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Energy Efficient Geographic Adaptive Fidelity in Wireless Sensor Networks

Payal Walia[1], Anuj Mehta[2]
[1](*M.Tech Pursuing (C.S.E.), S.K.I.E.T (K.U.K), India)*
[2](*Assistant Professor (C.S.E.), S.K.I.E.T (K.U.K), India)*

Abstract: *Wireless sensor network (WSN) is a quickly developing and existing research that has pulled in impressive exploration consideration in the later past. Routing is to figure out the way to send the detected information to the base station. In WSN, Geographic Adaptive Fidelity (GAF) is a location or zone based routing protocol which transmits data on the location information of destination node. It meets desires in three stages i.e. revelation (discovery) stage, dozing (sleep) stage and dynamic (active) stage. In this paper, a protocol which is a improved version of basic GAF i.e. EEGAF is proposed to enhance the discovery stage and reduces the energy utilized by nodes as a part of discovery state & also optimizes the data sending by using location aware multicast data sending protocol called Location Aided Routing (LAR) to decrease consumption of energy by nodes & enhance network lifetime. Execution of proposed protocol i.e. Energy Efficient Geographic Adaptive Fidelity (EEGAF) protocol is done utilizing MATLAB. The execution measures have been examined with a number of nodes. Our simulation results shows that the proposed protocol gives better execution & is more efficient in terms of dead nodes, balance energy & QoS metrices like throughput and routing overhead.*
Keywords: *EEGAF, Energy Efficiency, GAF, LAR, Location Based Routing, WSN.*

I. Introduction

Wireless sensor network (WSN) is considered as the most vital innovation for the twenty-first century. Because of the progressions made in the field of wireless correspondence and data advances, WSN have increased overall consideration. It comprises of vast number of small sensor nodes appropriated in a specially appointed way and have the capacity to correspond with one another remotely. Sensors are for the most part spread over a topographical territory in exceptionally thick way. These sensor nodes are of minimal effort and low power which can perform different capacities. These sensors can correspond with one another or course the information to other sensors or back to the base station. As sensors in wireless sensor networks correspond with the base station by means of a wireless model rather than straightforwardly being wired to an end client. This wireless correspondence between sensor nodes takes out the requirement for a settled framework in wireless sensor network. Along these lines, wireless sensor networks are more adaptable for acquiring information from the earth. Wireless sensor networks (WSNs) are being utilized as a part of a wide mixture of basic applications, for example, military and medicinal services applications. Diverse routing protocols have been intended to conquer the issue of the response limitation nature of the WSNs. As indicated by the nature and structural planning of WSN, routing protocols are isolated into distinctive classifications. [2] Energy proficient routing protocols are used to minimize the energy utilization and amplify the lifetime of node which builds the lifetime of entire network. Area mindfulness enhances the vitality proficiency of the protocols required for routing, information dispersal and self-association of sensor systems. Area construct routing is situated in light of the suspicion that the hubs transmit the information to other hubs by utilizing their area data. A large portion of the existing protocols don't utilize area data and thus are not vitality effective. This paper concentrates on one of the best energy efficient (vitality proficient) area based routing protocol GAF and proposed an Enhanced GAF i.e. EEGAF in which LAR i.e. Location (Area) – Aided Routing is used for data sending phase, it is an location aware routing protocol that uses the location data for enhancing the productivity of routing by diminishing the control overhead. LAR uses flooding; however flooding is confined to a little geological district. LAR assigns two locales a) Expected zone b) Request zone in fig.1. The Expected Zone is the district in which the destination node is relied upon to be available. The Request Zone is a topographical district inside which the way discovering control parcels are allowed to be proliferated. They utilize area data to guide directing disclosure and support and in addition bundle sending, consequently empowering the best routing to be chosen, diminishing energy utilization and streamlining the entire network. LAR uses location aided & multicast technique for data sending as shown in Fig.2 & Fig.4.

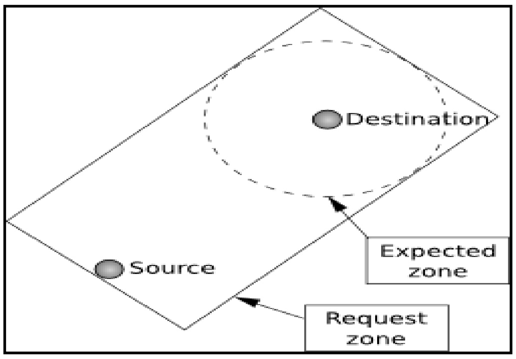

Figure 1: location-aided routing

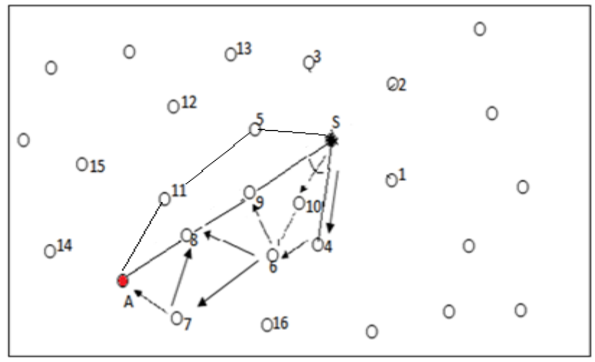

Figure 2: location aided data sending

Broadcasting

Broadcasting in Fig.3 is the synchronous transmission of the same message to various beneficiaries. In systems administration, broadcasting happens when a transmitted information bundle is gotten by all system gadgets. Vitality Consumption is more and Security issues may emerge amid broadcasting and lead to information misfortune if a system is assaulted by interlopers. In non-systems administration or electronic television, the term TV signifies the exchange of sound and feature information in the middle of hubs and gadgets.

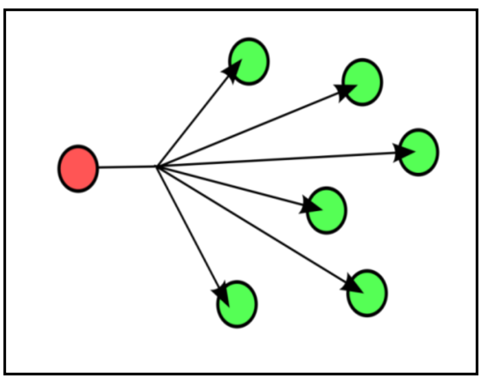

Figure 3: broadcasting technique

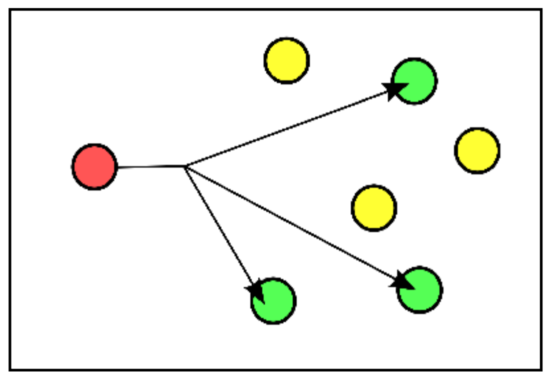

Figure 4: multicasting technique

So, in EEGAF we uses location aware multicast technique as shown in Fig.4 for data sending after the improvement in the discovery phase and both improvements leads to reduction in energy consumption & increase in network lifetime.

This paper consists of six sections as follows: Section II presents related work, Section III describes the basic protocol GAF, Section IV proposed protocol EEGAF working, Section V simulation results and Section VI conclusion & future scope.

II. Related Work

Location based routing protocols use the information of nodes location rather than its network address. Sensor node knows the location information of its neighbors to transmit the data. This reduces the energy consumption of nodes. This paper focuses on GAF (Geographic Adaptive Fidelity) which consumes energy by turning off the radios of unnecessary nodes. In [6], creators accomplish vitality effectiveness by advancing the radio scope of node. This paper investigates a 2-D specially appointed remote system in light of GAF topology administration convention and attempted to locate the ideal transmission scope of nodes and broke down the vitality utilization by utilizing the idea of cell models in GAF. By looking at the vitality utilization results demonstrates that the flexible cell model spares 62.6% vitality in examination to the equivalent cell model. A relationship between the ideal transmission range and system movement is indicated by the assistance of tests. It demonstrates that vitality of the system can be minimized by diminishing the quantity of nodes utilized as a part of activity transmission. The network division and selection of a valid group head additionally impacts the general execution of the network. The division of network is in light of figuring that is indicated by the location of data node has a place with which network division. Choice of group head is finished by the assistance of "Expense" component. The node having most reduced cost inside of the framework is chosen [7]. This proposed protocol is known as DGAF (Dynamic-division Geographical Adaptive Fidelity). The fundamental reason for this calculation is to locate the ideal position of the bunch head. The zone is separated into matrices as hexagons named as DGAF-6; or as squares named as DGAF-4. Results demonstrate that proposed calculation is superior to GAF regarding system lifetime and burden adjusting. In GAF, system is partitioned into an equivalent size of square network. In a square matrix structure, a node can reach to the contiguous frameworks just in vertical and level bearings yet not in corner to corner course. Hexagonal lattice structure (GAF-HEX) is proposed in

[8] to conquer the issue of inaccessible corner of GAF. GAF-C and GAF-E are two node mapping calculations presented for GAF-HEX. GAF-C maps the nodes with reference node at focus and GAF-E maps the nodes with reference node at end of framework. Network Simulator NS-2.3 is utilized for indicating recreation of execution assessment. GAF-HEX enhances bundle conveyance proportion and throughput and vitality utilization is verging on same as GAF. Hierarchical Geographic Adaptive Fidelity (HGAF) is proposed to spare the force of the nodes which builds the lifetime of entire network [9]. It spares control by expanding the cell size of GAF utilizing a layered structure for selecting a dynamic node in every lattice. Result shows that HGAF performs better to GAF if there ought to be an event of better energy utilization and packet delivery ratio. Also when there is a high node thickness and a cell is further divided into four sub cells then the lifetime of network is increased 200% in HGAF as compared to GAF. Assessment is performed utilizing Network Simulator NS-2.In [10], authors proposed the created version of HGAF i.e. e -HGAF (extended HGAF) which is further upgraded to save the energy utilization use by apportioning the sensor field in a capable manner and extend the network lifetime. This paper moreover focuses on the upper bound on the cell assess in e-HGAF. This paper takes a shot at two thoughts: Cell development by changing cell shape to triangle cells and Cell expanding by diminishing edges.

III. GAF (Geographical Adaptive Fidelity)

Geographic Adaptive Fidelity is a location based protocol which is utilized to conserve energy in WSNs. Nodes in the network finds itself alongside its closest neighbors by utilizing area information system like GPS. Nodes consume energy while transmitting information i.e. at the time of sending and also accepting. In the unmoving or idle state likewise some measure of energy is utilized however is less as a part of correlation to transmitting state. Vitality (energy) utilized as a part of the unmoving mode can be spared by killing or turning off the radios. The diverse move states utilized as parts of GAF are Sleep state, Discovery state and Active state [36]. One node per grid is in the dynamic state and all others are in resting state keeping in mind the end goal to spare the vitality. The choice of node to be dynamic relies on upon the remaining vitality of the nodes. Fig.5 demonstrates the diverse move states in GAF protocol [37] & Fig.6 demonstrates the GAF grid or matrix network.

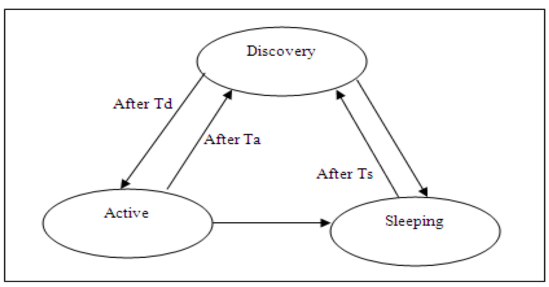

Figure 5: state transitions in GAF protocols

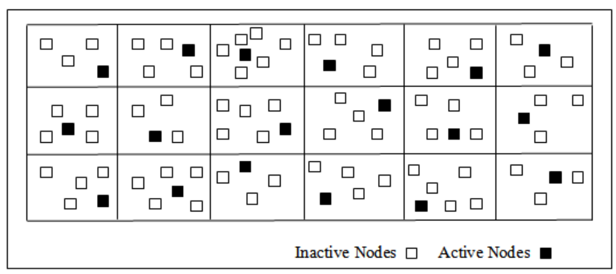

Figure 6: GAF grid network

IV. Proposed Work (EEGAF)

In Basic GAF protocol, a dynamic node is picked by researching the most raised remaining energy of a node. Every time node goes into a discovery state to pick next active node. To lessen the energy utilization of nodes and build the lifetime of network, the discovery period of GAF protocol is progressed. Change on the move states in the discovery state in an EEGAF, is demonstrated in Fig.7.

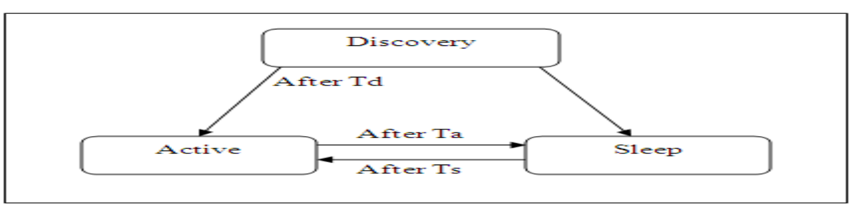

Figure 7: transition states of EEGAF

Working of EEGAF

EEGAF also have three transition states i.e. Discovery, Sleeping and Active but its working is different from Basic GAF model.

1. In the discovery phase, a sequence of nodes to become active will be assigned to the nodes having maximum remaining energy. From this sequence 10% of the nodes will be selected to become active before the next discovery phase. The discovery phase won't be repeated for the selection of each active node but only for finding the sequence of active nodes after discovery time (Td). Discovery time (Td) in EEGAF will be more as compared to the Basic GAF because in EEGAF discovery phase will begin again when all the selected nodes in previous discovery phase become active one after another.

2. After predefined Active Time (Ta), the active node will become inactive and go to the sleep mode. It will be

replaced by the next active node in the grid.
3. The next sleeping node after Sleeping Time (Ts) in the sequence will awake before the Leaving Time (T1) of active node expires. In this process the next sequenced node becomes active directly without entering into the discovery phase. In this way the energy consumed by the nodes in discovery process will be saved.
Fig.8 shows the change of transition state between active phase and sleep phase. In this there are 10 nodes in a grid, each having a sequence number assigned in a discovery phase according to the remaining energy of node. Node 1 having the highest remaining energy is in Active Phase and rest of the nodes is in Sleeping Phase. Suppose out of 10 nodes 3, 7, and 6 have the maximum energy in the sequence, then 3 will become active first, 7 after 3, and 6 after 7 and after that the discovery phase will start again to decide the next sequence.

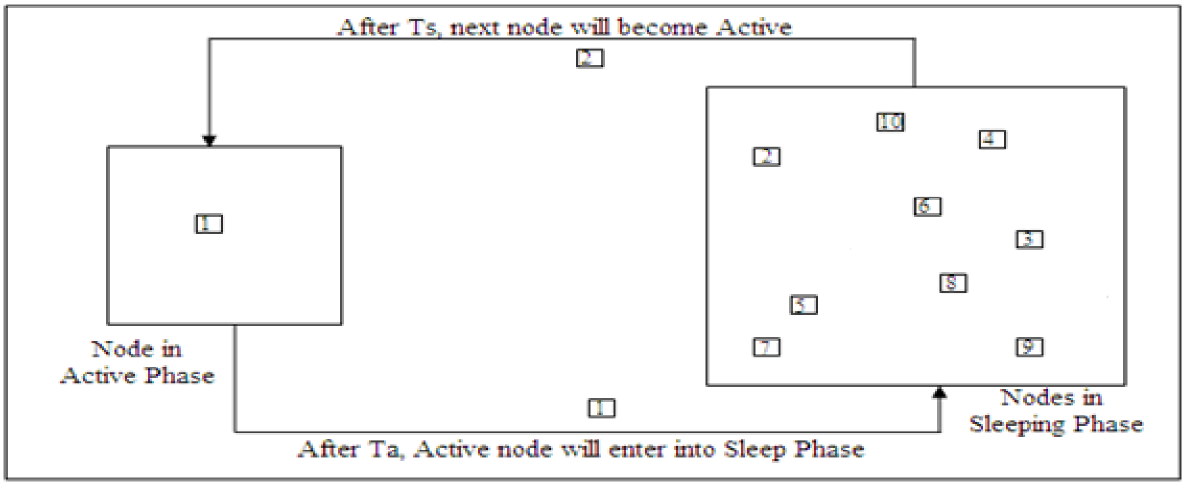

Figure 8: working between active phase and sleep phase

4. After the predefined sleeping time Ts, node having the next highest remaining energy will awake and enters into the Active Phase. After the predefined active time Ta, node will enter into the Sleeping Phase. Fig.9 shows the situation after the first round of phase change. Grey colored node indicates the used node.

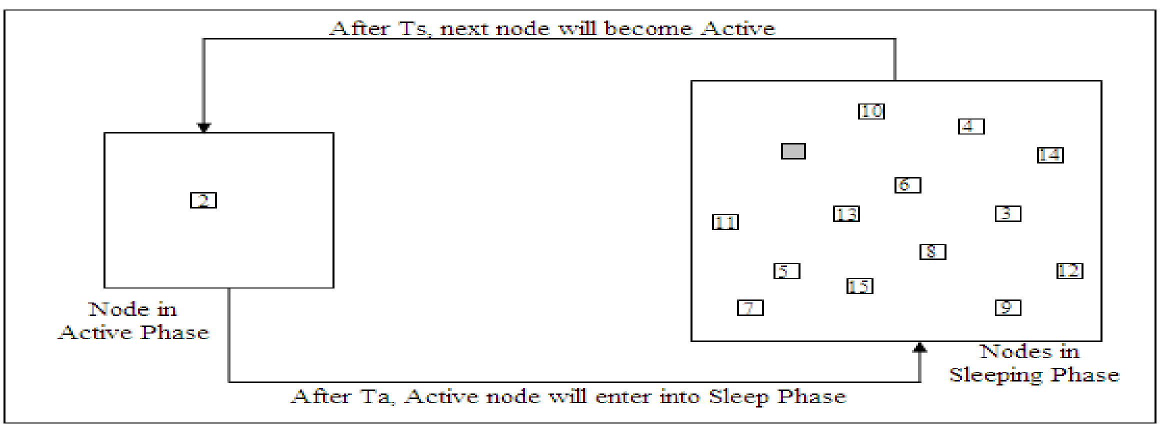

Figure 9: after the first round of phase change

5. After the improvement in the discovery phase, Data Sending phase begins. In the data sending phase, location aware data sending is used to remove the problem of broadcasting. In WSNs, communication among nodes is done via broadcasting. Broadcasting is the simultaneous transmission of the same message to multiple recipients around a node. In networking, broadcasting occurs when a transmitted data packet is received by all network devices. In broadcasting Energy Consumption is more as compared to multicasting or unicasting and Security issues may arise during broadcasting and lead to data loss if a network is attacked by intruders. In the data sending phase, location aided data sending is used. In this all the active nodes won't broadcast the data to all the nearby nodes but to the nodes which are towards the sink node only. It will decrease the wastage of energy while transmitting data to the nodes in opposite direction to the sink in broadcasting. So, to overcome this problem of broadcasting in WSNs, concept of multicasting by using multicast protocol i.e. LAR is used to reduce energy consumption and to increase network lifetime.

V. Results & Discussions

5.1 Simulation parameters:

Basic GAF and proposed EEGAF protocol have been executed using MATLAB. The objective of the implementation is to show the benefits of EEGAF Scheme over Basic GAF Schemes.Fig.10 shows the initial positions of 100 nodes & network division in 9 grids, where multi color nodes shows different grids.

Table.1: Simulation Parameters

Parameters	Values
No. of Node	100
Environment Size	100x100
No. of Grids	9
Sink Position	(100,100)
Starting Energy of Each Node	0.5 unit
Simulator	MATLAB 2009
Working System	Windows 7

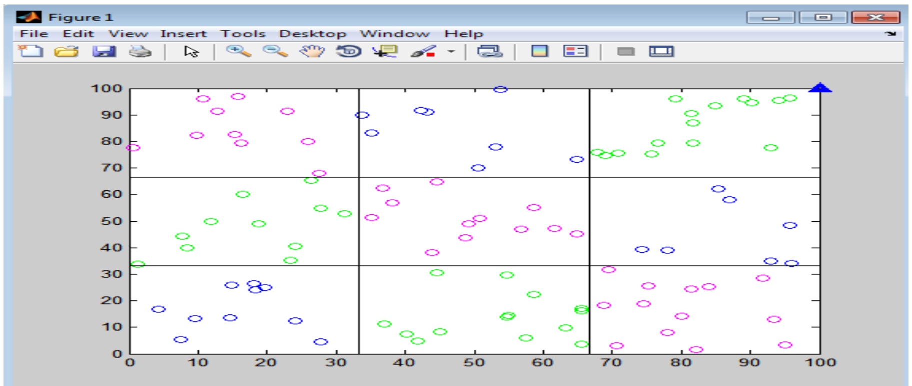

Figure 10: initial positions of 100 nodes & network division in 9 grids

5.2 Simulation Results

5.2.1 Energy Efficiency

In EEGAF, the change of discovery stage direct impacts its energy efficiency. Reenactment results are done up by watching 10 different propagations seeks after the sporadic sending of sensor nodes and separating it into 9 identical size grids. Quantities of dead nodes in both arrangements Basic GAF likewise, EEGAF Scheme are demonstrated in Fig.13. It is watched that Number of dead nodes is more in basic GAF. As EEGAF is a changed and improved interpretation of GAF, it has less number of Dead nodes. EEGAF shows favored results over Basic GAF and network survivability is more in EEGAF. The examination outline between Basic GAF and EEGAF on the reason of average balance energy of Nodes is exhibited in Fig.12. This result examination is similar to the relationship on the reason of dead hubs. A result shows that in EEGAF Normal Balance Energy of the Nodes is more as appeared differently in relation to the Average Balance Energy of basic GAF.

5.2.1.1 Dead Nodes

Amounts of dead nodes in both mirrored arrangements basic GAF and EEGAF are demonstrated in Fig.11. In Fig.11, dead nodes are exhibited in 10 assorted reenactment seeks after the subjective association of sensor nodes and dividing it into 9 networks. It is watched that Number of Dead Nodes is more in Basic GAF. As EEGAF is an adjusted and upgraded variation of GAF, it has less number of Dead Nodes. EEGAF shows best results over Basic GAF and network survivability is more in EEGAF.

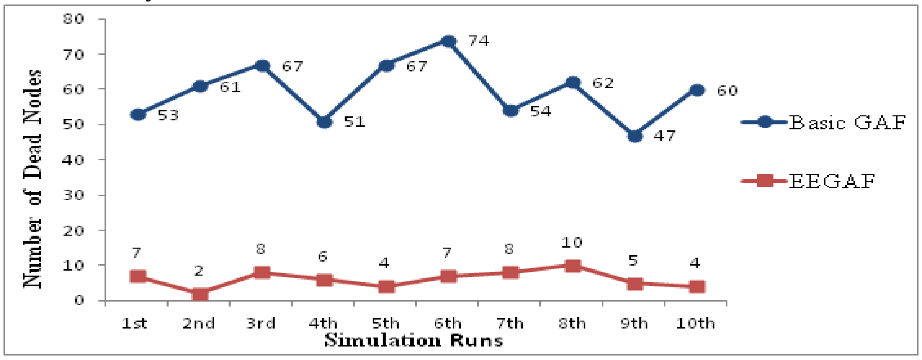

Figure 11: comparison graph of dead nodes

Table 2: shows no. of dead nodes in Basic GAF & EEGAF

Simulation Runs	Basic GAF	EEGAF
1st	53	7
2nd	61	2
3rd	67	8
4th	51	6
5th	67	4
6th	74	7
7th	54	8
8th	62	10
9th	47	5
10th	60	4
Total no. of dead nodes up to 10th simulation runs	596	61

Table 3: Shows Average Balance Energy of Nodes in Basic GAF &EEGAF

Simulation Runs	Basic GAF	EEGAF
1st	0.1157	0.3451
2nd	0.1075	0.3982
3rd	0.0732	0.3836
4th	0.1224	0.4283
5th	0.0732	0.3936
6th	0.0521	0.4075
7th	0.1203	0.3866
8th	0.0875	0.3951
9th	0.115	0.3602
10th	0.1003	0.3917
Total of balance energy of nodes up to 10th simulation runs	0.9672	3.8899
Average balance energy	0.9672/10	3.8899/10 2.9227 (improved)
% of avg. balance energy improved		292%

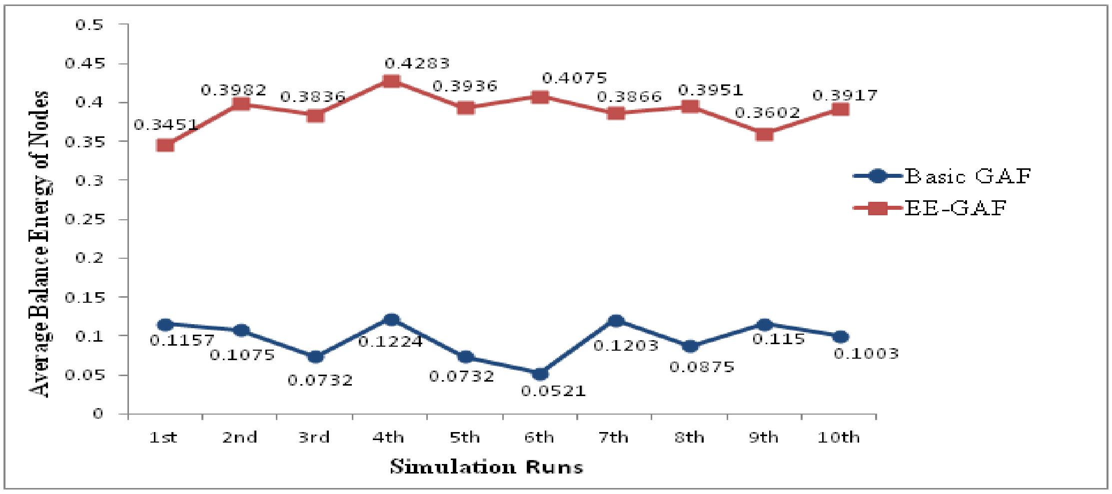

Figure 12: comparison graph in terms of average balance energy.

5.2.1.2 Balance Energy

Average Balance Energy: It is the average of the remaining energy of all the nodes in the network.

Balance Energy= Initial Energy of a node- Energy consumption during communication

Energy consumption is the amount energy that is consumed by the node for sending and receiving data/routing packets.

Energy consumption during communication = Initial Energy of a node - Balance Energy

Average Balance Energy of Nodes It is the average of the remaining energy of all the nodes in the network.

Fig.12 shows the examination diagram between basic GAF and EEGAF regarding Average Balance Energy of Nodes. This result examination is similar to past one which is the examination on no. of dead nodes. A result exhibits that in EEGAF Average Balance Energy of the nodes is more in comparison to the Average Balance Energy of Nodes in Basic GAF.

Fig.11 and Fig.12 unmistakably shows that the Network survivability is extended in EEGAF and it is performing better than the Basic GAF.

5.2.2 QOS Bound Performance Metrics: The execution measurements incorporate the accompanying QOS parameters:

5.2.2.1 Throughput

Throughput is the proportion of aggregate number of conveyed or got information bundles to the aggregate length of time of recreation time. The throughput is normally measured in bits every second (bps), and here and there in information parcels every second or information bundles per time space.

Throughput = Bytes/Time

Throughput of Basic GAF and EEGAF is indicated in Fig.13. Figure demonstrates that EEGAF has high throughput over Basic GAF.

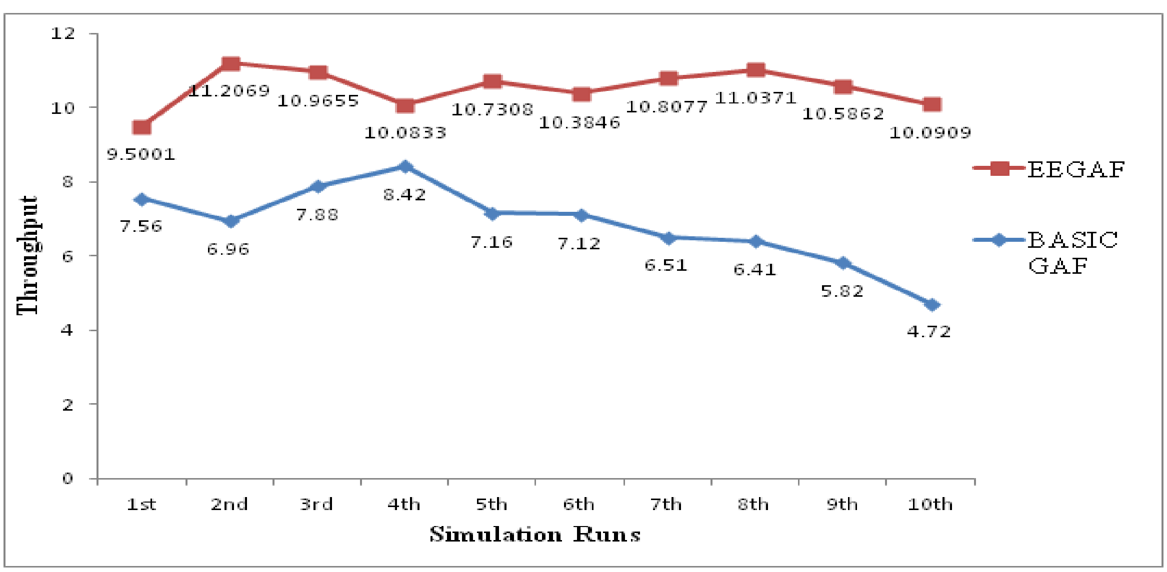

Figure13: comparison graph in terms of throughput

Table 4: shows throughput of Basic GAF & EEGAF

Simulation Runs	Basic GAF	EEGAF
1st	7.56	9.50
2nd	6.96	11.20
3rd	7.88	10.96
4th	8.42	10.08
5th	7.16	10.73
6th	7.12	10.38
7th	6.51	10.80
8th	6.41	11.03
9th	5.82	10.58
10th	4.72	10.09
Total Throughput up to 10th simulation runs	68.56	105.35
%age of Throughput improved		53.66%

Table 5: shows the routing overhead of Basic GAF &EEGAF

Simulation Runs	Basic GAF	EEGAF
1st	0.5952	0.3553
2nd	0.6466	0.2492
3rd	0.5711	0.2547
4th	0.5344	0.3347
5th	0.6285	0.2903
6th	0.6321	0.3001
7th	0.6923	0.2883
8th	0.7031	0.2718
9th	0.7732	0.2638
10th	0.9534	0.3649
Total Routing Overhead up to 10th simulation runs	6.7299	2.9731
%age of Routing Overhead		3.7568 55.82%

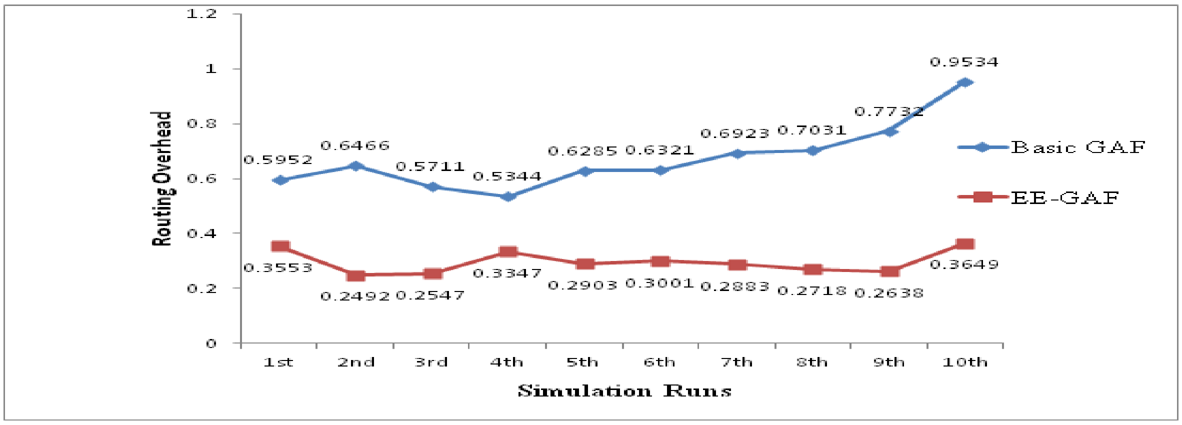

Figure 14: comparison graph in terms of routing overhead

5.2.2.2 Routing Overhead

Routing Overhead is the proportion of aggregate number of the directing parcels to the aggregate number of got information bundles at destination.

Routing_ overhead = Routing _packets / Received _data _packets

Examination of Routing overheads of Basic GAF and EEGAF is demonstrated in Fig.14. Figure demonstrates that Routing overhead of Basic GAF is all the more when contrasted with EEGAF. Thus, EEGAF is performing superior to anything Basic GAF.

From the above simulation results, EEGAF is more efficient as compared to Basic GAF in terms of the metrices calculated above in tables by considering various parameters where the total efficiency of EEGAF comes out to be 133.84% as compare to Basic GAF & it shows the improvement of proposed protocol EEGAF over Basic GAF protocol.

VI. Conclusion And Future Scope

So to reduce the energy utilization proposed EEGAF is implemented utilizing MATLAB. One noteworthy point of interest regarding the proposed protocol is its effortlessness. The entire network is partitioned into square grids of equivalent size. Active node is chosen on the premise of higher energy of the nodes in the lattice or grid. In this exploration work, energy utilization is reduced by enhancing the discovery stage of basic GAF and optimizing area (location) based data sending in the direction towards the base station (BS). The Discovery Phase won't be called again and again for selection of every active node yet just for discovering the arrangement of active nodes after Discovery Time (Td). By the usage consequence of Basic GAF and EEGAF, it can be concluded that EEGAF turns out to be more energy proficient in correlation to existing Basic GAF Scheme. In EEGAF Scheme dead nodes are lesser than the Basic GAF so the network will survive more with EEGAF. The hindrance of EEGAF Scheme is that it requires more memory to spare the succession of alternate nodes which will get to be active after the predefined time yet at the same time its general aggregate productivity is more i.e. 133.84% than existing Basic GAF plans and it demonstrates the change of proposed convention. The EEGAF, energy effective routing protocol proposed in this exposition offered great execution and results demonstrate that the performance of the proposed protocol is superior to Basic GAF. In future work, it should be possible on the security while executing EEGAF with best QOS execution environment. Researchers can build the extent of grid and diminish the quantity of active nodes to minimize the energy utilization.

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