

Performance Analysis of Energy Efficient Multi-hop Clustering Base Routing Protocols in Heterogeneous Wireless Sensor Network

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Abstract: Wireless sensor networks are energy constraint networks. Energy efficiency, to prolong the network for a longer time is critical issue for wireless sensor network protocols. Clustering protocols are energy efficient approaches to extend the network lifetime. LEACH protocol is one of the basic cluster based protocol in wireless sensor network. The performance analysis of energy efficient multi-hop clustering protocols like LEACH, DEEC and EAMR are carried out by considering change in the number of nodes for same network area with respect to the time using Network Simulations (NS-2) Software. This is efficiently helps the comparative study of node death rate, energy consumption and network lifetime.

Keywords: Energy efficient Clustering, LEACH, DEEC & EAMR Protocols.

1. Introduction

Wireless sensor network (WSN) is a wireless network that consists of base stations (BS) and numbers of nodes (wireless sensors) which is shown in figure1. These networks are used to monitor physical or environmental conditions like sound, pressure, temperature and co-operatively pass data through the network. Especially for monitoring applications, a large number of sensor nodes are deployed over an area to detect certain event. The sensor node passes the detected event to the base station (BS). During the communication between base station (BS) and sensor node consumes more energy. The base stations (BS) are the gateways between end users and sensor nodes.

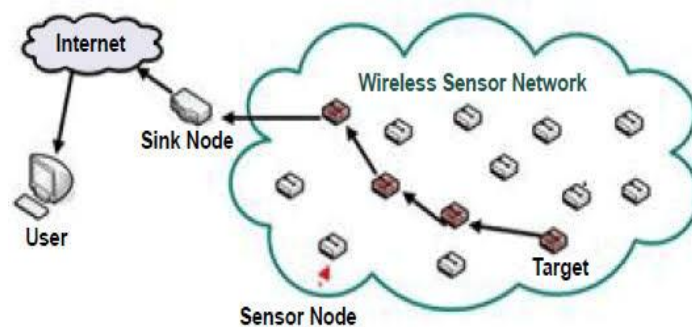


Figure 1: Wireless sensor network.

In wireless sensor network the power consumption constraint of sensor nodes has major impact on the lifetime of a sensor network.

The power source of each sensor node is limited and the nodes consume energy during data sensing, processing and communication. The sensing and processing parts consumes relatively low energy as compared to the communication. A key characteristic to evaluate the performance of WSN protocol is the network lifetime, which is depends on energy consumption in WSN [1].

To overcome this problem, cluster based transmission protocols have been proposed. In cluster based protocol, the WSN is divided into regions called as a cluster which is shown following Figure2. Clustering techniques for routing helps in reducing the energy consumption while transmitting the data from one node to another node or to base station (BS) and vice-versa.

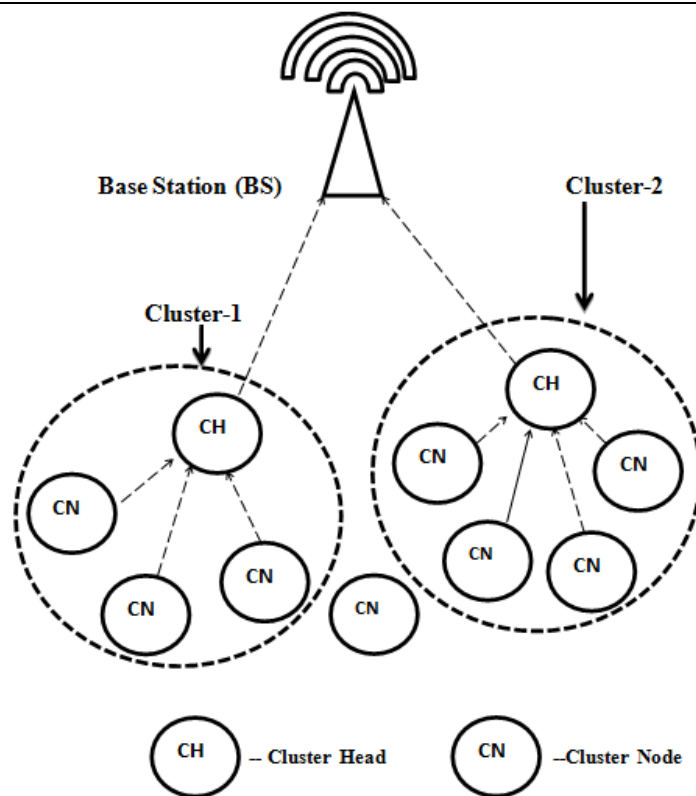


Figure 2. Clustering in Wireless sensor network.

2. Relevance

Energy is the key factor in wireless sensor network. Wireless sensor networks are energy constraint networks. By using a direct communication protocol, each sensor node sends its individual data directly to the base station and if the, base station is situated some distance far from sensor nodes then direct communication with the base station will require more transmit power from each node, this will quickly drain the battery of the nodes and will reduce the system lifetime.

As a solution, cluster based WSN protocols have been developed for lifetime maximization, energy minimization and scalability. With cluster based WSN protocols, the deployed sensor nodes are divided into clusters. A representative of each cluster called as a cluster head (CH) collects the sensed data from its clusters for transmission to the base station [1].

So that some of the well-known cluster based energy efficient protocols for wireless sensor network comes into picture. One of the most popular clustering protocol is the Low Energy Adaptive Clustering Hierarchy (LEACH) which handles the distributed information from the clusters. Low Energy Adaptive Clustering Hierarchy (LEACH) randomly selects a few sensor nodes as cluster heads (CHs) and rotates this role to evenly distribute the energy consumption among the sensors in the network. LEACH, a cluster-head can cause a failure because of energy deficiency. Re-clustering is done in LEACH, so Lifetime of a sensor network and its energy efficiency are thus greatly affected by the frequency of re-clustering [4].

To overcome this drawback Energy Aware Multi-Hop Routing (EAMR) Protocol is used for reduction of overhead by employing fixed clustering and reducing the number of cluster head changes. Also the overhead reductions significantly improve the lifetime as energy consumption [1]. Another protocol is the Distributed Energy – Efficient Clustering (DEEC) algorithm is implemented. In Distributed Energy-Efficient Clustering (DEEC), the Cluster head selected through a probability function based on the ratio between the residual energy and average energy in the network. The sensor nodes which have high residual energy selected as a cluster head [2].

3. Literature Review

3.1 KorhanCengiz and Tamer Dag, 2017 [1].

In this paper, Energy Aware Multi-hop Routing (EAMR) protocol has most significantly achievement of reducing the excessive overhead. The reduction of the excessive overhead typically seen in most of the routing protocols by employing fixed clustering and reducing the number of cluster head changes. The performance analysis indicates that overhead reduction significantly improves the lifetime as energy consumption in the sensor nodes can be reduced through an energy-efficient protocol. In addition, the implementation of the relay nodes allows the transmission of collected cluster data through inters cluster transmissions. As a result, the scalability of a wireless sensor network can be increased. The usage of relay nodes also has a positive impact on the energy dissipation in the network. Thus EAMR is suitable for a green WSN protocol.

3.2 Maddali M.V.M. Kumar and Dr.AparnaChaparala, 2017 [2].

In this paper author says that the Wireless Sensor network normally consist of the main cluster head connected with all other nodes. The selection of the Cluster head is the main problem in which the energy requirement is large because of its nature of collecting the data's from all other nodes. The cluster head requires the largest energy so that it can accommodate the whole network. Several Algorithms were proposed for this problem and new proposed algorithm is Dynamic Energy Efficient Distance Aware (DEEDA) for the Energy Efficient Cluster selection mechanisms in the Wireless Sensor Networks. The primary principle is selection of cluster head is based on the principle of RED (Residual Energy and Distance) algorithms.

3.3 WalidAbushiba,Princy Johnson , SaadAlharthiand Colin Wright 2017 [3].

In this paper, WSN protocols, clustering based hierarchal routing protocols are given more consideration because of their improve scalability. In particular, sensors are battery-powered, often limiting available energy, which is not changeable in most of the situations. One of the most common energy-efficiency sensor networks protocols is Low Energy Adaptive Clustering Hierarchy (LEACH) as source. In this paper, the performance is evaluated for LEACH and DEEC based on the most critical metrics in WSNs, such as: energy-efficiency (energy consumption), and network lifetime.

3.4 Junling Li, Danpu Liu, 2016 [4].

This paper proposes a novel energy-aware distributed clustering routing protocol for EH-WSNs, it takes the node current residual energy and the harvested energy in a short term prediction horizon into cluster heads election process of the distributed clustering routing. A neural network based solar energy prediction model is exploited to make the protocol energy-aware. Nodes with higher residual energy and stronger energy harvesting capabilities thus have higher probability of being cluster heads. The proposed routing algorithm is compared with LEACH (low-energy adaptive clustering hierarchy) in terms of the number of awake nodes and network throughput.

3.5 Saad A. AlharthiandPrincy A. Johnson, 2016 [5].

In this paper, a hybrid threshold sensitive and two-level heterogeneous LEACH (HT2HL) protocol is proposed. HT2HL combines the operation of heterogeneous LEACH and TEEN (Threshold sensitive Energy Efficient sensor Network) protocols. HT2HL has been simulated in MATLAB and the results are compared with the known heterogeneous protocols SEP and DEEC for two-level heterogeneity. The metrics used in the performance evaluation are stability period in which the first node dies (FND), network lifetime which gives the number of alive nodes until half of the nodes die (HND) and when the last node dies (LND), the remaining energy and data rate over the network (throughput).

3.6AnkitSolanki and Prof. Niteen B. Patel, 2013 [6].

In this paper evolution of routing protocol is described with its important classification for wireless sensor network. Energy efficient and reliability are two most important factors while designing the routing protocol. The survey of different classification of routing protocol is done with the description of classification proposed into four main schemes: Network Structure Scheme, Communication Model Scheme, Topology Based Scheme and Reliable Routing Scheme. Developed routing protocol named as LEACH-SCH is a multi-clustering type of routing protocol for some definite wireless sensor network.

4. Proposed Work

4.1 Scope

In wireless sensor networks (WSNs) clustering has greatly contributed for overall system scalability, lifetime, and energy efficiency and stability. In a clustering scheme the sensor nodes in a WSN are divided into various regions and they are allocated geographically adjacent into the same cluster according to some set of rules. Under a cluster structure, sensor nodes are assigned different status such as cluster head or cluster member. A cluster head normally serves as a local coordinator for its cluster, performing intra-cluster transmission arrangement, data forwarding and so on. The cluster heads can consolidate the data and send it to the data centre as a single packet. This intra-cluster transmission distance between the sensor node (cluster member) and cluster head should be very small as it plays an important role to minimizing the energy consumption by each node.

Thus one of the basic clustering protocol proposed for wireless sensor networks was Low Energy Adaptive Clustering Hierarchy (LEACH) performs heterogeneous network. To enhance its performance, a Distributed Energy Efficient (DEEC) Protocol and Energy Aware Multi-hop Routing (EAMR) Protocol is to be implemented. The comparison of all these protocols will help in evaluating the energy consumption, number of dead node, network lifetime, scalability, number of overheads and data units received at base station.

4.1.1 Low Energy Adaptive Clustering Hierarchy (LEACH)

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first hierarchical, self-organizing, adaptive cluster-based routing protocol for wireless sensor network. The clusters are formed on the basis of signal strength which is shown in the figure 3. LEACH protocol has two phases namely, set-up phase and steady state phase.

a) Set-up Phase:

In this phase, the cluster heads (CHs) are chosen and according to that clusters are organized. At start of set-up phase, each node in the network picks a random number between 0 and 1. If the number of particular node is less than threshold value, the node becomes a cluster head (CH) for current round.

b) Steady state Phase:

In this phase, the data is sent from cluster nodes (CNs) to the cluster head (CH). The nodes in each cluster (C) can exchange information with the cluster head (CH) via single hop transmission. Cluster head (CH) collects all the data and sends them to base station (BS). The following figure 3 shows that the cluster formation in Low Energy Adaptive Clustering Hierarchy (LEACH) protocol.

LEACH includes distributed cluster formation. In this a randomized rotation of the cluster head's role is allowed for reducing energy consumption within a cluster and to distribute the energy load evenly among the sensors in the network. In this protocol cluster formation is done in set-up phase and data transfer in steady-state phase. Every node gets a chance to become cluster head in consecutive rounds but while practicing this there can be a possibility of a cluster head being elected in the border area as in wireless sensor network.

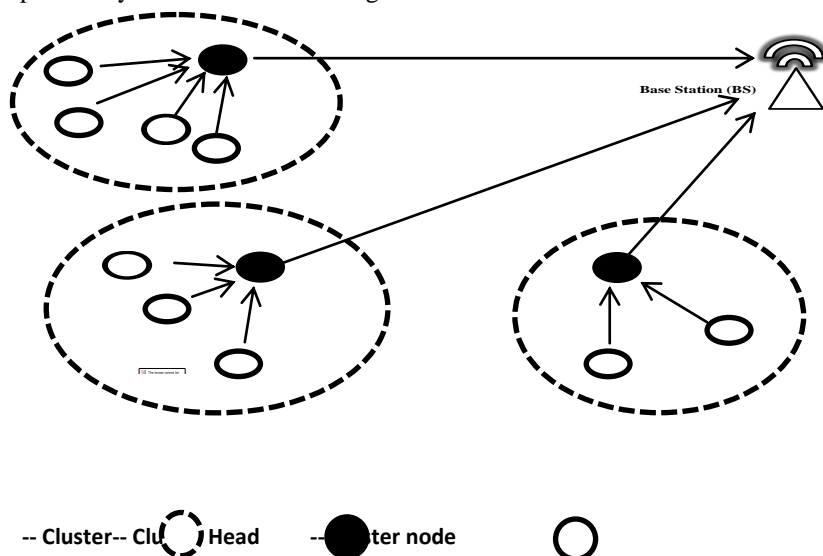


Figure3. Cluster formation in LEACH Protocol

4.1.2 Distributed Energy Efficient Clustering (DEEC)

The cluster heads are selected through a probability function based on the ratio between the residual energy of each node and the average energy in the network. The sensor nodes which have high residual energy are more likely to be selected as cluster head. The operation of clustering base routing in Distributed Energy Efficient Clustering (DEEC) protocol shown in figure 4.

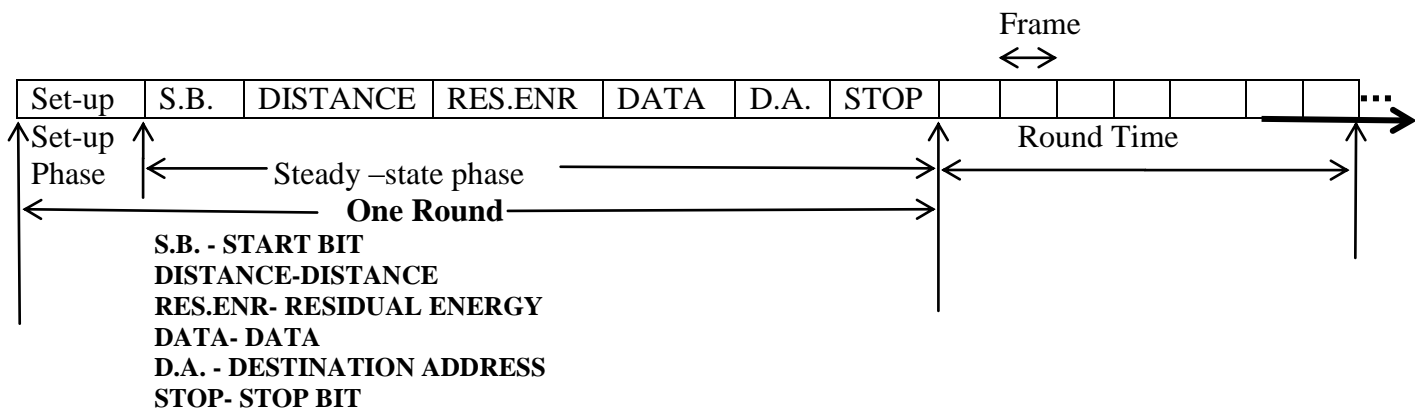


Figure 4. Operation of clustering routing.

There are two phases namely set-up phase and steady state phase. These two phases combined to form one round. In which, set-up phase select the cluster head (CH) through probability and steady state phase is broken into number of frames. The cluster nodes (CNs) send their data to the cluster head (CH) once per frame during their allocated transmission slot. The resultant data are then sent from cluster head (CH) to base station (BS).

4.1.3 Energy Aware Multi-hop Routing (EAMR)

In Energy Aware Multi-hop Routing (EAMR) protocol uses fixed clusters to provide communication between a sensor node and the base station. The purpose of using fixed clustering is to reduce the energy consumption overhead needed to form new clusters at every transmission round which is a common procedure for most WSN routing protocols.

Under the EAMR, the clusters near the base station transmit their collected data to the base station directly through their cluster heads. On the other hand, the remaining cluster heads forward their collected data to the relay nodes for a multi-hop transmission towards the base station. The employment of the multi-hop approach not only increases the scalability of the protocols such as LEACH and its variants but also decreases the overall communication.

The operation of the EAMR protocol is composed of two major phases: set-up phase and steady-state phase. During the set-up phase, fixed clusters are formed by electing the initial cluster heads, determining all remaining sensor nodes cluster memberships and choosing the initial relay nodes. With the steady-state phase each cluster head starts to collect data from its own cluster for transmission to the base station either directly or indirectly are using the relay nodes. In addition to data collection and transmission, cluster head and relay node change decisions are also implemented during the steady-state phase, if needed.

Figure 5. represents the flowchart of proposed Energy Aware Multi-hop Routing (EAMR) protocol.

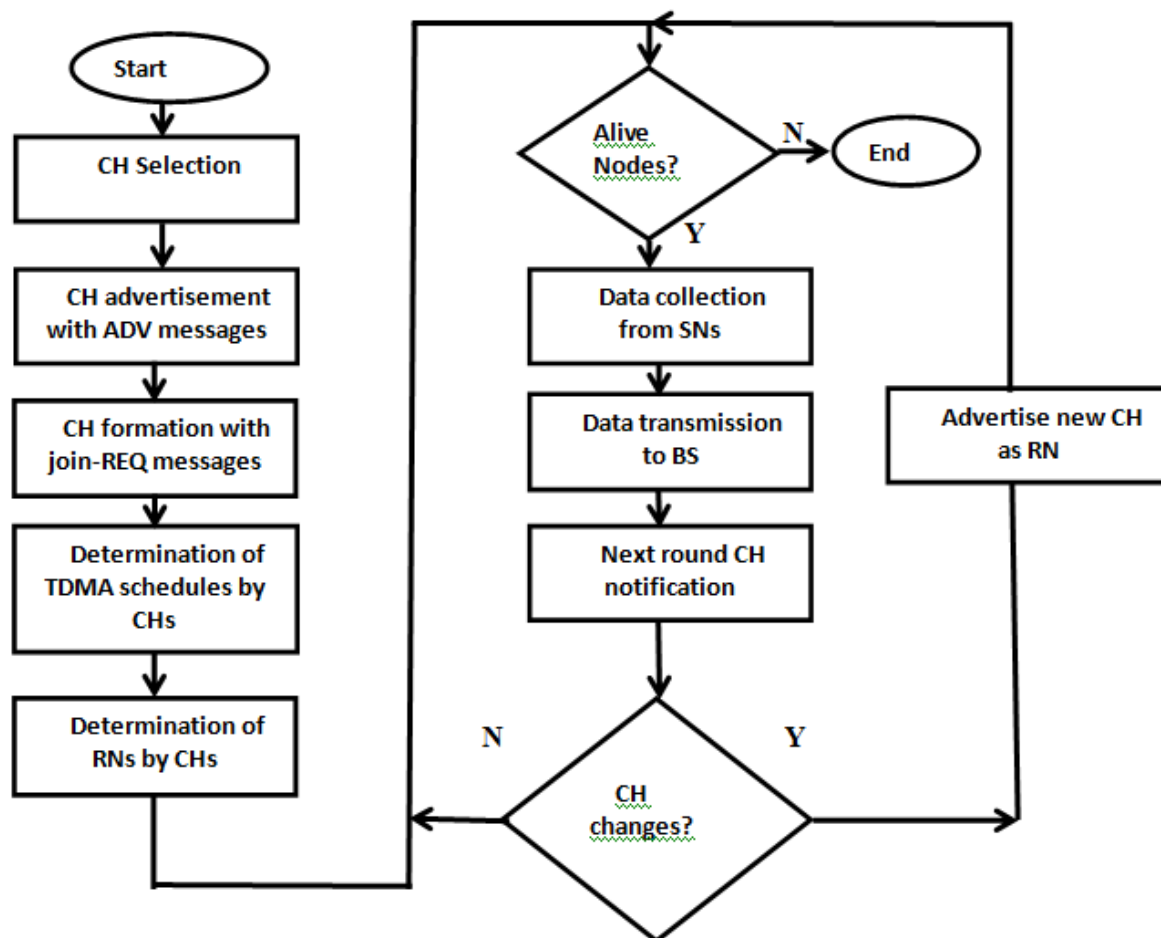


Figure 5. EAMR flowchart

4.2 Research Methodology

The proposed research work deals with following steps:

- A) The performance analysis of Low Energy Adaptive Clustering Hierarchy (LEACH), Energy Aware Multi-hop Routing (EAMR) and Distributed energy – efficient clustering (DEEC) considering following simulation parameters,

Parameter	Value
Sensor deployment area	50*50 m ² and 100*100 m ²
Coordinates for Base station	(150,50)
Number of Nodes	50 and 100
Initial Energy of each node	2 Joules
Packet size for data	6400 bits
Packet size for control information	200 bits
Transceiver energy	50 nJ/bit/signal
Energy per bit	5 nJ/bit/signal
Threshold Value (ThV)	0.05J

- B)** Implementation of Energy Aware Multi-hop Routing (EAMR) protocol and Distributed Energy Efficient (DEEC) and their performance is compared with basic Low Energy Adaptive Clustering Hierarchy (LEACH) on the basis of the following parameters,

- i) Network Lifetime
- ii) Number of dead nodes
- iii) Energy Consumption
- iv) Scalability
- v) Data transmission to the base station (BS)

5. Conclusion

This paper discusses the performance analysis of basic LEACH protocol compared with EAMR and DEEC protocols on the basis of network lifetime, energy consumption, scalability, node death rate and stability of network, which gives better energy efficiency to enhance the network lifetime.

6. References

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