International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-3, January 2020

Implementation of Enhanced AODV based Self-Organized Tree for Energy Balanced Routing in Wireless Sensor Networks

Meghana R, Annapurna P Patil

Abstract*: Wireless sensor networks (WSN) are gaining attention in numerous fields with the advent of embedded systems and IoT. Wireless sensors are deployed in environmental conditions where human intervention is less or eliminated. Since these are not human monitored, powering and maintaining the energy of the node is a challenging issue. The main research hotspot in WSN is energy consumption. As energy drains faster, the network lifetime also decreases. Self-Organizing Networks (SON) are just the solution for the above-discussed problem. Self-organizing networks can automatically configure themselves, find an optimal solution, diagnose and self-heal to some extent. In this work, "Implementation of Enhanced AODV based Self-Organized Tree for Energy Balanced Routing in Wireless Sensor Networks" is introduced which uses self-organization to balance energy and thus reduce energy consumption. This protocol uses combination of number of neighboring nodes and residual energy as the criteria for efficient cluster head election to form a tree-based cluster structure. Threshold for residual energy and distance are defined to decide the path of the data transmission which is energy efficient. The improvement made in choosing robust parameters for cluster head election and efficient data transmission results in lesser energy consumption. The implementation of the proposed protocol is carried out in NS2 environment. The experiment is conducted by varying the node density as 20, 40 and 60 nodes and with two pause times 5ms, 10ms. The analysis of the result indicates that the new system consumes 17.6% less energy than the existing system. The routing load, network lifetime metrics show better values than the existing system.

***Keywords* : AODV, NS2, Self-Organizing Networks, WSN.**

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are a group of sensors deployed in a particular area for recording and monitoring the physical parameters of the environment. The data recorded from WSNs are structured and stored systematically at a central location.

Revised Manuscript Received on January 30, 2020.
* Correspondence Author
Meghana R*, Department of Computer Science and Engineering, Ramaiah Institute of Technology, affiliated to Visvesvaraya Technological University, Bangalore, India. Email: meghanar95@gmail.com
Annapurna P Patil, Professor, Department of Computer Science and Engineering, Ramaiah Institute of Technology, affiliated to Visvesvaraya Technological University, Bangalore, India. Email:annapurnap2@msrit.edu

The advantages of such networks are that they are low cost, easy to implement, flexible to different types of topologies, and also consume less power. However, sensors in the WSNs have inherent constraints with respect to resources such as memory, energy, computational speed, and communication bandwidth due to its small size and capacity. The greatest challenge in a WSN is the energy of nodes. For a network to continuously operate and be efficient, the energy of the node should be kept to an optimum level. There have been lot of experiments related to energy consumption in WSNs, and several researchers have proposed ideas to reduce energy consumption and improve network lifetime. SONs are proven to be a good solution to improve energy consumption. Here, SON is used to reduce energy consumption. SON are those networks which can automatically configure themselves, find optimal solutions and which can diagnose and heal to an extent. There are three sub-functions of SON:

1. Self-Configuring

SON should be able to configure new network elements [2]. For example, when a new base station is installed, it should automatically configure, establish connectivity and integrate itself the existing network. This is usually carried out by the "plug and play" paradigm. When the new base station is powered on it is immediately recognized by the other stations and they make a note of technical parameters.

2. Self-Optimization

SON should be able to configure new network elements [1]. For example, when a new base station is installed, it should automatically configure, establish connectivity and integrate itself the existing network. This is usually carried out by the "plug and play" paradigm. When the new base station is powered on it is immediately recognized by the other stations and they make a note of technical parameters.

3. Self-Healing

SON should be able of detect any node failure or link breakages in the network and take corrective actions. The SON can also be programmed to notify the user when no corrective actions can be taken. For example, an alternate path can be chosen to reach the destination in case of link failure.

In this paper, we concentrate on the Self-Optimization sub-function for reducing energy consumption to balance energy to prolong lifetime. The energy balancing actions are triggered in the network when events which require more energy are detected automatically. AODV is used as it a standard routing protocol which is feasible with WSN. To improve the network lifetime and performance of the WSN, "Enhanced AODV based Self-Organized tree for Energy balanced Routing (E-ASER)" is proposed which aims to balance the energy consumption among nodes is proposed in WSN. The objectives of the proposed system are:

- To build a self-organized tree-based cluster by electing a robust cluster head.
- To implement an energy efficient data transmission model.
- To implement an energy efficient data transmission model.
- To prove that the energy consumption of the proposed system is better than the existing system using NS2 simulator.

One of the main challenges in WSNs is to reduce energy consumption without compromising on performance and scalability. Many routing protocols are implemented in an attempt to reduce energy consumption in WSNs. The proposed system implements one such protocol called Enhanced AODV based Self-Organized Tree for Energy Balanced Routing (E-ASER) to reduce energy consumption in WSNs. The E-ASER incorporates two mechanisms to achieve its objectives which are self-organized tree-based cluster formation and energy-efficient data transmission. The two mechanisms are outlined as follows:

- In self-organized tree-based cluster formation, the E-ASER forms cluster based on node density and elects a high energetic node as cluster head known. The cluster head aggregates the collected information from its cluster members and forwards it to the base station through root node selected by the base station.
- To implement energy-efficient data transmission model in E-ASER. The nodes involved data transmission based on a threshold value that is estimated using distance and residual energy level.

II. LITERATURE REVIEW

Routing methods with clustering techniques is an efficient way to solve the energy efficiency issue in WSN. The work in [3] describes the principles of clustering models and briefly classifies the clustering routing techniques over WSNs. Further, it systematically analyzes the typical clustering routing techniques and compares various cluster-based routing methods using diverse routing metrics. The work in [4] provides a detailed survey of clustering routing techniques over WSNs.

In [5], numerous energy-efficient routing algorithms for hierarchical routing protocol in Wireless Sensor Networks have been discussed based on the clustering approaches. These approaches of clustering algorithms are Distributed, Centralized or Hybrid.

The work in [6] proposes a Dynamic clustering and Distance Aware Routing (DDAR) routing method for WSN that considers distance metric in CH selection. This work elects the nodes that are closest to sink node ass CH, and the dynamic selection of Super Cluster Head (SCH) prolongs the WSN lifetime considerably.

The work in [7] introduces a routing mechanism called Chain-Cluster based Mixed routing (CCM) over WSN. The CCM exploits the advantages of the fundamental LEACH protocol to enhance WSN performance. It separates the WSN nodes into a few chains, named as clusters and routes the data packets within two levels. Initially, sensor nodes in a cluster send data packets to their CH node in parallel according to the routing steps. Secondly, the CCM forms clusters among CH nodes in a self-organized way. Further, the CH nodes forward fused information to the sink through a voted CH node.

The work in [8] proposes an intelligent framework to cluster the WSN nodes and to optimize the locations of sensor nodes within WSN for extending sensing coverage and diminishing the energy depletion of the entire network.

A Multi-weight Based Clustering Algorithm (MWBCA) in [9] solves the imbalanced energy expenditure of issue of WSN. In [10], an Adjustable Cluster-based Routing Protocol (ACRP) allows sensor nodes to form clusters in a self-organized way. In ACRP, the CH nodes allocate time slots to each sensor node for data forwarding. Further, CH fuses received information from its cluster and send the fused information to sink node along discovered routing path. Precisely, the sink node periodically adjusts the clusters in which the sensor node selects new CH node with high energy based on received data.

A multiple dimensional tree-based routing method has been presented in [11] over multi-sink WSNs. This work exploits ant colony optimization (ACO) to enhance the routing process. A Delay Aware Energy Balanced Dynamic Routing Protocol (DA-EBDRP) in [12] mainly aims to balance the energy depletion in WSN. The DA-EBDRP optimizes the routing process and evaluates the WSN performance using several routing metrics that are throughput, end-to-end delay, Portion of Living Node (PLN), and network lifetime.

The work in [13] designs an Energy-Balanced Routing Protocol (EBRP) builds a mixed virtual potential field by taking into account the depth, node density, and the remaining energy of nodes. Primarily, the EBRP forces the nodes to migrate towards a high energetic area to communicate with sink and enhance the WSN lifetime by protecting the nodes with minimum residual energy. It also proposes enhanced techniques to rectify routing loop issues over WSN.

A novel technique in [14] exploits the non-uniform node dissemination model and considerably balances the energy expenditure among WSN nodes. The novel technique regulates the number of sensor nodes in a corona and estimates the ratio between the node densities in neighboring coronas. Finally, it utilizes a q-Switch Routing technique and distributed shortest-path routing method to improve the non-uniform node dissemination model.

The work [15] proposes an energy-efficient routing strategy named as Cluster Tree-based Data Dissemination (CTDD). The CTDD separates the network nodes into uniform virtual grids and forms clusters using such grids.

Finally, it forms a tree structure using CH nodes over the grids for energy-efficient data forwarding.

An Entropy-Based Clustering Scheme (EBCS) in [16] exploits the local information of sensor nodes in entropy measurement to create clusters and elects CH nodes. Further, it separates the WSN nodes into two-levels of hierarchy and three-levels of energy heterogeneity.

A dynamic clustering protocol, known as k-means clustering-based GSTEB routing protocol has been proposed in [17]. The GSTEB organizes network nodes into several clusters by exploiting k-means clustering algorithm. The GSTEB constructs a routing tree in each round, and it chooses a root node with the help of the sink node. Further, it disseminates the information about root coordinates to the sensor nodes over WSN for parent node selection.

The work in [18] presents a power-aware tree-based routing protocol called TRP. In TRP, the sensor nodes determine its parent node by considering the energy depletion of communication, distance between adjacent nodes, and the remaining energy of adjacent nodes. Thus, the TRP builds a routing path to sink node using a near-optimal minimum spanning tree structure. The sensor nodes forward the gathered information using the tree structure.

A Tree-Based Routing Protocol (TBRP) in [19] constructs tree structure in a specific communication area, and each sensor node estimates the distance level to the sink. Further, it assigns a level based on the distance. The sensor nodes employ a join-REQ to migrate one level to the next level. The data forwarding process is initiated from the low-level nodes in a tree structure. The communication takes into multiple levels, and it is stopped when the data reaches the destination. The selected root node allocates time schedules to child nodes named as low-level nodes for data transmission.

The work in [20] proposes a Distributed Self-Organized Tree-Based Energy Balanced Routing Protocol (DSTEB) that balances the network load to prolong WSN lifetime and reduce energy dissipation. The DSTEB exploits a routing tree construction process in each round, and the sink node allots a root node in the data forwarding process. Each node chooses its parent node by comparing its information with the neighboring node information.

The existing WSN system, DSTEB, is a tree-based cluster protocol where the cluster head is elected purely based on the residual energy of neighbors. All the cluster members within a cluster send data to the cluster head without determining the distance to the cluster head and without considering the residual energy of the cluster head. Energy consumption is high since the criteria chosen for the cluster head election is not robust, and there is no energy balancing in the WSN. The data in the node is lost since the node dies without informing in advance. Network lifetime is less since the nodes may die sooner because of the poor selection criteria for cluster head and since data transmission is not energy efficient.

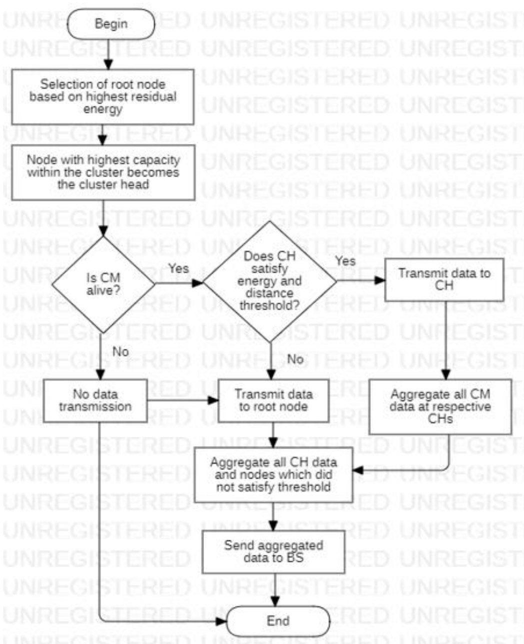
In proposed system the election of cluster head by considering suitable parameters result in an efficient tree-based cluster structure. Also, the threshold energy and distance decide the path for data communication between cluster members and cluster head which results in the improvement of network lifetime resulting in less energy consumption. In this study, the existing WSN system and the proposed system are compared, and it shows that the proposed system is better than the existing system in terms of energy consumption.

III. IMPLEMENTATION

The main objective is to reduce consumption of energy of the nodes and to increase the network lifetime. The proposed system can be viewed as two parts: the first part is the self-organization mechanism for tree-based cluster formation, the other part is the data transmission phase. Both of these phases have to be energy efficient to achieve the objective.

A. Flowchart of E-ASER

In self-organized tree-based cluster formation, the E-ASER divides the sensor nodes into several clusters and elects a CH in each cluster by choosing the node with highest residual energy level and least degree of neighbor nodes. The CH is known as a parent node which collects and aggregates the data sensed from all of its cluster members. In addition to that, the E-ASER selects a root node for energy-efficient data transmission. In efficient data transmission phase, the E- ASER estimates a threshold value based on energy and distance for transmitting data efficiently. The decision whether the node must send the data via the CH or directly to the root node is based on this threshold value. The root node then forwards it to the base station. Fig. 1 demonstrates the flowchart of E-ASER.



CH-> cluster head,
CM-> cluster member
BS->base station

Fig. 1. Flowchart of E-ASER

B. Pseudocode of E-ASER

Fig. 2 shows the pseudocode of the E-ASER protocol. The initial values are set for the energy model before the data transmission starts.

The energy efficiency is achieved by combining residual energy and the degree of neighboring nodes as criteria for the selection of the parent node.

Further, the pseudocode proceeds with the data transmission phase. The threshold is used to decide whether the data should be sent to the cluster head or to the root node.

```
Initialize energy parameters
while (request for data transmission arrives)
   for (each node i) // to select root node
      determine its neighbors and their residual energy
   end for
   root node ← node with highest residual energy

   for (each node i within each cluster) //to select cluster heads
      COMPUTE capacity (residual energy and degree of neighbors
      taken together)
   end for
   select node with highest value as cluster head for each cluster

   //data transmission conditions
   if (parent node energy > threshold_energy and distance   from
   node to parent >threshold_distance)
        transmit the data to the parent node for aggregation
   else
        transmit the data directly to the root node
   end else
   end if
```

Fig. 2. Pseudocode of E-ASER

C. Tree based cluster formation

The BS initially broadcasts a packet to every node in the network to start the routing process. The highest residual energy containing node is first chosen as the root node. In cluster formation, each node exchanges a hello message, including its own ID, residual energy level and neighbor count. The nodes which lie within the proximity of the communication range belong to the respective clusters. Each node evaluates its capacity for CH election using equation 1.

$$C_i = E_i + N_i \tag{1}$$

where, C_i = Capacity of the node, E_i =highest residual energy, N_i = number of neighboring nodes

In equation (1), C_i is the capacity of node i. The residual energy and neighbor count of node i is represented as E_i and N_i respectively. Each node broadcasts it's calculated capacity to all its neighboring nodes. Each node compares its capacity with its neighbor's capacity. The node with the highest capacity will be chosen as the cluster head for each cluster. If two cluster heads have same capacity, then the tie is broken by choosing one of them randomly. Each of the cluster heads report to the root node which in turn communicates to the base station. The possibility of energy hole problem is eliminated by introducing the root node. In scenarios where the base station is situated far away from the cluster heads or the target area because of which the energy gets drained quickly. The reason for quick energy drain is that the cluster head has the task of aggregating the collected data and then transmitting this to the base station which is located far away. The aggregated data may be lost in attempting to transfer the aggregated data over the long distance to reach the base station leading to energy hole problem. Root helps to address this problem. The root node lies between the cluster head and the base station which reduces the energy consumption of the cluster head in reaching the base station. The root takes the responsibility of sending the aggregated data from cluster head to the base station.

D. Energy efficient data transmission

The root, cluster head and the cluster members are chosen and a tree based cluster is formed. Each node calculates the distance between itself and cluster head and itself and the root node. It determines the residual energy of the cluster head at the point of data transmission. A threshold value is decided considering the application requirement. For the experiment purpose we have considered 40% of the initial energy to be the threshold energy of the cluster head. The threshold distance is 60% of the communication radius of the cluster. Each node compares checks the energy of the cluster head. If the energy of the cluster head is greater than 40% of the initial energy and distance between the cluster member and the cluster head is less than 60% of the cluster communication range, the cluster member sends the data to the cluster head. The energy threshold criteria make sure that the cluster head has enough energy to accept the data, aggregate and forward it to the root node.

If either the threshold energy or the threshold energy is not satisfied, the cluster member directly transmits the data to the root node. This method eliminates the re-election of cluster thus reducing a significant amount of energy. If the residual energy is less than the threshold energy or if the distance is greater than the threshold distance, the data is transmitted directly to the root node with the intent that energy of the cluster head can prolong further.

The cluster head collects the data from all the cluster members which satisfy the threshold criteria. Once it has received the data from all its cluster members, it aggregates the data and forwards it to the root node. On the other hand, the data sent directly to the root node will be aggregated when the root node has received the data from all its cluster head. The root aggregates the cluster member data with the aggregated data sent by all the cluster heads and sends them to the base station.

The topology of the network is disturbed when any node dies in the network. Therefore, any node which is about to exhaust the energy has to inform all other nodes in the network before it can die. When each round has ended, these nodes will broadcast packet to the entire network. All the other nodes which are continuously monitoring the channel on receiving this packet will perform an ID check and modify their tables accordingly. If no such packet is received it means that all nodes have sufficient energy, and the network will start next round. The intent of removing the node even before it's energy can become zero is to prevent any loss of data in the network.

The existing system DSTEB lacks the election of a strong cluster head for the tree structure which is taken care in the proposed system.

The data transmission in the existing system is restricted to the cluster head whereas it is extended to direct transmission to the root node under circumstances in the proposed system. These enhancements improve the network lifetime by reducing the energy consumption.

IV. SIMULATION AND RESULTS

The network simulation tool is used for simulating the network scenarios. NS2, a freely available simulation tool is used for simulating both wired and wireless networks. It can be used for measuring various performance parameters like throughput, delay, packet delivery ratio, network lifetime and so on.

The network is modeled by randomly deploying wireless sensor nodes around the base station in a rectangular area. The base station is the only static element with infinite energy. The sensor nodes have motion and are energy-constrained. The sensor nodes participate in tree-based cluster construction and data transmission only as long as they have energy. The popular AODV routing protocol is the base for the system model. The below table contains the system model used for simulation.

Table- I: Simulation Parameters

Simulator	Network simulator 2
Topology	Random
Interface type	Phy /wirelessphy/802.15.4
Mac type	IEEE 802.15.4
Queue type	Drop tail/priority queue
Queue length	50 packets
Antenna type	Omni antenna
Propagation type	Two ray ground
Routing protocol	AODV
Transport agent	UDP
Application agent	CBR

The system model is varied for 20, 40, 60 nodes and 2 pause times 5ms, 10ms to study the behavior of sensor nodes under different scenarios.

A. Energy consumption

The deployed sensor nodes in the system are subject to energy constraints except for the base station. The initial energy is assigned before the data transmission starts. The difference in energy we get by subtracting the initial energy of all the nodes and the current energy or the remaining energy after the data transmission ends is termed as energy consumption.

Energy Consumption = Initial energy– remaining energy

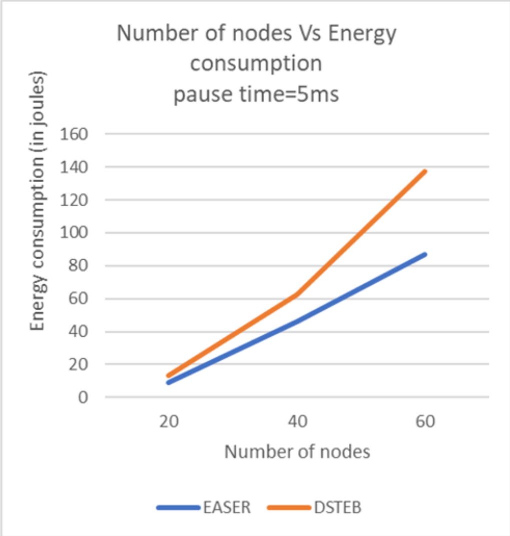


Fig. 3 Number of nodes Vs. Energy consumption with pause time=5ms

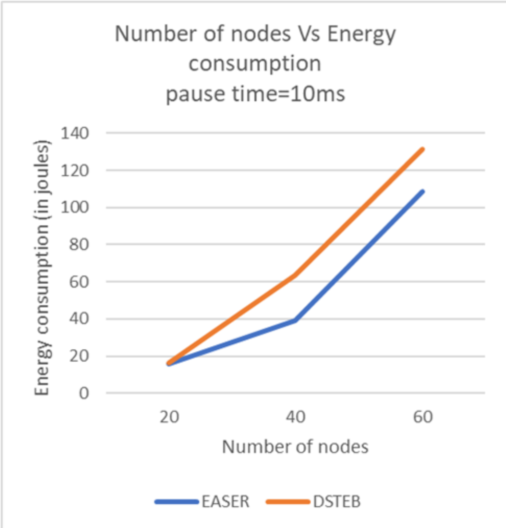


Fig. 4. Number of nodes Vs. Energy consumption with pause time=10ms

From both Fig.3, and Fig.4 the energy consumption of E-ASER is significantly lower than DSTEB because of good parameter selection for the cluster head election. When the parent node has already drained below the threshold its energy drains faster because it must aggregate the data. Data aggregation and transmission at cluster head is eliminated when the residual energy is less than threshold or when the distance between cluster member and cluster head is above threshold distance.

By transferring the data to the root node when threshold criteria are not satisfied results in less overhead on the parent node**.** Cluster head can prolong network lifetime for this reason. When pause time is 5ms nodes move slowly and there is enough time for communication whereas at 10ms the nodes move faster and topology quickly changes. This the reason why the energy consumption increases linearly for E-ASER when pause time is 5ms as shown in Fig.3 while it is not linear when pause time is 10ms as shown in Fig.4. When the number of nodes are too less, (20 nodes) nodes are spread out which make it difficult to reach out for neighboring nodes. When the number of nodes is high, (60 nodes) nodes are too close to each other which requires more computation in arriving at cluster head election. Due to the above mentioned reasons the best case scenario is when the number of nodes is average (40 nodes). Hence, we see a dip for E-ASER in Fig.4 at 40 nodes, and 10ms pause time. From the average value obtained, energy consumption is 17.6% less in E-ASER than DSTEB.

B. Number of dead nodes

As the sensor starts participating in activities like initialization, configuration, aggregation, transmission of packets, reception of packets they lose the energy as defined in the energy model. The state when the energy of the node becomes zero is called dead node. The dead node no longer participates in the network. The main aim is to balance the energy in the nodes such that they do not drain energy quickly to becomes dead nodes. More the number of dead nodes, lesser the network lifetime would be. Also, the packet drop rate will be high as number of dead nodes increases.

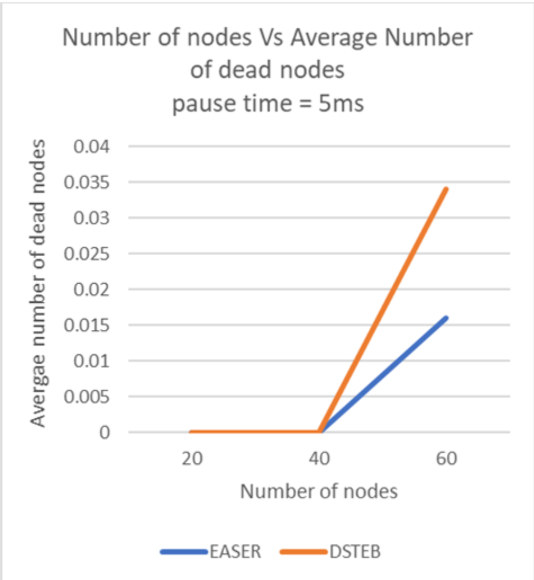


Fig. 5. Number of nodes Vs Dead nodes at pause time = 5ms

From Fig.5 and Fig.6 the number of dead nodes is almost zero until 40 nodes for E-ASER and DSTEB with pause time=5ms and 10ms. However, DSTEB has average dead node of 0.016 but is nearly zero at 10ms for 60 nodes in E-ASER. This is because the selection of the cluster head is based on both the residual and degree of neighboring nodes. Cluster head as a better lifetime when both metrics are considered. Also, data transmission when number of nodes is 60 is smooth since the nodes nearby are readily available. Only residual energy is considered in DSTEB which results in poor cluster head election and drains the energy of nodes quickly since frequent re-election of cluster head takes place. Nodes that are near to energy drain inform all the nodes before starting the next cycle and do not participate in the next round. This eliminates data loss in the E-ASER. Because of the above-mentioned reasons, the average dead node in E-ASER is less than DSTEB.

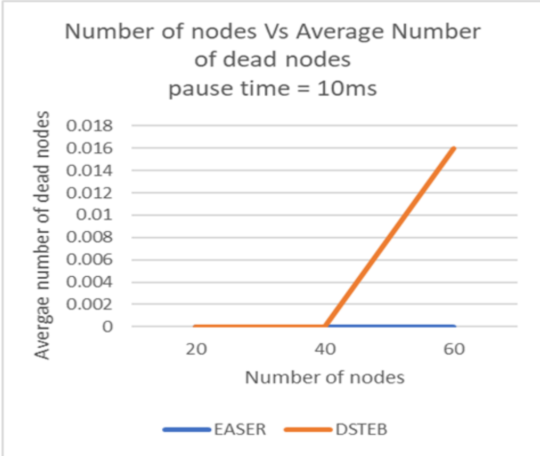


Fig. 6. Number of nodes Vs Dead nodes at pause time = 5ms

C. Routing load

For every packet to be transmitted from source to destination there should be enough routing information. Routing load is the number of routing packets required per data packet to successfully reach the destination. Each forwarded packet is considered as one transmission. The routing load can hence be defined as the ratio of number of routing packets sent to the number of packets received at the destination. If there are several routing packets for one data packet, it causes overload to the network hence reducing energy quickly. The routing load should be less in order to reduce energy consumption.

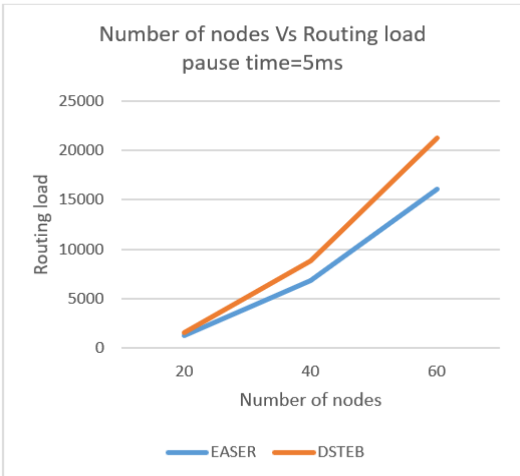


Fig. 7. Number of nodes Vs Routing load at pause time= 5ms

Routing load = No. of routing packets/Packets received at destination From Fig.7 and Fig.8 the routing load is significantly less in E-ASER as compared to DSTEB. All the cluster members send data to the cluster head irrespective of the residual energy of the cluster.

The load on the cluster head increases when it has almost drained energy. In E-ASER, energy is balanced by sending the data to the root node when the cluster head does not enough energy.

Overhead on the cluster head is eliminated. Root node takes the responsibility to aggregate the data of the nodes (cluster member) which to not satisfy the energy threshold or the distance threshold.

The routing load is almost the same for both 5ms and 10ms pause times indicating a stable network. The routing load is 23% in E-ASER as compared to DSTEB.

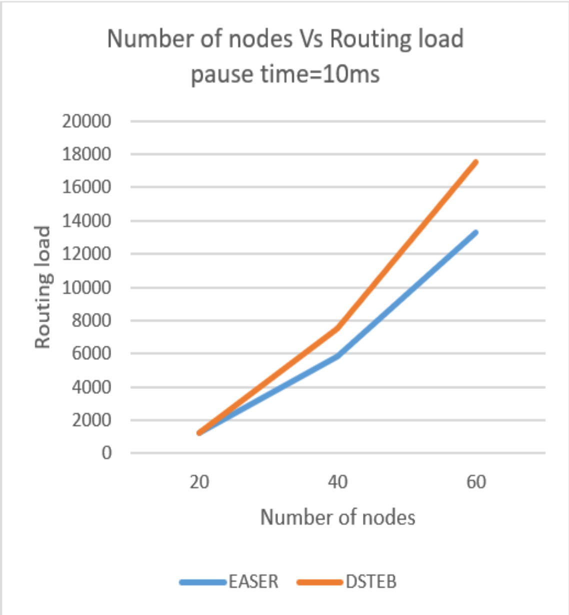


Fig. 8. Number of nodes Vs Routing load at pause time = 10ms

D. Network lifetime

The network lifetime can be defined as the time until which the nodes in the network are functional. Lesser the energy consumption, higher the network lifetime.

Network Lifetime = number of nodes * (initial energy/energy_consumption)

There is a small improvement in the network lifetime between E-ASER and DSTEB as shown in Fig. 9 and Fig. 10. Network lifetime depends on different network scenarios. There could be nodes in the system which are not participating in the data transmission while there are few nodes which are extensively transferring data.

Other factor to consider is the number of nodes. With higher number of nodes, the intermediate nodes are readily available for data transmission whereas, with a lesser number of nodes, the immediate node for data transfer might be at a farther distance. Hence, the network lifetime improves with an increase in the number of nodes.

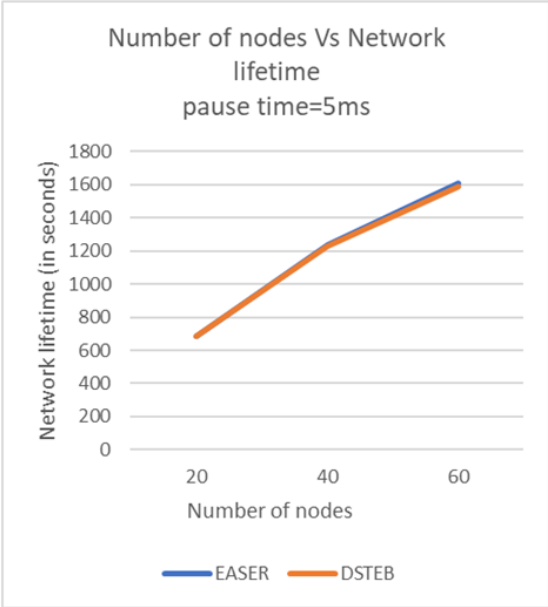


Fig. 9. Number of nodes Vs Network Lifetime at pause time = 5ms

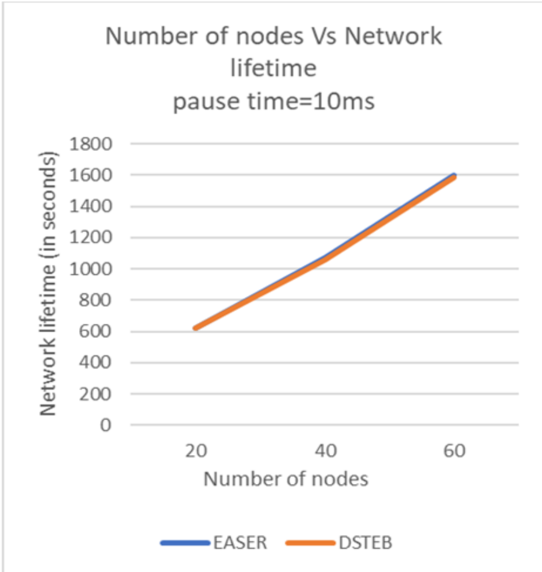


Fig. 10. Number of nodes Vs Network Lifetime at pause time = 5ms

V. CONCLUSION

In this work, an attempt is made to self-organize the network in terms of energy for achieving a higher network lifetime. Energy consumption is reduced by choosing combination of parameters for cluster head election. Electing cluster head with good parameters prolong the network lifetime of the nodes. Data transmission is made energy effective by defining thresholds for residual energy for cluster head and threshold distance between cluster members and cluster head. The path of the data transmission is decided on these threshold criteria. This reduces the overhead on the cluster head and prolongs its lifetime. Good selection of cluster head and efficient data transmission has reduced approximately 17.6% of energy as compared to the existing protocol.

The routing load or overhead is approximately 23% less than the existing protocol. The network lifetime improvement is slightly better than the existing protocol.

Further improvement can be made by considering better metrics for cluster head election. The tree- based cluster structure can be studied considering many levels of the tree to check scalability. The E-ASER is just a protocol for experimenting a new idea. This protocol can be used in applications where high dynamic topology is involved. Going further, E-ASER is planned to be implemented in real-time applications.

REFERENCES

1. I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “Wireless sensor networks: a survey”, Computer Networks, Vol. 38, No. 4, pp.393–422, 2002
2. O. Osterbo and O. Grondalen, “Benefits of Self-Organizing Networks (SON) for Mobile Operators,” Journal of Computer Networks and Communications, vol. 2012, pp. 1–16, 2012.
3. X. Liu and J. Shi, “Clustering routing algorithms in wireless sensor networks: An overview,” KSII Trans. Internet, Inf. Syst., Vol. 6, No. 7, pp. 1735–1755, 2012
4. S. P. Singh and S. C. Sharma, “A survey on cluster based routing protocols in wireless sensor networks,” in Proc. Int. Conf. Adv. Comput. Technol. Appl. (ICACTA), Vol. 45. 2015
5. A. Hassan, W. Shah, M.F. Iskandar and A.Mohammed, “Clustering Methods for Cluster based Routing Protocols in Wireless Sensor Networks: Comparative Study”, International Journal of Applied Engineering Research, Vol. 12, No. 21, pp. 11350- 11360, 2017
6. NavinGautam, W.-I. Lee, and J.-Y. Pyun, "Dynamic Clustering and Distance Aware Protocol for Wireless Sensor Networks," ACM Spain, pp. 9-14, 2010.
7. F. Tang, I. You, S. Guo, M. Guo, and Y. Ma, "A chain-cluster based routing algorithm for wireless sensor networks," Journal of Intelligent Manufacturing, Vol. 23, pp. 1305–1313, 2012
8. F. Awad, "Energy-Efficient and Coverage-Aware Clustering in Wireless Sensor Networks," Wireless Engineering and Technology, Vol. 3, pp. 142–151, 2012.
9. Z. Fan and Z. Jin, "A Multi-weight Based Clustering Algorithm for Wireless Sensor Networks," College of Computer Science & Educational Software Guangzhou University, 2012
10. L. Wei Kuang, S. Chin-Shiuh, and L. Yung-Tai, "A cluster-based routing protocol for wireless sensor networks with adjustable cluster size," in Communications and Networking in China, Fourth International Conference on, pp. 1-5, 2009
11. H. Zhou, D. Qing, X. Zhang, H. Yuan, and C. Xu, “A multipledimensional tree routing protocol for multisink wireless sensor networks based on ant colony optimization,” International Journal of Distributed Sensor Networks, 2012
12. N.Kaleeswari and Dr.K.Baskaran, “Reducing the energy consumption in wireless sensor networks using delay aware dynamic routing protocol” ACM, 2012
13. F. Ren, J. Zhang, T. He, C. Lin, and S. K. Ren, “EBRP: Energybalanced routing protocol for data gathering in wireless sensor networks,” IEEE Trans. Parallel Distrib. Syst., Vol. 22, No. 12, pp. 2108–2125, 2011
14. X. Wu, G. Chen, and S. K. Das, “Avoiding Energy Holes in Wireless Sensor Networks with Nonuniform Node Distribution,” TPDS, Vol. 19, No. 5, pp. 710–720, 2008
15. N. Bagga, S. Sharma, S. Jain, and T. R. Sahoo, ‘‘A cluster-tree based data dissemination routing protocol,’’ in Proc. 11th Int. Multi-Conf. Inf. Process. (IMCIP), Vol. 54, pp. 7–13, 2015
16. W. Osamy, A. M. Khedr, A. Aziz, and A. A. El-Sawy, ‘‘Cluster-tree routing based entropy scheme for data gathering in wireless sensor networks,’’ IEEE Access, Vol. 6, pp. 77372–77387, 2018
17. Pardeep Kaur and Vinay Bhardwaj, “K-Means based General Self-Organized Tree Based Energy Balancing Routing Protocol for Wireless Sensor Networks” International Journal of Computer Science and Information Technologies, Vol. 6, No. 4, pp. 3457-3464, 2015
18. Bencan Gong Tingyao Jiang, ‘Tree-Based Routing Protocol for Wireless Sensor Networks”, IEEE, 2011
19. M. Singh, M. Sethi, N. Lal and Saroj Poonia, A Tree Based Routing Protocol for Mobile Sensor Networks (MSNs), International Journal on Computer Science and Engineering, vol. 2, no. 1, pp. 55–60, 2010
20. V.A.Suresh1, P.G.Gopinath, “Distributed Self-Organized Tree-Based Energy-Balanced Routing Protocol for Wireless Sensor Networks”, International Journal of Innovative Research in Science, Engineering ansd Technology, Vol. 4, No. 6, 2015

AUTHORS PROFILE

Meghana R, completed her B.E in Computer Science from Visvesvaraya Technological University, Karnataka in 2017. She is currently pursuing her MTech at Ramaiah Institute of Technology, Bengaluru, Karnataka in Computer Science Engineering. Her areas of interest include Computer Networks, IOT and Android Application development.

Annapurna P Patil, received her B.E from Gulbarga University, Karnataka in 1994, M.Tech and Ph.D from Visvesvaraya Technological University, Karnataka in 2001 and 2014 respectively. She is a Professor at the Computer Science Department of Ramaiah Institute of Technology. She is also a Senior IEEE member, ACM member, LMISTE, LMCSI. Her areas of interest include Wireless Networks, Protocol Engineering, Cloud Computing, Data Analytics, Artificial Intelligence, and Analysis of Algorithm.