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Research Paper

Analyzing IoT based clustered protocols of dissimilar wireless sensor networks for energy optimization

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The most recent advancements and innovations in the micro electrical mechanical system allow the WSN to be used in a variety of ways because of their incredible ability to sense environmental and other variables. WSNs are made up of a large number of low-cost sensor nodes that communicate using a set of rules known as protocols. Sensor node performance can be affected by certain protocols. This paper analyzes the IoT based optimized energy clustered protocols for wireless sensor networks. Because some nodes are always powered by batteries, WSNs are always concerned with energy efficiency. There are many similarities between WSN in CPS and IoT. Different starting energies have been found for various nodes or end devices. Physical remote sensor setups and heterogeneous Cyber IoT environments are no longer incompatible. Based on the results section's performance measures, we can compare Hy-IoT and iHy-IoT.

Keywords: *Wireless sensor network (WSN), clustered protocols, Micro Electro Mechanical System (MEMS), Hy-IoT (hybrid IoT), Cluster heads (CH), improved hybrid IoT (iHy-IoT)*

1. Introduction

Various devices are found in the Internet of Things that are varied in terms of energy, Internet accessibility, and other characteristics. In areas with varying degrees of heterogeneity, such as densely populated urban areas, suburban sprawl, rural areas, and even rural areas with high levels of densely populated urban areas, these gadgets are commonly dispersed. Homogeneous and heterogeneous devices could both benefit from existing conventions. The Hy-IoT standard can be used to overcome any obstacle that stands between a legitimate heterogeneous Cyber IoT and the physical condition of a distant sensor organisation. As a result of this investigation, the "Hy-IoT" (also known as "green IoT") bundle communication convention for green IoT, as well as a real-world IoT network computing to compare the proposed protocol to currently available protocols, are both aimed at. The LEACH 2 and SEP 3 iHy-IoT family of protocols was created for comparison and contrast purposes. They were designed to improve the Hy-IoT protocol and modify the current data transmission approach. This enables multi-hop communication between cluster heads and the BS. Two additional benefits of selecting an efficient cluster head (CH) include increasing the network's lifespan and packet transmission rates to the base station. For complex IoT networks with many degrees of heterogeneity distributed throughout the network, this study presents a novel cross-breed heterogeneous vitality mindful IoT convention that takes into account the vitality of the network's cross-breed heterogeneity.

2. Related Work

Sadek proposed that sensors can be used in a variety of ways, and a new cross-breed heterogeneous energy-conscious IoT convention for Complex IIOT, such as the Internet of Things (IoT), is discussed in this paper. When it comes to the Internet of Things, the most difficult task is to develop an effective final stage energy-aware data transmission that can take advantage of the heterogeneity of devices and the diversity between them in terms of their energies with the other associated things. Nodes with limited battery life, as well as nodes that use external energy (such as smart phones) for green computing applications, need to conserve energy. Homogeneous (similar energy nodes) to near homogeneous (some nodes have similar energy and some have more energy than others) to highly heterogeneous regions are typical for IoT devices (some nodes have more energy than others).

LEACH (Low Energy Adaptive Clustering Hierarchy) is a self-organization adaptive clustering protocol presented in the paper by Heinzelman et al. To accomplish this, LEACH utilizes a WSN's weighted average energy load distribution across its member nodes. Each round of the LEACH process is broken down into three phases: the setup phase, the study state phase, and the data transmission phase. Data packets are sent directly from the CH to LEACH nodes via direct communication; this results in a longer lifespan for the LEACH network as the clustering task is rotated among nodes. The nodes' lifespans are reversed by introducing random rotation of CHs, which are chosen based on a prior probability distribution in LEACH.

There are limitations to leach protocols, such as the CH depleting more energy when the BS is located further away from the CH. If a network is heterogeneous, a finite number of LEACH clustering iterations will not guarantee a good CHs distribution and will not work as expected.

$$T(n) = \begin{cases} \frac{p}{1-p*(r.mod\frac{1}{p})} & if\ n \in G \\ 0\ , & Otherwise \end{cases} \qquad (1)$$

Each node in the set of G (the set of nodes that haven't become CHs since 1/p rounds) generates a random number between (0-1) and compares it to the energy threshold value T, which is the average of the network's residual energy. To determine the threshold value, use equation (1.1) provided above. In which p is the percentage of a node that will become CH, r is the current round, and G is the set of nodes that have not become CH since the 1/p rounds.

SamragdakisGeorgious, M. Ibrahim et al.. [3], SamragdakisGeorgious, M. Ibrahim et al.. According to the findings of this article, the impact of node heterogeneity on energy consumption in hierarchically clustered WSNs has been modelled and implemented. The initial energy of each node is weighed in relation to that of all other nodes in the same network, and there is no need for any global knowledge of energy at each election round in the SEP protocol [4]. An additional benefit of SEP is that it can be scaled. If there are more than two levels of heterogeneity and two types of nodes in the sensor network, the network performance deviates from expectations. Further heterogeneity support was added with the Enhanced SEP protocol. The normal and advanced nodes will be distributed in a random manner when the majority of normal nodes are located far from the BS. Thus, more energy is consumed by the nodes.

$$p_{opt} = \frac{k_{opt}}{N} \qquad (2)$$

Assuming that Kopt is the best number of clusters and n is the number of advanced nodes to use, this is how many clusters should be used. In Equation 1.2, the SEP is used to calculate the ideal probability of CH. A random integer is generated for each node between 0 and 1, which it uses to decide whether or not it wants to be the CH for the current round. If this random integer is less than or equal to the threshold T(n) of equation 1.1 for the node in question, then it is chosen as the CH. Figure 1 shows the transmission and communication of the data network at the ZSEP station.

$$p_{adv} = \frac{p_{opt}.(1+a)}{1+(a.m)} \qquad (3)$$

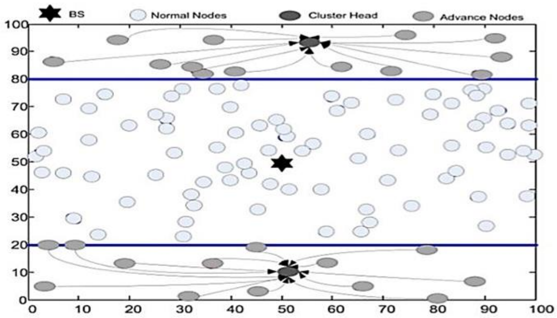


Figure 1: Data Transmission and Network Communication in the ZSEP (4) station

Head zones 1 and 2 transmit the data to the BS via a cluster head, shown in the diagram, using an appropriate clustering method. All member node data must be aggregated and communicated to BS by the selected CH. 1.2 Equation 1.2 states that the cluster head's SEP [3] optimal probability is used to select the CH. The CH selection threshold T(n) is calculated from equation 1.1, but the probability of advanced nodes is calculated from Equation 1.3. The The CH selection threshold T(n) for advanced nodes is calculated from Equation 1.3.

$$T(n) = \begin{cases} \frac{p_{adv}}{1-p_{adv}*(r.mod\frac{1}{p_{adv}})} & if adv \in G' \\ 0\,, & Otherwise \end{cases} \qquad (4)$$

For example, G' is a collection of advance nodes that have not been picked as cluster heads since the first Padv round. The 2- and 5-layer architecture of IoT is shown in Figure 2.

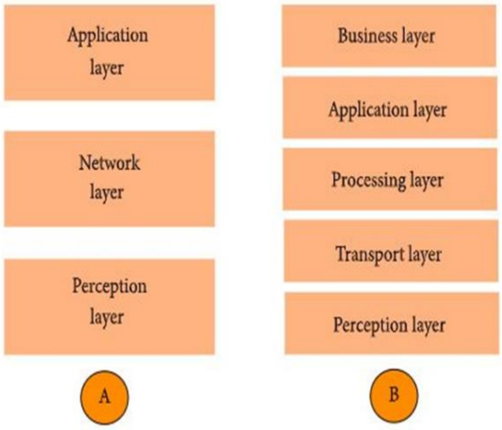


Figure 2: 2-Layer and 5-Layer Architecture of IoT [5]

The authors also proposed a new classification of IoT technologies, their characteristics, and their impact on human life. It compares the definitions of IoT by various authors, explains the potential applications of IoT in the current world, and outlines the scope of WSN with IoT.

1. Bluetooth, RFID, NFC, and 3G networks are used to transfer data from the perception layer to the processing layer via the transport layer.

2. Sensors in the network's transport layer will send data to the processing layer, which will store, analyze, and process it. Databases, big data, and other data processing methods are all part of it.

3. Managing the IoT system's applications, profit models, user privacy, etc. is the responsibility of the Business Layer.

Sudhanshu Tyagi, Neeraj Kumar, 2013 [6] Using the LEACH protocol for WSN clustering and routing, the authors of this review paper present a methodical evaluation of the subject. The article provides a comprehensive assessment of the relative benefits and drawbacks of many aspects of the LEACH protocol. The author explains the basis of LEACH paper along with the radio model of the LEACH protocol. It also explains the categorization of the LEACH protocol. Also tells about LEACH related routing protocols of WSN as well as clustering based & multi-hop data transmission for cluster-based routing protocol. The paper also explains heterogeneous protocols like EAHP and HEEP (hybrid energy-aware distribution clustering protocols) in great detail.

Meena Malik and Yudhvir Singh [7] this paper shows a point-by-point audit and investigation of the LEACH protocol. Correlation of different network parameters is done as tables and charts. The simulation work has been done by utilizing own set of parameters and in the last of the paper conclusion is drawn. WSN is a system of detecting nodes without having any centralized controller. Its improvement is rapidly growing, and that is the reason there is an immense field for research around there. Sensors depend completely on the trust of their battery for power, which cannot be rejuvenated or substituted. So, the structure of Energy efficient protocol is fundamental in regard to improve the system lifetime. LEACH is an efficient clustered protocol that spares node energy and consequently draws out the lifetime of the system.

3. IoT network

Sensors, actuators, processors, and transceivers are all part of the Internet of Things (IoT), which is referred to as a paradigm. In reality, it is a collection of many different technologies that work together to accomplish a single goal [8]. Sensors and actuators are devices that aid in interacting with the physical environment. The detector data must be carefully handled to draw useful conclusions [9]. A microwave oven, a cell phone, or even a microwave can be considered a sensor because they all contain information about their current state (inner state + environment). Air conditioner temperature regulators are examples of actuators, which are tools that can change the environment [10]. Data can be stored and processed at the edge of the network or on a remote server, depending on your needs. In most cases, pre-processing is done on the sensor itself or on a nearby unit.

3.1. Communication in IOT

There is a wide variety of smart devices connected to the Internet as the Internet of Things grows rapidly [11]. IoT systems with minimal computation and storage resources are powered by the battery. Due to their constrained nature, multiple communication difficulties arise as follows:

Address and identity: As millions of smart devices are connected to the Internet, a distinctive address must identify them based on which they can interact. For this to happen, for every smart object we needed a large address space and a unique address.

Low-energy communication: Transmission of information between computers, in particular wireless communication, is a energy-consuming job. Consequently, we need a way to communicate with limited energy use.

Routing protocols: Network rules or protocols are needed to create a network with low memory requirements and a streamlined communication pattern.

IoT systems generally access the Internet via the Internet protocol suite, which is complicated and requires a lot of power and memory from the connected devices.

Non-IP communication channels such as Bluetooth, RFID, and Zigbee can also be used to connect IoT devices to each other. As popular as they are, these methods of connection have limited communication ranges. Furthermore, they are classified as PANs (Personal Area Networks) [12]. Low-power communication was required to extend the range of these regional networks, so modifications of the IP stack were necessary. As a result, IPv6 and low-power personal area networks are included in 6LoWPAN and additional options. Compared to regional networks, the 6LoWPAN PAN consumes significantly less power. Figure 3 shows the typical IoT architecture.

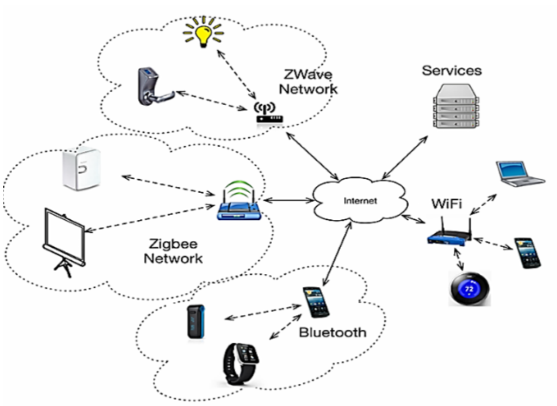


Figure 3: Typical IoT Architecture

3.2. Proposed Hybrid Protocol for IoT

Traditional LEACH and SEP protocols are used to drive clustering in an internet-of-things scenario, where the nodes have a lot of energy and other nodes in the network, respectively. When interacting over long ranges with the base station, the cluster heads will use a significant amount of energy because the proposed protocol only takes into account one hop of interaction between the cluster head and the base station. According to Hy-first IoT's phase implementation, all eligible nodes would broadcast an advertisement message to be considered for election as a CH during the first phase. Since the broadcasting method involves so many nodes, it will use a significant amount of energy. It is imperative that a new or modified strategy for relaying data from a CH's member nodes to the BS be developed because CHs already consume more energy (both for broadcasting advertisements and for doing so).

The CSMA and MAC protocols both request a message that includes the node ID, the cluster head ID, and the same spreading code as with CSMA, but not with MAC. Selective CSMA is used for this purpose, which includes an announcement message that includes the Cluster Head's identifier, a header indicating that it is an announcement message, and an important spreading code, which is critical in order to reduce inter-cluster interference, as well as other factors [13]. Similarly, after a cluster has been built, each CH specifies its TDMA plan for its sensor nodes to stimulate the collection of information from nodes in the cluster during their designated slots. Only for the duration of the TDMA slot does each node come out of sleep mode to send data to CH and then go back to sleep again.

4. Proposed Methodology

The advertising process begins with each sensor node, which broadcasts an advertisement message to all sensors within its communication range at the beginning of the process. Essentially, this is the very first stage in the clustering procedure.

If a node receives several advertising messages, it will be added to the cluster head for which the most available energy is available. When the cluster head is selected, the member nodes send a packet to it, alerting it that it has been accepted into the cluster.

A non-CH node must send a join packet to a CH node to join the cluster. The remaining energy of the node will also be broadcast. The present CH would acquire all the information from the members of its cluster in this manner. This information will be used to determine which CHs will be turned on in the next rounds. The current CH will sort the persons in the order of the most energy and least separation from the base station, as requested by the individuals themselves. The member at the top of the list would be chosen to be the CH for the following round, and so on. As a result, the CH advertisement phase would be skipped at the beginning of every round.

For the time being, the present system only takes into account single-hop communication between the BS and the CHs in the usual zone. In the proposed work, our goal is to develop the relay node chains (chosen from inside the clusters) that will be used to forward data from CHs to BS.

The data from the child CH would be transmitted to a member node of each CH's cluster, which would then select a path. The node with the most residual energy and the shortest distance to CH and BS would be selected as the member node. Relay nodes would be used to connect the cluster heads to the base station in this scenario.

When selecting a relay node for the CH role, the node with the second-highest energy will be selected. As a result, every CH would now transmit the data to the selected relay node, which would then operate as the child CH's parent. This would lower the strain on the CH, which would allow it to transmit data from other CHs as well.

The load on the CH is greatly decreased as a result of this technology, which in turn results in an increase in the network throughput. Furthermore, the Network model [6] and the Energy model [7] employed in this study are the same models that are used in a conventional wireless sensor network.

4.1. Radio Energy Model for WSN

The base station receives a packet from the selected CH. This results in the use of some of the sensor node energy during communication [14]. This means that the amount of power consumed by a WSN can only be estimated by calculating the energy used in the communication process. Figure 4 shows a simple radio model used to estimate the amount of energy used. Both free-space and multipath fading channel models calculate dissipation in this first-order radio energy dissipation model. For example, the free space model is selected if the distance between transmitter and receiver is less than or equal to the threshold distance; otherwise, the multipath model is specified. For example, for a distance d between the transmitter and receiver [6], the following equation can be used to calculate the amount of energy required to send messages k:

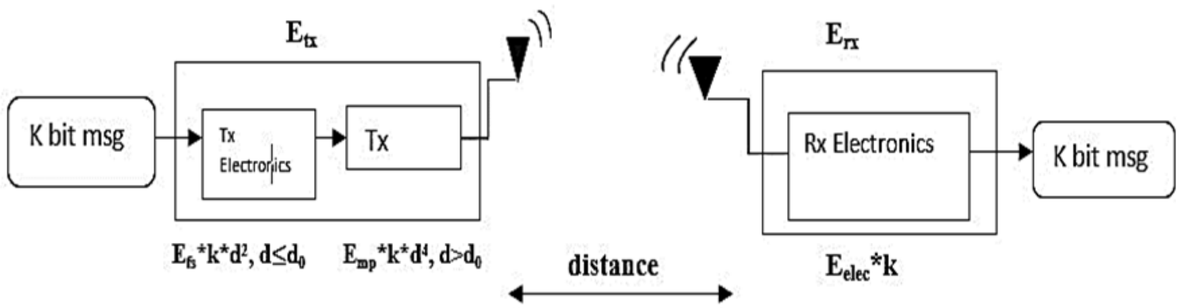


Figure 4: Radio energy model

$$E_{tx}(k,d)= \begin{cases} E_{elec} * k + E_{fs} * k * d^2, & d \le d_0 \\ E_{elec} * k + E_{mp} * k * d^4, & d > d_0 \end{cases} \quad (5)$$

The threshold distanced0 can be represented as:

$$d_0 = \sqrt{\frac{E_{fs}}{E_{ms}}} \quad (6)$$

Calculating the amount of energy it takes to receive this message:

$$E_{Rx}(k) = E_{elec}*k \quad (7)$$

k bit message energy consumed is: if the receiver performs data aggregation in addition to receiving,

$$E_{Rx}(k) = (E_{elec} + EDA) * k \quad (8)$$

When coding, modulation, and filtering techniques are used, Eelec represents the amount of electronic energy required to run the circuit. Similarly, Efsd2 and Empd4 are the amounts of amplifier energy needed to transmit a k-bit message over a distance d in free space communication and multipath communication, respectively. An assumption has been made for this model that radio channel is symmetric; this means that energy consumption in both directions between two nodes is the same for the same conditions.

4.2. Selection Phase of Cluster Head

In a heterogeneous environment, the CH determination stage is the most challenging. When comparing Hy-IoT to LEACH, the difference is that Hy-IoT uses a weighted election probability for each node to be the Cluster-head based on their energies, while SEP uses an election probability for each node to be the Cluster-head based on their energies as well. As a result, there are a fixed number of CHs K and a fixed length Cr for each cluster. Because of the distance between them and the energy expenditure associated with that distance, nodes will associate with the declared CH from the superior region Rs or the specific region Rra when instability begins.

4.3 Cluster Head Selection for Superior Nodes

As a result of their high energies, the superior nodes of the Superior location are regarded as power-stable devices. As a rule of thumb, the superior nodes can be found in a specific location marked by the letter Rs. The LEACH is used throughout the entire process to randomly select the cluster head [15]. The consumption of these nodes, despite the fact that they are energy positive, should be reduced or eliminated in green computing environments [17].

This information is broadcast through the network by BS to ensure that each node knows the average residual energy and the optimal number of CH (kopt) for the network [18]. Put another way, each node now knows what the network's average residual energy is and what the ideal number of CHs is.

We may obtain the optimal number of CHs using the following equation, which is shown in [10]:

$$k_{opt} = \frac{\sqrt{N}}{\sqrt{2\pi}} * \sqrt{\frac{E_{fs}}{E_{mp}}} * \frac{M}{d_{bs}^2} \quad (9)$$

There are N nodes in this model, E_fs and E_mp are the free space and the multipath energy, M is the field size, and d_bs2 is the distance between each node and its center.Then, using equation (1.2), each node calculates p, the proportion of the node that will become CH and the threshold is set by equation (1.4).

4.4 Selection of the head of the regular node cluster

In a regular Rra area, there is a random distribution of the bulk of normal nodes and objects, with a few advanced nodes thrown in for good measure. The selection of the CH is accomplished by using the SEP, which takes into account the residual energy content in each round.

4.5 Cluster formation phase

All nodes receive an ad message once the CH has been selected. The nodes receive these messages to determine with which cluster head they will be paired in the upcoming round of pairing [19]. In choosing a cluster head, the nodes use distance and received signal strength as the two most important factors. Nodes join forces with the closest CH to reduce energy use [16]. Every node maintains a list of the three closest CHs and ranks them from closest to farthest away. The nodes are assigned to other CHs when they reach their maximum number of members in order to reduce transmission delays and ensure load balancing, as well as extend the life of the system by a node [20]. As an MAC protocol, the chosen CH uses CSMA to send an ad that includes its ID, an announcement message header, and a spreading code. To encourage the cluster nodes to accept data during their allocated time slots, each CH specifies its TDMA plan for its nodes. To send data to CH, each node briefly awakens for the duration of its TDMA schedule before returning to sleep [21].

5. Simulation and Results

This section explains how the proposed protocol for routing in an IoT heterogeneous network is implemented.

There are several protocols already in use, including LEACH, SEP, and Z-SEP, that are compared to the proposed iHy-IoT protocol and their performance in the proposed real-world IoT region-based environment. MATLAB R2016a version 9.0.0.34136 was used to implement the proposed algorithm [22].

5.1. Parameter Initialization and Simulation Setup

A sensor field of 100 m x 100 m has N sensor nodes, and the sink node is placed in designated areas based on the energy criterion, as shown in Figure 5. 80 percent of standard nodes and 20% of advanced nodes have been deployed. The position of the sink node should be set to X = 50, Y = 80 to get the best results.

Table 1 provides a summary of the radio characteristics and parameters used in the simulation. There are two sections in the field. Normal nodes in the first regular region, Rra, are randomly distributed in an area of (0 X 100; 0 Y 80), whereas superior nodes in the second superior region, Bb, are randomly distributed in the same area (0 X 100; 80 Y 100). The total number of IoT devices in this environment is M+N.

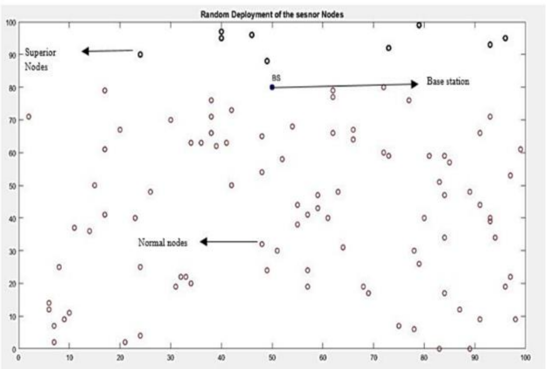


Figure 5: Random deployment of nodes regular and superior region

Table 1: Simulation Parameters

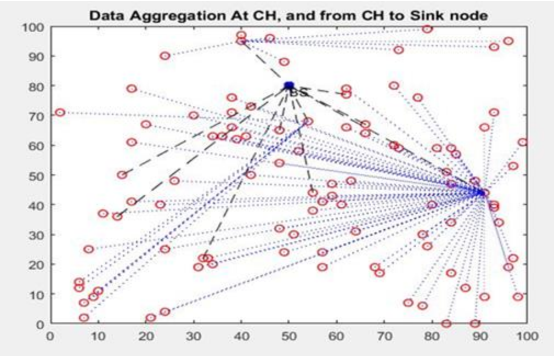
1	Network Size	100m * 100m
2	Number of nodes (N)	100
3	Packet Size (K)	4000 bit
4	Initial Energy (E_0)	0.15 J, 0.3 J, 1.5 J
5	Data Aggregation energy (EDA)	5nJ/bit
6	Transmission (E_{TX}) & Reception (E_{RX}) Energy	5nj/bit
7	Amplification energy for short distance (E_{FS})	10pJ/bit/m^2
8	Amplification energy for long distance (E_{amp})	0.013pJ/bit/m^4
9	Optimal Probability P_{opt}	0.1

5.2. Results

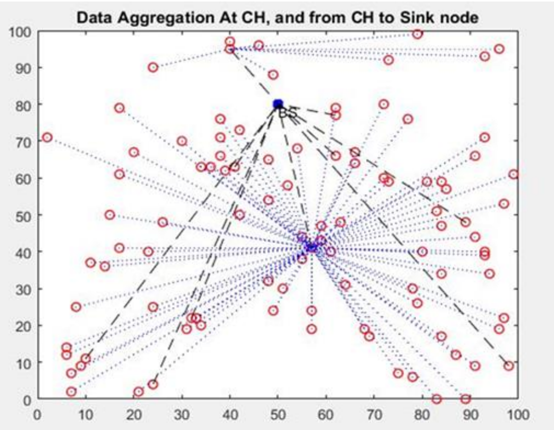
On the basis of the results of this section, we conclude that iHy-IoT is a better fit for real-world heterogeneous IoT networks than the base paper recommended Hy-IoT protocol. The effectiveness of the proposed protocol can be evaluated by looking at some performance metrics, such as those shown in the graphs below in Figure 6.

The simulation scenario investigates the effect on network performance of various levels of energy heterogeneity. 80% of standard nodes and 20% of superior nodes have been installed, according to estimates. In the ordinary region Rra, 10% advanced with doubled energy is randomly distributed; in the superior region Rs, 10% advanced are distributed randomly.

Clustering research has focused on analyzing network performance by placing the base station in network's centre, but this thesis' sink node is situated near homogeneous and heterogeneous regions at X=50, Y=80, which is in the middle of the two areas." To be used in the computation of all of the KPIs.



(A)



(B)

Figure 6: (A), (B) Data Aggregation and CH rotation in different rounds

5.2.1. Network Lifetime

(a) Stability Period Figure 7 shows the network's lifecycle from the moment it is created until the first node fails. Table 2 compares the simulation results for Hy-IoT and iHy-IoT performance. The comparison shows that the proposed protocol's network life time is increased by 315.25%.

Table 2: Comparisons of FND with Base Paper

S. N	**Routing Protocol**	**First node death round no. (Stability period)**
1.	Hy-IoT	59
2.	Implemented iHy-IoT	246

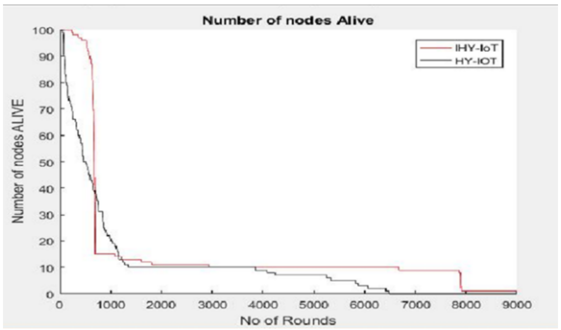


Figure 7: No. of rounds after first node in the network is dead

(b) Instability Period: When a node dies, the network is unstable for a predetermined amount of time. Hy-IoT [1] and IHy-IoT [2] have been compared in Table 3. We can see from the results that the results have risen by 19.17 percent.

Table 3: Comparison between Hy-Iot and IHy-IoT

S. N	**Routing Protocol**	**No. of rounds after all nodes are dead**
1.	Hy-IoT	6426
2.	Implemented iHy-IoT	7659

5..2.2. Number of packets sent to the base station

Figure 8 shows the total number of packets sent to the base station during each communication round. The graph clearly shows an increase in network longevity and communication. A direct connection from a nearby node to the base station results in 45.30 percent more packets being transmitted to the sink node from nearby sensor nodes and cluster heads than other clustering methods [23]. Table 4 shows the comparison of the delivery of packets to the base station.

Table 4: Comparison of packet delivery at Base station

S. N	Routing Protocol	Number of Packet Delivered
1.	Hy-IoT	98010
2.	Proposed iHy-IoT	142414

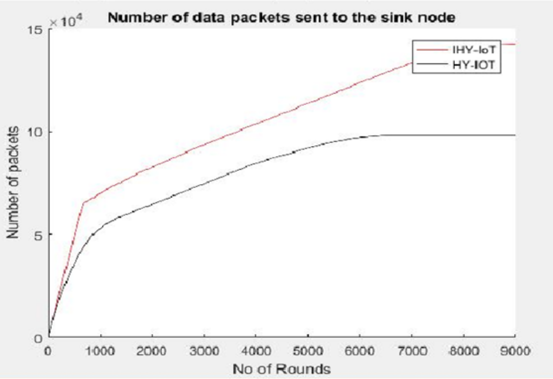


Figure 8: No. of packets sent to base station

5.2.3. Number of dead nodes

The number of dead nodes in the network after a specific round in which they lost their energy is shown in Figure 9. Dead nodes influence the network's stability period as well as throughput. The duration of insecurity has been reduced by 20.82%. The comparison of rounds considering dead nodes is shown in Table 5.

Table 5: Comparison of rounds considering dead nodes

S. N	Routing Protocol	No. of rounds considering dead nodes
1.	Hy-IoT	6487
2.	Implemented iHy-IoT	7902

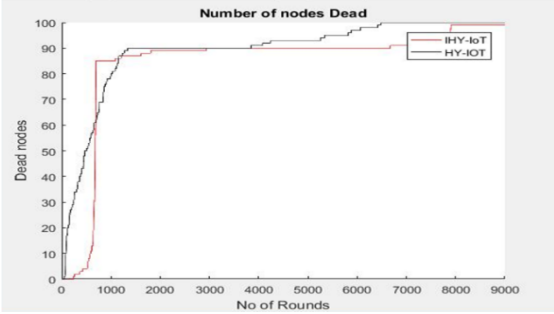


Figure 9: Number of dead nodes

6. Conclusions

In this paper, the optimization of the Hy-IoT protocol is done and its performance is compared with the proposed protocol for heterogeneous wireless sensor networks of the IoT because conventional protocols such as LEACH and SEP deal with homogeneous or heterogeneous networks. Furthermore, real-world IoT networks include a wide range of devices with varying energy requirements, such as some that consume a large amount of power, while others consume very little. Therefore, the nodes in the described IoT network architecture have different energy requirements, and data are relayed using a more efficient and optimized technique in the regular and superior regions [25] [26] [27] [28] [29] [30]. This decision was made in order to extend the network's usefulness. Using multihop replaying techniques and building chains between CHs, data from the far-off node can be relayed quickly. According to simulation results, the Hy-IoT protocol improves network stability by up to 315% while also increasing throughput by 45.30 percent. Thus, the implementation of the proposed protocol improves the overall performance of the IoT network.

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