are well suited for document-term data, and how LDA can be made feasible with high-dimensional data.

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IV. Methodology

In this paper, we have compared two techniques that is used to enhance the efficiency and life time of the Wireless Sensor Network. We have implemented Leach network and to optimize the working of the network Genetic algorithm has been used. After this results are being extracted and is compared with another technique in which M-gear network is implemented along with Genetic Algorithm and Discriminant Analysis to optimize the working of the network.

LEACH Network

LEACH network results are calculated based on 4 different regions of area where the area dimension is 100*100 m^2, with number of nodes 100. The region has their own cluster head which keeps on changing with drainage of energy.

LEACH with Genetic Algorithm

In wireless Sensor network, communication system mostly depends on the energy of a device. Here in the calculation is mostly based on what we have received in the form of LEACH Protocol. To provide an intuitive move toward the LEACH Protocol this section of LEACH can be used and to optimize the results LEACH R. There is an interesting question on how a optimization algorithm is working in sync with a routing algorithm to provide optimized results.

Therefore we have using some of the specific parameters which are used by Genetic Algorithm that it uses to optimize the results.

This technique is used to increase the energy efficiency of the Network and to optimize the results.

MGEAR with Genetic Algorithm

In multipath multi hop network, communication system mostly relies on the energy of a device. Here in the calculation is mostly based on what we have received in the form of M Gear Algorithm. To provide an insightful approach the M Gear Algorithm the above section of M Gear can be used and to optimize the results of M Gear Result. There is an interesting question on how a optimization algorithm is working in sync with a routing algorithm to provide optimized results.

Thus we have to understand a statement about using some of the specific parameters which are used by Genetic Algorithm that it uses to optimize the results.

The M Gear and Leach Algorithm uses a fixed value of probability pl = 0.2577 to calculate the results of probability of alive nodes and dead nodes, this probability value is fixed for both algorithm. However in case of the Genetic Algorithm the results are calculated based on variation of this probability value.

The following instruction set, let us calculate the probability value of Alive nodes and dead nodes using genetic algorithm

```
gaDat.Objfun='objfun_schwefel';
lb=[-5 5];
ub=[5 5];
gaDat.FieldD=[lb; ub];
% Execute GA
gaDat=ga(gaDat);
pl=gaDat.fxmin+abs(floor(gaDat.fxmin));
```

Here we restrict the calculation of Genetic algorithm Lower bound and upper bound to -5 to 5. For calculating its objective function. Thus the probability value with a base of 5 is used to calculate the results.

M-Gear with Genetic Algorithm and Discriminant Analysis

Discriminant Analysis is the part of machine learning algorithm which exercises regression technique.

In regression for each input there will be a prediction which is calculated based on some learning. To utilize the capability of the algorithm it is necessary to use the same part of probability which has been modified by Genetic Algorithm to improve the results, thus in Genetic algorithm the probability calculated is further optimized by Discriminant analysis.

```
gaDat.Objfun='objfun_schwefel';
lb=[-5 5];
                ub=[5 5];
          gaDat.FieldD=[lb; ub];
               % Execute GA
            gaDat=ga(gaDat);

      % apply discriminant analysis
                 Disc =
fitcdiscr(gaDat.Chrom,gaDat.ObjV,'Discrim
          Type','diagLinear');
     val = predict(Disc,gaDat.xmin);
        pl=val+abs(floor(val));
```

V. RESULTS

In wireless sensor network, Leach and MGear algorithm initially defines a region over which they operate, in this research work it is made to be 100*100 m2. The second step is to define a number of nodes which can operate in a given region, for this research work , this number is 100.

Then the nodes will require number of nodes to have a energy level, which will be the initial energy at the starting, however this value will decrease with constant rate to produce a linearity relationship.

The nodes used will create a problem if they do not have a minimum energy threshold below which they will not operate, this level is defined next. As the nodes have a initial energy and a threshold energy, research will try next to distribute the nodes in the region of 100*100 m2.

The next phase is to initialize the value of nodes with an index number to create a identity of each node, this will help trace energy of every node.

Nodes will also distribute their energy and space in 2 regions in case of leach and in 4 regions in case of MGear.

Next is to define a cluster head, a gateway node for communication. Now once this initialization is completed it is expected to start the simulation with number of iterations.

With each iteration progressing the number of nodes will start communication with nearby and far by. This will allow the nodes to interfere with surroundings and this with communication the energy level will start reducing, this will go below a certain threshold and thus the node

will be declared as dead. But to slow down this process, it is expected to reduce the energy decrease rate by using multiple optimization techniques, which control the communication probability, and thus renders the node with ample energy.

This process will continue for a given number of iteration, in this research work, the iteration is 3000. Thus after completion of research work the complete research generate three different results, Alive nodes , Energy of nodes, Throughput of the nodes.

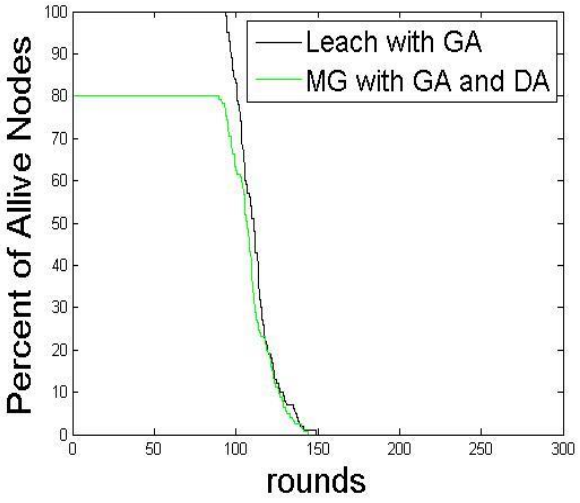

Fig 6: In this figure the comparison is mode on percentage of alive nodes. This figure shows that LEACH with GA first starts with 100 nodes and then after 100 rounds there is steep decrease. However the MGEAR starts with 80 alive nodes and After100 rounds there is a decrease but before 150 rounds the difference remains visible, but after 150 rounds the result are almost equal with alive nodes set to 0.

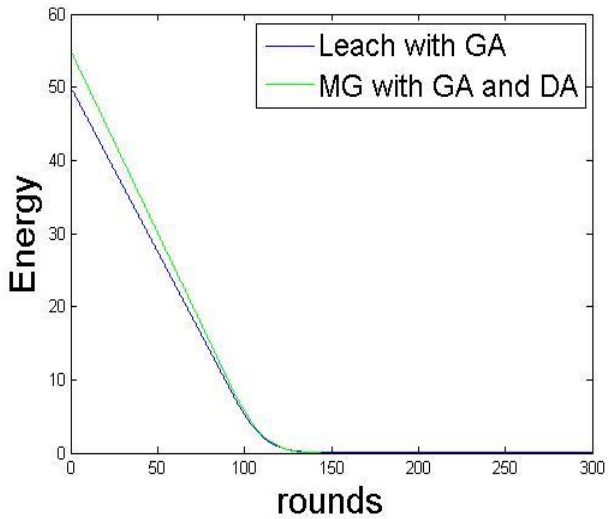

Fig 7: In this figure the energy of two algorithms for the sensor nodes are compared. In this figure if research is analyzed , initially the MGear Algorithm starts with higher energy level for all nodes, but after almost 100 rounds the energy level of both leach and Mgear are almost equal, Similarly after 150 rounds the energy level is equivalent and almost 0.

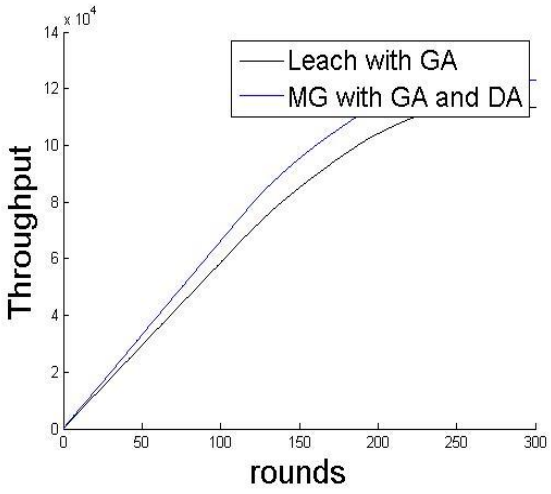

Fig 7: In this figure throughput of Leach and MGear are calculated. The throughput of both algorithm remains same for around 20 rounds then with increase in communication packets the difference starts between both algorithm and reaches to a level of nearly 10000 packets after 200 rounds.

VI. CONCLUSION

WSNs have extraordinarily drawn out assuming a key part for the information effective choice and conveyance. The vitality proficiency is a most imperative issue for the systems especially for WSNs which are portrayed by "restricted battery capacities". Because of complexity in WSNs operations, what is required is the utilization of vitality productive steering systems and conventions, which will guarantee the system network and directing of data with less required vitality. In this paper, our emphasis was on the vitality effective various leveled conventions that have been created for WSNs. On the off chance that we discuss a extensive system, the level conventions get to be "infeasible" in light of connection and the preparing overhead. This is an issue and the various leveled conventions attempt to settle it and subsequently deliver adaptable, proficient and successful arrangements. They split the system into "groups "to capably keep up the vitality utilization of sensor hubs furthermore perform "information collection and combination" to reduce the quantity of transmitted messages to the sink. The bunches are masterminded in light of the vitality reinforcement of sensors and sensor's proximity to the CH. Subsequently, we can infer that the various leveled conventions are fitting for sensor systems with the substantial burden and wide scope region. So keeping in mind the end goal to build up a plan that will drag out the lifetime of the WSNs is expected to expand the vitality utilization of the sensors within the system. Subsequently, the use of the suitable directing convention will improve the lifetime of the system and in the meantime it will promise the system availability and powerful and productive information conveyance.

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