A Review on Energy-Efficient Mechanisms for Cluster-Head Selection in WSNs for IoT Application

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Abstract. Internet of things (IoT) incorporates sensing, connectivity, networking, or cloud computing technology into a wide variety of control fields. The wireless sensor networks (WSNs) are better placed for IoT applications. Developing an energy-efficient (EE) cluster head (CH) system is of great importance to enhance the network life of WSNs. WSNs are now becoming an emerging research field through technological growth. Sensors are integrated to gather the data from which this is known in a collective of clusters. CH maintains a process of transmission that requires high energy. This review paper discusses various techniques, advantages, disadvantages, objectives, and different methods for EE clustering techniques in WSN on IoT-related research. This study is beneficial to identify the problems associated with EE-CHS in WSN and how to resolve it.

1. Introduction

IoT consists of allowing things or non-computers to understand, see, think, compute or behave, enabling them to communicate throughout the decision-making process or coordinate among themselves. Two terms are: 'Internet' or 'things.' In brief, it keeps us wise and makes decisions implemented in several ways. They turn artifacts or instruments into successful computation, coordination, cooperation, and important decisions. They are passive observers. However, IoT provides essential services focused on fundamental technologies like powerful embedded sensors, modern paradigms, data processing, lightweight connectivity, and web protocols, which introduce the need for technical standards and protocols like connectivity to resolve the ensuing challenges [1].

IoT is focused on WSNs in which computers are linked to the Web without human intervention or interact with each other. WSN, as well as IoT security, is a critical problem that is not simple. Firstly, the WSN and IoT battery-powered devices usually are cost-effective, but with limited resources. Advanced safety methods, which require high power, are in-deed not appropriate. Instead of unified protection and control systems, the too complicated design of these networks is made ineffective. In addition to the essence of wireless communication, each node is likely to be physically identified [2].

WSN means a small-scale sensor collection node used to monitor, think, obtain, and process data around an application — that is to say, focus phenomena [3]. The resource-needng and battery-control, storage, computing, data size and accessible bandwidth nodes at the same time are highly dependent. These nodes are usually fixed and often left to track and record the details, as a single node, in a remote and humanly unreachable stage. The term "wireless" has become a non-specific and
A commonly used word for representing communications utilizing electromagnetic waves to transmit a signal along part or entire communication line [4]. Clustering is a key technology used by reducing energy consumption to extend sensor network life. Forming of clusters allows a network sensor to be scalable. It is often known as the CH, the cluster member. The sensor in the cluster may select a CH or can be reassigned by the network builder. Different clustering algorithms have been designed especially for the WSN for scalability and efficient communication. For efficient WSN routing, the concept of cluster-based routing is also used. The key strategy for energy conservation is clustering [5]. For the performance of clustering algorithms, the CHS is crucial. It is based upon the number of cluster members, overall intra-cluster heads gap or total distance from CHs to the base point. When the CHs are smaller, the overall gap between CHs and BS reduces while the intra-cluster cumulative contact gap increases. The average intra-cluster contact gap is decreased if the number of CHs is higher, but the overall gap from CHs to base stations is increased [6].

A novel method for WSN lifetime estimation is introduced in which functions on combined firmware images and models the difficult behaviour of batteries. This method overcomes two main limitations over other methods that firstly rely on theoretical methods or high-level protocol implementations and most often overlook low-level constraints such as drivers, hardware, etc. which have a major effect on network lifetime and secondly they use an ideal battery model which overestimates the network lifetime due to its constant voltage and linear nature. The method is divided into four main steps i.e., Firmware design, firmware emulation, lifetime prediction, and design iteration. Network lifetime was increased by a factor of three in one of the case studies using this method without compromising on performance [7].

2. Internet of Things (IoT)

IoT is critical in numerous healthcare, transportation, robotics, agriculture, automobiles, and disaster response. New tasks would be required to enhance the quality of life, enterprise applications, and smart homes. The emerging IoT architecture is an example of connected homes comprising temperature, heat, and air conditioning control remotely operated. Future extension devices such as food, power, safety figures, and car driving may be utilized. These applications impose additional challenges and requirements for standards to deal with diverse applications as shown in Figure 1[1].

![Figure 1. Basics of Internet of Things [1]](image)

2.1. IoT Challenges

Availability: To provide anywhere and at any time for customers, IOT availability must be realized at the hardware and software level. Platform compatibility relates to the capacity of IoT systems to seamlessly provide functionality across all locations.
Security Concerns: If IOT systems are not protected correctly, cyber-criminals can use them as input points to damage other network devices. This adds to the public destroying sensitive knowledge.

Privacy Issues: The devices collect user information, which is only recognized to the parent group to evaluate, without their authorization. The societal acceptance of IoT apps encourages citizens to allow such systems to gather their details without knowing potential effects [7].

Inter-operability standard issues: An exchange of information between all interconnected IOT devices should occur in the ideal environment. However, the real situation becomes more complicated and relies on various contact protocols between such tools. There are lots of applications associate with the IoT, as mentioned in Figure 2.

Smart Parking: The new sensor or switches for vehicle detection to be entered in the car park. Smart parking provides robust traffic control strategies that save time and fuel for motorists [7].

Smart Home: Smart Home is the top internet platform for stuff on all calculated networks. Various electrical appliances around us, including oven, refrigerators, heaters, air conditioners, ventilators, and lamps, are accompanied by us. In these systems, actuators and sensors may be mounted for ample energy usage and comfort in existence.

![Diagram of IoT Applications](image)

**Figure 2.** Applications of IoT
Smart City: Smart City ranges from road control and water delivery, waste management, public health, and climate tracking to a broad range of applications. The fact that several ideas from Smart Design aim to mitigate citizens' real suffering in cities nowadays is boosting its success. Smart City IoT systems eliminate traffic congestion, minimize noise and emissions, and allow communities to become cleaner.

Smart Cars: Smart M2M communications and Smart Cars, in particular, may support improving avoidance of accidents. Such driverless vehicles do not only have protection but save energy, rising driving tension, and so on.

Smart Water Supply: Smart cities must track water sources to ensure that people and companies have sufficient access. WSNs provide cities with the technology to monitor their tube systems more accurately and determine their greatest risk of water loss. Cities that solve sensor application water leakage issues produce substantial investment savings [8].

3. Wireless Sensor Networks (WSNs)
In recent years, WSNs have attracted the interest of research groups, motivated by a combination of theoretical and functional problems. The incremental WSN research has studied many different systems, relaying sensed data to distant locations and gathering information from the atmosphere via wider sensor node networks. WSNs are mostly used for restricted bandwidth and delay tolerance in applications ranging from civil, military, health, or environmental care control. WSN Node contains low power sensors, an embedded processor, a communication channel, and a power module. Signal data are collected and processed by an integrated processor from sensors. The sensor function provides a measured reaction to changes in physical temperature, humidity, objects (e.g., CO₂) as shown in Figure 3 [9].

Figure 3. Wireless sensor networks (WSNs).

3.1. Advantage
- In extreme and hostile conditions, WSNs have been applied where wired networks are not feasible.
- Simple running of the WSNs.
- Quick installation of WSNs.
• WSN’s increased performance, greater energy output, and high(er) channel bandwidth over static WSNs

3.2. Disadvantage
• The only drawbacks of WSNs have restricted processing and networking capabilities.
• Low battery capacity, restricted storage, and retrieval capacities, susceptible to security threats and
• Restricted contact capacity.

3.3. Characteristics of Wireless Sensor Networks
• Frequency cap usage for battery nodes
• Failure to handle node faults
• Other node stability or node heterogeneity
• Large delivery scalability
• Capacity to ensure strict conditions for the environment
• Easy to operate
• Design of cross layers [10].

3.4. Applications and its Objectives
Table 1 describe the applications and their objectives of WSNs with IoT.

| Applications               | Objectives                                                                 |
|----------------------------|---------------------------------------------------------------------------|
| Precision Agriculture      | Senses temperature and pressure parameters and guarantees a correct seed    |
|                            |   cultivation climate.                                                    |
| Environmental Monitoring   | Since all the environmental criteria and prevent disasters such as a gas    |
|                            |   explosion, inundation, forest fire.                                     |
| Vehicle Tracking           | helps avoid obstruction in traffic and parking networks as well as car     |
|                            |   positioning.                                                            |
| Health care Monitoring     | Helps to track physiological signals in real-time and eliminates the danger |
|                            |   to their lives.                                                         |
| Smart Buildings            | Small energy use and to extent security for homes and buildings           |
| Security and Surveillance  | Helps to detect enemies early and to track vehicles                      |
| Animal Tracking            | Monitors the animal's vibration and movement by optimizing the recovery    |
|                            |   conditions and controlling the stress level of the animal [11].          |

4. Cluster Head Selection
The clustering method is the division into a sequence of coherent components, known as clusters, of a collection of data (or objects). This allows users to consider standard form or classification inside a dataset. A decent clustering technique will yield high-quality clusters, in that similarity between intra-class and between-class is high. The quality of the clustering outcome depends both on comparison as well as the application of the method. The consistency is also calculated by the clustering system's capacity to locate any or the whole cached pattern [12].

4.1. Cluster-Based Routing and CHS
Hierarchical routing is based on cluster-based routing protocols. This protocol organizes nodes into clusters and chooses higher-energy nodes as cluster heads. Cluster design includes several parameters, including the number of clusters and communication between clusters, Nodes and CH mobility, Node types, CHS and multi-level clustering. Energy and network lifetime are major concerns for designing
the clustering. Clustering organizes a network into a connected hierarchy, but balances network load and increases system lifetime as shown in Figure 4.

![Cluster Head](image)

**Figure 4. Energy-Efficient Cluster Head Selection**

Low-energy adaptive clustering hierarchy (LEACH): LEACH cluster formation is in a distributed manner. In this algorithm, CH is rotated among all nodes, and any sensor node can be the head randomly during each round. LEACH is a specialized hierarchical clustering protocol for minimizing energy dissipation in the network. In this protocol, cluster set up, and operation is well coordinated with localized control, and CH selection is based on a random rotation. Local compression techniques are used for reducing global communication from CH to the base station [12].

Threshold sensitive SS sensor Network protocol (TEEN): TEEN is designed for reactive networks. In this protocol, closer nodes form the cluster and repeats until it reaches the base station. The CH broadcasts a hard threshold and soft threshold values to the other nodes in their cluster in every round. The hard threshold value indicates the sensed attribute value, and beyond this value, the node transmits the value to the CH. This is called the sensed value [12].

Power-Efficient Gathering in Sensor Information Systems (PEGASIS): PEGASIS is a chain-based protocol and a single node in the chain is applied to send data to BS. Each node can connect to its closest neighbour, and the chain is made greedily. Then, data is collected from node to node and moved in a chain. Designated node aggregates and transmits data to BS. CHS in this protocol is not considering about energy of nodes and location of BS [13].

Distributed Information storage and collection: Data storage is a major component of WSN. Storage can be local or distributed within the network. Distributed Data storage is the major component of storage that protects the critical data from the failures. The authors proposed a protocol called DISC for distributed storage and collection in the wireless network. A distributed Information Storage and Collection (DISC) protocol selects the backup node randomly. Bloom filters are used to store the data inside the network.

Passive Clustering for EE Conservation (PCEFC): In PCEEC, six states are defined: dead, initial, ordinary, cluster head ready, gateway, and alternate cluster head. Initially, all nodes are in the first state. This state continues until the time node receives a packet. Once the node receives the packet, it checks for the state of the sender. If the sender is not a cluster head, the receiver switches to CH ready otherwise switches to the gateway or ordinary node. It switches to gateway state in the case of several clusters heads greater than or equal to no. of gateways [14].

Fuzzy based enhanced CH selection (FBECS): WSN is grouped into clusters for optimal data collection about energy dissipation. In this document, the authors introduced a Fuzzy based balanced cost algorithm for CHS. The main objective of the algorithm is balancing the load by select-ing the
best node as a CH. The fuzzy logic algorithm uses the following inputs: the leftover energy level of the sink, ability to harness the energy, vicinity of the head to the nodes while creating eligibility index [13].

4.2. CH Selection Methods

Topology based CHS scheme: The purpose of CHS based on topology is to classify the node position in the cluster. These characteristics should be avoided (mobility of the node from one cluster to another, division of the cluster). If the chosen CH cannot perform its function, it took a certain amount of time to reflect the CH and restart clustering to stop the process.

Coverage Preservation based CHS: The function of the CH is equally distributed among the nodes present in the WSN in probabilistic approaches. This means uniform distribution of the energy consumption of nodes. This helps the network to extend its existence. The main objective of CH selection in WSN is to have an extensive area covered by CH. The CH can efficiently handle the whole group.

CHS is based on counting: Take into account that "M" sensor nodes (SN) are in a WSN. Each sensor node is provided a unique No. The number starts from 0 to M-1. This unique number serves as the SN's identifier. Suppose these sensors are integrated as a cluster.

5. Energy Efficient in WSNs

As the resources and the service life of every WSN Routing Protocol are two main restrictions, much work has been done to achieve the objective. It is difficult to choose an EE routing algorithm that evenly distributes the load on the network.

5.1. Energy Efficient Clustering Scheme (EECS)

EECS is a distributed clustering algorithm that gathers periodic WSN data, energy-efficient, and load-balances applications. The EECS algorithm is based on features of the most popular LEACH classification algorithm. This algorithm uses CH and BS with single-hop contact. During creating a cluster, BS sends a "hi" message to all nodes at a certain amount of control. The nodes will measure the distance to BS dependent on signal intensity obtained after receiving the "hello" message.

5.2. Energy-Efficient Heterogeneous Clustered Scheme (EEHCS)

An EEHCS, is an EE, heterogeneous clustering framework for WSNs focused on the weighted probability of each node deciding to become residual energy CH for each node. The algorithm starts with clustering nodes in a heterogeneous network, which initially has different energy content. Many of the sensor nodes here have more energy capacity than ordinary network sensor nodes. Authors propose three types of sensors, super nodes, advanced nodes and normal nodes used in the network.

5.3. Hybrid-Energy-Efficient Distributed

The CH is periodically picked by a distributed Mind hierarchic energy-intensive clustering protocol. The energy of the sensor node is a parameter for choosing the cluster ends. Lifetime is also improved in this protocol by distributing energy throughout the network. Following a sufficient amount of runs, the CHS process is completed. Heed protocol allows single-hop communications among CH and BS.

5.4. Energy-Efficient Level Based Clustering Routing Protocol (EELBCRP)

EELBCRP, a protocol for WSNs, is an EE level based clustering routing protocol. This protocol considers dissimilar power levels at the base station and the network is divided into ring circles. The core theory of CH is the residual energy of each node and the interval between nodes and base stations [14].

6. Literature Survey

Panchal et al. (2020) proposed an algorithm for stabilizing the creation of clusters in residual energy based on LEACH (RCH-LEACH). WSN has a primary duty of saving electricity, and CHS plays a
significant part. The CHS is focused on various parameters such as node capacity, Euclidean distance, and randomness. This algorithm uses several other parameters for selecting CH, including threshold power, residual node energy, or optimal cluster size. Compared to LEACH and E-LEACH algorithms, RCH-LEACH improves the network life by FND (First Node Die) (15% or 10% rise compared to FND). We have shown that the number of network clusters in RCH-LEACH stagnates relative to older algorithms [15].

Lipare and Edla (2019) suggested that a fuzzy inference system is useful to select appropriate CH. Flow variables are the distance from BS, node as well as the energy of the sensor node, while the "competition radius" and "size" are two flow-based output variables. CHs are selected based on 'competition range' values. The design of the cluster is based on the 'size' values. At the nearest distance and available CH area, the sensor nodes are allocated to their respective CH. The solution is more effective than LEACH and EAUCF under assessment conditions such as energy usage, active sensor nodes per process, and network stability. [16].

Chit and Zar (2018) explained the LEACH protocol, which is famous for its grouping method, indicates energy efficiency. The clustering is split into two main stages: CHs to build phases and clusters. The set of CHs is the most important. LEACH has an early dead node problem, as it selects the CH without taking residual energy into account in each node. Therefore, this paper proposes to boost WSN's service life using the residual power and BS distance (BS) parameters of the LEACH protocol and calls the RED / LEACH protocol proposed. RED: LEACH has two parameters to improve the service life of the network in WSNs: in each Node and Remoteness at BS in CHSs, resident power is in contrast to initial LEACH results in circular nodes and circular nodes. [17].

Abushiba et al. (2017) suggested that the Sensors are battery-powered and often restrict the amount of energy usable, something that cannot be modified in most situations. LEACH is a frequently used protocol of energy efficiency sensor networks. Authors proposed CH-leach in this article. They proposed a schedule and test architectures—the success by study and simulation. The assessment was based on the most critical WSN metrics: energy efficiency (energy consumption) or lifetime network. The estimation or comparison with current approaches indicates that our planned CH-leach's energy usage has been popular over DEEC or LEACH. At 91 percent and 43 percent greater than LEACH and DEEC, respectively, the average net-work lifespan is improved. [18].

Rajput, and Babu (2017) proposed that HC is more EE than flat routing under WSN protocols like LEACH. In this article, Authors recommend the ICHS Approach. The benefit of unified protocols is that the CHs are chosen without many resources. ICHS output is tested with a MATLAB simulator. The simulation results show that ICHS increases the survival potential of the node relative to other standard protocols [19].

Krishnakumar and Anuratha (2017) explained the proposed solution strengthens LEACH's threshold function but gives demonstrated distance energy efficiency and the number of adjacent node metrics. Power amplification to improve network efficiency for high voltage selected for the preferred chamber. The current model tests the number of live nodes and residual capital in a network based on distance metrics. The simulation results indicate that the scheme proposed has a strong impact on the existing WSN approach [20].

Sony et al. (2015) studied and showed that LEACH is efficient WSNs protocols. To change the LEACH protocol even more efficiently resources, few changes have been made, such as CHS, Cluster Members' allocation of the time break period, and long-distance hop multihop contact. In this article, they suggested the LEACH Protocol adjusted for narrow network areas and the LEACH multihop protocol adjusted for large parts of the network. Simulation is rendered on LEACH, LEACH modified, or LEACH multihop updated procedure. Results indicate that the LEACH changed network is longer than the LEACH protocol [21].

Ghasemzadeh et al. (2014) explained LEACH is one of the most common clustering protocols to ensure the EE of the sensor nodes. Almost all of the revamped LEACH interface ensures that the CHs are not distributed equally across the network. To choose CHs based on three parameters, authors plan to use the Bayesian Network Model (BN), the BN-EACH proto-col. This model determines the likelihood of CH for every sensor node. A competitive zoning method and greedy approach have selected appropriate CHs to delegate cluster heads equally. Simulation results, compared to the
LEACH protocols LEACH-C and WEEC, which are LEACH improvements, suggest that our protocol offers a pro-position of energy-sensor equilibrium for sensor nodes and expands network life and FNDs from the above protocols [22].

Gao and Li (2013) described the disruption of the LEACH procedure. The distance is selected randomly without parameter in the LEACH energy node. There may be evidence of the unbalanced consumption of energy that limits the life of the WSN. Dynamic Cluster LEACH (DCL) protocol is now being implemented based on the LEACH. In the first place, all nodes are grouped by location, and each group chooses a CH, which means that the network area of CHs is uniformly spread. Moreover, more energy utilization node capacity is considered a big factor in selecting CHs by WSNs. The results suggest that DCL increases energy efficiency and enhances the network's working life. [23]. Table 2 shows the discussion of different approaches given by various authors for Efficient cluster head selection techniques.

7. Analysis

It has been shown by study of different papers that there are different clustering techniques available in Wireless Sensor Network and there are different methods to improve the life span of the network, reduce energy consumption and efficient node selection for clustering the nodes and leader of different cluster. Table 2 shows related work in tabular form.

| Authors          | Year | Approach                | Purpose | Outcomes                                                                 |
|------------------|------|-------------------------|---------|--------------------------------------------------------------------------|
| Panchal et al.   | 2020 | Residual Energy-based CHS in LEACH (RCH-LEACH) algorithm | To secure cluster creation in network for IoT software networks | Improves LEACH's threshold function with distance and number of neighbouring nodes, improves energy consumption and efficiency of the network. |
| Lipare & Edla    | 2019 | fuzzy inference system | To select the appropriate CH | Enhances energy consumption, active sensor nodes per round while networking stability and network life. |
| Liu et al.       | 2018 | fuzzy CHS algorithm     | Improve EE and extend the life of the network | Better network life and electricity use. |
| Saeid et al.     | 2018 | Hesitant fuzzy method   | Reducing energy use and choosing CH | Clustering can be used to reduce energy use in WSNs. |
| Garcia-Najera et al. | 2018 | multi-objective approach | For optimal CHS and multi-target CHS problem resolution | Minimize the distance from the head of clusters to their headquarters, (ii) the distance from their headquarters, and (iii) the leaders' residual energy. |
| Babu et al.      | 2017 | dynamic CHS (DCHSM)     | Extend the network existence of the IoT consumption or network life for IoT networks higher than current algorithms | Performs in energy consumption in the potential structure procedure. |
| John et al.      | 2017 | Intermittent CHS (ICHS) | Balancing energy consumption in the potential structure procedure | Enhances the nodes' survival potential. |
| Krishnakumar & Anuratha | 2017 | LEACH Protocol          | To boost network efficiency | Improves LEACH's threshold function with distance and number of neighbouring nodes, improves energy consumption and efficiency of the network. |
efficiency, and achieve high impact

Sony et al. 2015 Modified LEACH protocol Efficient usage of electricity services protocol's network life required to increase the existence of a network

Gao & Li [23] 2013 Dynamic Cluster LEACH (DCL) protocol To regulate and maintain a fair well as extend the network distribution of CHs life across the network region

8. Conclusion
The IoT is a network of linked computers or objects that can transmit and receive data through the internet. WSN groups advanced transducers that offer minimal integration of renewable energy space to IoT sensing tools. Because it is almost difficult to remove or refresh the batteries in sensor nodes, power usage is one of WSN's main design challenges. In the resources, limited network, clustering of algorithms play a key role in power conservation. Choosing a CH will manage the network load correctly, thus growing energy usage and increasing lifespan. For more studies in this area, the analysis of this paper might work.

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