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Hybrid TABU-GA Search For Energy Efficient Routing in WSN

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Abstract— The heterogeneity is contextual in wireless sensor network. In the case of hardware terms, there might be different batteries, memory, MAC layer, communication protocol, and computing architecture. To measure the system's lifetime, this paper focuses on node heterogeneity that implies it has three kinds of nodes: advance nodes, supernodes, and normal nodes. In this paper, proposed a new multilevel stable and energy-efficient clustering protocol using TABU-GA search mechanism carries out two neighborhood generating operations to detect the optimal path with the aim of maximize the network lifetime in the area of 200m×200m. The simulation is done under the MATLAB environment to observe network stability, throughput, average remaining energy, etc. Our proposed protocol outperforms in comparison with the multilevel stable and energy-efficient clustering protocol.

Keywords— Wireless sensor network, heterogeneity, multilevel stable and energy-efficient clustering protocol, tabu – GA search, MATLAB, network stability, throughput, average remaining energy.

I. INTRODUCTION

A wireless sensor network comprises of an extensive number of low - cost, low - capability, and multi-purpose sensor nodes that are distributed in areas that are difficult to access, which requires sensors to be energetically autonomous and able to operate without manual intervention.[1]

The Sensors are mainly used to sense the environment and to gather the data to a centralized location. Advent of processing devices and networks makes it as “Wireless Sensor Network”. Development in Semi-conductor technology and Networking method has stimulated the use of sensor networks for observing and information collection. In Wireless sensor network, information collected by sensors is gathered at a distant location for analyzing and computation purpose via wireless links. From last few decades researchers are making exertions for Wireless Sensor Network (WSN) routing technology with more power efficient protocols.

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Diverse government and research agencies are trying to put different proposals for Wireless Sensor Technology advancements. Wireless sensor network contains battery functioned small nodes which are positioned over a wide geographical area to monitor the events and to accumulate the collected data to a distant centralized location called as base station. Nodes are deployed in such a way that the entire area is in the coverage of wireless nodes The deployed nodes sense the data from its neighborhood and transmit the collected data for further processing. The main distinction between ad hoc networks and Wireless Sensor Networks is their applications area. Ad-hoc networks primarily focus on communications aspects whereas wireless area networks focuses more on monitoring and information collection. In this paper TABU-GA MSEEC routing protocol is proposed .The main aim of this protocol is to prolong the network period .The performance of purposed approach will be compared against basic multi-level stable and energy efficient clustering protocol and TABU based multi-level stable and energy efficient clustering protocol.[2]

The rest of the paper is in the following order: Section II examines related work, Section III characterizes the network model. Section IV depicts the TABU-GA based MSEEC Protocol, Section V gives the experimental setup, and Section VI gives the results and discussion and in conclusion Section VII finishes up the paper with future degree.

II. RELATED WORK

D. Kumar et al. [3] have reviewed the impact of heterogeneity of nodes in terms of their energy. They assume that the sensor nodes are randomly distributed and measurements of the sensor field are known. Homogeneous nodes have the same amount of energy. Adjusting to this methodology, they presented a energy productive heterogeneous bunched conspire for WSN depend on weighted political decision probabilities. At last, the recreation results exhibited that proposed heterogeneous grouping approach is progressively sufficient in drawing out the system lifetime related to LEACH.

Saini, Parul et al. [4] have studied the upgraded conveyed energy proficient grouping plan for heterogeneous systems. It contains three sorts of sensor nodes to improve the security of the remote sensor organizes and to make longer lifetime of the network. Along these lines, the heterogeneity and energy level of the whole system is expanded. The outcome shows that the exhibition of EDEEC is better when contrasted with SEP. V. Raghavendran, G Naga Satish et al.

[5] have depicted the Swarm Intelligence (SI) approach for the routing process and found the Bee Ad Hoc which is the distribution among traffic to find out the various routes proportional to the quality and the capacity. The main disadvantage of network is control overhead created by per packet and furthermore, the limitation of longer route. A reliable approach has to find out while solving the routing problems in mobile Ad hoc networks.Ants directing is fundamental system from SI and gives a proficient arrangement.

Fifi, Rawya et al. [6] presented the two energy-efficient clustering protocol, which used the optimum number of energetic nodes that achieves the minimum energy consumption for the network. The M-SEEC is a different protocol and prolongs the stability period, increases energy efficiency, and above-average throughput.

Tandon, Ravi et al. [7] studied about the heterogeneous sensor networks. In the heterogeneous sensor network, various types of protocols have been discussed like SEP, DEEC and their improper utilization of energy. So, they proposed the CRP which is called as cluster head re-election protocol ehich is heterogeneous in nature and upgrade the system's lifetime.

Gu, Yu et al. [8] kept an eye on the issue of adventures sink portability to draw out the system lifetime in remote sensor systems (WSNs) where the data postponement brought about by moving the sink ought to be limited. Because of the combinational multifaceted nature of this issue, most past recommendations center around heuristics, and provable ideal calculations stay obscure. In this paper, they construct a bound together system for examining this joint sink portability, directing, delay, and so on, yet neglected to clarify the speed of the system depends on the versatility parameter.

Shilpa et al. [9] proposed a chain weight estimation approach. This method lessens the essentialness dissipating and adjusts the store by picking cluster head centers first, in light of three parameters center point degree, typical imperativeness and minimum way incident factor, and after that forming the inside and out divided group. This procedure decreases the overhead of the framework and correspondence cost and expanding higher imperativeness profitability, better load adjusting and extending framework period, but the parameters are limited.

III. NETWORK MODEL

In this network model, the base station is static and three different types of nodes are using that are normal nodes, advance nodes, and supernodes. The base station's position is in center, and it will be static, and WAN is the portion of all nodes having α times more energy than the normal nodes which is called as an advance nodes and WSN is the portion of all nodes having β times more energy than the normal nodes which is called as a supernodes. The rest of the nodes have initial energy as E_0. n=n1+n2, where n1 denotes the entire normal nodes attached to the AN's, and n2 is the entire normal nodes attached to the supernodes. The total initial energy of the 3 level heterogeneous networks is given by:

$$E_{total} = n.E_0 + M_{AN}.(1+\alpha).E_0 + Msn.(1+\beta).E_0 \quad (1)$$

Therefore, the three-level M-SEEC has ($\alpha .M_{AN} + \beta . M_{SN}$) times more energy.

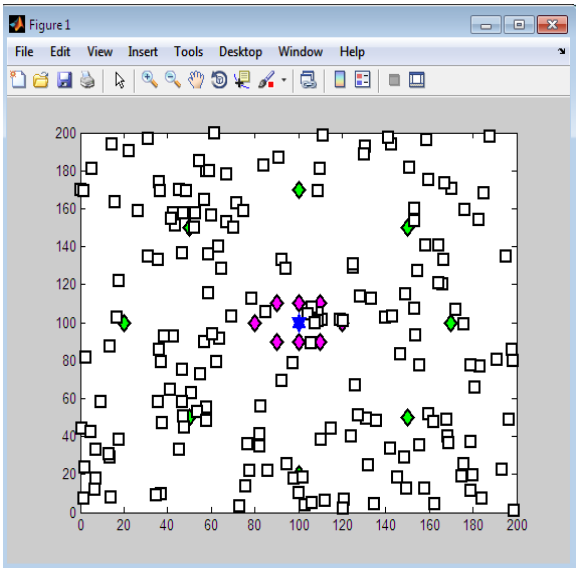


Fig. 1: Network environment in MATLAB

This figure shows the network model of the M-SEEC protocol in which base station is stationary and supernodes are placed at a distance R2 contingent with base station and advance nodes are placed at a distance of R1contingent with the base station.

Level of heterogeneity

The level of heterogeneity is represented by the given formula that is

$$R_{i-1} = \frac{\sqrt{2}}{0.765} R_{i-2} \quad (2)$$

Where i denotes the level of heterogeneity.

Optimal Number of ANs

The amount of energy consumed during a single round is expressed by the following condition

$$E_{AN} = n_A.L.E_{elec} + n_A.L.E_{DA} + L.Eelec + L.e_{fs}.R1^2 \quad (3)$$

Where E_{DA} represents the data aggregation cost and R1 represents the distance among advance node and base station. The following equation expresses the Energy utilized by normal nodes:

$$E_{NN} = L.E_{elec} + L.e_{fs}.d_{tO\ AN}^2 \quad (4)$$

Where $d_{tO\ AN}^2$ represent the distance between the normal node and advance nodes.

The following condition expresses the total energy consumed during a single round

$$E_{Round} = m_{AN}\left(\frac{n1}{m_{AN}}.L.E_{elec} + \frac{n1}{m_{AN}}.L.E_{DA} + L.E_{elec} + L.Efs.R12 + n1mAN.LEelec + n1mAN.LEfs.dto\ AN2\right) \quad (5)$$

After differentiating E_{Round} correspond to m_{AN} and equating with zero, the optimal number of advance nodes found to be

$$m_{AN\ opt} = 0.7668\sqrt{n1} \quad (6)$$

The required energy for AN

For computing the energy of advance nodes, firstly calculate the total lifetime of a network which is the total of all rounds from beginning to end.

$$\text{Rounds}_{AN} = \left(\frac{E_{total}}{E_{round}}\right)_{AN} \quad (7)$$

and

$$\text{Rounds}_{NN} = \left(\frac{E_{total}}{E_{round}}\right)_{NN} \quad (8)$$

The value of the advance node should be higher than that of normal nodes in each cluster.

IV. TABU-GA BASED MULTILEVEL STABLE AND ENERGY-EFFICIENT CLUSTERING PROTOCOL

TABU search invented by Fred W. Glover in 1986 and infurther replenished in 1989. It is used for local search methods used for mathematical optimization. Tabu search upgrades the performance of the local search by relaxing its primary rules.

One of the meta-heuristic technique which is called as TABU search is depending upon the local search method which uses the memory structure called it as Tabu list. This list of TABU contains the solutions of low quality as forbidden and stops them from revisiting for duration of iterations. The term Recency is used where the previous solution is avoided and the term tabu tenure is another concept which elaborates the total number of search iterations for the solution. Another term is Intensification in which the search is again started with the best knowing solution. The GA which is called as genetic algorithm is also a meta- heuristic approach used for exploring a wide solution space, deals with tabu search for combinatorial problems. The main features of genetic algorithm are mutation and crossover, the GA has power to losing the solution which is called as chromosome that may lead to find out the best solution. The solution strings have binary elements used in GA for solving the problem of routing. Another feature of GA that aligns with the intensification characteristic of tabu search is elitism, wherein the best solutions provides a starting point for finding the next best solution. To improve diversity and allow the algorithm to evaluate more solutions, a multi-starting approach was used. This multi-starting technique combined with the characteristics of GA and tabu search mentioned above for the proposed multi-starting hybrid tabu-GA search method [11,12]
The working of TABU-GA is expressed in the form of flow chart which is mentioned in Figure 2.

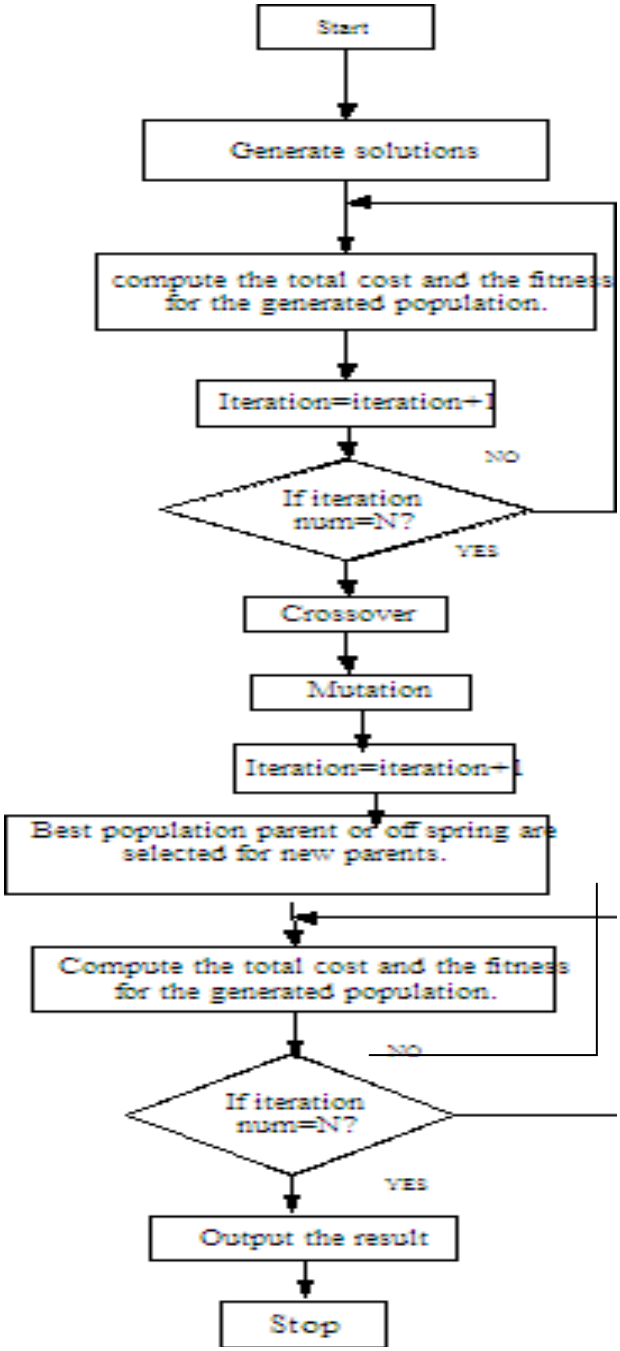


Fig. 2:- Flowchart of TABU-GA MSEEC

V. EXPERIMENTAL SETUP

The MATLAB simulator is used for the implementation. The simulations are run with 200 nodes and 400 nodes in which 8 advanced nodes and 8 supernodes are fixed and rest are the normal nodes that are randomly deployed inside the area of 200×200 m2. Here, the parameters are used in the simulation are mentioned below in table 5.1.

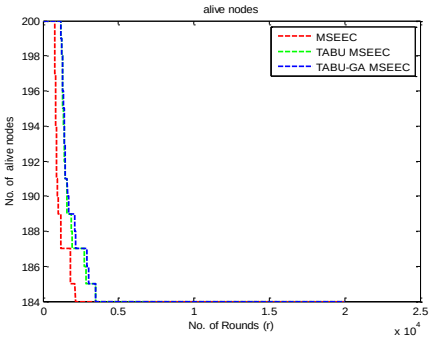
Table I:- EXPERIMENTAL SETUP

Parameter	Value
Area of the network(x,y)	200×200
Placement of Base station(x,y)	100,100
Total number of Nodes(n)	200
Probability to be a cluster head(p)	0.1
Starting Energy given to nodes (Eo)	0.5
Transmitted energy of nodes	50nJ/bit
Receiving energy of nodes	50nJ/bit
Free space	10nj/bit/m2
Multipath	0.0013pJ/bit/m4

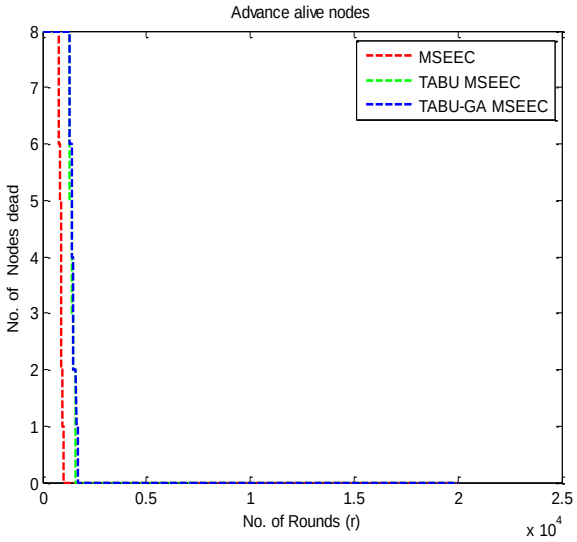
VI. RESULTS AND DISCUSSION

On applying TABU-GA search mechanism, the following results will come out. For simulation, MATLAB tool is used for easy computing of results. All results were compared with the basic multi-level stable and energy-efficient clustering protocol and TABU based multi-level stable and energy-efficient clustering protocol and TABU-GA technique. The performance metrics used in the results show that the proposed TABU-GA based multi-level stable and energy-efficient clustering protocol provides a more extended stability period, more energy efficiency, and high throughput than the basic multi-level stable and energy-efficient clustering protocol.

A. **Alive nodes:-** Results are evaluated on the performance of alive nodes in the case of 200×200m^{2}networks. The red dotted lines represent the performance of MSEEC protocol while Green dotted lines represents the performance of TABU MSEEC protocol and the last one blue dotted lines represents the performance of TABU-GA MSEEC protocol Figure 3 shows that more number of alive nodes are present with TABU-GA MSEEC when compared to TABU-MSEE and MSEEC algorithm Alive nodes represents the number of nodes, which are still alive against time steps (rounds).This is one of the critical parameters of wireless sensor networks.



(a)



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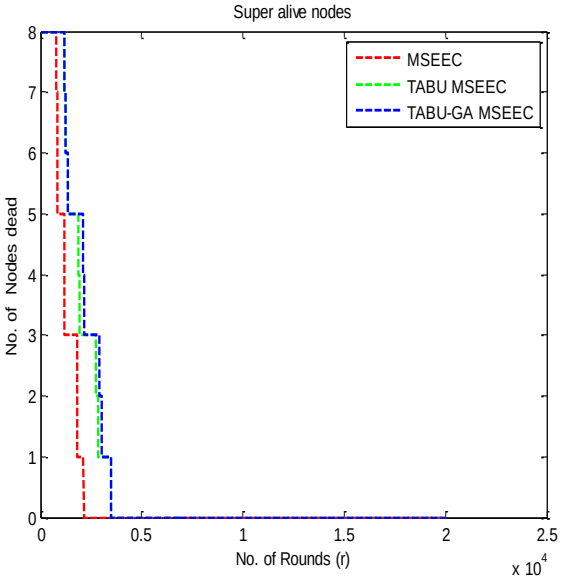


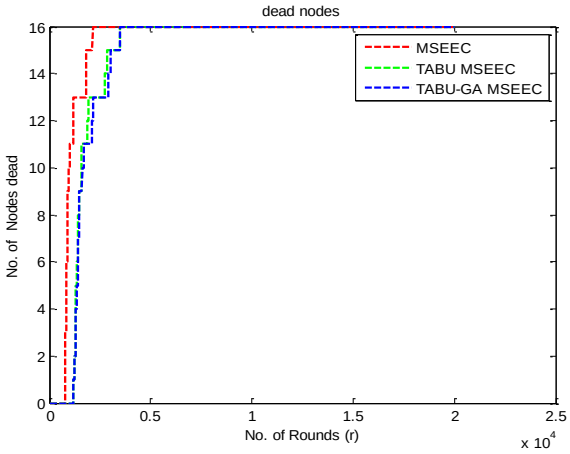
(c)

Fig. 3:- Number of alive nodes

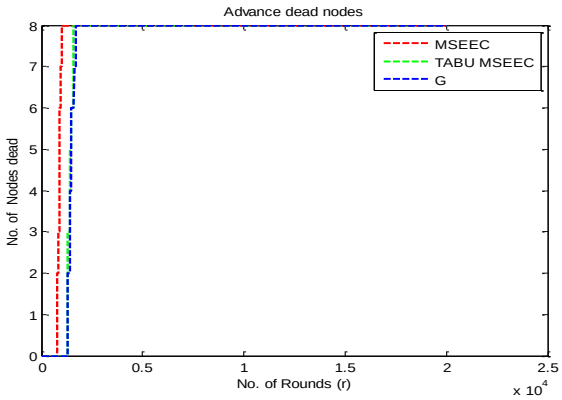
(a) Alive node
(b) Advance alive node
(c) Super alive node

Figure 3 represents the number of nodes that are alive during rounds. Figure (a) represented the alive nodes versus rounds, and figure (b) shown the advance alive nodes versus rounds, and figure (c) shown the super alive nodes versus rounds. It is shown that in all the cases TABU-GA MSEEC performs well. The performance of TABU-GA MSEEC in all cases is more than that of TABU MSEEC and MSEEC protocol. From the figure, it is clearly seen that the number of alive nodes are present in TABU-GA MSEEC in case of alive nodes, advance alive nodes and super alive nodes. At the round of 1000, MSEEC nodes start to dead, while in the case of TABU-MSEEC, it started at the round of 2000 and in the case of TABU-GA MSEEC, it started at the round of 2500.

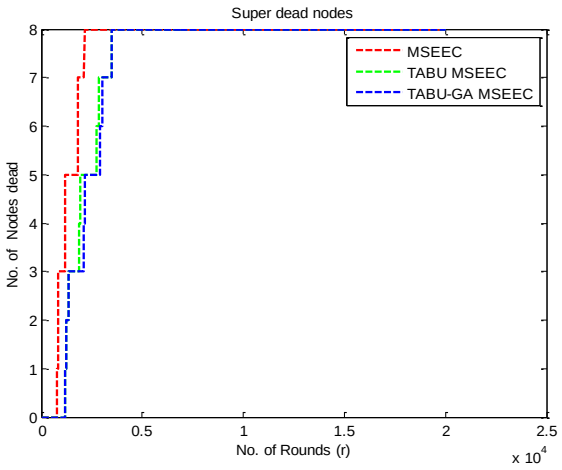
B. **Dead Nodes:-** The lifetime of the network can be evaluated by using the number of dead nodes.



(a)



(b)



(c)

Fig. 4 Number of dead nodes

(a) Dead node
(b) Advance dead node
(c) Super dead node

Figure 6 shows the behavior of dead nodes in detailed manner in MSEEC and TABU MSEEC and TABU-GA MSEEC routing protocol. Figure (a) represented the dead nodes versus rounds, and figure (b) shown the advance dead nodes versus rounds, and figure (c) shown the super dead nodes versus rounds. It has been shown that TABU-GA MSEEC proved to be better than TABU-MSEEC and MSEEC. It is just opposite to the alive nodes and represented the lifetime of the network. From the figure, it is clearly seen that less number of dead nodes are present in TABU-GA MSEEC in case of dead nodes, advance dead nodes, and super dead nodes. At the round of 1000, all MSEEC nodes are dead, while in the case of TABU-MSEEC, the nodes are dead at the round of 2000 and in the case of TABU-GA MSEEC, the nodes are dead at the round of 2500.

C. **Packet Transferred:-** Throughput is the number of data packets which is received at the sink. It is considered as the complete data which is transferred through the network, the total data sent from advanced nodes, or supernodes to the base station. It can also be considered as the aggregate data transmitted from the normal nodes to the advanced nodes and supernodes. The comparison of the proposed protocol with new protocol proves that the proposed protocol shows improved throughput.

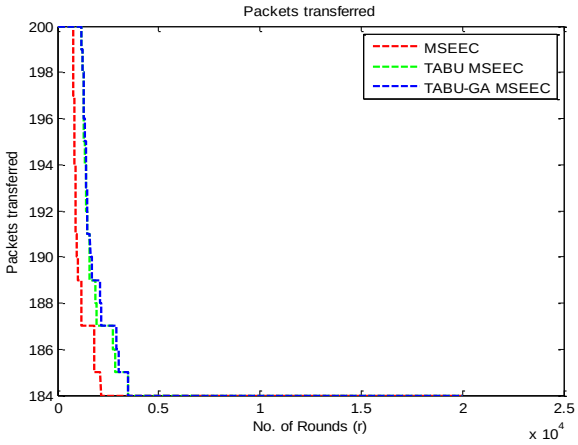


Fig 5: Packet transferred Vs Rounds

Figure 5 shows that the throughput of the network means the number of data messages received to the base station. The lifetime of the network is high if nodes die rate is low and vice-versa. The number of alive nodes will send more data to base station. It has shown that TABU-GA MSEEC proved to be better than TABU-MSEEC and MSEEC. In MSEEC the packets sent to the base station are at 1200 rounds, while for TABU MSEEC it is after 2500 rounds and in case of TABU-GA MSEEC it is 2600 rounds.

D. Remaining Energy:-

It is defined as the amount of energy left with sensor nodes. It is computed at the beginning of each round during the execution of the algorithm. This parameter helps to determine the stability period, consumption of energy, and lifetime of WSNs. The residual energy is a significant parameter to be considered for WSNs, that is calculated using

$$\text{RemEng(re)} = \sum_{N=1}^{n} E_{rr}(Nd) \qquad (9)$$

Where $E_{rr}(Nd)$ is the energy of Ndth node for the rr^{th} round. Table 6 represents the numeric values that correspond to the RemainingEnergy.

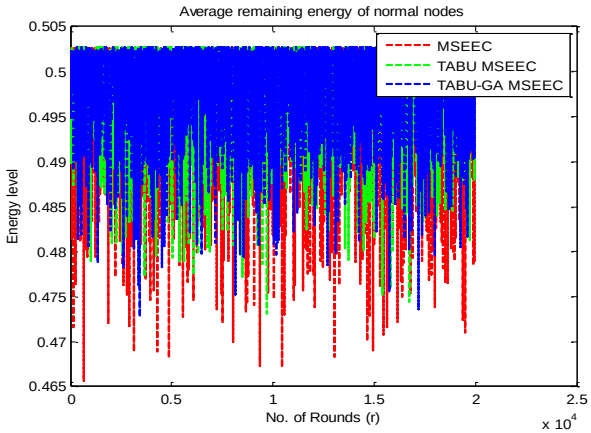


Fig 5: Average remaining energy Vs Rounds

Here the results envisage that the average remaining energy in case of MSEEC, TABU MSEEC, and TABU-GA MSEEC protocol. From the figure, it is clearly shown that number of energy remains with TABU-GA MSEEC protocol, and its observation states that 0.502-joule energy is remaining with TABU-GA MSEEC protocol, while in the case of TABU MSEEC it is 0.495 joule and in the case of MSEEC it is 0.49 joule. So, the observations reveal that the performance of TABU-GA MSEEC is very high as compared to the TABU MSEEC protocol and MSEEC protocol because TABU-GA search chooses the most effective solution.

VII. CONCLUSION AND FUTURE SCOPE

Current work forwards our last studies done in the same area of WSN [13,14]. While now this work going towards development of IoT[15-17]. In this paper, MSEEC, TABU MSEEC, and TABU-GA MSEEC protocol have been compared for wireless sensor networks. Here, the performance comparison is done under the 200×200 m^2 scenario. The performance of TABU-GA MSEEC is more in all cases like more number of alive nodes are present in TABU-GA MSEEC in case of alive nodes, advance alive nodes and super alive nodes. At the round of 1000, MSEEC nodes start to dead, while in the case of TABU-MSEEC, it started at the round of 2000, and in the case of TABU-GA MSEEC, it started at the round of 2500.Similarly, the remaining energy observation states that 0.502 energy is remaining with TABU-GA MSEEC protocol, while in the case of TABU MSEEC it is 0.495 and in the case of MSEEC, it is 0.49. So, the observations reveal that the performance of TABU-GA MSEEC is very high as compared to the TABU MSEEC protocol and MSEEC protocol because TABU-GA search chooses the most effective solution.

REFERENCES

1. Holms, A., & Culler-Mayeno, E. (2006). A Technical Report: Wireless Sensor Networks and How They Work. University of California, Santa Barbara.
2. Dargie, W., & Poellabauer, C. (2010). Fundamentals of wireless sensor networks: theory and practice. John Wiley & Sons.
3. Kumar, Dilip, Trilok C. Aseri, and R. B. Patel. "EEHC: Energy efficient heterogeneous clustered scheme for wireless sensor networks." Computer Communications 32.4 (2009): pp. 662-667.
4. Saini, Parul, and Ajay K. Sharma. "E-DEEC-enhanced distributed energy efficient clustering scheme for heterogeneous WSN." Parallel Distributed and Grid Computing (PDGC), 2010 1st International Conference on. IEEE, 2010.
5. V.Raghavendran, Naga Satish, P. Suresh Varma, "Intelligent routing techniques for mobile ad hoc networks using swarm intelligence", I.J Intelligence systems and applications, 2013, Vol. 01, pp 81-89.
6. Farouk F, Rizk R, et al. "Multi-level stable and energy efficient clustering protocol in heterogeneous wireless sensor networks" published in IET wireless sensor systems, special issues on intelligent wireless sensor networks and application, 2014 Volume 4, Issue 4, pp159-169.
7. Tandon, Ravi, and Sukumar Nandi. "CRP: Cluster head Re-election Protocol for heterogeneous wireless sensor networks." In Communication Systems and Networks (COMSNETS), 2013 Fifth International Conference on, pp. 1-10. IEEE, 2013.
8. Gu, Y., Ji, Y., Li, J., & Zhao, B. (2012). ESWC: Efficient scheduling for the mobile sink in wireless sensor networks with delay constraint. IEEE Transactions on Parallel and Distributed Systems, 24(7), 1310-1320.
9. Mahajan, S., Malhotra, J., & Sharma, S. (2014). An energy balanced QoS based cluster head selection strategy for WSN. Egyptian Informatics Journal, 15(3), 189-199.
10. Ouzineb, M., Nourelfath, M., & Gendreau, M. (2008). Tabu search for the redundancy allocation problem of homogenous series–parallel multi-state systems. Reliability Engineering & System Safety, 93(8), 1257-1272.
11. Li, R., Hu, S., Wang, Y., & Yin, M. (2017). A local search algorithm with tabu strategy and perturbation mechanism for generalized vertex cover problem. Neural Computing and Applications, 28(7), 1775-1785.
12. Sivaram, M., Batri, K., Amin Salih, M., & Porkodi, V. (2019). Exploiting the Local Optima in Genetic Algorithm using Tabu Search. Indian Journal of Science and Technology, 12(1), 9.
13. Kumar, N., Kumar, A., & Chaudhry, D. (2011). A Novel Approach to use Nano-Sensor in WSN Applications. International Journal of Computer Applications, 975, 8887.
14. Pandey, A., Kumar, N., & Tripathi, R. C. A Framework to Prevent Mobile Sinks Accessing by Unauthorized Nodes in WSN.
15. Kumar, N., & Khan, R. A. (2017). Emergency Information System Architecture for Disaster Management: Metro City Perspective. International Journal of Advanced Research in Computer Science, 8(5).
16. Kumar, N., Agrawal, A., & Khan, R. A. (2017, October). Smartphone with solar charging mechanism to issue alert during rainfall disaster. In International Conference on Recent Developments in Science, Engineering and Technology (pp. 442-449). Springer, Singapore.
17. Kumar, N., Agrawal, A., & Khan, R. A. (2019). Cost estimation of cellularly deployed IoT-enabled network for flood detection. Iran Journal of Computer Science, 2(1), 53-64.

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