# Energy Optimization protocols within Wireless Sensor Networks - Comparative Study

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**ABSTRACT: Energy optimization within wireless sensor network requires for increasing lifetime of network. Energy consumption of sensors depends upon several factors including distance, number of packets transferred towards base station, number of packets transferred towards cluster head and many more. As long as the network has energy, packets from cluster head are transmitted towards base station. As the energy completely dissipates, packet drop will take place. To increase lifetime of the network, there exists several protocols for enhancing energy optimization. In this paper, protocols like LEACH, DEEC, SEP and TDEEC are comprehensively analyzed to evaluate the performance . The parameters that are used for evaluating these protocols includes energy efficiency, throughput, packet drop ratio, packets to base station and cluster head. From the analysis ,it is concluded that Distributed Energy Efficient Clustering (DECC) protocol performs better as compared to other protocols and has shown improvement by 5% in terms of energy efficiency.**

**Keywords:Wireless sensor network, Metrics, DEEC, LEACH, SEP, Cluster Head (CH)**

## I. INTRODUCTION

Sensors plays a critical role in the transmission process within Wireless networks. The wireless sensor network today used in wide variety of applications including wearable devices, health monitoring, wind prediction ,weather prediction and many more. In almost every application, energy conservation is critical. Wireless sensor network used to transmit information in terms of packets. They are similar to wireless ad-hoc networks in that rely on wireless connectivity and spontaneous network to enable wireless transfer of sensor data. WSN monitors physical conditions such as temperature, sound and pressure

Communication among sensor within the network is established with the help of sensors. Sensors can communicate only if they possess sufficient energy. The consumption of energy is highly dependent on the distance in between the nodes . Higher the distance more will be the energy consumption. Thus, node selection within the network plays quite a vital role in the optimization process.

The first protocol that is in line for energy optimization includes LEACH (Low-Energy Adaptive Clustering Hierarchy). This is the low energy adaptive clustering protocol. In this protocol, single cluster head is selected by nodes per round. The selected cluster head is very much responsible for transferring the packets towards the base station. The issue with this approach is single cluster head selected and hence load is not distributed among multiple nodes causing high energy consumption[8].

After LEACH, stable election protocol was created to overcome the issues associated with the LEACH. In SEP, election is conducted when each round ends for the selection of cluster head. The cluster having highest energy is elected as cluster head. As the cluster head per round shifts hence network lifetime is increased [12].

The load allocation still is an issue with SEP protocol, to overcome the problem, Distributed energy efficient clustering protocol comes into existence. In DEEC, each cluster head selection is based on energy consumption and distance between the nodes. Multiple cluster heads are selected per round allowing workload division; Thus, nodes survive over longer period [7].

The modified DEEC also known as TDEEC provides better results as compared to DEEC. In TDEEC, cluster head is rotated based on the allotted time. This time interval is termed as time quantum. As the time quantum expires, next cluster head with highest energy is selected for packet transmission. Packet drop ratio greatly reduce using this mechanism [4].

The organization of this paper includes : section 1 introduction of protocols used to achieve energy efficiency, section II presents Literature survey, section III presents proposed methodology that can be used to improve the results achieved existing protocols, section IV presents the results indicating validations based on metrics and last section gives the conclusion and future scope.

## II. LITERATURE SURVEY

This section elaborates on background analysis corresponding to different protocols used to achieve energy efficiency within network.

**Amgoth et al [8]** proposed enhanced routing aware protocol for energy conservation within wireless sensor network, In formed network, all of the sensor nodes are arranged into separate clusters using this method. Each node starts the selection process for CHs by starting a time delay that is based on its remaining energy. Nodes join CHs by taking into account their distance and leftover energy to form clusters. The clustering mechanism used in this case will be used to transmit the packets towards sink node with least energy consumption.. In data routing, each CH transmits the data packets to the next hop CHs in a way that allows for a balance in their energy usage

**Grids et al [11]** has proposed the idea of the smart house and the emergence of the smart grid. The market's smart products and smart technologies that enable houses to manage their energy effectively have been examined. The architecture of a general system as well as the difficulties, advantages, and emerging trends that smart grids and future homes may encounter were also covered. Utilizing electricity effectively lowers peak loads, lowers energy costs, and reduces greenhouse gas emissions. A well-tuned home automation system and the promotion of the transition to bi-directional communication networks are essential for the successful integration of smart houses into a smart grid.

**Heinzelman et al [1]** Proposed a LEACH protocol for energy conservation within wireless sensor network. The formed network selects the cluster head having highest energy. The issue however is that in each round only one cluster head is selected. This means that whenever a case arrives when there are large number of packets, then the energy will be consumed at a very much greater pace which in turn leads us to the to least lifetime of the network. This protocol also uses a very much randomized and well rotated local cluster of base stations (CH) for distributing the load of energy amongst all of the sensors present in WSN network.
**Mahajan [10]** Proposed quality of service within wireless sensor network. It is used in wide essense for optimizing the life of the network so that it can be prolonged and so that distribution of packets happen with very much lower rate and which in turn has significantly reduced routing overhead and has greatly helped in optimizing the network. In this The quality of service which is suggested in this literature is based upon the distance and energy associated with the network. The distance and highest energy cluster enables the lifetime of the network to be increased. Each transmitting node sends the packets towards the cluster head. From the cluster head , packets are transmitted towards the base station. The metrics used for evolution includes lifetime, packet drop ratio and throughput of the network. The issue however is selected cluster head is least within each round.
**Nadeem [3]** proposed a novel approach of gateway based energy efficient protocol. The primary factor used for the selection of cluster head in this case is distance. The nodes closer to the gateway or sink node is selected as the cluster head. The gateway of base station is placed at the center of the sensing area. This means each node from the network is placed aside the base station. The nodes having least distance and high energy will be selected as the cluster head. Once the energy of the nodes depreciates, next node in sequence will be selected as the cluster head. The metrics used for evaluation in this case is energy efficiency associated with the network.
**Pati B et al [9]** proposed energy efficient clustering approach for the selection of cluster head. The selected cluster head will be used to transmit the packets towards the base station. Game theory based approach is applied for the selection of cluster head randomly. This approach result depends upon the optimized cluster head selection but in case cluster head selected is not optimized, throughput of the network will be reduced greatly.
**Shah et al [12]** presented a WSN routing system that is even more optimal. Enhancing the cluster-head selection procedure was the main goal. In EESAA, CHs are chosen based on available energy. In order to use little energy as possible, nodes in EESAA alternate between sleep and active states. The network's life span and stability period have been optimised according to this strategy. According to the simulation results, all of these parameters have significantly improved when compared to some of the current routing protocols, such as SEP, LEACH, and DEEC.
**Priyadarshi et al [20]** suggested that issue with limited battery in WSN has been one of the most troublesome things. For withstanding this and improving the network lifetimes the networks are predominantly divided into three clusters with each cluster has been differently classified on the basis of their network energy. It takes two major criteria into consideration one is threshold and other is power factor. A better choice of CH improves the performance of network and also helps in inproving optimality and functionality of the network.

## III. PROPOSED METHODOLOGY

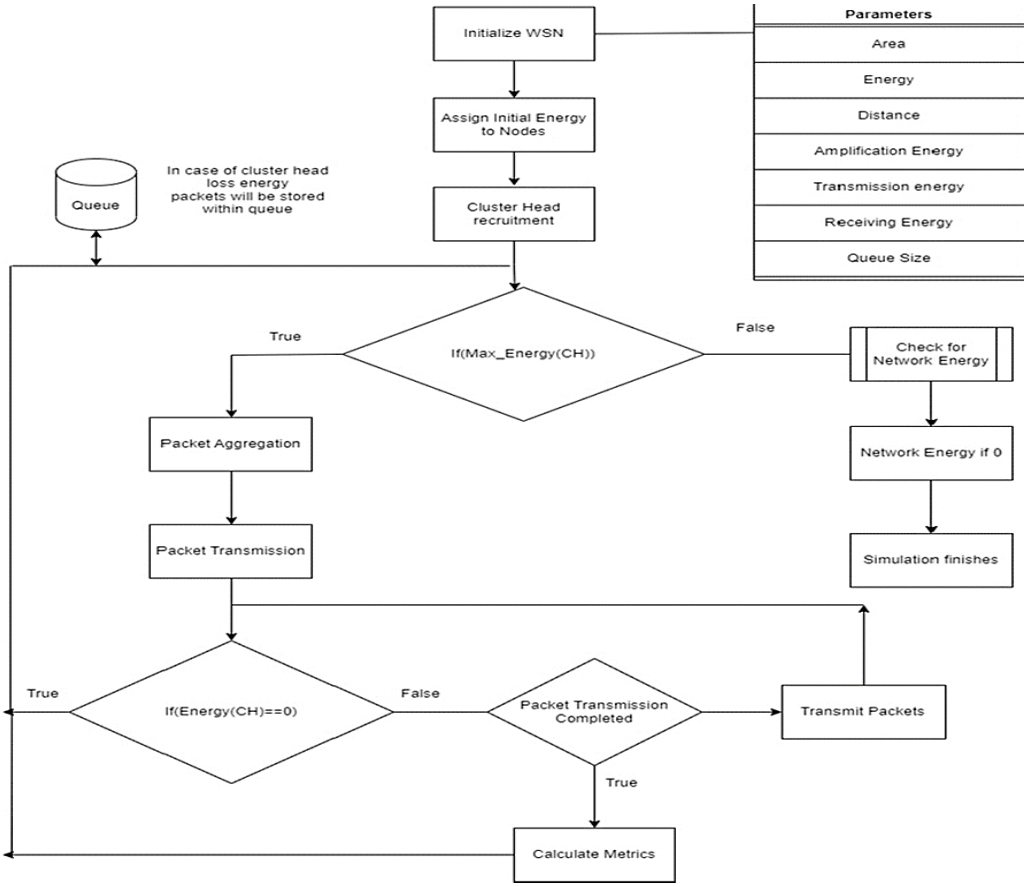


***Figure 1:- Proposed Methodology***

The methodology of the proposed work consists of initialization of the network. The network initialization parameters are given within table 1. The methodology of the proposed work is given as above and explained as under. The description of the proposed methodology includes initialization of wireless sensor network. The metric initialization includes initial energy of the network, distance between nodes, distance between the nodes, amplification energy, Transmission energy, receiving energy and size of the queue. At first, cluster head recruitment process is carried out. Cluster head selection is based out of the maximum energy possessed by the nodes. Once the CH is selected, it will be used to transmit the packets towards destination. All the packets will be aggregated at the CH. CH in case loose energy then packets will enter the queue. Packets will be fetched from the queue and then transmitted towards the destination. Once network looses energy, then throughput will be evaluated as the final result.

## IV. PERFORMANCE ANALYSIS AND RESULTS

The results corresponding to different protocols are analyzed within this section. At first, simulation setup is provided indicating parameters required for conducting simulation.

***Table 1:- Network related parameters***

| Parameter | Value | Meaning |
|---|---|---|
| Required Energy | 5 Joules | This is a starting energy |
| Area | 10x10= 100m$^2$ | Total area of the network |
| Energy for filtering | 0.3 J | Energy for packet classification |
| Distance between nodes | 0.5 | This is a distance between individual nodes. |

The network will perform operation at maximum level of 5000 rounds. The initial energy associated with the network is 5 J. It means in case this energy is consumed, network terminates. The distance between the nodes is 0.5 m. As the nodes are mobile, this means this distance will change over the period of time.

***Table 2:- Network Lifetime in terms of rounds***

| Framework/Protocol | Network Lifetime |
|---|---|
| LEACH | 2700 |
| SEP | 2900 |
| TDEEC | 3600 |
| DEEC | 4070 |

Lifetime of the network is highest corresponding to Distributed Energy Efficient Clustering Protocol. This is given within figure 2. Time Distributed Energy Efficient Clustering is also effective however shows little less optimization as compared to DEEC protocol.

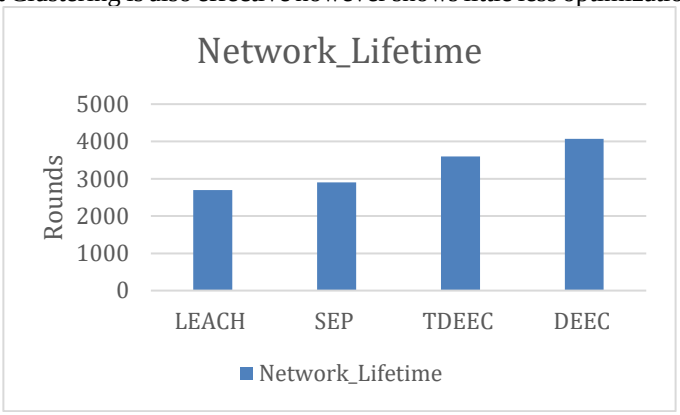


***Figure 2:- Result in terms of network lifetime***

The next parameter that is evaluated is packet to base station. This metric also contributes towards the throughput of the network. Packet to base station is maximized in case of distributed protocols. The performance of different protocols is given within table 3.

*Table 3:- Packet to base station*

| Framework/Protocol | Packets delivered at base station |
|---|---|
| LEACH | 27056 |
| SEP | 31909 |
| TDEEC | 40236 |
| DEEC | 48087 |

The visualization corresponding to the table 3 indicates that performance of the DEEC protocol is better as compared to other protocols.

The bar plot for the packet to base station is given in figure 3.

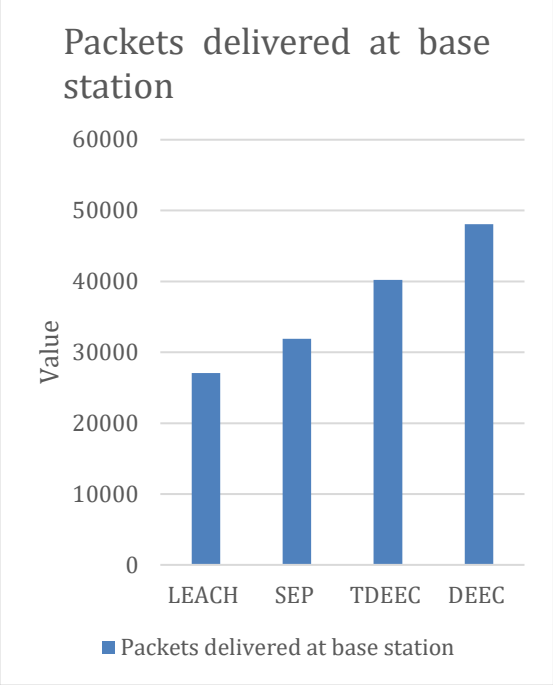


***Figure 4:- Packets delivered at base station***

Packets that are delivered at cluster head is another critical parameter to be evaluated within this research. Packets to base station is originated from packet to cluster head. Higher the packets at cluster head, more packets will be transmitted towards the base station. This parameter is specified within table 4. This parameter also contributed towards the throughput of the network. Thus, both packets to base station and packets to cluster head must be maximized

***Table 4:- Packet to cluster head***

| Framework/Protocol | Packets received by CH |
|---|---|
| LEACH | 50800 |
| SEP | 54678 |
| TDEEC | 62345 |
| DEEC | 64567 |

The plots given in figure 4 corresponds to the packets to cluster head. DEEC protocol in this case as well shows optimality. The performance of the TDEEC is not that behind from DEEC however observing timing in shifting cluster head costs extra energy consumption

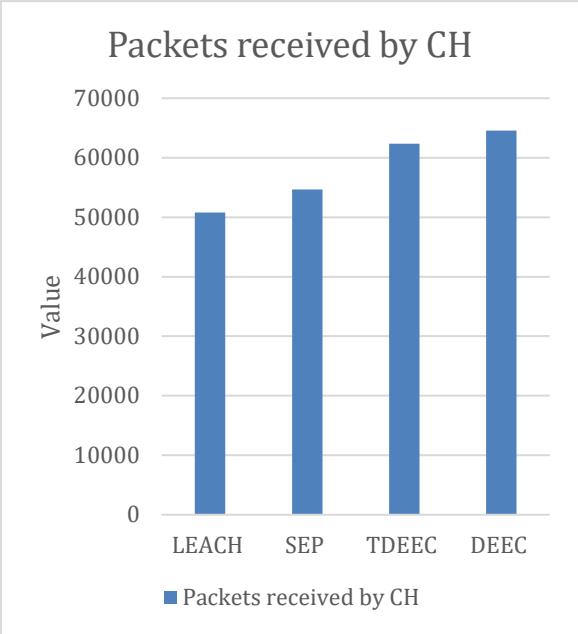


***Figure 5:- Packets received by CH***

## V. CONCLUSION AND FUTURE SCOPE

The energy consumption has to be minimized to achieve optimal network having longest lifetime. Mobile devices thus can survive over longer periods. This can be achieved by using protocols. This research work analyzes best possible protocols used to achieve optimality within WSN. From the experimental analysis, it was found that the Distributed Energy Efficient Clustering protocol performed much better as compared to the LEACH, SEP, and TDEEC protocols. To observe performance, metrics such as packets to base station, packets to cluster head, and lifetime of the network are checked. The visualization or plots elaborates the difference in performance of each protocol as compared to DEEC. The DEEC protocol outperforms other protocols by significant margin but however it doesn't employ any compression mechanism so for this particular reason packet transmission is always poor. However, It can be further improved by applying either queue prioritization or compression simultaneously, so for this particular reason the future mechanism of compression in similarity to RLE (run length encryption) can be used to further conserve the energy of sensors and also prolonging the lifetime of the network.

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