International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 6 Issue 7, November-December 2022 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

An Energy Aware Routing to Optimize Route Selection in Cluster Based Wireless Sensor-IoT Network (EACW)

Apurva Anand[1], Dr. Sadhna K. Mishra[2]

[1]Research Scholar, [2]HOD CSE,

[1,2]Department of CSE, LNCT, Bhopal, Madhya Pradesh, India

ABSTRACT

A Wireless Sensor Network (WSN) is an autonomous, self-organizing, and self-configuring network with the capability of speedy deployment anywhere. Internet of Things (IoT) nodes are use cloud storage to collect information from sensors and transfer it to other IoT nodes or networks via cloud services. Energy-efficient communication is likely one of the main conversation factors in WSN, so efficient routing is critical to make use of full power consumption and enhance the network performance. This research proposes an Energy Aware Cluster-based Wireless Sensor (EACW) routing protocol that optimizes route selection by clustering of nodes in a Wireless Sensor IoT network. However, one of the biggest problems to be handled is the energy wastage in transport. Limited energy is one of the prime concerns in WSN-IoT and efficient routing is the primary focus to improve energy utilization, which increases the network performance. LEACH is an energy-based protocol that works on a cluster-based mechanism to make use of the energy efficiently. In this research, we compare the performance of the LEACH protocol with that of the reactive on-demand protocol in order to make the most of the network's energy constraints. The proposed scheme shows that nodes have at most imprecise state information, mainly under strong link establishment. EACW routing selects optimizes routes (higher energy base route resolution), generates clusters, and has power measurement of each cluster member and cluster head. LEACH chooses that specific node for data transmission so that work raises the reliability of communication. The efficiency of the proposed EACW protocol is compared with CBRW and the performance matrices like live nodes, throughput, overhead and CH and CB information.

How to cite this paper: Apurva Anand | Dr. Sadhna K. Mishra "An Energy Aware Routing to Optimize Route Selection in Cluster Based Wireless Sensor-IoT Network (EACW)" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-7, December 2022, pp.239-246, URL: www.ijtsrd.com/papers/ijtsrd52292.pdf

IJTSRD52292

KEYWORDS: *LEACH, WSN-IoT, Energy, Routing, EACW*

I. INTRODUCTION

A variety of different technologies are combined to form the Internet of Things (IoT). IoT is mostly composed of five components. The core component of the Internet of Things is the wireless sensor network, which enables anything (an object) with a sensor and actuator thanks to a microcontroller called a sensor node. Through the sensor and the signal actuator meant to move the item, the sensor node creates data. The data produced by the sensor node must be sent to the gateway node, which is the second component of the IoT. The gateway node, sometimes referred to as the base station, sink, or network device, is really connected to the internet and has an IP address. The gateway node collects and aggregates all the data generated by the wireless sensor network before sending it to the IoT's cloud computing component. The cloud, which uses an analytical model to store and analyze data, is the Internet of Things' fourth component. Following processing, the user receives the information via the interface. The fifth component of the Internet of Things is the interface. An interface might be a message, a web application that can be accessed using a web browser, or a mobile app. The Internet of Things (IoT) offers a variety of uses due to its capabilities, including monitoring, surveillance, remote access, and automation. Common examples of IoT's primary applications include the smart home, smart hospital, smart city, smart farming, smart agriculture, smart grid, and many more [15,16]. To make all those applications a reality, information must be acquired and transferred. Due to its restricted transmission capability, every sensor node's information flow can be wrapped to a specified distance. Other intermediary nodes must cooperate to properly send data from the sensor node to the gateway node. The source node serves as a sensor node in addition to being a relay node. Great energy efficiency is the driving force behind providing any routing method; the information should reach the gateway node with the least amount of latency. We focus more on energy usage in the vast majority of applications where sensor nodes are powered by batteries. The article consist of VII section, in section I describe the introduction about MANET, section II elaborate about existing work of energy and location based routing, section III describe about proposed EL-DMR technique, in section IV discuss the proposed EL-DMR working architecture, section V describe the simulation environment, in the section VI describe the simulation analysis result and in section VII describe about conclusion and future approach on MANET network.

II. RELATED WORK

Many academics have suggested various routing strategies for wireless sensor networks with IoT capabilities. There are different type of routing protocol exists; here we are focusing on routing protocols which is based on clustering.

Jaya Mishra, Jaspal Bagga *et.al.*[1] A cluster-based routing protocol for IoT enabled WSN networks has been presented in the article titled “Performance Evaluation of Cluster-based Routing Protocol utilized in Wireless Internet-of-Things Sensor Networks” The cluster-based routing protocol is also called the energy-efficient protocol because it can collect information in the cluster head and send as little information as possible to the gateway node.

Muhammad Nadeem Akhtar.*et.al* [2]. “Cluster based Routing Protocols for Wireless Sensor Networks: An Overview” This study focuses on clustered-based routing protocols, which are mostly used in WSNs to reduce energy consumption and are a subtype of "network structure" scheme. On the basis of various key performance indicators, including energy efficiency, (ii) algorithm complexity, (iii) scalability, (iv) data delivery latency, and (v) clustering technique, this study evaluates and summarizes popular cluster-based energy-efficient routing protocols.

Asha Jerlin Manue *et.al.*[3] The primary focus of this paper, "Optimization of Routing-Based Clustering Approaches in Wireless Sensor Networks: Review and Open Research Issues," is multi-hop routing in a clustering context. Our study was divided into three method types in accordance with cluster-related metrics and properties: Specifically, parameter-based, optimization-based, and methodology-based approaches. There are numerous approaches within the overall category, so the concept, parameters, benefits, and drawbacks are explored.

Masood Ahmad *et.al.* [4] “Optimal Clustering in Wireless Sensor Networks for the web of Things supported Meme-tic Algorithm: meme-WSN” In this chapter, they suggest using local exploration strategies in conjunction with WSN clustering assisted by the meme-tic algorithm (Mem-A) to reduce the likelihood of early convergence. Mem-A is frequently used in WSN-IoT to dynamically balance the load among clusters and find the best clusters. This study aims to find a cluster head set (CH-set) as soon as feasible once a requirement arises. The WMNs with high weight values are chosen instead of the newest residents in the next generation.

Yamin Han *et.al.* [5] “Energy-Balanced Cluster-Routing Protocol supported Particle Swarm Optimization with Five Mutation Operators for Wireless Sensor Networks” The goal of each CH is to designate one sensor node in each cluster as the cluster head. In this title technique, sensor nodes are organized into a number of clusters (CH). It gathers information from opposing sensor nodes in its cluster, then delivers that information to the sink.

Raúl Aquino-Santos *et.al.*[6] “Performance analysis of routing strategies for wireless sensor networks” The three most commonly used algorithms by wireless ad-hoc and sensor networks are source, shortest path, hierarchical, and geographical routing. This title analyses their presentation. Source routing was chosen because it doesn't require expensive topology upkeep; shortest path routing was picked for its straightforward discovery routing method; and hierarchical and geographical routing were chosen because they make use of position data from the Global Positioning System (GPS).

Shio Kumar Singh *et. al.*[7] “A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in Wireless Sensor Networks” In this article, the focus is mostly on a study of the energy-efficient hierarchical cluster-based routings that are currently available for wireless sensor networks. Recent developments in communications and processing have made it possible for wireless sensor networks to contain inexpensive, low-power, compact, and multifunctional sensor nodes. One of the major problems with wireless sensor networks is the sensor nodes' built-in restricted battery life since radio transmission and reception need a lot of energy. The design of the algorithm must take battery power into account to increase the longevity of the network's nodes.

Huanan Zhang [8] "Cluster-based routing protocols for wireless sensor networks" This title examines wireless sensor network cluster-based routing techniques. Three essential methods in cluster-based routing protocols are cluster head selection, cluster creation, and data broadcast. Recent ambassador cluster-based routing protocols are introduced, and their characteristics and application domains are compared as seen from the three approaches. The longer-term research questions in this field are finally authorized.

Sultan Alkhliwi [9] "Energy Efficient Cluster based Routing Protocol with Secure IDS for IoT Assisted Heterogeneous WSN" This chapter introduces EECRP-SID, a secure intrusion detection system with an energy-efficient cluster-based routing protocol for HWSN. The three primary stages of the upcoming EECRP-SID approach are cluster formation, optimum route selection, and interruption detection. The selection of the cluster head (CH) is initially done using the sort II fuzzy logic-based clustering (T2FC) method with three input parameters.

Walid Osamy *et. al.*[10] "Deterministic clustering based compressive sensing scheme for fog-supported heterogeneous wireless sensor networks" In this chapter, we address the information gathering challenge for fog-supported heterogeneous WSNs by introducing an effective deterministic clustering-based CS scheme (DCCS). DCCS leverages the fog computing idea, decreases overall overhead and computational costs necessary to self-organize sensor networks by using a straightforward method, and then utilizes CS at each sensor node to minimize overall energy consumption and extend the lifespan of the IoT network.

Maman Abdurohman *et. al.* [11] "A Modified E-LEACH Routing Protocol for Improving the Lifetime of a Wireless Sensor Network" In order to extend the lifespan of a wireless sensor network, this article suggests a modified end-to-end secure low energy adaptive clustering hierarchy (ME-LEACH) method (WSN). Every action in a WSN must effectively use energy since energy restrictions are a key constraint. A number of protocols are offered to modify how a WSN transmits and receives data. A hierarchical routing protocol technique called the end-to-end secure low energy adaptive clustering hierarchy (E-LEACH) protocol has been developed to solve high-energy dissipation issues.

Chaitra H.V *et. al.* [12] "Secure and Efficient Cluster Based Routing Model for Wireless Sensor Network" In this paper, a multi-objective cluster selection method employing an improved Imperialist Competitive Algorithm is presented. Furthermore, the current model is built using asymmetric cryptography, such as RSA, Diffe-Hellman, and others, to provide secure communication.

Huarui Wu *et al.* [13] "Energy Efficient Chain Based Routing Protocol for Orchard Wireless Sensor Network," In this paper, we examine how wireless sensor network nodes have a finite amount of energy. It has become a hot topic to discuss how to get the most out of the little energy available for efficient data transfer. They propose an improved chain-based clustering hierarchical routing (ICCHR) algorithm based on the LEACH algorithm, which takes into account the characteristics of orchard planting in rows and the shade caused by sparse random features, to increase the energy efficiency of the orchard wireless sensor network and lengthen its lifetime.

Yasameen Sajid Razooqi *et. al.* [14] "Intelligent Routing to Enhance Energy Consumption in Wireless Sensor Networks: A Survey," In this title, they discuss energy-saving techniques for wireless sensor networks, such as data compression technologies, shortest path selection, and artificial intelligence routing algorithms. For a more complete understanding of the energy consumption problem and to offer some real-world solutions in the field of wireless sensor networks, we also compared the typical research methods.

III. PROPOSED RESEARCH

The Internet of Things (IoT) refers to the network of physical things equipped with sensors and software to exchange data with other devices via the internet. The Internet of Things is made up of things like smart surveillance, automated transportation, city security, and environmental monitoring.

The Internet of Things is a hybrid type of communication structure in which actual objects are implanted with sensors or other devices to perform a certain purpose collaboratively. Using a cluster-based routing method, which is more practical for sensor-based networks, solves the problem of IoT device-based communication efficiency. To optimize the routing behavior of sensor-based communication, we collect information on each sensor node's real-time energy, energy discharge rate, node location, processing power, etc. At random, one of the nodes (sensor devices) computes the route from the sensor zone to the base station as the originator of the route discovery message. The proposed Energy Aware Routing to Optimize Route Selection in Cluster Based Wireless Sensor-IoT Networks (EACW) builds a table containing (starting energy, per packet consumption, and location information) and broadcasts it into the network in order to receive input according to the defined field.

As the sensor nodes receive the broadcasted packet, the base station will process and evaluate it to identify the cluster head based on the higher energy of the node, the low power requirements for transmission and reception, and the location of the sensor nodes that handle the greatest number of nodes in the vicinity. The network is divided into zones based on the location of sensor nodes, and each zone has a cluster head selected using an LLCH algorithm based on energy and maximum node coverage. The suggested cluster head-based data gathering and forwarding approach selects the cluster head dynamically at each time interval, thereby enhancing the network's lifetime and load distribution. When a cluster head is chosen, the subsequent step is for all IoT sensor devices to provide their input data to their respective cluster head, which is then responsible for forwarding the data to the next neighboring cluster head or directly to the base station. Finally, the server at the base station collects all incoming data and analyses it to extract important information. The proposed EACW protocol base protocol is a low energy adaptive cluster head (LEACH) protocol that can be used to select cluster heads based on energy. Location detection of sensor nodes is performed by their coordinate identifying method (x, y) and movement speed on nodes, which combined way cluster heads are selected and network efficiency is increased.

The IoT sensor network is a type of heterogeneous environment in which IoT devices function as data collecting modules and cluster heads function as routers that transfer all incoming data from source IoT devices to a base station that is helpful for data aggregation and computing. Each sensor network is configured using EACW routing, varied energy and beginning location values, transport layer protocols as TCP or UDP, and application layer protocols as CBR or FTP using network simulator-2. The simulated output data are parsed into a trace file and the awk utility is analyzed further. Using network metrics such as throughput, network lifetime, the number of cluster heads in each zone, and the number of members under each cluster head, network performance is measured.

IV. EACW ROUTING ALGORITHM

The objective of Energy Aware Routing to Optimize Route Selection in Cluster-Based Wireless Sensor-IoT Network (EACW) Routing for IoT sensor devices is to address the routing problem, thereby increasing the network's lifetime and location efficiency. This section provides a formal description of the EACW method, which is divided into input, output, and procedure sections and is implemented in network simulator-2.

Algorithm: Energy Aware Routing to Optimize Route Selection in Cluster Based Wireless Sensor-IoT Network (EACW)

Input:

- S_n: IoT Sensor devices
- Ch_i: cluster head
- e_i: initial energy of S_n
- e_d: energy discharge /pkt
- M_b: Member Node $\in Ch_i$
- (x_i, y_i): IoT coordinate value
- L_i: Location of i^{th} devices
- T_n: transmitter nodes $\in S_n$
- R_n: receiver nodes $\in S_n$
- BS: Base Station
- LC_i: Number of node cover by IoT device
- R_P: EACW
- ack_j: acknowledge packet
- Ψ: radio range of $550m^2$

Output: Node Alive, Throughput, Routing Load, Number of Member node in each cluster

Procedure:

Step1: $\forall S_n$ under Ψ
$\forall S_n$ use line of sight in Ψ

Step2: For Zone = 1 to k

Step3: Election-Perform(S_n, e_i, e_d, L_i)
Temp: Ch_i
LC_i: 0
$\forall S_n$ receive msg
Calculate $e_i, e_d, L_i(x_i, y_i)$

Step4: While $(i<n$ & $e_i \geq 50$ & $L_i > 70\%)$

Step5: If (Compare $(\max(e_i, e_{i+1})$, $\min(e_d, e_{d+1})$ & L_i cover number of max devices in Ψ)
$S_i \leftarrow$ Temp
$SLC_i \leftarrow LC_i$
Else
$S_{i+1} \leftarrow$ Temp
i = i +1
End If

Step6: Found Ch_i in one Zone
Ch_i broadcast wining message to $\forall M_b$
M_b communicate to BS through Ch_i

End while
End for

Step7: T_n use EACW(T_n, BS, Ch_n) to search R_n

Step8: If T_n in Ψ of Ch_i && R_n ! in Ψ of Ch_i **Then**

Step9: While (R_n ! in Ψ of Ch_i)
Ch_i forward route packet to next Ch_{i+1}
I ← I + 1 in route
End While
Else if R_n in Ψ of Ch_k **Then**
R_n ← receive (T_n, BS, Ch_n)
Calculate e_d between (T_n, R_n)
Select low e_d path of (T_n, R_n)
R_n ← generate ack_j packet send to T_n via Ch_k
T_n ← receives ack_j
Call data (data, T_n, R_n)
Else
R_n not found or not in Ψ
End if

Step10: Data (T_n, R_n/BS)
T_n generate data (data, T_n, R_n)
EACW provide Route through Ch_i
Send data through selected path by EACW
R_n/BS receive data using Ch_i
Calculate e_d and life time of network
End Procedure

V. SIMULATION ENVIRONMENT

NS2 is an open-source event-driven simulator intended specifically for investigates in computer communication networks. The simulator we have used to simulate the ad-hoc routing protocols in is the Network Simulator 2 (ns) from Berkeley. To replicate the mobile wireless radio environment we have used a mobility extension to ns that is developed by the CMU Monarch project at Carnegie Mellon University. Since its beginning in 1989, NS2 has continuously increase marvelous attention from industry, academia, and government.

To investigate network performance, we can simply use an easy-to-use scripting language to configure a network, and observe results produce by NS2. NS2 has turn out to be the most widely used open source network simulator, and one of the greater part widely used network simulators.

VI. SIMULATION PARAMETERS

Table 1 is representing the following simulation parameters to make the scenario of routing protocols. The detailed simulation model is based on network simulator-2 (ver-2.34), is used in the evaluation. The NS instructions can be used to define the topology structure of the network and the motion mode of the nodes, to configure the service source and the receiver in dynamic network.

Table 1: Simulation Parameter's

Parameters	Configuration Value
Routing Protocol	CBRW, EACW
Simulation Area	1000*1000m^2
Network Type	Mobile Ad-Hoc
Number of Nodes	100
Physical Medium	Wireless, 802.11
Node Speed	Random
Mobility Model	Random
Energy	Initial 100J Transmission Power 1.5J Receiving Power 1J Sensing Power 0.0175J
Simulation Time (Sec)	200Sec
Transmission Range	550m
MAC Layer	802.11
Antenna Model	Omni Antenna
Traffic Type	CBR, FTP
Propagation radio model	Two ray ground

VII. RESULT ANALYSIS

A. Node Alive Analysis

The number of nodes in the network that are considered for simulation is 100 nodes for 200 seconds of simulation time. In this table, the performance of the remaining energy in joules in CBRW and EACW is mentioned in table 1. The proposed EACW communication consumes less energy and provides better communication between sender and receiver. In the CBRW scheme, about 50 nodes lost their full energy, but in EACW approach, only 25 nodes lost full energy. It means about 75 nodes are live in the network. This energy is utilized for further communication in the WSN-IoT network.

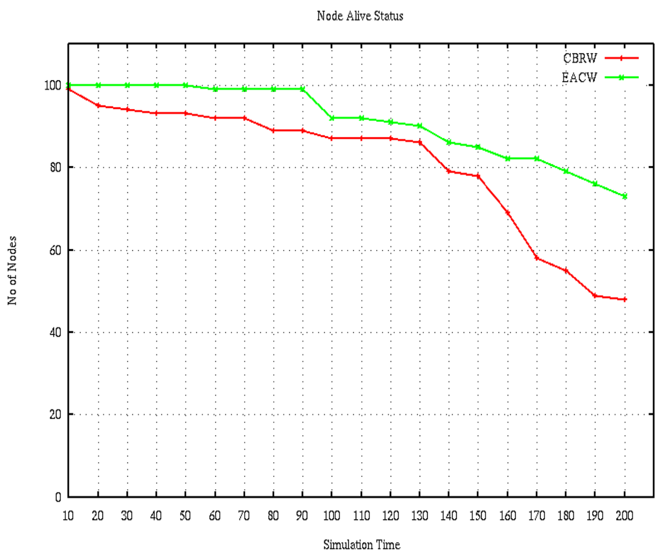

Figure 1: Node Live Analysis

B. Throughput Analysis

The better throughput performance shows the better sending and receiving of data packets at the sender end and receiver end. This graph represents the throughput of the previous CBRW and the proposed EACW approach.

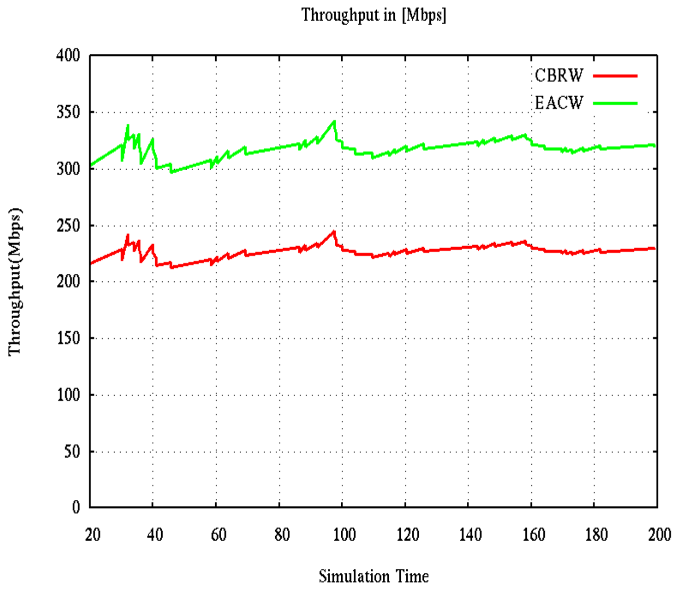

Figure 2: Throughput Analysis

Here we clearly visualise that the throughput in the proposed cluster-based EACW approach is better because of the select strong links for communication. The throughput of CBRW does not seem better than the proposed scheme. It means that the proposed LEACH protocol increases energy utilisation by optimising routing performance. Now the results in the case of the CBRW route enhance the possibility of energy consumption, but the EACW approach is able to control energy consumption.

C. Normal Routing Overhead Analysis

Routing packets in a network are required to establish a connection between source and destination through intermediate nodes. The routing packets are used to establish a connection with the destination. If the destination is busy in any communication, it replies to the sender by way of a connection confirmation packet. The routing packets in a network consume energy. It means a minimum number of routing packets are delivered to deliver a maximum amount of data packets in efficient routing. In this graph, CBRW cluster-based routing with energy factor shows high routing load and more load means the problem of connection drop in the network is greater. For more routing packets, more energy is also required for routing packet transmission and in the proposed EACW cluster-based routing with cluster formations that reduces consumption and minimizes the routing overhead as compared to previous CBRW scheme.

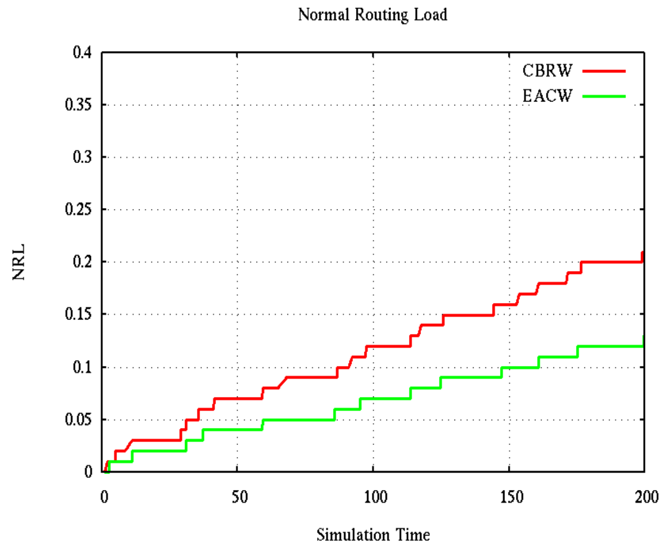

Figure 3: NRL Analysis

D. Cluster and Member in Cluster Analysis [Initally]

The Cluster Members (CMs) and Cluster Heads (CHs) play an important role in communication. This graph shows the cluster formation at the start of the simulation. Here, the number of clusters formed in the case of the proposed EACW protocol and the number of members in this protocol is greater. The highest member's quantity is 34, but in the previous scheme it was not more than 27. That shows the better energy utilization. The quantity of cluster formation in the previous scheme is greater because of weak connections or movement of sensor nodes. In the proposed EACW scheme, fewer clusters are formed but the connections between the CHs and CMs show strong connections.

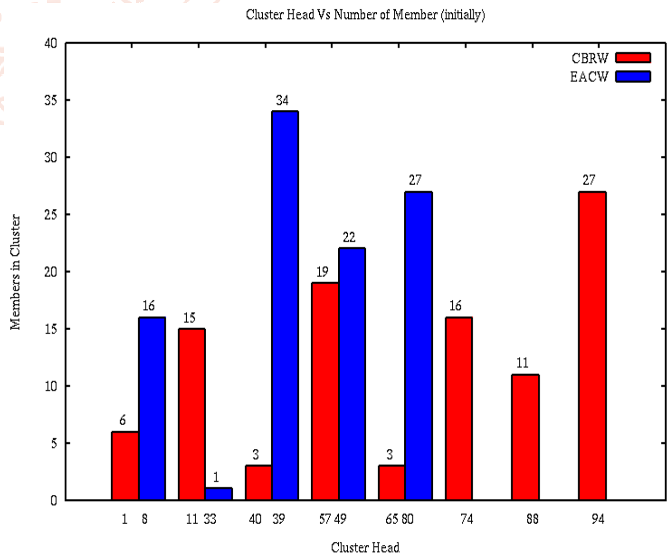

Figure 4: Cluster Head and Cluster Member at Beginning

E. Cluster and Member in Cluster Analysis [At Last]

When a large number of CMs are connected to CHs for an extended period of time, it demonstrates optimal routing and proper energy utilizations of sensor nodes. This graph shows the cluster formation at the end of simulation time at 180 seconds. Here, the number of clusters formed in case of proposed EACW protocol and the number of members in this protocol is more. The highest member's quantity is 23, but in the previous scheme it is not more than 7. That shows the better energy utilization. The small cluster formation consumes more energy, and the larger cluster formation utilizes node energy efficiently. In the proposed EACW scheme, fewer clusters are formed but the connections between the CHs and CMs show strong connections.

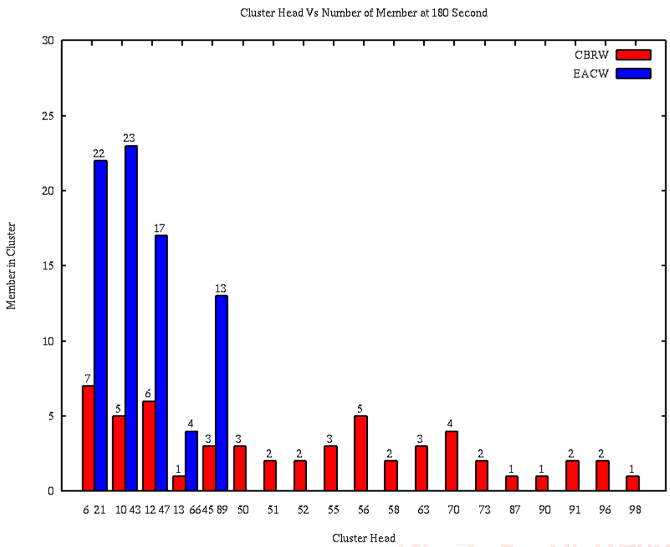

Figure 5: Cluster Head and Cluster Member at End of Simulation

F. CONCLUSION AND FUTURE WORK

The nodes in a Wireless Sensor Network (WSN) are able to store information and also transfer data to other sensor nodes for data delivery outside the network area or city with the help of IoT nodes. The IoT nodes are not only for switching off or on the other IoT-enabled devices; we can also use them for routing data or transferring information from one network to other networks. The cluster-based routing approach utilizes the energy and performance of the clusters better than the traditional routing for sending the data in the groups. All nodes do not participate in routing, and the role of CHs and CMs reduces flooding in the network. To improve route efficiency in WSN-IoT, energy-efficient utilization is required. The proposed Energy Aware Cluster Based Wireless Sensor-IoT Network (EACW) focuses on residual energy level as an efficiency metric, which has been used for routing choices in energy efficient routing to optimize route selection. The performance of EACW compared with CBRW and proposed EACW shows better performance. In our first parameter, the number of live nodes is greater as compared to the previous scheme. In the second outcome, evaluated the throughput performance and proposed scheme, showing a 90Mbps difference in data received per unit of time. The routing overhead of EACW is 0.12 and the previous scheme, CBRW, is 0.2. The flooding of routing packets is more because of broken links or connection problems in CH and CMs. The efficiency of the proposed CBRW protocol gives an exceptional outcome for given simulation parameters. The connection between the CHs and CMs is stronger. That shows the efficient utilization of sensor node energy and, because of that, the possibility of link breakage is less. The EACW approach optimizes the routing performance by utilizing energy efficiently in the WSN-IoT network.

For the longer-term work, this subject will be investigated with location-based routing for the reason that location-based routing protocol minimizes the flooding of packets and likewise compares the performance of the proposed scheme with future location-based routing protocols.

Reference

[1] Jaya Mishra, Jaspal Bagga et.al. "Performance Evaluation of Cluster-based Routing Protocol used in Wireless Internet-of-Things Sensor Networks" 29 june 2021 IEEE Xplore.

[2] Muhammad Nadeem Akhtar. et. al."Cluster based Routing Protocols for Wireless Sensor Networks: An Overview" (IJACSA) Vol. 9, No. 12, 2018.

[3] Asha Jerlin Manue et.al. "Optimization of Routing-Based Clustering Approaches in Wireless Sensor Network: Review and Open Research Issues" MDPI Electronics 2020.

[4] Masood Ahmad et.al. "Optimal Clustering in Wireless Sensor Networks for the Internet of Things Based on Memetic Algorithm: meme WSN" Hindawi Wireless Communications and Mobile Computing Volume 2021.

[5] Yamin Han et.al. "Energy-Balanced Cluster-Routing Protocol Based on Particle Swarm Optimization with Five Mutation Operators for Wireless Sensor Networks" sensor MDPI 16 December 2020.

[6] Raúl Aquino-Santos et.al. "Performance analysis of routing strategies for wireless sensor networks" Univ. Antioquia N.° 52 pp. 185-195. Marzo, 2010.

[7] Shio Kumar Singh et. al. "A Survey of Energy-Efficient Hierarchical Cluster-Based Routing in Wireless Sensor Networks" Advanced Networking and Applications Volume: 02, Issue: 02, Pages: 570-580 (2010).

[8] Huanan Zhang "Cluster-based routing protocols for wireless sensor networks" MATEC Web of Conferences 336, 04016 (2021) .

[9] Sultan Alkhliwi "Energy Efficient Cluster based Routing Protocol with Secure IDS for IoT Assisted Heterogeneous WSN" International Journal of Advanced Computer Science and Applications, Vol. 11, No. 11, 2020.

[10] Walid Osamy et. al. "Deterministic clustering based compressive sensing scheme for fog-supported heterogeneous wireless sensor networks" Peerj Published 7 April 2021.

[11] Maman Abdurohman et. al. "A Modified E-LEACH Routing Protocol for Improving the Lifetime of a Wireless Sensor Network" J Inf Process Syst, Vol.16, No.4, pp.845~858, August 2020.

[12] Chaitra H.V et. al. "Secure And Efficient Cluster Based Routing Model For Wireless Sensor Network" (IJITEE) , Volume-8 Issue-11, September 2019.

[13] Huarui Wu et. al. "Energy Efficient Chain Based Routing Protocol for Orchard Wireless Sensor Network" Journal of Electrical Engineering & Technology (2019).

[14] Yasameen Sajid Razooqi et. al. "Intelligent Routing to Enhance Energy Consumption in Wireless Sensor Network: A survey" coference title 29 jan 2021.

[15] Ravi Kumar Poluruet. Al. "A Literature Review on Routing Strategy in the Internet of Things" Journal of Engineering Science and Technology Review 10 (5) (2017).

[16] Deok Hee Nam "Comparison Studies of Hierarchical Cluster-Based Routing Protocols in Wireless Sensor Networks" CATA 2020 (EPiC Series in Computing, vol. 69).