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Optimised Clustering Technique Based Chimpanzee Behaviour and Fittest Clusterhead Routing Technique for Lifetime Enhancement of Wireless Sensor Networks

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Abstract-- In this paper Clustering is executed using a new approach that is influenced by the herd behaviour of Chimpanzees. They live in groups that comprise of 20 to 100 members in a group called communities. They tend to form small groups while travelling. The social structure composition is such that the males are the core of the structure that performs the primary duties such as patrolling, protecting and searching for food for other members. Males are said to be dominant and they form coalitions to maintain their dominance. Low ranking males continuously shift allegiance towards the dominant males who eventually lead the group.

This typical behaviour of chimpanzees is the motivating factor for the proposed clustering technique where about 100 nodes are presumed which are spread out in inaccessible areas with the purpose of collection of different parameters and data that may be useful to the source. Clustering is achieved when 10 groups are formed with each group comprising of 8 to12 nodes. Out of these nodes, two are set aside to perform as cluster heads, and the other nodes gather and dispatch the statistics to the cluster heads. Then these Cluster heads transfer the information to the base station where this data is analysed for further processing. The purpose of reserving two cluster heads is that in the event of first cluster head exhausting its energy the other cluster head take over and the communication to base station continues even if the energy of one cluster head eventually runs out and exceeds a particular threshold. After some nodes run out of energy, reclustering occurs, in which neighbouring or close clusters merge to resulting in emergence of a new cluster, and new Cluster head is chosen again based on same criterion. The benefit of this approach is that data transmission occurs for a longer duration due to reclustering as the groups persist for a longer duration. If the base station is nearer, the cluster heads send the data to it directly for the data transmission called routing procedure; if it is farther away, the data is sent to an intermediate cluster head, and then to the base station. When compared to current methods, this approach exhibits improvements in enhancing the lifetime of the network.

Keywords:- Chimpanzee behavior, Clustering, Routing, Cluster head, Reclustering, Base Station.

1. INTRODUCTION

As is known WSNs are composed of several nodes that are dispersed across the area and arranged in clusters to accumulates statistical information regarding various parameters and dispatch to destination. Each node is made up of one or more sensors and also has memory storage apart from a rechargeable/non-rechargeable battery. Clustering and Routing in sensor networks is a much-followed research topic in contemporary times with many propitious techniques. The rising intricacies of the real-world problems are such that it is not possible to solve these problems using old age techniques. The new contemporary methods that apply a meta heuristic approach are able to provide competent solutions within a reasonable time span. Various kinds of metal heuristically programs have been put forward and successfully applied and utilised to solve innumerable real-world optimization problems.

There are many proposed Meta-heuristic methods of which the most prominent method is the algorithms based on swarm traits. Swarm-based algorithms are one of the most representative paradigms & and also hugely used in contemporary times. Variety of applications utilizes this technique for getting to competent solutions to many problems.

These techniques are inspired by the way many animals, birds, and insects behave in groups. Few distinguished techniques include Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO). The social behaviors of birds, such as flocking, are what initially sparked the discovery of PSO. Among the many new methods that have been presented are the artificial bee colony (ABC), lion optimizer (ALO), and many others.

These new bios inspired methods can be designed by systems that can be configured using hardware or software. These systems are able to refine the paths set by the contemporary biological systems. In most of the herd behavior of animals it can be observed that some of the species show a typical behavior where dominance is a factor that influences the herd behavior. There is one dominant individual in a group who acts as a leader. This sort of behavior is commonly observed in case of monkeys, deer and lions. But this is not a rule. There are also other species in which no dominancy is observed. In such groups every individual follows a organized approach that determines their movement through the environment without the influence of a leader. Such typical behavior is generally observed in flocks of sheep, birds, bees, fish and ants. In this type of behavior animals or birds are ignorant of the group or the environment in which they tend to move. Their movement in the environment is done by them sharing information with their neighboring members. This individual interaction amongst members is what makes the animal behavior systematic.

In the bio inspired behavior systems there are also cases wherein one can observe in biological models there is spread of epidemics resulting in disturbance of immune systems. It is well

known fact that the immune system of human or animal is actually a convoluted natural defense mechanism that is able to sense foreign particles called pathogens that penetrate into the body. The body responds by generating antibodies that destroy the antigens that are identified with the disease. These behaviors which are biological in nature is a result of continuous evolution through millions of years. Hence research is going on to design systems inspired by this bio inspired behaviors.

The main advantages of these methods as perceived by technologists are as follows

1) Ability to adapt to medium changes.
2) These bio-inspired systems remain unaffected due to failures caused by internal and external factors.
3) These systems allow implementation of elaborately complicated problems in a few and limited set of fundamental rules.
4) These systems are continuously evolving and give optimum solutions as new conditions occur.
5) The ability to utilise limited resources available in an optimal manner.
6) Also, the ability of nodes to self-organise and distribute in an optimised manner is an advantage of these systems.

II. LITERATURE REVIEW

According to authors of Paper1, nature influenced methods are taking forefront positions in providing good solutions to very vital issues regarding improvement of lifetime of wireless sensor networks. Optimal network coverage is one important issue that should always be considered before designing or setting up a network. The network if is optimal is advantageous as it reduces the consumption of energy that is already limited in the sensors. As is known sensors are driven by battery which can be energised only once before distribution. Reduction of sensing of redundant information is also an important factor that is taken care of. This paper proposes some nature inspired optimization algorithms that takes care the coverage of the relevant areas in an optimal manner. The authors categorize the many optimization techniques that are available and the issue domains in sensor networks in the initial portion of the paper. The two new nature-based processes that have impacted the two algorithms that were compared in the study's second half and new techniques are proposed by amalgamating two techniques such as Genetic, Ant and Lion Optimizations.

Inspired by particle swarm technique, the authors have put forth a novel and intriguing bio-influenced approach named PSO-WZ. The authors of this strategy propose that cluster heads be chosen at random and non-cluster heads be chosen in accordance with the division rules. In subsequent rounds, the fitness function for the aforementioned process is used, and this process is repeated until the utmost time is attained . This method of division is connected to network topology and also to the way in which the energy is distributed to the nodes. The topology is designed by considering CHs and the

remaining nodes in the network. This is done with the purpose of utilising lesser energy and conserving as much energy as possible The designers of this promising strategy have included the Gini coefficient in the target function with the goal of maintaining the maximum network coverage range while simultaneously reducing the number of nodes used.

Another contemporary approach is put forward in paper 3. The authors have combined the lightweight dynamic trust mode approach with the promising honey bee mating algorithm to invent a hybrid method that can help in avoiding malicious node from becoming a CH. This suggested choice of using a light weight trust model is an added advantage that helps in making the proposed method a bit more secure and also the energy utilised is also optimum. These issues are very much critical when one considers the design of a sensor network because the resources such as energy is very limited and constrained. This approach is divided into two steps a) choice of a suitable CH and b) process of cluster evolution. Additionally, there are two stages to the CH decision process: the premier phase is the first, and the stable condition phase is the second.

The process of selecting a cluster head occurs in the premier phase. In the subsequent phase called the attendant phase or steady phase, the first phase Ch plays a role in naming the Ch for the second phase. It is imperative that the cluster's size be predetermined during the cluster formation procedure.

This approach helps in boosting the longevity of the system. In case size of the cluster is large and the space between the CH and BS is huge, naturally the overhead allied to data transmission shall be more and hence energy consumed shall also be more. However, it makes sense that the energy used will be less if span between source and destination is minimum.

Similarly, the same effect is analogous to a small cluster with distance between CH and BS being less or more. If distance is less energy consumption is less and if distance is more energy consumption is more. Therefore, the way the clusters are to be formed is dependent on the equilibrium size of the cluster. Here the authors have put forward a promising technique that is named BTCWSN method which utilises a A lightweight dynamic trust and a bio-inspired honey bee mating algorithm are used to select a node that is reliable and energy-efficient, making it deserving of being Head of Clusters

. Additionally, the network is built so that in order to promote an energy-efficient distribution of energy, clusters nearer the base station are smaller than clusters farther away. This method just requires one cluster creation process. This results in lower overhead and lower energy consumption when using this strategy. The net result is an overall increase in the network's lifespan.

According to authors of paper 4, the communication model is directly impacted by the routing and MAC protocols and hence it is impertinent that there should be a consideration of the energy conservation aim while implementing the protocol design of these two domains. The authors contemplate the different state of art protocols and their consideration in MAC as well

as Routing domains that have been put forward with an aim of preservation of energy. According to the authors, the design of protocols in the routing and MAC domains should include energy conservation because these two protocols have direct access to the communication component. To accomplish the overall objective of extending lifetime of the system, authors address various cutting-edge protocols that have been proposed for WSNs in the MAC and routing domains. Of the location based, data centric and hierarchical, only the first two are discussed here, as location-based routing protocols typically require prior knowledge of sensor location, which is frequently unavailable due to random sensor deployment. Next, the authors go over how schedule-based and contention-based MAC protocols can help ensure the best possible use of the finite energy resources by lowering or eliminating the likelihood of collisions and, consequently, the requirement for retransmission.

The authors of Paper 5 put forward a technique for Routing which is inspired by the way cuckoos tranmit information and named it Bio-inspired Ant Cuckoo Optimised Relay Based Energy-Efficient Data Aggregation (BACREED-LEACH). There are two parts to the planned activity. The first step identifies the number of clusters, relay node (RN), cluster membership, and CHs (CH). The second stage consists of acquisition of information by nodes and transferring it to CH the subsequent transfer of the aggregated data via RN to destination.

Goal envisaged in paper 6 is to prolong the duration of WSNs. This paper discusses how to balance load in clusters in a proper way by placing the CHs in Optimal way. The method is motivated by the evergreen PSO technique. Lifetime, Fitness values and convergence plots have been replicated for three different scenarios. In the end, the statistics indicate that when comparing the two, the optimal CH placement provides has a longer lifespan. An efficient fitness function too has been implemented. .

III. PROPOSED WORK

Energy model proposed by Yuan Zhou, Ning Wang, and Wei Xiang (2017) has been used. Transmitter and receiver is an integral part of the circuit.Let N be the total nodes are presumed to monitor the environment.

Let the energy consumed in transmitter electronics be E_{tx} and energy consumed in receiver electronics is E_{rx} and energy consumed in transmitter amplifier is E_{amp}.Let the transmitter and receiver be separated by distance ‘d’. The stretch that separates the transmitter and receiver determines whether the multipath model or the free space model is to be used.

In case the separation is smaller than a threshold ‘dt’ then a free space model with a power loss of $d^2$is preferred and if the separation is greater than the threshold ‘dt’ then a multipath pattern is preferred where there is a power loss of d^4.

The energy equation for transmission of data for distance d is given as:

$$E_{tx(l,d)} = \begin{cases} l \times E_{elec} + l \times E_{fs} \times d^2 if d \le d_t \\ l \times E_{elec} + l \times E_{mp} \times d^4 if d > d_t \end{cases} \dots (1)$$

"Eelec" is the quantity of dispersed per bit to the transmitter and receiver circuit, "l" is the length of data conveyed, "dt" is the ion distance threshold during transfer of data, and "Efs" is the energy received while using free space model and “Emp" is the energy received while using the multipath.

Th equation is written as

$$d_t = \sqrt{\frac{Efs}{Emp}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Energy consumption for reception of l bit energy is given as

$$E_{rx}(l) = l \times E_{elec} \dots\dots\dots\dots\dots\dots\dots\dots\dots... (3)$$

In many applications the networks continue to function even when a few nodes die. This is because other nodes replace the dead nodes and perform their functions. Therefore, we may define Lifetime as the time say uptill the fraction of nodes that are alive goes beyond the threshold that has been defined earlier.

Therefore, Lifetime of a Network is expressed as

$$LT_N^a = LT[\,\Delta = \frac{a}{N}\,] \dots\dots\dots\dots\dots\dots\dots\dots....... . (4)$$

where sum of all nodes is ‘N’, of which nodes that are alive is ‘a’.

It is presumed that each cluster consists of ‘n' nodes in each cluster and 'm' nodes overall. The proposed algorithm has two cluster heads. Therefore if we exclude the cluster heads from the total number of nodes we have in all (m-2) sensor nodes for every cluster. The expression to decide how much energy a sensor node needs to send and receive signals as well as for intermittent sleep phases is

$$E_{sn} = (1 - ps)[E_{tx}(l, d) + E_{rx}(l)] + p_s E_s \dots\dots (5)$$

whereEs is the energy utilized when the node is asleep and ps is the sleep probability. After compiling the information, data is relayed to the destination.

Thus, dispersion Energy of CH is given as energy that the cluster head dissipates is

$$E_{ch} = E_{tx}(l, d) + (m - 2)E_{rx}(l) + ml(E_{da}) \dots. (6)$$

where m is a cluster's total number of sensor nodes.

$E_{da}$is the energy dispersed per bit because of data aggregating.

Therefore, dissipation of energy in a cluster is given as

$E_{Cluster} = E_{ch} + mE_{sn}$…….…..…… (7)

Therefore, total Energy used is

$E_{total} = E_{Cluster} \times n$ …… (8)

Where Cluster count is n

IV. PROPOSED METHODOLOGY

It is well known that the most important characteristics of Chimpanzees is that they tend to live in communities and each of these communities comprise of about 20 members and maximum up to 100 members. But as far as travel is concerned these prefer travelling in small groups that are temporary and comprising of small number of individuals. The groups that reformed are not limited to a particular age or sex and comprise of animals of all ages and sexes. The groups that are formed are basically classified as a) All male) All females c) adults of both sexes and d) Females and their offsprings. These groups are small in size, with a variety and with a aim to serve various purposes. A Classic example could be that a group comprising of all males may be constituted for hunting purpose whereas a group that may consist of lactating females can act as a caring group for the young breed.

The basic structure comprises of a core group of males whose duty is to monitor the whole area, act as a shield for the group members and scout for food. Males are retained in their inherited communities whereas females migrate during the adolescent age. Therefore, the chances of males being related to each other are more in comparison with females. The community has male dominant structure. The group behavior when analyzed shows that some of the members separate from the group and later on join the groups. This is a regular feature observed. This is because the animals are given a huge autonomy in its behavior and hence individual chimpanzees in a group or alone foray for food and then later on join the whole group of chimpanzees to encompass a large group.

Group behavior in Chimpanzees clearly exposes a linear male dominance hierarchy. Male chimpanzees that are used to leaving the groups for some time and returning back to the groups and may tend to show aggressive behavior at the time of rejoining. Males maintain and raise their standing socially by forming new coalitions thereby improving their ability to dominate a third individual that they could not have been able to do otherwise. With the help of the coalitions formed, they also challenge the dominance of existing leaders. But coalitions continue to make and break and low-ranking males continuously change their allegiance based on the present dominant structure and always support a dominant leader On the basis of the above behavior of Chimpanzees, an optimization technique is proposed for a wireless sensor network. By assuming that there are about 100 Chimpanzees in an area and they form 10 groups

each consisting of eight to twelve nodes. Therefore, in an area of 300m×300m, we assume that about 100 nodes analogous to 100 Chimpanzees are randomly spread out. After then, eight to twelve nodes are grouped together to form clusters. These clusters are formed by drawing 10 squares and node falling in that particular square will form one group. Therefore, we may say that the number of nodes in each group will be non-uniform with some groups having lesser nodes and some having more nodes. Of these nodes two nodes are reserved to act as cluster heads though they may also participate in data collection except the node that acts as Cluster head. Each of these two nodes will act as Cluster heads one after the other after exhaustion of their energies. After clusters have been formed, the following step is called cluster evolution. Next follows the choice of Cluster head which is done by choosing the node that has the maximum energy. The remaining nodes collect the information and forward it to the head in each cluster which subsequently passes it to the destination.

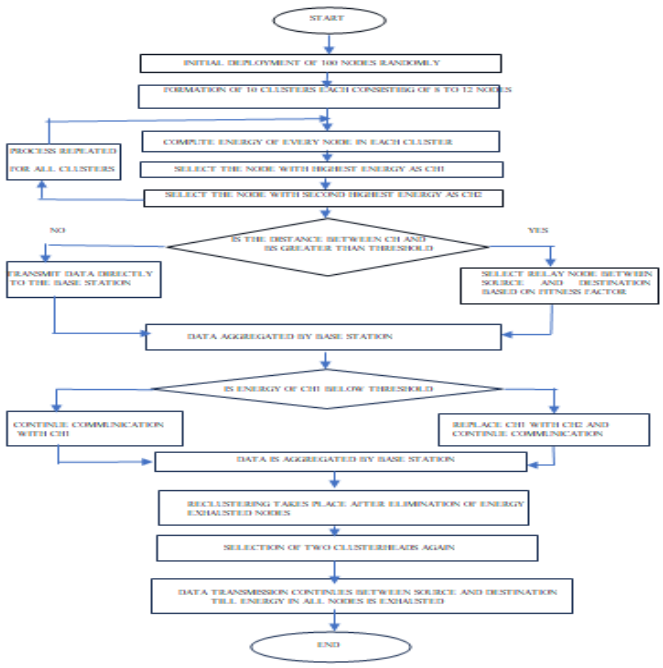

Fig.1 Steps to select head and base station

The Cluster head uses up all of its energy after a few communication rounds are over and are unable to continue the conversation. After that, the node with the second-highest energy becomes the CH, and energy is transferred via this cluster head. The nodes gather data, send it to the new cluster head, and then continue sending it to the base station.

The cluster will eventually be reduced to small sizes after the death of the second cluster head and a few more nodes. After that, two clusters are joined to create a new group or cluster, a new head is chosen, and the communication continues. Consequently, re clustering occurs, extending the sensor network's lifespan. The head of each cluster accumulates the information and relays data directly to the sink. If the

distance between the cluster head and base station exceeds a predetermined threshold, an intermediary node may be utilized. A predetermined fitness function is used to choose these nodes, also called Relay nodes.

Relay nodes are usually selected so that the node with the maximum energy and the node that is evenly distanced between the cluster head and base station are selected if there are several nodes in the vicinity.

The method that has been discussed will include the subsequent actions and also described inFlowchart of Fig.1

a) An area that is square in nature with dimensions 300m×300m is presumed and about 100 nodes are dispensed randomly.
b) These nodes are allotted random energies.
c) It is assumed that the the sink shall be located at a distance from the square area.
d) Next 10 clusters are formed with every cluster.
e) These clusters are created by dividing square area into 10 small squares.
f) These clusters are marked sequentially with initial cluster as 1 till 10.
g) Energies of every node are measured.
h) In each cluster, the node that has the maximum energy shall be designated as Head.
i) Data forwarding to the Cluster heads is the responsibility of the remaining nodes after that.
j) The statistics that are aggregated data is then sent to the sink by the cluster heads.
k) In order to send data, an intermediary node must be used in case the sink is at a greater distance ie. above a predefined threshold distance.
l) After the first round of communication is concluded it is possible that energies of the cluster heads have exhausted or decreased to an extent that their energies are lesser than other nodes.
m) Then the node that is having the highest energy in the cluster takes over as cluster head in every cluster.
n) Again, communications take place for few many rounds. Energies of nodes after every round are computed.
o) After energy of the present cluster head reaches its threshold, and energy of some nodes is exhausted then these nodes stop participating in the communication process.
p) Then two clusters nearer to each other combine together to form a new cluster. Thus, the number of clusters reduces from 10 to 5 and communication continues.
q) This process continues till energy of remaining nodes and cluster heads reaches its threshold and communication stops.
r) Then routing process is envisaged wherein firstly the source node is determined. Base station is considered as the destination node.

s) Now the span across source and sink is computed.
t) If the span is greater than the predefined limit, necessity of intermediate node is envisaged and selected.
u) All the remaining cluster heads between source cluster head and destination base station are selected.
v) The energy of cluster heads in this area is computed.
w) The cluster head that has the maximum energy is selected as intermediate node.
x) Data is transmitted through this cluster head.

V. RESULTS and ANALYSIS

NS2 simulation has been used to test the method proposed in this paper. It is assumed that the traffic pattern is constantly active with a constant bit rate (CBR). For calculating purposes, a threshold of 0.2 mJ is taken into account for every node. The characteristics that are computed and compared in this approach are the alive node count, energy consumed and network longevity. Table 1 shows
the values of various variables presumed.

Suggested method is contrasted with other contemporary bioinspired methodologies, including Genetic (GO), Particle Swarm Optimization (PSO), Horse Optimization (HO), and Elephant Herd Optimization (EHO), as shown in Fig. 2. Compared to the various methods already in use, it has been shown that the suggested strategy, which consists of 942 rounds, operates for the longest duration.

Sr. No	Simulation Parameters	Values
1	Channel Type	Wireless
2	Network Size	300m × 300m
3	Number of Nodes	100
4	Transmitting power	2mw
5	Packet size	1000bits
6	Performance parameters	Number of Alive Nodes and lifetime and energy consumption.

Table 1. Simulation Parameters

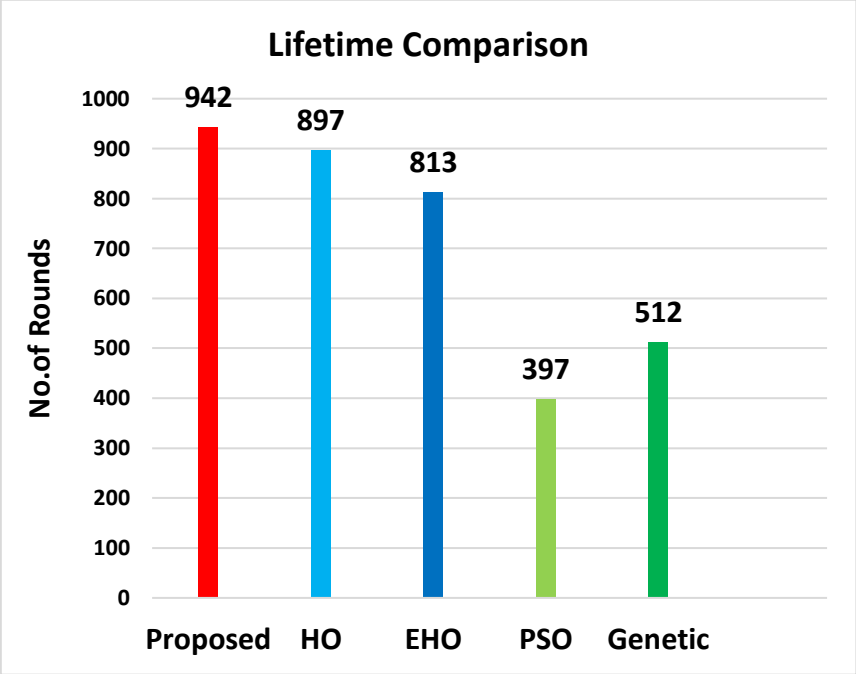

Fig 2. Lifetime comparability with contemporary methods.

In terms of the alive nodes count, Fig. 2 compares the suggested method with a few of the current methods. The analysis reveals that the nodes in these methods die sooner than those of the suggested strategy, suggesting that the latter is more efficient.

Fig. 4 displays the energy usage observations for the various techniques. Observations show that the recommended utilises less energy than the alternative approaches, resulting in a longer lifespan than the other comparable strategies.

VI DISCUSSION and CONCLUSION

A novel and distinctive clustering and routing method inspired by chimpanzee behaviour is presented in the aforementioned research. By using uniform squares to divide the nodes into groups of about ten each, clustering is accomplished. A fitness function based on minimum distance and maximum energy is then used for routing, and if the distance exceeds a predetermined threshold, it is used.

In addition, if the distance exceeds the routing threshold, an intermediary node helps deliver the data to the target. This strategy is compared with

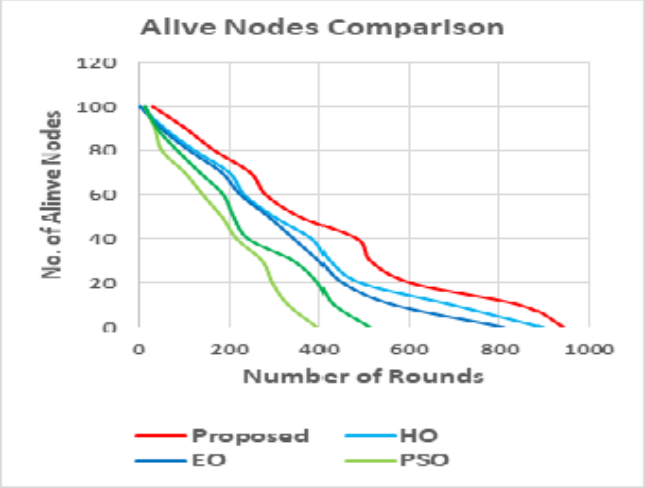

Fig 3. Alive node count comparison

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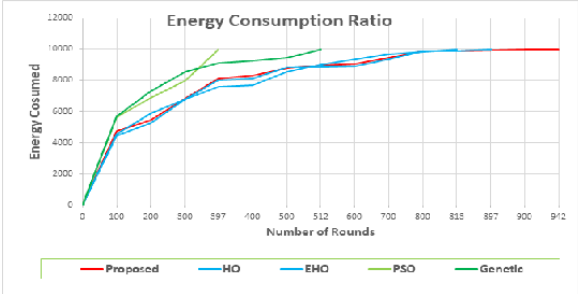

Fig 4. Energy consumption comparison

established, modern approaches. With this approach, it is shown that more nodes remain alive for longer periods of time. Additionally, this technique requires less energy than others. Consequently, it may be said that the approach used here yields better results than other comparable contemporary approaches.

The proposed method has been compared with the existent, predominant as well as old techniques such as the particle swarm optimization, Genetic based algorithm as well as the newly proposed Elephant herd optimization and horse optimization techniques. The unique features of the proposed techniques that use re-clustering technique, the longevity of clusters further increases. Also, the use of selection of intermediary node for routing helps in sustaining the information transfer extended duration and hence ensuring logetivity of the sensor network.

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