Improved wireless Sensor Network Routing by Convex optimization using EM

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***Abstract*- Wireless sensor network is a group of nodes that are connected to each other by wireless connection. These type of network work on the dynamic topology of the network because positions of nodes in the wireless network are changing continuously. The nodes in WSN are basically made up of small electronics device which are used for sensing, computing and transmitting the data. The nodes are run on the battery power during communication process. The battery consumption in WSN is very high due to high computation operations on it. In the recent years WSN grows at very high at the research area is also increased in this field to provide effective computation. By considering the network structure routing is categorized into two parts that are flat and hierarchical routing. In this proposed work cluster are made by GWO (Grey Wolf optimization) on the basis of distance and energy parameters. The cluster head is also selected on the basis of GWO and IPV6 in three different metrics. At the end the performance evaluation of the proposed work is compared with the existing approach Leach on the parameters of Throughput, dead node, alive nodes, and energy.**

***Keywords*— Wireless sensor network, Grey Wolf optimization, Dead node, Alive nodes.**

I. INTRODUCTION

Wireless sensor networks are the application based networks which comprise of various sensor nodes. WSN is an arrangement of many sensor gadgets which speak with wireless networks with the assistance of restricted vitality expending steering conventions. Wireless Sensor networks are thick wireless networks of little, cheap, low-control, disseminated self-ruling sensors which amass and proliferate natural information to encourage checking and controlling of physical conditions from remote areas with better exactness. For the most part, it is accepted that every sensor in a system has certain limitations as for its vitality source, power, and memory and figuring capacities [3]. It contains a door that gives wireless network back to the wired world and dispersed nodes. It can likewise be characterized as a system of gadgets that can impart the data accumulated from an observed field through wireless connections. The information is sent through different nodes with an entryway and the information is conveyed to different networks like wireless Ethernet. These networks are utilized to control physical or ecological conditions like sound, weight, temperature and so forth. WSN nodes have constrained battery limit. To build the life expectancy of WSN the usage of vitality in a productive way is a most normal issue. As the utilization of WSN are expanding step by step and has numerous varieties like target following condition observing, air contamination checking and so on. These applications require fast correspondence between sensor nodes.

A. WSN Architecture

There are three main components in WSN: nodes, gateways and software. Spatially distributed cluster heads interface with sensors to monitor assets. The collected data transmit to gateway wirelessly, and can operate independently. It is connected to a host system where the data can be collected, processed, analyzed and presented by using software. To extend WSN distance and reliability, special type of measurement node is used such as router node. WSN is a widely used system because of its low costs and high efficiency. Wireless sensor networks (WSN) contains sensor nodes which basically utilized for detecting, imparting and information preparing. Sensor nodes can be utilized as a part of numerous fields like businesses, military, and farming applications, for example, transportation activity checking, natural observing, keen workplaces and front-line observation. In these applications, sensors are conveyed in a specially appointed way and work independently. In these unattended conditions, these sensors can't be effectively supplanted or energized, and vitality utilization is the most basic issue that must be considered [4, 5]. The sensor is a small device which is used to detect the amount of physical parameters, event occurring, measures the presence of an object and then it converts the physical parameters to electrical signal values using electrical actuators.

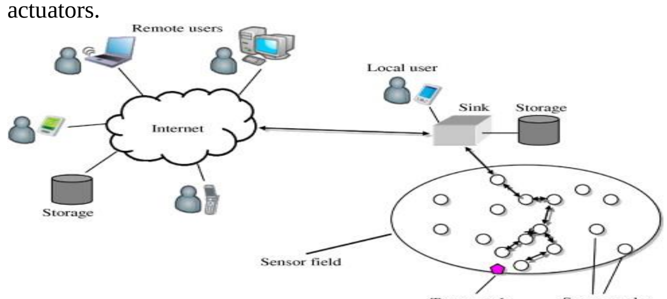

Fig.1 WSN Architecture

B. WSN TOPOLOGY

The different types of network topology are used for the development and deployment in wireless sensor network that are tree, bus, ring and mesh etc.

(a) Bus Topology: In this topology the node sends the message to another node on the network and all nodes are able to see this message but only the actual recipient node accepts and processes the message. This topology is easy to install when the resources and nodes are in limited amount but the congestion in increased due to single path of communication.

(b) Tree Topology: In the tree topology the central root node is worked as a router and selects the route for all the nodes. The central hub in this topology is just one level below the root node. The lower level of the topology is worked like a star topology and it is considered as hybrid. This topology worked as single and multi-hop and data is send by the central hub to the sink nodes.

(c) Star Topology: In this topology the sensor nodes are connected to the sink node and send the data through it. The direct communication of the nodes is not possible in this type of topology. The data sharing in this topology is easy due to a central communicator but if the sink node is fail then the whole network is not working and a condition of jamming is performed on network.
(d) Ring Topology: In Ring topology each node has two neighbor nodes and the communication in ring topology is performed in always one direction. The direct communication between the nodes is not possible in this topology because all the nodes are connected through a loop. If the single node is failed in this network then the communication between the all nodes is stopped completely.
(e) Mesh Topology: In mesh topology every node is connected to each other and able to share the data. Many paths are available between the sources and sink if the one path is failed due to some reasons then the communication does not affected and other path is taken by the nodes.
(f) Circular Topology: In circular topology the sensing area is defined by the tiers in which sensing nodes and random nodes are deployed for the communication. The sink node is available at the center of the network. This topology is easy to maintain, easy to deploy and more efficient than other topologies.
(g) Grid Topology: In this topology the network is divided into the equal sizes grids that are non-overlapped and square in shape. In each grid at least one node is working at the anytime. Each grid has a node head which is responsible for sending the information to the other node related to routing and data transmission. This topology is fast among all topologies and congestion is not possible in this topology due to the grids structure.

C.ROUTING APPROACHES

The WSN network is explained under the feature guidance at node as well as network level. The network is explained with variable position as well as fixed position scenarios. The location of nodes is explained under mobility guidance and narrow range setting under the implication of stability [8]. The network is explained under the limitation of route identification and volume limit guidance. The network is explained under the node neighbor identification that can identify the efficient next hop to create the effective communication route over the network system. The hop recognition can be finished with the range and other parameters guidance. The routing approaches adapted by different mobile network are shown and discussed. These approaches are given below fig.2

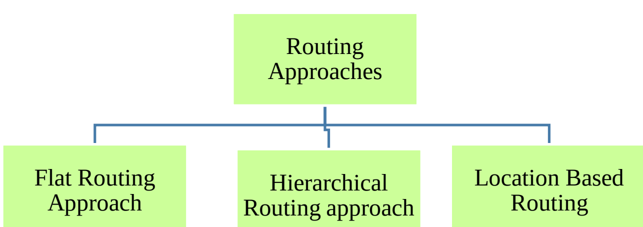

Fig.2 Routing Approaches

(a) Flat Based Routing: Such kind of routing technique is used in identical network with randomized parameters guidance. All the network nodes are of same type and the multi hop route is used to optimize the network route. In most of the intra- cluster mobile network, these kind of routing approach is been used to carry out the network communication [10. This routing approach works on the destination adaptive and data adaptive communication carried out over the network. The network also has the multi case communication to minimize the communication effort. To carry out the multi cast communication aggregative communication approach is adaptive in these networks. Such kind of routing technique also requires minimizing the number of intermediate nodes as well as minimizing the communication effort of each involving node over the network. Such kind of communication route read the next neighbor under different physical and communication parameters and choose the node with effective throughput and minimum expected loss and delay [6]. The work is about to minimize the flooding by capturing the routing information as well as minimize the redundancy in communication. The work is also effective to carry out the broadcasting of the network as well as effective hop selection over the network.

(b) Hierarchical Routing: In this routing technique, the inter cluster communication is carried out. The nodes can identical or different but the nodes in a same network are considered as identical. The network area chosen in this network type is generally big and measurable. Each sub network is explained under the guidance of controller node so that the effective network aggregation will be carried out by the node. This controller node takes the adaptive decision regarding the node guidance and the sub network head specification. The segmented communication is made in the form of tree and at each tree node decision regarding the adjacent network election will be done [7].

(c) Location Based Routing: The routing technique explained here for the guidance of network node and tracking of node under the location guidance and creation. This routing technique relies on the node location and the signal strength of various positions over the network. The satellite guidance is used to select the position of the node and to carry out the activity of the network under guidance of protocol. GPS analysis is carried for node location monitoring and indication to select the node and to perform the zoning of the network with guidance of the criticality for the network with specification of routing and mobility.

Classification of Ad hoc Networks Routing Protocols

Routing protocols in Ad hoc Networks are divided into three types depending on their functionality and way of working in the network. Below given fig.10 shows the routing protocol [1, 2].

a. Reactive protocols; b. Proactive protocols; c. Hybrid protocols

D. Existing Issues

The existing issues are illustrated in the section below:
(a) Routing: Routing is the main problem which occurred in the wireless sensor networks and many solutions has been developed to solve this issue. For providing effective routing WSN faces many challenges due to its flexible changes in nodes [8, 9]. These difficulties block existing directing conventions created for wireless specially appointed networks from being utilized as a part of WSNs.
(b) Energy Consumption: The main goal of this research is to provide the energy efficient routing protocol. These protocols are used to provide efficient data transfer between sensor and the sink. In the development of the protocol energy consumption is the main concern because the energy resources of sensor nodes are limited.
(c) Neighborhood discovery: Mostly the routing protocol requires each node to exchange the data between its adjacent nodes. The exchange of information changes according to the routing method and the location of the nodes. In data centric routing protocol may require the information content of the observed value of each sensor in its nearby nodes.
(d) Scalability: Wireless sensor network is consists of huge number of nodes in it. High- density deployment of nodes required physical phenomena to observe. In this each node contains a lot of

information and supports the distributed network topology. In this scalability is the main issue in wireless sensor network. If the density is high in the network then it exchanges the data in limited amount for energy efficiency.

E. WSN: Advantages and Disadvantages

A WSN consists of a large number of low power multifunctional sensor nodes, operating within the unattended environment [10]. WSN has various advantages and disadvantages as listed below.

Advantages:

- Without permanent framework network setup can be done.
- Ideal for the non-accessible places
- Ad-hoc when the situation requires an additional workstation.
- Cheaper and economical.

Disadvantages:

- Less storage capacity (100 KB) and modest processing power.
- Consumes large power and works in short communication range.
- Less energy is provided by the devices.

II. RELATED WORK

The countless number of studies target upon WSN technology resulting in accurate results. The paper presents the analysis of various methods of data-mining established in the recently. Some of the magnificent researches are as follows:

Kumberg, Timo, et al. [1] proposed a simple and effective cross-layer routing protocol called as T-ROME. In this nodes are containing wake up receivers. This by the protocol used to save energy skipping nodes during data transfer. In this protocol, Markov chain model is also used for verification. This protocol enhanced the performance of the wireless sensor network. Krishna et al. [2] conducted their work on sensor- media access control protocol and Leach to provide energy efficient wireless sensor network. In this method, Leach is used for adaptive clustering of the nodes in remote sensor systems. This method uses TDMA based MAC convention to adjust utilization. In these work different types of Leach is also used to enhance the performance. Tan, Cheng Kiat, et al. [3] introduced FAEM data collection protocol which is used for energy efficient multicast multichannel routing in wireless sensor networks. It works on the basketball net topology in which it establishes a table for each node and also pre-assigns the channel which is different from the neighbor nodes. Time is divided into duty cycle and each cycle consists of two phases. The first phase called iterative scheduling phase and second phase called as slot-based packet forwarding phase. In this network tree upload nodes are called parent node and download nodes are called child node. Results of the proposed method give low energy consumption, low latency, and high data reliability. Bahbahani, et al. [4] proposed cooperative clustering protocol to enhance the longevity of energy harvesting based WSN. It maintains the energy consumption between the cluster heads and nodes according to the duty cycle. In this TDMA approach is used with the cross-layer approach. Performance of the proposed system is analyzed by using parameters bandwidth utilization, latency, and energy consumption.

Jacob et al [24] worked on reduction the energy consumption on the wireless sensor network PHY-MAC cross layer design is proposed by the author in this article. Sleep time vary according to the information comes from the physical layer. To solve this issue Sensor-MAC protocol is used which uses sleep-wake up cycles and enhance the performance of the system.

GB Zionna et al. [6] introduced the Multi-aware Query Driven routing protocol for wireless sensor network which is based on the neuro-fuzzy system. This protocol focused on the life of the sensor, delay transmission of data and total cost of network and path on the network. Fuzzy rules are used to select the proper path. The performance evaluation is done by comparing the proposed protocol with the existing and it provides best data delivery with minimum routing overhead. Kulshrestha et al. [7] introduced an adaptive energy balanced and energy efficient approach for data gathering in wireless sensor networks. This method considers the neighbor nodes and link reliability to determine the energy consumption on nodes. This mechanism reduced the end-to-end delay and energy consumption in the wireless networks. In this work, the author uses Forwarding approach to reduce the excessive overhead in the multi-hop network. The result of the paper shows that it reduced the message overhead, energy consumption, and end-to-end delay. Zhang, Xiaoying, et al. [8] Energy efficient MAC protocol is proposed for wireless sensor networks. It works on the basis of best partnership selection algorithm which considers the energy consumption during the data transmission. It checks the total power allocated to the senders to transmit data packets. This protocol gives congestion free network and nodes consuming low energy. Bouachir, Ons, et al. [9] introduced EAMP-AIDC energy-aware protocol which works on the basis of duty cycle optimization. Duty cycle considers the active and sleep periods of the nodes which are used for balancing of the nodes. This experiment is performed on OMNET++ and gives better energy consumption and enhanced the energy savings over the network. Chao, et al. [10] proposed hybrid beaconless geographic routing. In this approach data packets are divided into two type of packet that are normal packets and delay sensitive packets. It uses two kind of handshake mechanism for delay sensitive packets that are request to send and clear to send. Priority method is used for the channel assignment. The analysis of the proposed approach shows that delay sensitive packets have lower latency and higher packet delivery ratio and low energy consumption. Doudou, Messaoud, et al. [11] Cascading wake-up MAC protocol is proposed low power wireless sensor network. This work mainly focused on energy/delay, optimization and switches between two modes on the basis of traffic type and delay. First mode is high duty cycle and second mode is low duty cycle these modes are used to adjust the wake-up nodes according to load. The proposed MAC protocol is compared with existing protocol and it performs better in energy saving and data delay reduction.

III. THE PROPOSED METHOD

In this section, we discussed the proposed approach and the methodology used to achieve the results.

A. Proposed Technique: The proposed technique involves the following steps:

Step 1: Deploy the wireless sensor network.
Step 2: Make the cluster of nodes in WSN
Step 3: Use the distance and energy of the nodes.
Step 4: Check the distance from the sink node.
Step 5: Initialize the GWO and input the population as nodes.
Step 6: Set (NewCH/ OldCH) = $-\infty$
Step 7: Compute the fitness function and objective function.
Step 8: Update the value of cluster head θ^*
Step 9: Analyze the value of dead node, live node, throughput and energy of nodes.

B. Proposed methodology: Algorithm/Flowchart

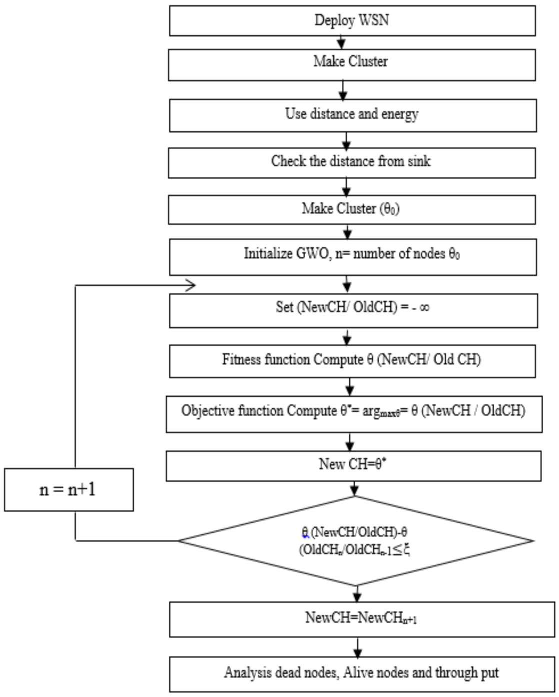

Fig.3 Proposed Flowchart

C. Algorithm

(a) Grey Wolf Optimization: It is a meta-heuristic algorithm which simulates the leadership hierarchy and hunting behavior of wolves. The fitness of the wolves measured in the form of alpha, beta and delta. Grey wolves have the ability of memorizing the prey position and encircling them. The alpha as a leader performs in the hunt. For simulating the behavior of grey wolves hunting in the mathematical model, it is assumed that the alpha (α) is the best solution, the second optimal solution is beta (β) and the third optimal solution is delta (δ). Omega (ω) is assumed to be the candidate solutions. Alpha, beta and delta guides the hunting while position is updated by the omega wolves by these three best solutions considerations.

Encircling prey: Prey encircled by the grey wolves during their hunt. Encircling behavior in the mathematical model, below equations is utilized.

$$\vec{A}(T+1) = \overrightarrow{A_P}(T) - \vec{X}.\vec{Z}$$
$$\vec{Z} = \left|\vec{Y}.\overrightarrow{A_P}(T) - \vec{A}(T)\right|$$

Where

$\vec{Z}$ *and* $\vec{X}$ *are vectors that are calulated by above given equation.*

T←iterative number

$\vec{A}$←grey wolf position

$\overrightarrow{A_P}$←prey position

$$\vec{X} = 2x.\overrightarrow{r_1} - x$$
$$\vec{Y} = 2\overrightarrow{r_2}$$

Where

$\overrightarrow{r_1}$and$\overrightarrow{r_2}$←random vector range[0,1]

The x value decrease from 2 to 0 over the iteration course.

$\vec{Y}$←random value with range [0,1] and is used for providing random weights for defining prey attractiveness.

Hunting: For grey wolves hunting behavior simulation, assuming α, β, and δ have better knowledge about possible prey location. The three best solutions are firstly considered and then ω (other search agents) are forced for their position update in accordance to their best search agent's position. Updating the wolves' positions as follows [37]:

$$\vec{A}(T+1) = \frac{\overrightarrow{A_1}+\overrightarrow{A_2}+\overrightarrow{A_3}}{3}$$

Where $\overrightarrow{A_1}, \overrightarrow{A_2}, and\ \overrightarrow{A_3}$ are determined,

$$\overrightarrow{A_1} = \left|\overrightarrow{A_\alpha} - \overrightarrow{X_1}.Z_\alpha\right|$$
$$\overrightarrow{A_2} = \left|\overrightarrow{A_\beta} - \overrightarrow{X_2}.Z_\beta\right|$$
$$\overrightarrow{A_3} = \left|\overrightarrow{A_\delta} - \overrightarrow{X_3}.Z_\delta\right|$$

Where $\overrightarrow{A_\alpha}, \overrightarrow{A_\beta}, and\ \overrightarrow{A_\delta}$← first three best solution at a given iterative T

Z_α, Z_β, and Z_ω are determined,

$$\overrightarrow{Z_\alpha} \leftarrow \left|\overrightarrow{Y_1}.\overrightarrow{A_\alpha} - \vec{A}\right|$$
$$\overrightarrow{Z_\beta} \leftarrow \left|\overrightarrow{Y_2}.\overrightarrow{A_\beta} - \vec{A}\right|$$
$$\overrightarrow{Z_\delta} \leftarrow \left|\overrightarrow{Y_3}.\overrightarrow{A_\delta} - \vec{A}\right|$$

(b) IPV6: The current trend encourages connecting the WSN to outside networks in order to allow remote data collection and control, which involves the use of the IPv6 protocol. From the viewpoint of network, there are two types of mobility: node mobility and network mobility. The node mobility is when a node (robot, vehicle, animal, etc.) changes its attachment point. While the network mobility occurs when a router, with all devices attached to it, changes its attachment point and all of these nodes appear as a single entity. This case of mobility can be found in many applications, such as military applications, etc. From the viewpoint of mobility, there are also two types of mobility, micro and macro mobility (Fig.11): (i) the micro-mobility is when nodes move within the same field (e.g. nodes move within the same network or to another network that uses the same IPv6 prefix). Within this area, a Mobile Node (MN) can change its access point without changing the IPv6 prefix. (ii) In contrast, the Macro-mobility is when nodes move between different areas (e.g. from a network to another that uses a different IPv6 prefix).

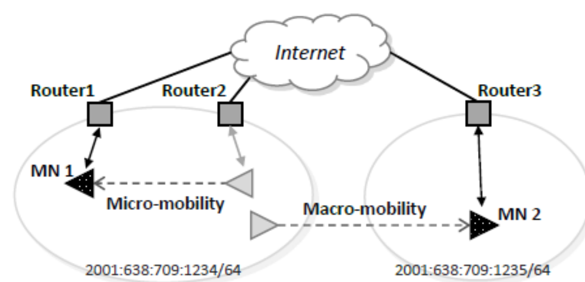

Fig.4 IPV6 Based WSN

IV. RESULT ANALYSIS

This analysis describes the detailed result or the proposed work by using tables and graphs of the results. The performance evaluation of the proposed GWO Leach is compared with IPV6 Leach and with leach also. The comparison based on the number of rounds and the nodes in the cloud. The comparison I based of the following parameters:-Live Nodes; Dead Node; Throughput; Average residual Energy.

Table.1 Number of Live Nodes

Number of Rounds	Number of Live Nodes (GWO Leach)	Number of Live Nodes (IPV6 Leach)

100	200	199
200	198	194
300	187	180
400	178	170
500	164	152
600	155	142
700	148	135
800	143	136
900	139	128
1000	134	116

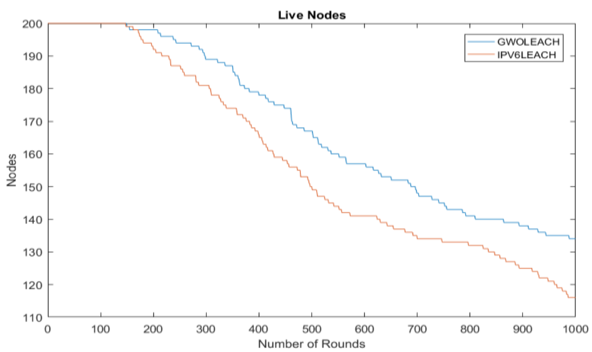

Fig.5 Number of live nodes in GWO Leach and IPV6 Leach

The above given Fig.5 represents the live nodes in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the GWO Leach and red line represents the IPV6 leach nodes. The round starts from the 0 to 1000 and the maximum number of live node is present in round 200 and changes according to the number of nodes changes.

Table.2 Number of dead Nodes

Number of Rounds	Number of Live Nodes (GWO Leach)	Number of Live Nodes (IPV6 Leach)
100	0	0
200	2	8
300	11	18
400	22	37
500	30	42
600	44	57
700	47	62
800	54	62
900	57	69
1000	62	82

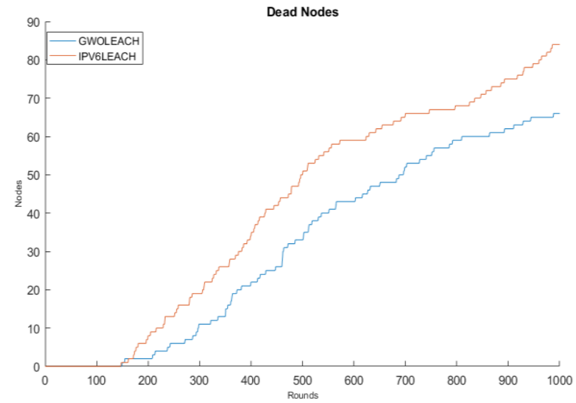

Fig.6 Number of dead Nodes in GWO Leach and IPV6 Leach

The above given Fig.6 represents the dead nodes in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the GWO Leach and red line represents the IPV6 leach nodes. The round starts from the 0 to 1000 and the minimum number of dead node is present in round 150 and changes according to the number of nodes changes. The graph curve concluded that the number of dead nodes in GWO leach is less than IPV6.

Table.3 Throughput on GWO Leach and IPV6 Leach

Number of Rounds	Throughput (GWO Leach)	Throughput (IPV6 Leach)
100	220	200
200	480	460
300	590	550
400	775	623
500	958	845
600	1125	920
700	1180	1060
800	1340	1250
900	1395	1280
1000	1685	1595

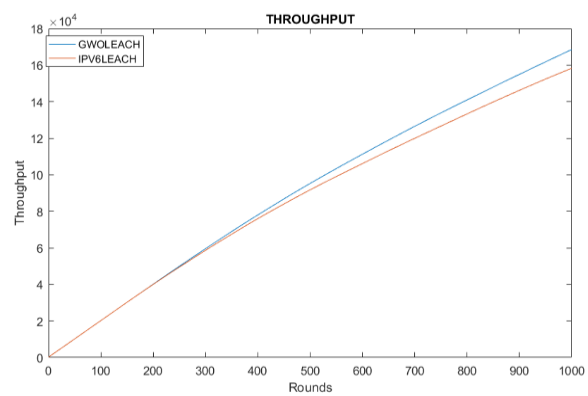

Fig.7 Throughput on GWO Leach and IPV6 Leach

The above given Fig.7 represents the throughput in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the GWO Leach and red line represents the IPV6 leach nodes. The throughput of the grey wolf optimization algorithm with Leach is better than the existing IPV6.

Table 4 Average Residual Energy GWO Leach and IPV6 Leach

Number of Rounds	Energy (GWO Leach)	Energy (IPV6 Leach)
100	100	87
200	87	69
300	81	63
400	78	52
500	70	48
600	64	42
700	68	37
800	58	28
900	55	25
1000	53	24

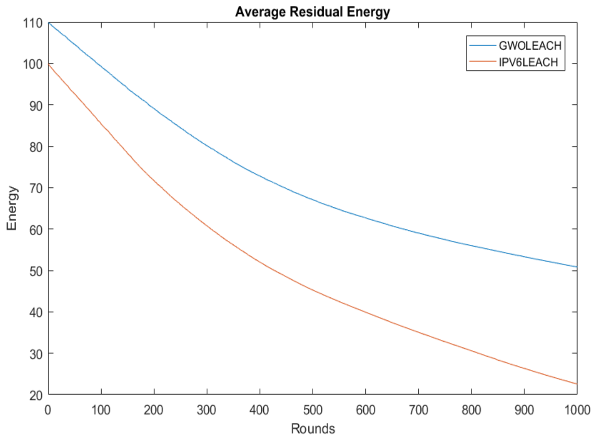

Fig.8 Average Residual Energy GWO Leach and IPV6 Leach

The above given Fig.8 represents the average residual energy in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the GWO Leach and red line represents the IPV6 leach nodes. The average residual energy of the grey wolf optimization algorithm with Leach is better than the existing IPV6.

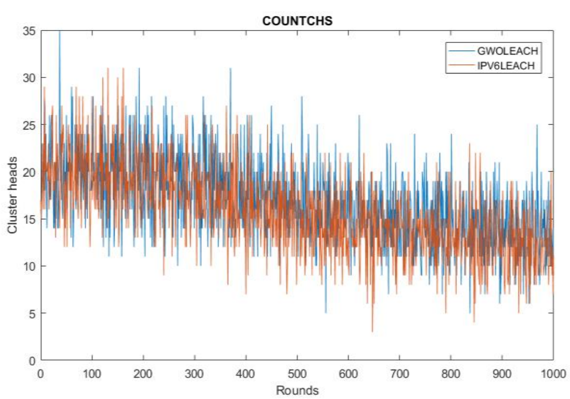

Fig.9 Cluster Heads according to rounds

The above given Fig.9 represents the cluster head in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the GWO Leach and red line represents the IPV6 leach nodes. The spikes in the graph represent the changes in the algorithms according to the rounds.

Comparison of GWO Leach, IPV6 Leach and Leach.

In this section the comparison of three algorithms GWO Leach, IPV6 Leach and Leach algorithm is performed. The comparison based on the number of rounds and the nodes in the cloud. The comparison I based of the following parameters Live Nodes, Dead Nodes, Throughput, Average residual Energy.

Table.5 Number of Live Nodes in GWO Leach, IPV6 Leach and Leach

Number of Rounds	Number of Live Nodes (GWO Leach)	Number of Live Nodes (IPV6 Leach)	Number of Live Nodes Leach
100	200	0	0
200	198	193	196
300	189	185	187
400	178	170	168
500	164	152	161
600	155	142	152
700	148	135	142
800	143	136	119
900	139	128	109
1000	134	116	107

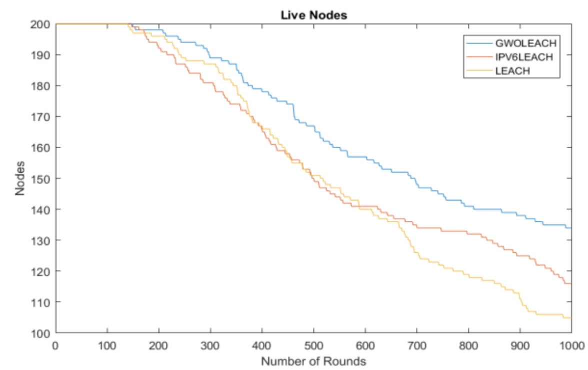

Fig.10 Number of live nodes in GWO Leach, IPV6 Leach and Leach

The above given Fig.10 represents the live nodes in the number of rounds on the three algorithms GWO Leach, IPV6 Leach and Leach. The Blue line on the graph represents the GWO Leach, red line represents the IPV6 leach nodes and Yellow Line represents the Leach. The round starts from the 0 to 1000 and the maximum number of live node is present in round 200 and changes according to the number of nodes changes.

Table.6 Number of Dead Nodes in GWO Leach, IPV6 Leach and Leach

Number of Rounds	Number of Live Nodes (GWO Leach)	Number of Live Nodes (IPV6 Leach)	Number of Live Nodes Leach
100	0	0	1
200	3	7	4
300	8	18	12
400	21	31	32
500	32	49	48
600	41	59	60
700	47	64	73
800	55	67	82
900	59	75	91
1000	63	84	94

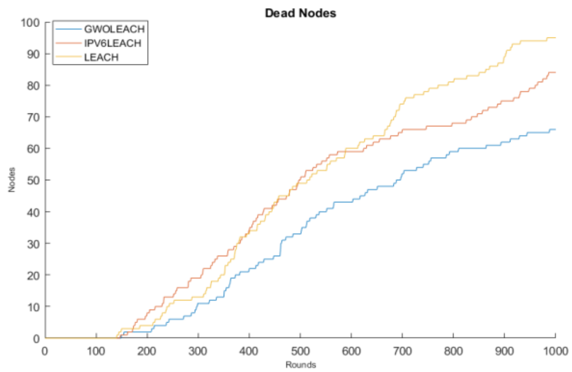

Fig.11 Number of Dead nodes in GWO Leach, IPV6 Leach and Leach

The above given Fig.11 represents the Dead nodes in the number of rounds on the three algorithms GWO Leach, IPV6 Leach and Leach. The Blue line on the graph represents the GWO Leach, red line represents the IPV6 leach nodes and Yellow Line represents the Leach. The round starts from the 0 to 1000 and the minimum number of dead node is present in round 150 and changes according to the number of nodes changes.

Table.7 Throughput on GWO Leach, IPV6 Leach and Leach

Number of Rounds	Throughput (GWO Leach)	Throughput (IPV6 Leach)	Throughput (Leach)
100	220	200	198
200	480	460	420
300	590	550	520
400	775	623	556
500	958	845	725
600	1125	920	869
700	1180	1060	1020
800	1340	1250	1235
900	1395	1280	1220
1000	1685	1595	1480

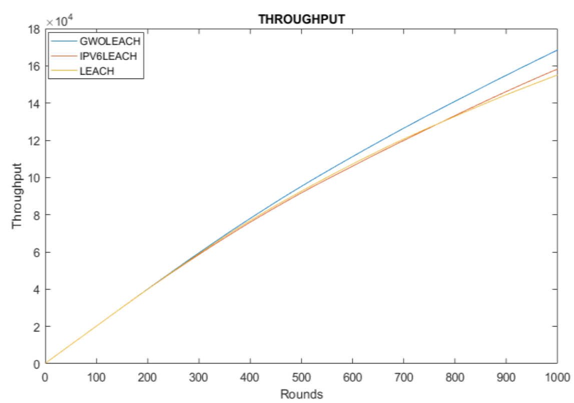

Fig.12 Throughput on GWO Leach, IPV6 Leach and Leach

The above given Fig.12 represents the throughput in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the GWO Leach, red line represents the IPV6 leach nodes and Yellow Line represents the Leach. The throughput of the grey wolf optimization algorithm with Leach is better than the existing IPV6 and Leach.

Table.8 Average Residual Energy in GWO Leach, IPV6 Leach and Leach

Number of Rounds	Energy (GWO Leach)	Energy (IPV6 Leach)	Energy (Leach)
100	100	87	86
200	88	71	69
300	80	60	58
400	70	51	49
500	68	45	41
600	64	39	37
700	60	35	32
800	59	36	31
900	55	27	25
1000	52	24	19

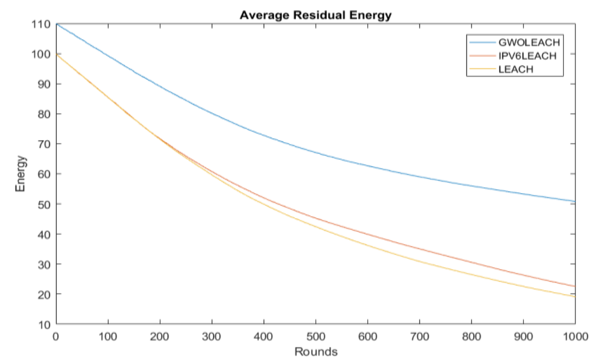

Fig.13 Average Residual Energy on GWO Leach, IPV6 Leach and Leach

The above given Fig.13 represents the average residual energy in the number of rounds on the two algorithms GWO Leach and IPV6 Leach. The Blue line on the graph represents the red line represents the IPV6 leach nodes and Yellow Line represents the Leach. The average residual energy of the grey wolf optimization algorithm with Leach is better than the existing IPV6 and Leach.

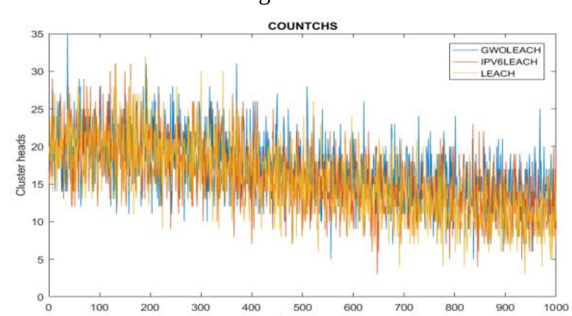

Fig.14 Cluster Heads according to rounds

The above given Fig.14 represents the cluster head in the number of rounds on the two algorithms GWO Leach, IPV6 Leach and Leach algorithm. The Blue line on the graph represents the GWO Leach red line represents the IPV6 leach nodes and Yellow Line represents the Leach. The spike in the graph represents the changes in the algorithms according to the rounds.

V. REFERENCES

[1] Kumberg, Timo, et al. "T-ROME: A simple and energy efficient tree routing protocol for low-power wake-up receivers." *Ad Hoc Networks* 59 (2017): 97-115.

[2] Krishna, KondaHari, Tapas Kumar, and Y. Suresh Babu. "Energy effectiveness practices in WSN over simulation and analysis of S-MAC and leach using the network simulator NS2." *I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2017 International Conference on*. IEEE, 2017.

[3] Tan, Cheng Kiat, et al. "A fast, adaptive, and energy-efficient multi-path-multi-channel data collection protocol for wireless sensor networks." *Recent Advances in Signal Processing, Telecommunications & Computing (SigTelCom), International Conference on*.IEEE, 2017.

[4] Bahbahani, Mohammed, and EmadAlsusa. "A Cooperative Clustering Protocol with Duty Cycling for Energy Harvesting Enabled Wireless Sensor Networks." *IEEE Transactions on Wireless Communications* (2017).

[5] Jacob, Aswathy Mariam, S. ViswanathaRao, and Sakuntala S. Pillai. "Reducing energy consumption by cross layer design in wireless sensor networks." *Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2016 International Conference on*.IEEE, 2016.

[6] Sen, GB Zionna, and GG Zionar Sen. "An energy efficient for WSN using mobile co-ordinator in fuzzy method." *Information Communication and Embedded Systems (ICICES), 2017 International Conference on*.IEEE, 2017.

[7] Kulshrestha, J., and M. K. Mishra. "An adaptive energy balanced and energy efficient approach for data gathering in wireless sensor networks." *Ad Hoc Networks* 54 (2017): 130-146.

[8] Zhang, Xiaoying, et al. "Performance of energy-efficient cooperative MAC protocol with power backoff in MANETs." *Wireless Personal Communications* 92.3 (2017): 843-861.

[9] Bouachir, Ons, et al. "EAMP-AIDC-energy-aware mac protocol with adaptive individual duty cycle for EH-WSN." *Wireless Communications and Mobile Computing Conference (IWCMC), 2017 13th International*.IEEE, 2017.

[10] Hong, Chao, ZhongyangXiong, and Yufang Zhang. "A hybrid beaconless geographic routing for different packets in WSN." *Wireless Networks* 22.4 (2016): 1107-1120.

[11] Doudou, Messaoud, et al. "Delay-efficient MAC protocol with traffic differentiation and run-time parameter adaptation for energy-constrained wireless sensor networks." *Wireless networks* 22.2 (2016): 467-490.