Enhanced Network Stability and Energy Efficient Routing Protocol in Heterogeneous Wireless Sensor Networks

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Abstract.

Wireless Sensor Networks (WSNs) are networks typically created of miniaturized autonomous entities known as Sensor Nodes (SNs) which will communicate with one another by radio links. They typically have restricted resources in terms of transmission power, processing and storage capability and energy. So as to scale back energy consumption, the techniques of clustering are used. It will improve measurability, lifelong. Energy-Efficient cluster rules need to be formulated for specific of heterogeneous WSN. During this planned work, a replacement energy-efficient cluster theme for heterogeneous wireless device networks is used that not solely minimizes the common energy consumption however additionally minimizes the residual energy and will increase the network life time and outturn(throughput). We take TDEEC protocol in comparison with the proposed design of ETDEEC which helps in minimizing the energy consumption of the nodes in network and maximize the network lifetime. In ETDEEC (Enhanced Threshold Distributed Energy Efficient Clustering), the threshold value has to be adjusted with respective to whether the node becomes CH or not which is in respect to optimal number of cluster heads and residual energy average and total energy ratio. Each node will carry over a remaining energy over the network which can be further used as reference to increase the lifetime. Each node with maximum energy elects itself as the cluster head, all the nodes send the data to CH which is further transferred to BS. Through this network stability and lifetime is improved.

Keywords: Heterogeneous Environment, Cluster Head, TDEEC, Clustering, Wireless Sensor Networks, Energy Consumption
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1 Introduction

WSN is a network, which is self-organized and which uses sensors to analyze parameters such as temperature, vibration etc., The data which contains the conditions of the environment are saved in a sensor node, then the data is stored at the base for final processing. Operations of WSN is achieved by mesh networking protocols which will exploit the path used for communication by data hops from one node to another. With the help of recent improvements in hardware have helped in deploying small sensors due to which use of WSN has been extended to be used [13]. The use of WSN has rapidly increased in today's world for various applications like transportation traffic monitoring, surveillance. Due to vast use of WSN, the nodes are placed in open grounds so that the nodes are severely damaged and are hard to replace and expensive. So, in many cases wireless nodes must have battery replacement for extended period of time. Therefore, energy efficiency is a highlighted major issue when designing a network route. The challenge would be to increase the stability and lifetime of the network [1]. Sensor nodes can be grouped together inside a cluster. Each cluster has a dedicated cluster head with pre-defined tasks of collecting data. While communicating within the BS, clustering protocols needs to be created in a hierarchical method. This method is used widely to increase the lifetime and scalability. Applications of WSN is listed in Fig. 1.

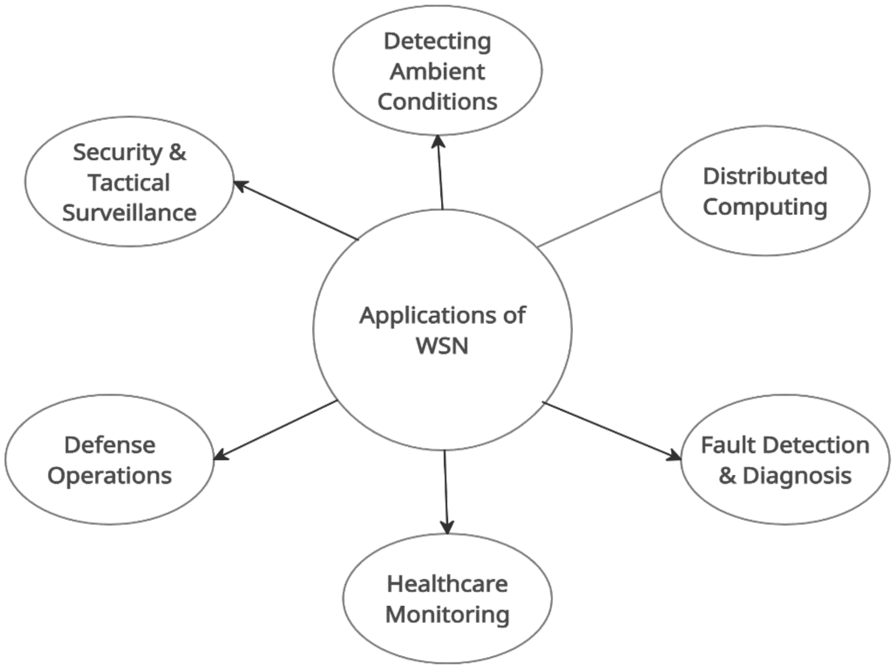

Fig. 1. Applications of WSN

1.1 Challenges in WSN

While designing an architecture for WSN, several issues, constraints and challenges are faced by researchers and it is listed below and in Fig. 2.

Routing: While implementing WSN for a big environment, challenge would be to design adaptive routing schemes to transmit information from one sensor to another. This may occur due to limited energy and poor sensors.

Algorithms: To overcome limited energy availability each node needs to be fed with simple and efficient algorithm so that minimal energy is consumed. Commonly an architecture is carried over with a centralized algorithm, so it is challenging problem to design suitable algorithms for various environments.

Topology Control: With the increasing number of sensors, it is challenging to provide efficient network connectivity with dynamic topologies

Localization: While using in indoor, readings would be deflected because of the obstacles and it is a problem to achieve best algorithm.

Field Construction: The information transmitted from the sensors could be noisy due to the environmental property. Data saved could be spatial or temporal correlation.

Event Detection: Algorithm for calculating the event detection is challenging for fluctuating wireless channels. When the channel conditions are bad, it is difficult to propose algorithm for event detections.

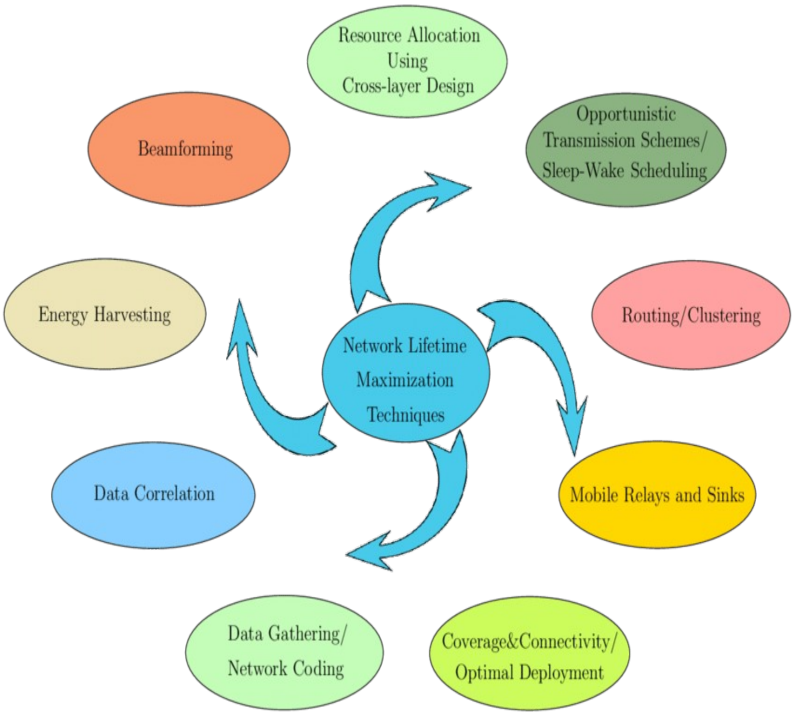

Fig. 1. WSN Design Challenges for Network Lifetime Maximization

Security: WSN is widely used across in commercial and military purposes. In such cases it is important to safeguard the privacy and safety of millions of users. There is always possibility of attacks from internal or external, due to which the nodes may collect false information and transmit them which creates unnecessary confusions leading to incorrect decisions. Here the challenge occurs in creating a secure schema from saving WSN from any such attacks.

Middleware: New updates and improvements to the applications can be difficult since the hardware used in the WSN would be limited to certain upgrades. Introducing or adding additional feature to existing setup may require upgrades on applications and this would be difficult to perform on all nodes or it would require for new set of costly hardware.

These challenges motivated me to use the clustering techniques effectively to overcomes the challenges and issues. WSN when used in a large network has a number of nodes due to which energy consumption would be more, which in turns leads to information loss, end-to-end delay and reduced stability.

TDEEC is a threshold distributed energy-efficient clustering algorithmic rule for heterogeneity WSN that predicates on clustering, once the election of CHs depends on remaining energy of each and every node with also average energy. TDEEC, nodes with high initial and remaining energy can additional possibilities for becoming cluster-heads. So TDEEC will increase network period of time, particularly the stability period, by heterogeneous-aware cluster algorithmic rule.

This alternative penalizes invariably advanced nodes, once their remaining energy exhaust so become within the vary of traditional nodes. During this scenario, the advanced nodes die faster. To overcome these all, The ETDEEC is planned, Enhanced Threshold Distributed Energy-efficient Clustering, for Effective design and use of clustering algorithm to minimize the energy consumption of the nodes within the network, to maximize the network lifetime in Wireless Sensor Network (WSN).

2 Literature Review

In Stability Enhancement in LEACH (SE-LEACH) for Homogeneous WSN, SE-LEACH is planned for homogeneous network wherever all the nodes have capabilities like sensing, processing, energy etc. With an objective to beat the constraints and enhancing the steadiness of LEACH protocol, SE-LEACH [2] is planned in this paper. While forming clusters, all non-CH nodes showing intelligence in selecting their CH by calculating probability of every CH nodes.

Simulation experiments are performed for two scenarios by changing the position of Base Station making the protocol appropriate for any application type in WSN. Simulation results show the extended stability period together with balanced energy consumption with better throughput however not achieved more prolonged stability period. In CLP routing protocol and projected methodology based on hierarchical routing protocols (LEACH and PEGASIS) [3] to pick a cluster head and construct the chain between all CH using LEACH and PEGASIS protocols are given. Here the better performance of CLP-Protocol compared with the initial LEACH and PEGASIS showed.

In [4] CLP-Protocol reliably further reduced the energy utilization also extends the life span of WSN. Work done here can be utilized in future works to propose a protocol with higher consumption of energy and increase more the life of Wireless sensor Network. In ECRSEP [5] for WSNs, because of very little power batteries, economical usage of power may be a crucial issue. In WSN, nodes aren't continuously homogeneous they could be heterogeneous, that will increase complex design WSN. This is vital for extending stability, to reduce utilization.

In [6], new unequal protocol is extended so as enhancing lifetime. The exploitation of non-uniform approach happened during here. In [7], Novel energy efficient clustering protocol technique is used for choosing the cluster heads in an optimal way with an option to adjust sensing range and data aggregation using chaining approach. This is sorted by classifying data's with and without aggregations. This approach helps in avoiding redundant data transmission which improves network lifetime.

In [8], Multilevel heterogeneous network mode is used in WSN where up to seven level of heterogeneous can be achieved where multiple parameters can be optimized. This can be applied to clustering protocols as distance and distance between base station and sensor, node density and residual energy. In [9] energy uses by dividing the sensing regions into multiple subregions and with different reliability requirements. The use of efficient selection of node helps in improving spatial and convergence for data aggregations. In [4], using HEED the information sensed and forwarded by nodes uses large portion of system vitality. So, the main concern is to utilize the vitality to expand the system's lifetime and to make the operation better.

3 Proposed System

ETDEEC is relied on TDEEC scheme, here the energy remaining and starting are used for defining CHs. The estimation of perfect value of WSN time period, TDEEC and ETDEEC for calculating reference energy, throughput.

3.1 Parameters taken for WSN

The performance metrics used to evaluate the clustering protocols [10], [12] such as lifespan, range of alive nodes. Fig. 3 represents the architecture of WSN.

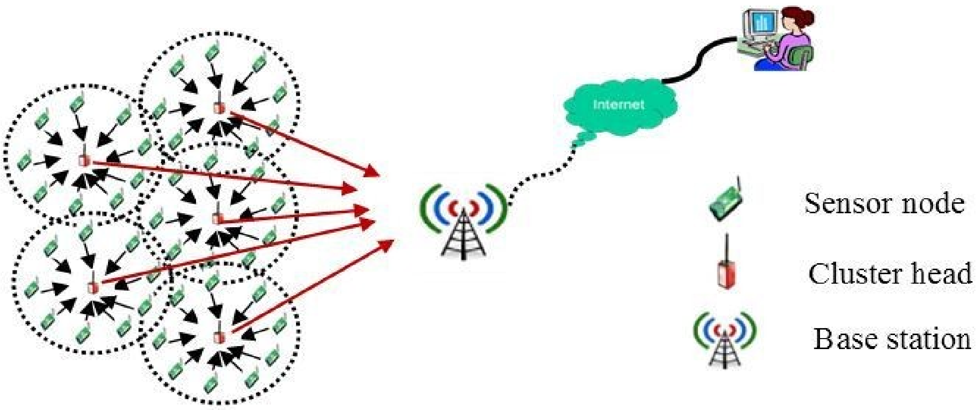

Fig. 1. WSN Model

Network Life Time: The lifespan of the network that is until starting node dies how many rounds were happened.

Lifespan: Lifespan of the network can be calculated based on alive and dead nodes. Additional to this we will have half dead nodes, these are the nodes which become un operational in a network. These can be used to increase or decrease number of active nodes for a longer run in the network.

Stability: Stability is total time duration interval; maximum duration refers to the network stability.

Throughput: Throughput is the average of the network bandwidth where it is calculated by taking the packet size and the packet start and end time.

Mean Jitter: This is the time variation in the delay due to the components along with the communication path.

Residual Energy: The energy absorbed by the network is determined by the residual energy and it deals with the leftover energy of the sensor node per round in the network. The lifespan of WSN depends on the residual energy.

Data Aggregation: It is an addition of data from a multiple source points, which is used to save energy and data transfer.

Data Package: Total amount of data transmitted through the base station.

Packets delivered to Cluster Heads (CH): It is defined as the number of sensor node packets which are sent to cluster heads.

3.2 Two Level heterogeneity WSN

Usually, we use nodes in the network of WSN is of two types, those are normal nodes (NN) and advanced nodes (AN). Basically, starting energy of NN assumed to be E_0. Energy for AN is that 'a' time greater to that of NN. Also 'm' can be advanced nodes fraction. So, we will be having 'm.N' advanced nodes and 'N.(1-m)' NNs which equips with energy in two-level heterogeneity. The overall energy of two-level heterogeneity WSN is

$$E_{total} = (1-m).N.E_o + N.E_o(a+1) \quad (1)$$

3.3 Three Level heterogeneity WSN

Here, WSN sensor nodes classified to 3 different sensor types which includes normal, advanced, and super nodes [11]. Also, some assumptions like 'm' which is fraction of overall count of nodes (N), 'm_0' can be defined as overall node count percentage. Supernodes defines as its equipped with 'b' times greater energy with normal nodes, whose count is 'm_0.N.m'. Advanced nodes which are given with energy 'a' time than ordinary nodes, whose count will be '(1-m_0).m'. Therefore, '(1-m). N' is count of normal nodes. Three-level hierarchical structure of proposed WSN network is shown in Fig. 4.

The distance of two cluster nodes is

$$d^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2 \quad (2)$$

The overall energy of three-level heterogeneity WSN is,

$$E_{total} = E_o.N.(1-m) + m.E_o(1+a).N.(1-m_o) + E_o(1+b).m_o \quad (3)$$

Thus, 3-level WSN gives more network stability compared to previous ones.

3.4 Assumptions for the 3-level Heterogeneous ETDEEC model

- Post deployment, all the Base Station (BS) and sensor nodes are stationary. They can be identified with a unique ID reference.
- In terms of capability all the nodes are defined in same way, however during heterogeneity their energy varies.
- In this setup there is no issues with memory, compute and energy. Since the BS was deployed at center of network where power supply is constant.
- Data aggregation is possible, hence multiple nodes can be added and combined as a packet.
- Power transmission can be controlled and monitored by the nodes.
- All the nodes are capable of sending data during transfer. Metadata of the nodes are copied and stored on their cluster array.
- Consumption of energy from node 1 to 2 and vice versa is always same since the radio links are symmetric.

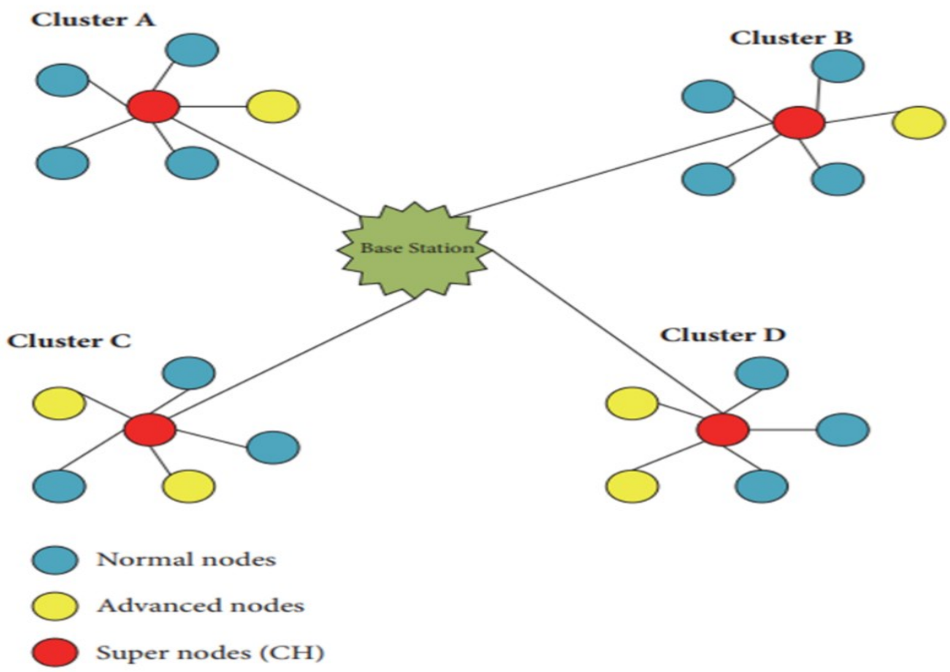

Fig. 1. Three-level Heterogeneous WSN

- The initial energy transmitted across network is same and this can be setup as a predefined condition to evaluate if the network is capable of handling the energy until the end.
- For every round the Super Node (SN) that's the node in a cluster with additional energy and costlier chooses as Cluster Head (CH).
- For every round, Advanced Node (AN) that's the node with additional energy and costlier is chooses as Cluster Head (CH).
- Normal Node (NN), the node with less energy and cheaper is chosen as its cluster members.
- The value of nodes that are alive and dead are executed and available at the end of each round.
- Same node cannot be assigned as CH for multiple time.
- The data from nodes are sent to CH as a single hop, this being added into packets are further sent to BS on a single hop.
- As the simulation progress, the AN, SN gets weak and starts dying slowly.
- The value of dead and active nodes, data sent across to BS and energy consumed are represented across various figures.

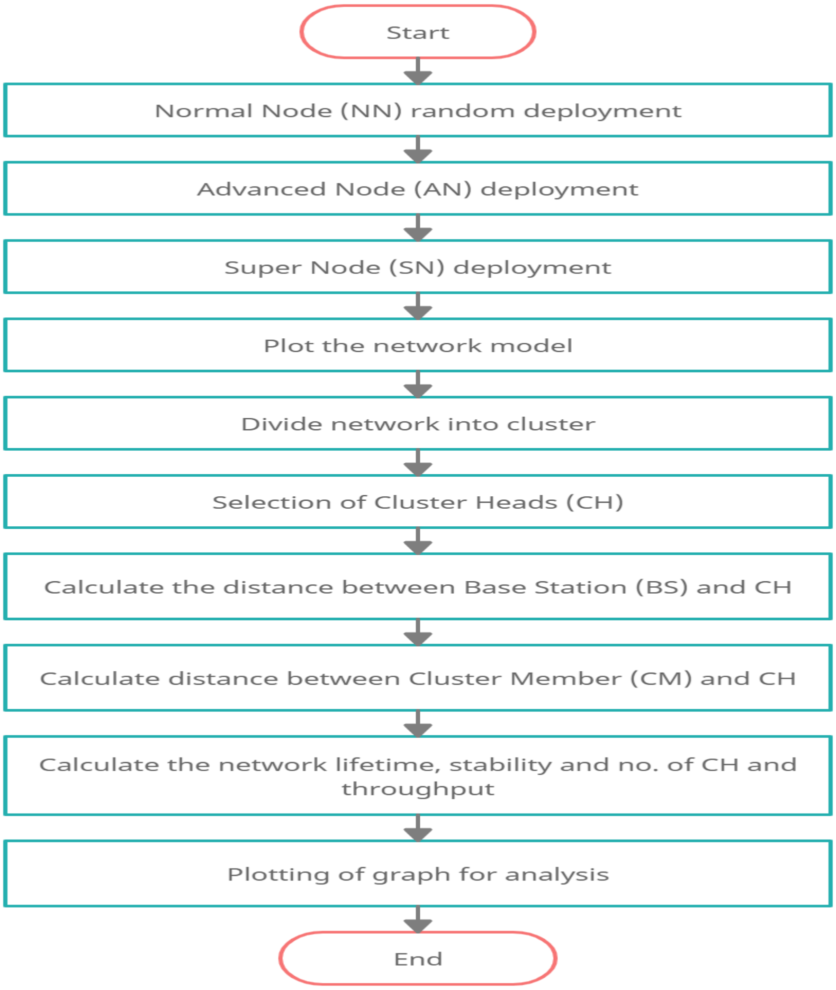

Fig. 1. Flowchart of Proposed Methodology

3.5 Proposed Work- ETDEEC Details

ETDEEC, Enhanced-Threshold Distributed Energy Efficient Clustering [1] rule implements an equivalent like TDEEC, Threshold based Distributed Energy Efficient Clustering for estimation of average energy and therefore choice of cluster head algorithmic program that is predicated on residual energy average and overall energy.

The distance measurement is given by

$$d_0=\frac{\sqrt{E_{fs}}}{\sqrt{E_{mp}}} \quad (4)$$

The average energy in r th round follows

$$E(t)=\left(\frac{1}{N}\right)*E_{total}.\left(1-\left(\frac{r}{R}\right)\right) \quad (5)$$

Total rounds denoted by R

$$R=\frac{E_{total}}{E_{Round}} \quad (6)$$

E_{Round} – dissipation of overall energy within network throughout one round

$$E_{Round}=L(2N\,E_{elec}+N.E_{DA}+k.E_{mp}.d_{toBS}^{4}+N.E_{fs}.d_{toCH}^{2}) \quad (7)$$

wherein 'k' is the range of clusters, 'E_{DA}' is the exhausted value of information aggregation, 'E_{fs}' is freespace loss and 'E_{mp}' is multipath loss. d $_{toBS}$ is that average distance between the cluster head and therefore BS, and d $_{toCH}$ is that average distance between the cluster members and therefore CHs

$$d_{toCH} = M / \sqrt{2\pi k} \quad (8)$$

$$dtoBS = 0.76(M/2) \quad (9)$$

Optimal number of cluster heads

$$k_{opt} = \left(M / d_{toBS}^{2} \right) \sqrt{\frac{N}{2\pi}} \cdot \sqrt{\frac{E_{fs}}{E_{mp}}} \quad (10)$$

The Energy dissipated $E_{dis\,N\,N}$ in one round is

$$E_{dis\,N-N} = L \left(E_{Tx} + E_{fs} \left(d_{toCH}^{2} \right) \right) \quad (11)$$

4 Simulation Results

The performance of ETDEEC protocol using MATLAB was evaluated. In the simulation of this proposed system, the values of a and b is 1.5, 3.

Table 1. Simulation Parameters of ETDEEC protocol

Parameter	Value
Network Size	100*100
Initial Nodes	50
Maximum Number of Rounds	5000
Packet Size	4000 bits
Sink Location	$0.5*x_m$; $0.5*y_m$
Optimal Probability	0.4
Initial Energy	0.5 Joules
Cluster Head Election Energy	5 nJ/bit
Transmission Energy	50 nJ/bit
Receive Energy	49 nJ/bit
Data Aggregation Energy	5 nJ/bit

4.1 Simulation Results of Existing TDEEC versus Proposed ETDEEC

Network Stability.

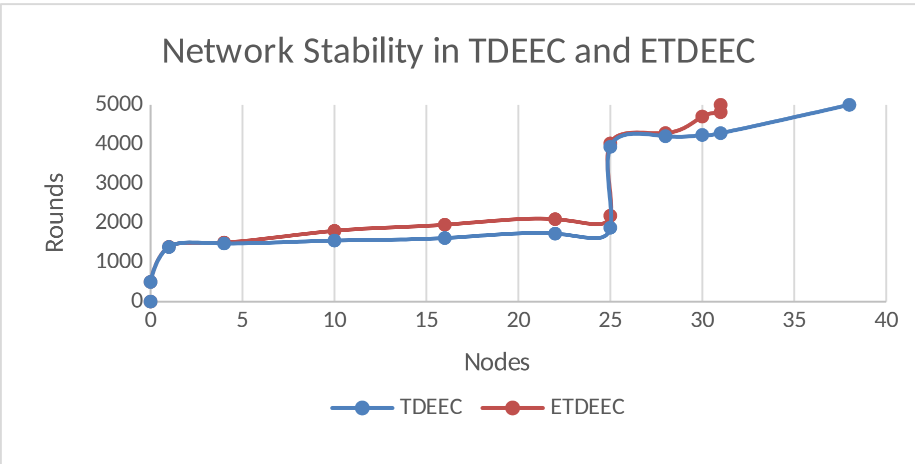

Fig. 1. Network Stability in DEEC and ETDEEC

In the Fig. 6 we can see that in the proposed design, the number of dead nodes start to increase from more rounds compared to the dead nodes of existing design. So, we can say that Network Stability increased from existing system to the proposed system.

Network Lifetime.

In the Fig. 7, the number of alive nodes starts decreasing from more rounds compared to the alive nodes of existing design. So, we can say that Network Lifetime increased from existing system to the proposed system.

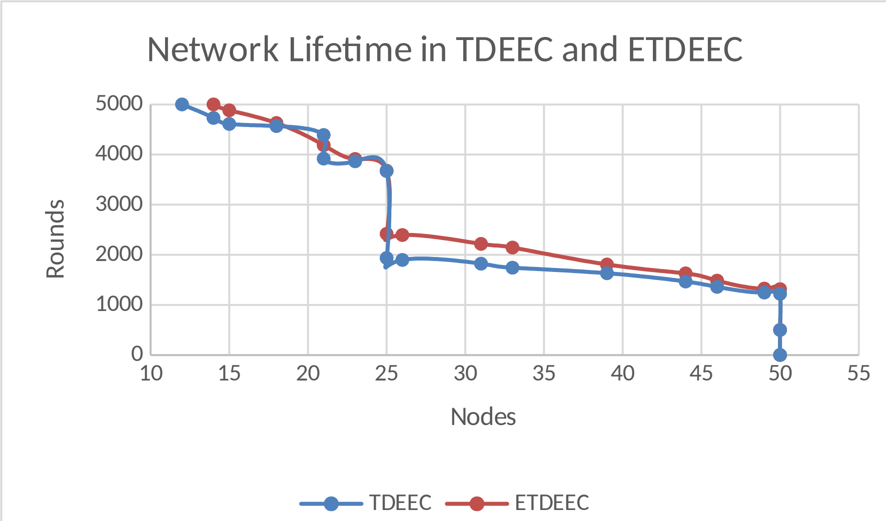

Fig. 1. Network Lifetime in TDEEC and ETDEEC

Network Throughput.

From Fig 8, in existing system the total throughput at maximum rounds is 141444 whereas in proposed system, throughput is 160782. So, we can see approximately 14 percent improvement takes place from existing to proposed system.

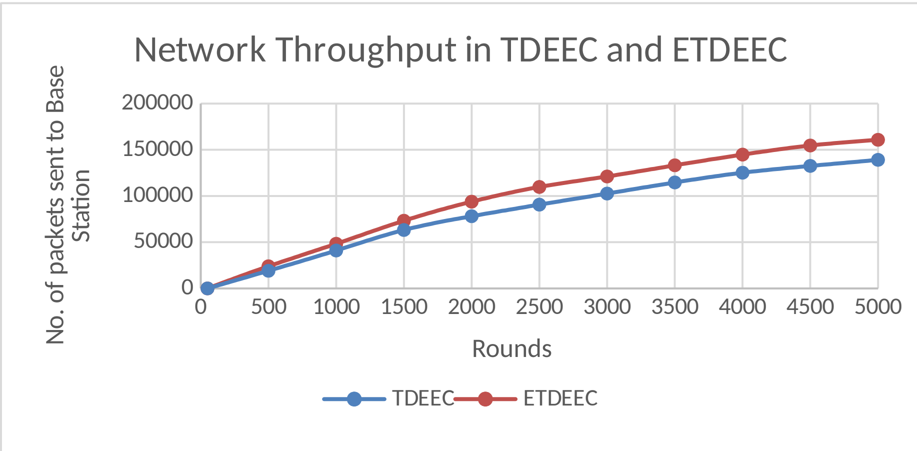

Fig. 1. Network Throughput in TDEEC and ETDEEC

5 Conclusions and Future Work

In proposed work, multiple parameters like stability, lifetime, throughput of the network is optimized. The results are generated and stimulated using MATLAB, these are compared with existing TDEEC protocol. Results convey the optimized Quality of Service (QoS) values from ETDEEC protocol are much better and suited compared to normalized QoS parameters in WSN. The QoS parameters need to be further optimized for better performance of heterogeneous WSN is left as future work.

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