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An ANN Based Energy Efficient Clustering and Routing Algorithm for IOT Network Monitoring

Devanshi Vaidya, Er. Avni Sharma
Department of CSE
HPTU

Abstract-Presently, Internet of Things (IoT) network enables new procedures of communication between persons and electronics things and between electronic things themselves. Each of the electronic things or devices in IoT networks communicates with the others and plays a defined role to improve the communication quality of services (QoS). To improve the communication quality in the IoT networks, routing protocol is an important step to generate a quality performance. It is a challenge to find the suitable characteristic of IoT network routing protocol which conforms to a certain network condition scenario. In the last ten years in IoT network, many researchers connected research to analyze the performance of routing protocol for the IoT network but still lots of problems are faces such as energy consumption, slow transmission, high drop rate and security concern. Basically, there three types of routing mechanism in the IoT network named as flat, hierarchical and geographical based routing. But most affective is hierarchical routing that includes the concept of the clustering-based routing mechanism. In this paper, an Artificial Neural Network (ANN) based energy efficient clustering and routing algorithm for IoT network monitoring purpose is designed where, K-means is used as a clustering approach that helps to select the cluster head based on the residual as well as coverage distribution concept. The designed clustering-based energy efficient routing (CEER) mechanism is work on the basis of five different communication scenario such as Node to Node (N2N), Node to Cluster Head (N2CH), Cluster Head to Cluster Head (CH2CH), Cluster Head to Node (CH2N) and Cluster Head to Base Station (CH2BS). After the simulation of the designed scenario, we compare with existing works to validate the proposed CEER mechanism and we achieve maximum throughput with higher rate of Packet Delivery Ratio (PDR) and energy consumption also reduced by the 28.87%.

Keywords:-IoT, Routing Protocol, CEER, Clustering, K-means, ANN, QoS.

I. INTRODUCTION

Internet of Things (IoT) network is one of the emerging technologies and it is the fundamental idea of a collection of heterogeneous as well as homogeneous devices that are uniquely addressable, and also capable to share information from sender to receiver [1]. IoT networks have lots of applications in many aspects of human life, such as monitoring of Environmental conditions, to control the industries and military fields [2]. In IoT networks, devices are deployed in large amounts that having sensing capacity to monitor the ambient environment and each deployed device that is also known as sensor node needs to transmit the sensed data to the base station via intermediates nodes [3]. So, for sensed data transmission over the IoT network, many aspects play an important role such as routing protocols, energy management and simulation area management. In an IoT network, small sensor nodes are used for data sensing and it is powered by a small battery having a limited resource that is tough to charge or replace.

The massive number of smart devices and the ubiquitous connection demands generate a problem for the energy in the IoT network. So, efficient energy based routing mechanism is widely considered to prevent disruption and prolong the lifetime of the IoT network. So, to design an energy-efficient routing mechanism in an IoT environment, we need to utilize the concept of clustering mechanism for better route discovery because routing protocol in wireless communication performs an important task [4].

Routing mechanism is used to find out the better routes via intermediate sensor nodes or cluster heads (CHs) in IoT network and forwarding the data packets containing information which choose the route between any two sensor nodes in the network. A good routing protocol in an IoT network must be able to keep its energy usage as low as possible during the route discovery mechanism and also make secure data transmission [5].

It must be done to prevent its sensor node from getting down which can create disrupted data communication in the IoT network. Hence, how to create a decent routing scenario which can regulate sensor nodes with minimal energy consumption in the network becomes very important. IoT network has a different number of routing protocols and it can be categorized into three types as Flat, Hierarchical and Geographical edifice based routing protocols [6]. The types of MANET routing protocol is shown in Fig. 1

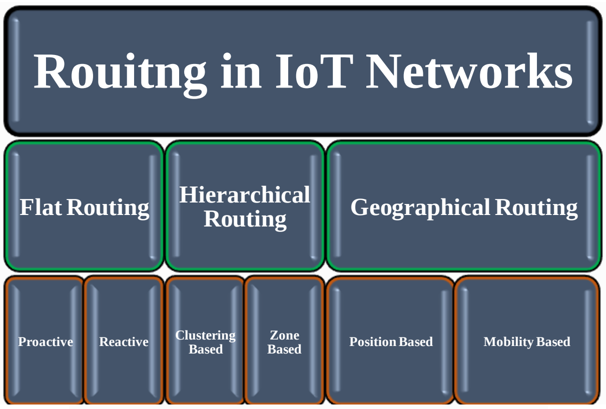

Fig 1. Routing Protocols in IoT Networks.

The routing mechanism of the IoT networks are adopted from the Wireless Sensor Networks (WSNs) because the working architecture of the IoT network is based on the sensor nodes and types of routing protocols in IoT networks is given as:

1. Flat Routing Protocols:
In this routing, IoT network communication protocol is designed by routers in which all sensor nodes are connected with each other. It is a distributive type routing mechanism and it may be predefine or on-demand [7].

Types of flat routing protocols are:
- Proactive Routing Protocol (PRP)
- Reactive Routing Protocol (RRP)

2. Hierarchical Routing Protocols:
They are also called clustering-based routing protocols because they use the concept of clustering mechanism for route discovery mechanism.It is also known as a divide and conquer approach for the IoT networks in which entire network is divided into different regions or clusters then a route will selected for the data transmission [8]. Clustering-based routing is an energy efficient routing mechanism, so, in this research, we introducing this concept for IoT the network.

Types of hierarchical routing protocols are:
- Clustering-based Routing Protocol (CRP)
- Zone-based Routing Protocol (ZRP)

3. Geographical Routing Protocols:
This type of routing protocols is also termed geo-routing or position-based routing in IoT network and it works on the basis of the exact sensors geographic position based information.

It requires that each node can determine its own location and that the source is aware of the location of the destination [9].

Types of geographical routing protocols are:
- Position-based Routing Protocol (PBRP)
- Mobility-based Routing Protocol (MRP)

Above mentioned routing mechanisms are used in the IoT network for the communication process but clustering-based and multi-hop-based routing is the common approach to improve energy efficiency of the network.

II. MAIN CONTRIBUTION

In this research, we focus to design a clustering-based energy efficient routing (CEER) mechanism for IoT network using Artificial Neural Network (ANN) as a classifier to detect the fail sensor nodes during the communication because the network has limitations in terms of transmission capacity, as well as energy capacity [10].

The working of the IoT network is based on the clustering approach where we utilize the concept of K-means for the selection of CHs instead of letting each node in the network forward its own information to the base station directly, they are grouped into different clusters. In each cluster, a CH node is selected based on residual energy or coverage distribution.

The CH node will collect information from other cluster member nodes and then forward the processed information to the base station using other CH nodes via multiple hops. The working of CEER is based on the clustering mechanism that is known as the cluster-based approach where we use K-means as a clustering technique to create a distributed network. By using this concept, the problem of energy-efficient routing is almost solved but they face other problems like failure of nodes during the data transmission [11].

So, the main motivation behind introducing the CEER mechanism is to provide a better energy efficient route along with the failure detection capacity by utilizing the ANN as a classifier in IoT network and major contributions are listed as:

- We present a brief analysis of the existing clustering-based routing mechanism for IoT networks to find out the issues faced by the researchers during the communication.
- We introducing CEER mechanism with K-means and ANN to discover an energy-efficient route for data transmission via CHs with multi hops.
- Here, ANN as artificial intelligence is used to detect the failure of sensor nodes during the transmission of data packets in an IoT network.
- To validate the proposed CEER mechanism, a comparison with the existing state of the art using different approaches are performed in terms of Throughput, Packet Delivery Ratio (PDR), Delay and Energy Consumption as a Quality of Service (QoS) parameters.

In this section, we provide a brief introduction about the proposed CEER mechanism and the main focus of the research is to introduce an energy-efficient mechanism for IoT networks with nodes failure detection, and the rest of the paper is organized as: in Section 2, literature survey is discussed related to the clustering-based mechanism where the architecture of CEER is discussed in Section 3 with the experimental setup.

In Section 4, simulation results of the IoT network are discussed and the conclusion with the future possibilities is discussed in Section 5.

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III. LITERATURE SURVEY

This section describes the literature survey of the existing work related to the clustering-based routing mechanism in IoT network by the researchers in the previous years.

In **2020, Ouhab et al.** had conducted a new efficient routing model for large scale networks. The model used an SDN controller with a Q-learning approach over a wireless sensor network organized in multi-hop clusters. In this network, packets are transmitted using a modified version of the RPL protocol. The use of this combined solution allows the network to save energy, a major concern of the WSN domain, while guaranteeing better performance concerning certain evaluation parameters, compared to conventional solutions in the literature. They intend to deploy the RPL nodes on a real tested, to ensure that the results of the model used are consistent. Furthermore, they desired to explore the multi-homed solutions, where nodes have multiple communication interfaces and the choice of one over the other depends on different QoS metrics and real-time test bed.

Praveen Kumar Reddy and RajasekharaBabu in 2019 also presented the optimal cluster head selection model in the WSN-based IoT network using a hybrid algorithm with the combination of MFO and ALO algorithms. The main objective of the proposed model was to select the cluster head by not only preserving the energy of the node by minimizing distance and delay but also by balancing the temperature and load of IoT devices. Next to the simulation, it has compared the performance of the hybrid model with conventional models like ABC, GA, PSO, GSA, ALO, MFO, and AGSA. The performance of the proposed hybrid model has extended the life expectancy of the WSN–IoT network as it preserves more energy and minimizes distance, delay, load, and energy of sensors and IoT devices.

Li et al. in 2018 proposed a new clustering-based routing metric for multi-channel and multi-hop IoT aware WMNs. This metric obtains information on intra-flow interference, inter-flow interference, and traffic load to uplift the network performance. The proposed scheme efficiently reduced the interference delay and balances the load among different links in IoT WMNs. The proposed scheme in-concatenates the new routing metric with the AODV protocol for testing in an environment of IoT aware WMN. In an IoT environment, they believed that their results are able to provide in-depth insight into the routing algorithm designed for multimedia communication services in IoT. The proposed scheme performs efficiently by selecting optimal routes in the network.

The simulation results showed that the proposed scheme can be incorporated into a load-balancing path discovery algorithm. This algorithm will be used to design a load balancing protocol that will choose a path that will deliver high throughput, reduce the average end to end delay with minimized interference, and can help in increasing the network capacity effectively. Finally, the proposed scheme is compared with the existing scheme in the literature and it showed better results and hence improves the network performance.

Zhang et al. in 2017 had conducted research on an incremental clustering algorithm by fast finding and searching of density peaks based on k-medoids (ICFSKM). In the proposed algorithm, two cluster operations, namely cluster creating and cluster merging, are defined to integrate the current pattern into the previous one for the final clustering result and k-medoids are employed to modify the clustering centers according to the new arriving objects.

Finally, experiments are conducted to validate the proposed scheme on three popular UCI datasets and two real datasets collected from the industrial Internet of Things in terms of clustering accuracy and computational time. They should further validate their proposed schemes in the large-scale cloud platform.

Hodo et al. in 2016 presented a threat analysis of the IoT and uses an ANN to combat these threats. A multi-level perceptron, a type of supervised ANN, is trained using internet packet traces, and then is assessed on its ability to thwart Distributed Denial of Service (DDoS/DoS) attacks. This research focuses on the classification of normal and threat patterns on an IoT Network. The ANN procedure is validated against a simulated IoT network. The experimental results demonstrate 99.4% accuracy and can successfully detect various DDoS/DoS attacks.

In IoT network, we know that it is a connection of different tiny wireless mobile sensor nodes or electronic devices and powered by small batteries. The batteries cannot be recharged once the sensor nodes are deployed into the IoT network. In such a case, it becomes quite important to use the battery very efficiently and need an energy-efficient route for the data transmission from the source to the destination node.

The battery in terms of energy is consumed to perform the following set of operations within the IoT network:

- During Route Discovery
- During Failure Detection
- During Network Trafficking

IoT network routing is used to set up the path for the transfer of the data packets from the source (T_X-Node) to the destination (R_X-Node). According to the survey, there are a lot of routing algorithms are available but still, an IoT network suffers security and energy management problems during the routing. So, we conclude some important and major point which helps to short out existing IoT network security as well as energy-efficient problem.

Our contribution in this research is to solve mentioned energy management as well as failure detection problems in three scenarios. Firstly, we introduce a CEER routing mechanism to discover a secure and energy-efficient route with the help of CHs. Secondly, the concept of ANN as an AI technique is used to detect the fail or malicious mobile sensor nodes during the transmission of data packets and the last, to validate the proposed CEER mechanism in IoT network, a comparison with the existing state of the art using different routing protocols are performed and our designed IoT network can be easily generalized to other challenging routing and security problems.

IV. MODEL ARCHITECTURE

In this section, we explain the used methodology and designed algorithms that are to discover a route using CEER mechanism with the help of ANN and the model is shown in Fig. 2.

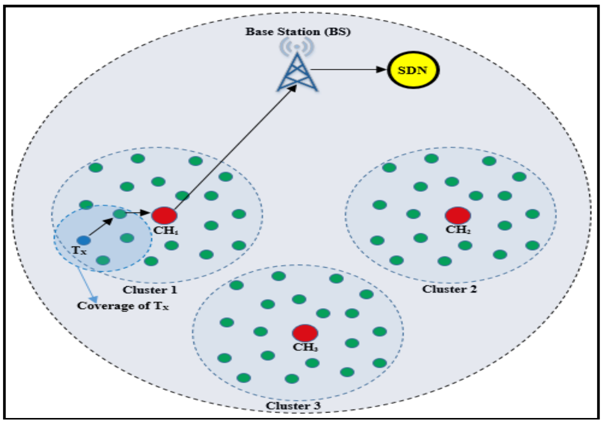

Fig 2.CEER Mechanism in IoT Network.

In this research, we focus to design an algorithm of CEER routing using the ANN as a classification approach that utilizes the properties of clustering-based routing protocols. So, it is called the CEER mechanism and having better capacity compared to the other existing routing mechanisms. In this research work, the CEER mechanism is used to find a route between the T_X-Node to BS-Node (Base Station Node). The methodology of the proposed CEER for IoT network is defined as follows:

1. IoT Network Simulator:

In this section, we describe the system architecture work for the IoT network. So, firstly we need to design an IoT network simulator with the concept of MATLAB-GUI (Graphical User Interface) in the version of 2016a software with CEER mechanism. To design an IoT network simulator, a specific area should be defined using the network height and width according to the given equation:

$$\mathbf{IoTNetworkArea, A = H(m)XW(m)} \text{ .... } \mathbf{(1)}$$

Where;

H → Height of the MANET simulator and

W → Width is the MANET simulator

Here, both are assumed as a fixed number and it is 1000m for height and 1000m for width, so the total MANET Simulator area become 1000m2 and the developed MANET simulator is shown in Fig. 3.

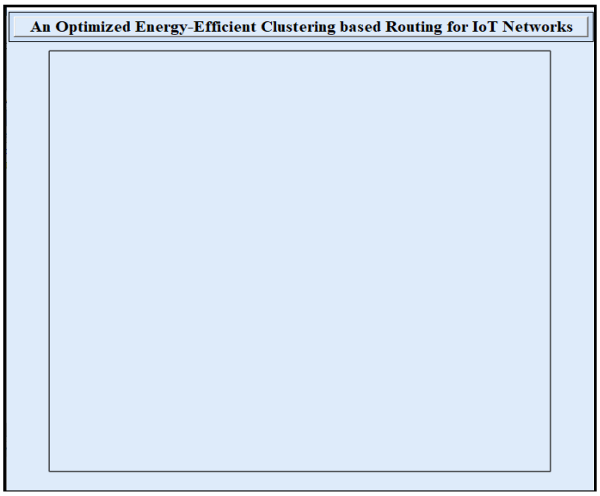

Fig 3.IoT Network Simulator.

For the simulation of the IoT network, design and develop IoT Network simulator is shown in the Fig. 3 with specific network height (H) and width (W) and once area of network simulator decided then, we move to further sensor nodes deployment processing with mobile sensor nodes.

2. Nodes Deployment in IoT Network:

When we create an IoT network simulator then we need to deploy sensor nodes within the area for simulation purposes. So, we deploy a total of 100 nodes within the IoT network area and nodes deployment is shown in Fig. 4.

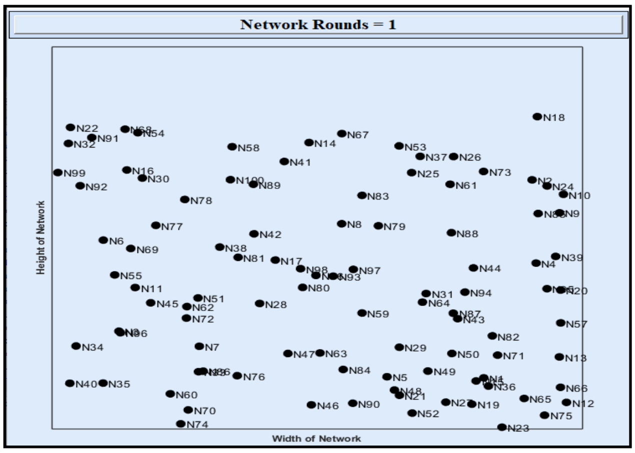

Fig 4. Sensor Nodes Deployment in IoT Simulator.

Above Fig. 4 characterizes the deployed 100 nodes within the area if IoT network simulator and name of each node are written with nodes marker.

Each deployed node having some basic properties like coordinates, residual energy, data transmission rate etc. Based on the residual energy of the sensor nodes, we decide the status of node in terms of Active or Dead nodes.

3. Active and dead nodes Segementation:

After the sensoe nodes eploymnet in the IoT network simulator, we segment the sensor nodes into two categories such as Active and Dead for better communication without any disturbance. The active sensor nodes are denoted according to their CH and dead nodes are denoted using read color as shown in the Fig. 5.

Here, the CH selection is performed using the K-means with residual energy concept and to find out active and dead node, we use given procedure:

Set Residual Energy Threshold, RE_T = 25% of Maximum Residual Energy (RE)
For I = 1→Nodes
    If RE (I) > RE_T
        Consider as an Active Node
    Else
        Consider as a Dead Node
    End – If
End – For

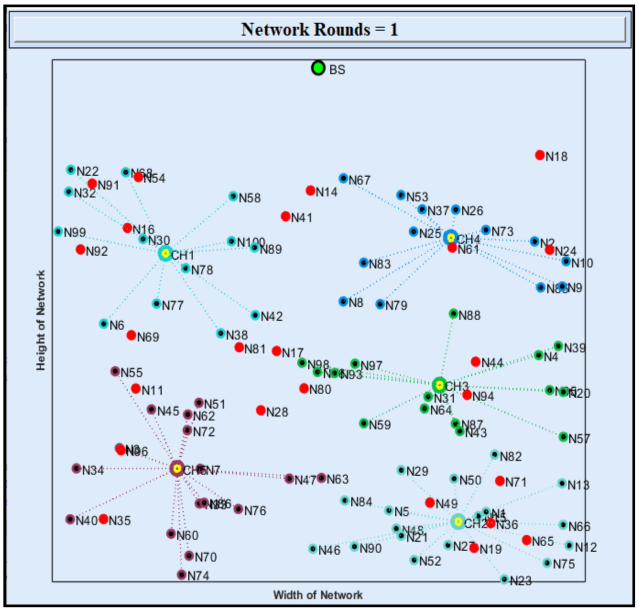

Fig 5. Status of Deployed Sensor Nodes in IoT Network.

Above Fig. 5 epitomizes that the status of each deployed sensor nodes within the IoT network, where entire network is divide into five number of clusters and in each cluster, a node is selected as CH of those cluster to monitor the entire region. We represents the sensor nodes according to their CH color, so visualization become simple and easy to understand. Above the IoT network area, a green color node is deployed that is known as the BS-Node and our motive is to deliver the data packets to BS-Node for further communication.

4. Source Node Deployment in IoT Network:

After the complete deployment of sensor nodes within the IoT network, we select source nodes as T_X-Node that transmits the sensed data packets to BS-Node using the route. In this step of CEER mechanism is sued for the routing according to the different zones or clusters or regions and T_X-Node report the sense data to own CH within cluster based on their available energy and the deployment of T_X-Node is shown in the Fig. 6.

Where, five clusters are formed using the concept of K-means with CEER mechanism. In the each cluster, a CH is defined and according to the figure, these are sensor nodes are represents with a unique color code. In the IoT network simulator, we assume each CHs can cover the entire cluster that is situated in the cluster area of CHs and we deploy a node as T_X-Node using given procedure:

For I = 1→Nodes
    Position = randomly (From 1 to Alive Node)
    T_X-Node=Alive Node List (Position)
    Deploy in the IoT Network Area
    Provide Name
End – For

In this step, we select a sensor nodes as a source node (T_X-Node) and BS-Node as a destination (R_X-Node) for the simulation purpose. In the Fig. 6, the source and destination nodes are shown with the help of green color with circular marker shape. We see that the source that is known as T_X-Node is lies in the cluster 3, where the destination that is known as BS-Node is lies above the network.

The selection of the nodes as source or destination is a random method, so we can't specify the source and destination manually. After the selection of T_X-Node and R_X-Node, we create a route for the data transmission purpose using the concept of CEER mechanism.

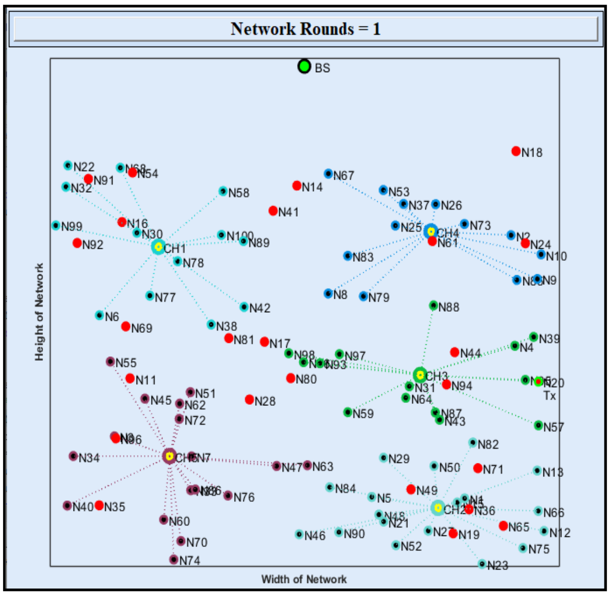

Fig 6. T_X-Node Deployment in IoT Simulator.

5. Routing using CEER Mechanism:
After the basic set up of IoT simulator, route discovery is performed to transmit the data packets from T_X to BS-node via CH of the particular cluster region. The route discovery mechanism using CEER is shown in the Fig. 7.

Based on the figure scenario, T_X transmit the data packets to its CH and then CH decide to next hop or node as an intermediate nodes in the route. So, the discovered route is denoted as R_T.

$$\mathbf{RouteinIoTNetwork, RT} = [\mathbf{Node - 20, CH - 3, CH - 4andBS - Node}]$$

In the Route (R), Node-20 is T_X and BS-Node is R_X-Node, when route is discovery mechanism performed then CH-3 and CH-4 is considered in route as intermediate nodes and discovers a route but still the route is not verified.

So, after that, ANN is used with CEER mechanism for the detection of fail and dead node within the route because we introducing the concept of five different type of communication such as:

- Node to Node (N2N)
- Node to Cluster Head (N2CH)
- Cluster Head to Cluster Head (CH2CH)
- Cluster Head to Node (CH2N) and
- Cluster Head to Base Station (CH2BS)

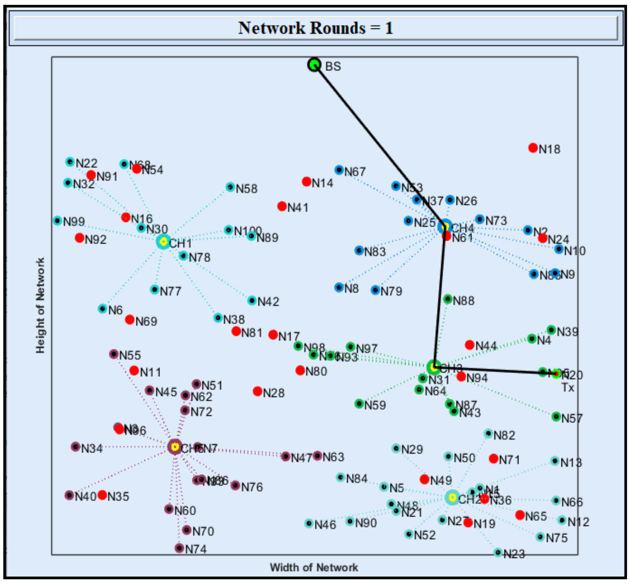

Fig 7. Route Discovery in IoT Network using CEER Mechanism.

After the routing mechanism, in this research we evaluate the performance parameters of the MANET in terms of QoS such as Throughput, Packet Delivery Ratio (PDR), Packet Drop Ratio, Delay, Energy Consumption and Control Overhead. If these QoS is not satisfactory, that means data packets are losses, then we utilize the concept of GOA-based ANN as classifier to detect the fail or malicious node within the route.

According to the figure, Node-15 is a dead or fail node that is not deliver the data packets successfully to the next node and loss the data packets. So, to identify the dead or fail nodes within the route we use the GOA-based ANN in IEE-ZRP mechanism and the algorithm is written as:

Algorithm: CEER Mechanism with ANN
Required Input
N_{SN}← Number of Sensor Nodes
T_X←Source node as transmitter
BS-Node←Destination node as receiver
N_{DATA}← Nodes Feature Data
Cat ← Target of ANN as an Active and Dead Nodes
N ← Carrier Neurons Number
Obtained Output
EER and Dead Node ←Energy Efficient and Verified Route from $T_X$to BS Nodewith dead or fail nodes
Start IEE-ZRP
Divide total IoT Network Simulator into Clusters
C = C_1, C_2, C_3 ...CN
If BS-Node is not in T_X Coverage
Discover route

Route, R = [] // Assign an array
Nodes (T_X) start searching its CH
Route, R = [T_X, CH of T_X]
While BS-Node not founded and update R and search again
If BS-Node founded
Final route, FR = [T_X, CH of T_X, N, BS-Node]
Else Check next route condition
End – If
Call and set the ANN using nodes properties as training data (T), number of T as group (G) and Neurons (N)
Set, IoT Net = NEWFF (T, Group, N)
IoT Net = TRAIN (IoT Net, T, G)
Current Sensor Nodes, NC = Properties of current node in IoT Network
Sensor Nodes Characteristics = SIM (IoT Net, NC)
If Sensor Nodes Characteristics is valid then
EER = Validated
Else
EER = Fail or Dead Nodes
End – If
Returns: EER as an Energy Efficient and Verified Route from T_X to BS-Node with dead or fail nodes
End – Function

Based on the above mentioned CEER mechanism with ANN algorithm, we create an energy efficient route from T_X-Node to BS-Node via CH and then we again calculate the QoS parameters to validate the proposed simulation by comparing with existing work on the basis of below given experimental setup in Table I.

Table 1.IoT Network Simulator Setup.

Mobile Sensor Nodes	100 to 1000
IoT Network Area	$1000m^2$ (Without BS-Node)
Simulation Tool	Communication and ANN Toolbox in MATLAB Software
Routing Protocol	CEER Mechanism
Simulation Time	10 to 50 sec
Classifier	ANN
Validation Parameter	Energy Consumption
Evaluation Parameter	Throughput, PDR, Delay and Energy Consumption

In the next section, the simulation of proposed CEER mechanism for IoT network scenario using the concept of ANN is described.

V. RESULTS AND DISCUSSION

The simulation results of the proposed ANN-based CEER mechanism for IoT network monitoring is discussed in this section of research article and compare with the **Ouhab et al.** [12] in the Table II.

Table 2.Delay (s) Comparison.

No. of Nodes	Existing (Ouhab et al. [12])			Proposed
	ETX RLP	Adaptive RLP	MHC RLP	CEER
100	2.8	2.5	1.7	0.6
200	4.2	3.6	2.7	1.1
300	6.9	5.2	3.8	2.4
400	8.8	7.3	6.5	3.2
500	10.6	10.1	8.2	4.7
600	13.2	12.1	11.8	5.5
700	14.6	13.1	12.2	6.8
800	15.6	14.9	14.1	7.4

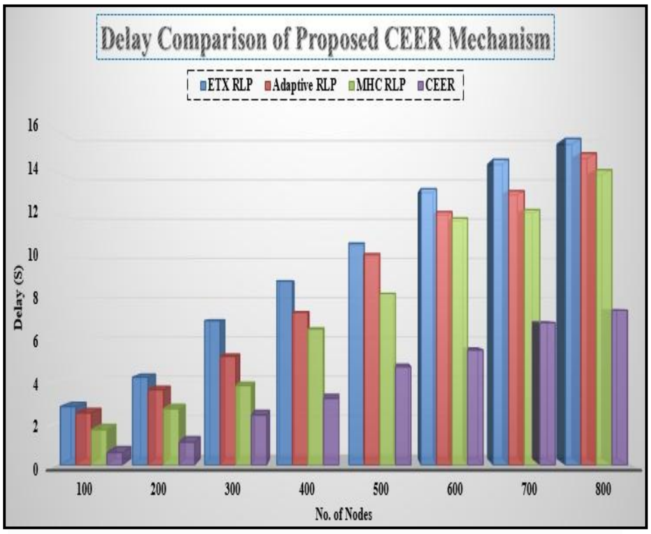

Fig 8. Comparison of Delay of CEER Mechanism with Existing Protocols.

In the Fig. 8, the comparison of transmission end to end delay of CEER mechanism with existing protocols is shown. Where, we consider three different routing mechanism named as ETX-RLP (Expected Transmission Count Routing Protocol for Low-Power Networks), Adaptive-RLP and MHC-RLP (Multi-hop Clustering RLP).

The transmission delay of the proposed CEER mechanism less comparatively others routing mechanism that is clearly observed from the above Fig. 8. Finally, we can say that the utilization of ANN to design a CEER mechanism is a beneficial step for the IoT network and delay is the sum of total time taken by network to transmit data packets from the T_X node to the BS-Node in the IoT networks and it is represented in terms of second. For better analysis of the CEER, we further compare the PDR in the Table III.

Table 3.PDR (%) Comparison.

No. of Nodes	Existing (Ouhab et al. [12])			Proposed
	ETX RLP	Adaptive RLP	MHC RLP	CEER
100	79.5	92.6	94.2	99.3
200	58.4	84.2	90.5	94.8
300	48.6	58.7	77.6	92.3
400	42.8	55.3	66.2	90.2
500	39.7	52.8	59.9	88.7
600	34.4	41.9	57.3	85.2
700	23.5	37.3	41.4	82.9
800	19.4	24.8	39.7	76.2

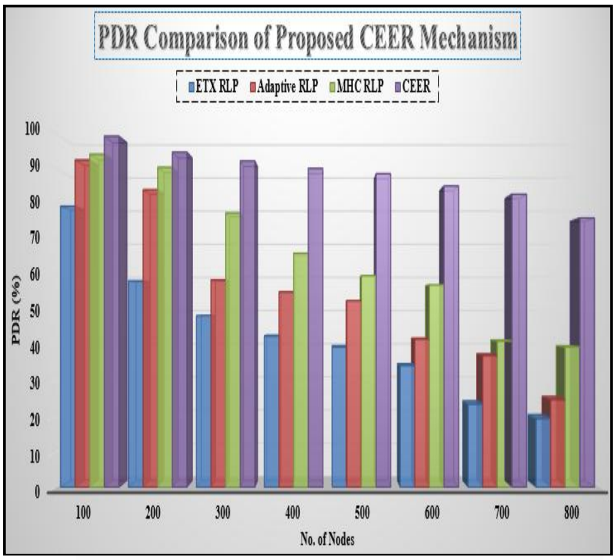

Fig 9.Comparison of PDR of CEER Mechanism with Existing Protocols.

From the above Fig. 9, we observed that the PDR of proposed CEER mechanism for IoT network using the ANN as an AI concept to detect the dead node is far better than the existing ETX-RLP, Adaptive-RLP and MHC-RLP. The PDR of IoT network is depends on the data transmission rate of network and it is the ratio of the total summation of data packet received at BS-Node and the total summation of data packets generated at T_X node in the networks are represented in terms of percentage. The formula of the PDR is given as:

$$PDR\,(\%) = \frac{\sum_{i=1}^{N} DataPacketsatT_X(i))}{\sum_{i=1}^{N} DataPacketsatBS(i))} \times 100 \;....\; (2)$$

Where, N is the total number of the sensor nodes in the proposed IoT network. But the main focus of this research is to design an energy efficient routing mechanism.

So, in Table IV, we present the comparison of CEER with existing routing mechanism based on the energy consumption rate.

Table 4.Energy Consumption (J) Comparison.

No. of Nodes	Existing Work [12]	Proposed CEER
100	0.25	0.11
200	0.29	0.17
300	0.31	0.19
400	0.36	0.26
500	0.39	0.29
600	0.42	0.32
700	0.44	0.35
800	0.45	0.38

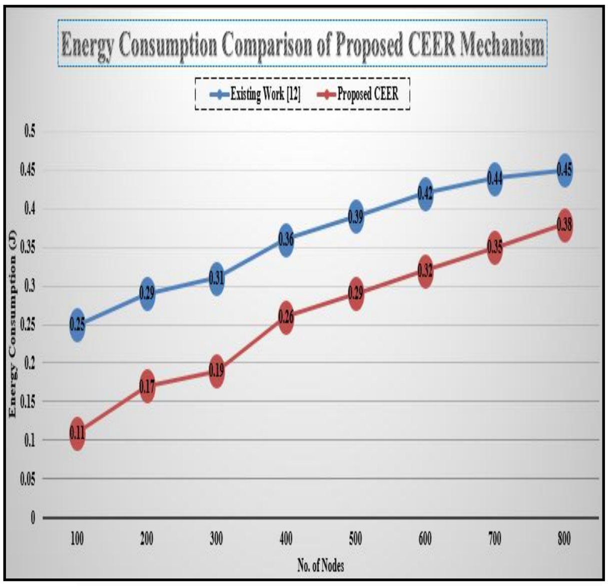

Fig10.Comparison of Energy Consumption of CEER Mechanism with Existing Protocols.

Based on the above analysis, we conclude that the utilization of CEER mechanism for IoT network is a beneficial step but our motive to construct an energy efficient routing model. So, for this prospective the evolution of energy consumption becomes a compulsory step.

The consumption of energy is calculated using written equation:

$$\mathbf{Energy_{Consumption}} = \sum_{i=1}^{N} \mathbf{T_p} + \mathbf{R_p} + \mathbf{W_p} \;....\; (3)$$

Where,Tp is the consumed energy by nodes during the transmission, Rp is the all consumed energy by nodes during the relieving a data packet and Wp is the consumed energy by a node during the waiting of data packets. From the Fig. 10, we observed that the energy consumption rate is degraded by using ANN-based CEER mechanism.

Total reduction in the energy consumption rate is near to 28.87% by utilizing the CEER mechanism for IoT network. Now, we show the effect of ANN with CEER on the data packets transmission using the Throughput as a QoS parameters.

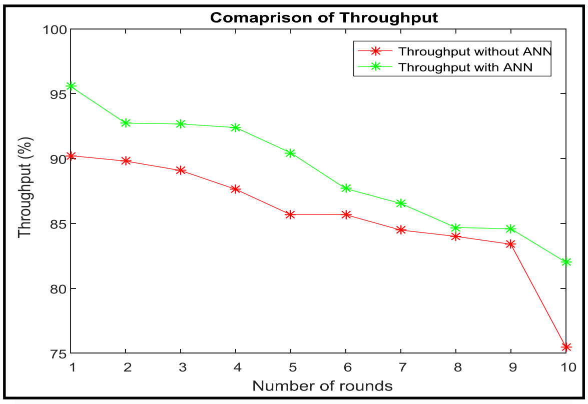

Fig 11.Throughput with ANN and without ANN.

Based on the above analysis of the experimental results, we observed the utilization of the ANN with CEER routing mechanism is a beneficial step regarding the communication in IoT networks.

VI. CONCLUSION AND FUTURE WORK

In this paper, an ANN-based CEER mechanism for IoT network monitoring is proposed based on the concept of K-means as a clustering technique. Based on the simulation experimental results analysis which observes about the QoS parameters of the CEER mechanism, we founded the utilization of CEER mechanism with ANN as an AI concept is most effective step.

Comparative analysis of proposed CEER mechanism represents the hybrid approach has the most efficient mechanism to deliver the packets from T_X-node to BS-node with maximum throughput or PDR and energy consumption also reduced by the 28.87%. It happens because the CEER mechanism can maintain the updated routing table more efficient manner than the other existing routing mechanism based on the energy consumption as well the residual energy of the sensor nodes in the network. The performance of CEER mechanism is much better than the existing work mechanism like ETX-RLP, Adaptive-RLP and MHC-RLP in all respects like throughput, PDR, end to end transmission delay, and energy consumption. So, in future, the idea of deep learning with optimization techniques will be utilized with the CEER as a classifier to for quick identification of fail nodes inside the IoT network.

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