Original Article

An Improved Energy Efficient Solution for Routing in IoT

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Abstract

The concept of the Internet of Things (IoT) is an innovation paradigm that suggests linking physical devices together to share data and work toward a common goal. Nodes in an IoT network are anticipated to communicate with one another and with third-party Internet services. However, not all network nodes have direct Internet access due to high deployment costs. As a result, additional network nodes should be using Internet-connected nodes as gateways to transmit data to online services. Due to its central role in establishing connections between nodes in a network and distributing data packets, routing protocols have emerged as a significant challenge in IoT use cases. The work of routing is complicated in mobile IoT scenarios due to the topology changes brought on by the mobility of nodes. To better handle the mobile nature of the devices, existing Iot routing solutions typically exhibit severe constraints and poor performance in such cases. This study proposes an improvement to the existing protocols; the Cluster Formation Protocol with Neuro Fuzzy Rules, in light of the fact that main routing techniques for low-power network are unable to achieve adequate performance in the shown IoT context. The energy efficiency of the routing process in WSN can be improved with the help of cluster based routing thanks to the proposed efficient routing algorithms. In addition, the efficiency of clustering & cluster based routing protocols can be enhanced by employing intelligent approaches like fuzzy rules, temporal constraints, and categorization via deep learning. Therefore, the safe transfer of data packets from of the source point to the sink node necessitates careful consideration in the development of cluster dependent routing algorithms. The cluster dependent routing method presented is developed, evaluated with respect to a number of criteria, and shown to be effective.

Keywords: Wireless Sensor Networks (WSN), IoT, load balancing, Routing.

1. INTRODUCTION

IoT has emerged as a key technology in numerous fields over the past decade [1,2], including "smart" buildings, "smart" cities, "smart" grids, "smart factories," and more. The Internet of Things (IoT) is the networked, connected & cooperative use of diverse physical objects and technologies for a variety of applications [3-5]. This includes but is not limited to mobile phones, sensors, cameras, actuator, and Broadcast Identification (RFID) tags. Some Internet of Things use cases, like smart houses and smart cities, require copious amounts of data for monitoring and controlling a defined region [5,6]. However, Wireless sensing networks (WSNs) are useful for monitoring and regulating a specific region because they provide a framework for managing and constructing the sensor nodes. [7-9]. Sensor nodes are thus regarded as primary building blocks of the IoT architecture in such contexts.

Deployed sensor nodes in a WSN monitor and gather data about their surrounding environment, then relay that information to a ground station or sink that is hooked up to the internet via gateways [10,11]. IoT devices in WSN-based IoT networks have challenges in areas including radio range & processing power.

Unfortunately, sensor nodes have a finite power supply, typically an irreplaceable battery [12-14]. Constant efforts to extend the lifespan of the network make conserving the power of the sensing nodes a top priority [15,16]. Green Internet of Things (IoT) systems necessitate a routing approach that takes into account not only the overall energy consumption of every node, but also the energy consumption of every node individually. The warm or energy gap problem [17,18] arises if this is not the case.

Because of the multi-hop forwarding style in these networks, nodes closer to the sink have a larger traffic load than those distant from the sink, leading to a hot-spot problem. Mobile sinks, first proposed in [19], are a practical solution to this issue.

It is necessary to propose a solution to WSNs' massive data and energy limits in order to achieve a balance in the network's energy consumption and increase its lifetime. Energy can be saved through alternative routes [20]. Through strategic routing, we can equalize network energy use. Multiple protocols for data forwarding, most of which utilize hierarchical clustering methods, help networks last longer. An optimal utilization of available power can be achieved by the topology-control framework [21].

One typical efficient routing algorithm is the Low-Energy Adapt Clustering Hierarchy (LEACH)[22] protocol. The LEACH protocol evenly distributes network energy usage by choosing a new Cluster Head (CH) at random at regular intervals. However, there are three significant flaws in this protocol: The protocol has three major flaws: 1) it does not account for the nodes' energy consumption; 2) it does not take into account the distance between the cluster heads (CHs) and the base stations (BSs); and 3) it requires frequent updates to the cluster network and CHs, which results in high energy consumption because of the constant rewiring required. It's not the best option for both CH and path, regardless of the state of the nodes. For optimal protocol performance, the LEACH centralised (LEACH-C) protocol [23] provides a centralized regulator method in BS that takes into consideration the number of clusters. It is forbidden for a nodule with a small level of energy to take on the role of CH. In order to do clustering, the nodes in this protocol have their mean distances to a CH added together.

To reduce power consumption during the CH selection stage, LEAC-C takes into account the energy and position of each node. LEACH-biggest C's flaw is that it doesn't take into account power usage during data transmission. In this method, a CH's communications with the BS are unrestricted by considerations of energy, CH location, or data throughput. Therefore, from an efficiency standpoint, this protocol is subpar. Another algorithm, improved LEACH [21], was presented to pick the route from the source to the BS with the lowest energy cost based on the original LEACH algorithm. Every node is linked to a CH using this protocol, and clustering is carried out according to node distance and the amount of energy required for data transit. It's possible that CHs won't be able to make direct contact with the BS via this protocol due to the disparity in their energies and the great distances between them. When attempting to contact the BS, they turn to nearby clusters to act as relay nodes. Every one of these protocols looks at data forwarding from a purely internal perspective. However, SDN could provide the global network view necessary for proper routing.

In general, the many nodes that make up the IoT network have severe limits placed on their memory, processing capability, and even energy consumption. This makes the network low power and lossy (LLN). The hardware capabilities and application goals of individual nodes in an Iot ecosystem will vary from deployment to deployment. Several network nodes in the IoT scenario depicted in Figure 1 may have an Internet connection that allows them to transmit and receive messages directly from the Internet. However, some nodes in the same network cannot have an Internet connection of their own due to hardware constraints and must rely on the Internet-connected node to gain access to the wider web and its resources. Each of these node can communicate with one another locally, eliminating the need to send data across the network. The routing protocol is responsible for determining the paths between nodes and facilitating the transfer of informational messages between them. Thus, the system performance in an LLN is directly related to how well the routing protocols exploit the limited resources of the network nodes.

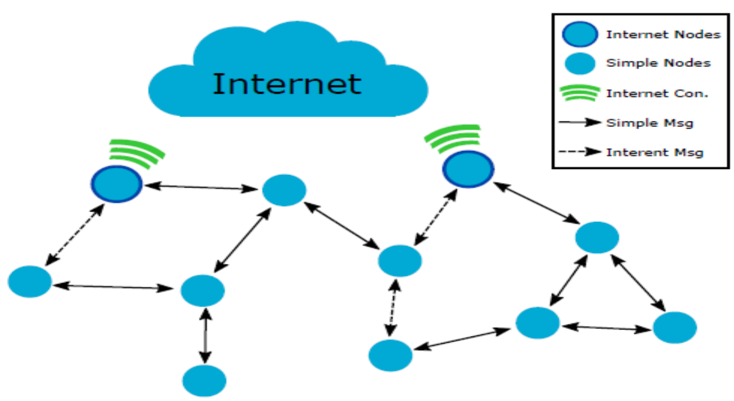

Figure 1. a sample IoT network architecture complete with nodes, links, and data messages.

For low-power IoT networks, there are two broad categories of routing protocols that may be broken down by how routes are created: reactive and proactive [8]. Without waiting for data messages to be sent, proactive protocols immediately begin building connections between the nodes. In most cases, gateway nodes are responsible for initiating the route building process by gathering data from other nodes in the network (MP2P traffic). This is why periodic data gathering applications use this kind of protocol. The IPv6 Routing Protocol with Low-Power and Lossless format Networks (RPL) [24] is the most prominent proactive routing protocol used for LLNs. On the other hand, reactive protocols generate paths only when a node is preparing to transport data to a certain location. Thus, the node that seeks the message initiates the process of route discovery. The generated routes are stored in the nodes' routing table, where they remain active until they are no longer needed. Since each node can transmit messages to any other node (point-to-point (P2P) traffic), this form of protocol is recommended for non-periodic traffic applications.

This paper is organized as follows: Section1 introduces importance of routing in IoT and Various Cluster based routing algorithms in IoT. Section2 Provides the Related works which has given predominant routing solutions in WSN & IoT. Section 3 Discusses about the Fuzzy Based Cluster configuration steering Protocol which is energy proficient algorithm for routing. Section 4 evaluates the proposed algorithm and provides the results of it and section5 concludes the work.

2. Related Works:

In this example, we provide a quick literature analysis of recent routing techniques in the IoT. In [25], for instance, the authors proposed a block chain-SDN-based allocated design for NFV-enabled smart cities. In addition, the authors presented an energy-optimized group leader determination method that can efficiently select a group leader. As an added bonus, the SDN controller manages and monitors how the IoT components function. In this study, we use block chain technology to locate and counteract cyber-attacks on Internet of Things (IoT) infrastructure. In regards to throughput, time, fuel usage, and communication overhead, the test results show that the suggested architecture performs better than the existing structure.

Distribution-based routing techniques, which make use of the network's topology to route packets, are notoriously inefficient. Since the overhead of centralized algorithms is low, and the chance of route failure is also low, they are advantageous [26]. Energy consumption can be reduced through load balancing. Balancing has been employed extensively in research to save power. [27]. In [28], a smart routing system for IoT-enabled WSNs is proposed using Deep Reinforcement Learning (DRL), which helps to drastically cut down on delay while simultaneously increasing the network's lifetime. The proposed method divides the network into uneven clusters according to the data transfer in each sensor, thus significantly extends the network's lifespan. The experimental outcomes show that the proposed strategy is effective in terms of network throughput, energy efficiency, delay in communication, and the percentage of living nodes.

A multilayer SDN-based system [29] is proposed to speed up data monitoring & load balancing across IoT devices in a local region and across network clusters. The proposed architecture safeguards against the controller becoming a bottleneck. 2,and it facilitates the use of various management & load balancing mechanisms in a hierarchy and multi-step setting. Experimental findings showed that their technique enhanced processing performance by decreasing average turnover and waiting times. The proposed method also optimizes the utilization of network resources by distributing jobs uniformly across the system.

The software-defined sensor network was created when SDN & WSN were fused to create a more resilient system, and then in [30] a fuzz route discovery protocol was proposed to solve the problem of wasted energy in a WSN setup. (SDWSN). The FTDP is used in the SDWSN architecture to determine which new hop is optimal given the residual power (RP), node price (NP), Amount of nearest neighbors (NN), & queue Extent (QE). The sink in algorithm is fed details about the network's nodes and the deciding factors. After that, the data is sent to the controller, who then makes the next move based on the data and a fuzzy system.

In [31], the authors zeroed in on a service called SDN Based On load Balancing (SBLB) that takes into account both the response time and resource utilization of cloud server customers. The components of SBLB are an application module, a software-defined-networking (SDN) controller and server farms talking to one another through switches and routers with SDN functionality. There are other sub-modules within the program itself, including active load balancing, observing, & service categorization. All incoming communications are processed instantly, and the controller also oversees the pool of available hosts. The algorithm cuts down on typical response and reply times, as well.

To lessen the burden of control messages, a cluster-based traffic control strategy is proposed for use in hybrid SDNs [32]. The method takes advantage of both decentralized legacy routing and controlled SDN routing, making it a hybrid. The SDN controller's induced communication overhead also causes a trade-off with the fine-grained control of traffic flows. With this method, the amount of border nodes between clusters in a network is kept to a minimum. Rather than controlling the flows within each node, a dispersed legacy WSN routing handles the routing of traffic between clusters at their borders, while the flows within each cluster are managed by the SDN controller. In [26], various energy spaces are explored depending on the nodes' remaining energy. Using wireless connections, the nodes in this system are able to exchange information from different locations, with the controller prioritizing routes that take advantage of areas with a higher power rate.

As described in [33], Hybrid Cloud Trying to offload is set up, in which the jobs connected by advanced tasks are delegated to the servers, & the answers are then returned to related elements. This is an innovative approach for complex IoT applications, as it allows the IoT node to offload work to the most suitable fog node or cloud, depending on application needs and local fog node availability. Nodes' ability to offload work to each other or the cloud computing helps to distribute the workload and improves the state of affairs. A Markov Decision Processes model is used to describe the issue (MDP). In addition, a Q-learning dependent approach is introduced for resolving the system and picking the best offloading strategy. The proposed method has been shown to perform better than existing approaches in terms of time, number of tasks executed, and load balancing in numerical simulations.

Network congestion can be reduced through careful management of traffic flows, as suggested in [34], which proposes an Admission Method Of control (Opt-ACM) based on optimum load balancing. An MILP-based optimization problem is developed, and the effectiveness of Opt-ACM is verified by running it via the popular mathematical optimization solver, Gurobi. In [10], we see the proposal of a revolutionary Economical SDN-Based Wireless Sensor Infrastructure (ESD-WSN) that utilizes SDWSN and the Internet of Things (IoT) using proxy. Proxy nodes with a lot of processing power are picked to handle control traffic & data aggregation. Multiple rounds are used to select proxies, with the resulting node taking on some of the controller's duties.

For Internet of Things (IoT) applications across wireless mesh networks, a new routing mechanism based on clustering has been presented in [35]. Message exchange rates are kept low by using the cluster head nodes as well as the relay node in this approach. The relay can facilitate conversations across different clusters. In order to cut back on power usage, the authors of [36] suggest cutting down on the size and number of elements in the flow table. As part of this technique, only highly probable flow entries are kept in the table, while the rest are discarded. The Hidden Markov Models will purge the flow table of entries if there are none that correspond during a given time period (HMM). In [37], a novel architecture for efficient routing called Quality-of-Service-based Routing Protocol with Software-Defined Features of the input less Entity (QSDNWISE) is presented. Because of the high power requirements of individual nodes, this design makes extensive use of clusters or cluster - head arranged in a dense cluster around the sink. The method executes separate route for each type of data by dividing them apart.

In [38], the best quantizes for sink and controller localisation were identified. Through this technique, energy usage drops by reducing the number of hops required to reach the sink and controller from the source node. In addition, the optimum number of sinks or controllers are used to cut down on their effort. For the purposes of load balancing, the amount of flows is calculated in [39] by counting the number of connections among controllers as well as between switches or controllers. Having a greater bandwidth and an infinite number of links allows for the transfer of more data. As a result, this parameter could be utilized for flow control and equalization. [40] uses data flow in WSN to lessen the load and cut down on energy costs. Node queue length and remaining energy are used for this purpose.

Numerous controllers are discussed in [41], along with a proposal for dynamic load balancing. Assigning switches to controllers with smaller domains helps regulate the controller area and boosts the clustering effect. This approach uses the Broadness Search (BFS) to map switches to their corresponding controllers across a variety of domains. The ideal mapping of switches to controllers is carried out by this algorithm, which also takes into account the logical amount of controllers in order to cut down on communication costs and delays.

3. Fuzzy Based Cluster Formation Routing Protocol:

The fundamental goal of this effort is to improve the reliability of the Sensor WSN. In order to extend the usefulness of networks, the authors of this paper propose using a deep learning-based technique in conjunction with a Neuro Inference System (NFIS). NFIS is a helpful decision-making tool since it takes in a variety of data and outputs a single qualitative score. Much to other cluster-based routing protocols, such as LEACH, the suggested model operates in a series of rounds, beginning with an initial round and concluding with a final round. When compared to LEACH, the Fuzzy Logic based Clustering Protocol (FLCFP), and the Self Configured Cluster Head, the suggested work is distinct beginning with the cluster formation step (SCCH). The key distinction is in the range of inputs used to generate the cluster. While LEACH only takes into account a single parameter, FLCFP makes use of three, and SCCH only takes into account two. All of the potential nodes inside the CH's reach gradually converge on it in SCCH. When a node comes into distance of two or more CHs, it transmits the information to all of them, even though doing so would be redundant. Therefore, four criteria are employed in this study to facilitate the clustering process. In addition, this work takes a deep learning method by making use of a Convolution Neural Network (CNN) to formulate rules for locating energy efficient routing.

One input layer supplies the data, sixteen hidden layers perform the actual processing, and one output layer displays the final results in this work using a CNN. The convolution layer is implemented in one of the hidden units. Data from past and present exchanges is used to "train" the neural network. Previous information is mined for the first training phase. Using the existing information & executing fuzzy rules triggered by the suggestion scheme, the weights are changed. There is a continuous process of adjusting the cluster's constituents based on their proximity from the cluster's leaders and the collective available energy. To achieve this goal, a convolution neural network is used to assess the routing patterns and energy consumption of individual nodes. Convolution neural networks are trained to build rules that help determine the best possible path with the lowest possible energy expenditure. Due to the interconnected structure of these networks, training occurs at the hub and the regulations are broadcast to the sensor network. The sensor nodes perform the testing by relaying a collection of data they have gathered. This testing verifies the energy efficiency of the path discovered by the suggested routing algorithm. In order to offer an energy-efficient route method, the suggested routing algorithm makes use of a convolution neural network to accomplish deep convolution neural network of the node behaviors with regard to communication.

Cluster Head (CH) degree, CH distance from the sink, CH distance from the node, and the CH distance from the CH are all discussed in detail, as are the other four characteristics necessary for proper cluster formation. Once the CH has been elected, other nodes can connect to the network by selecting a suitable CH to affiliate with in order to join any of the clusters; the CH then gives approval or disapproval based on the use of fuzzy criteria. Figure 2 depicts the FBCFP's proposed protocol's Fuzzy rule based navigation system design. The output layer has one output, the input layer has three inputs, and the hidden layers each have 300 rules. The suggested parameter (CH) degree is one of four linguistic variables employed in this system, each of which has three possible values. As can be seen in Figure 2, the proposed routing system is comprised of various modules such as sensor nodes based on the Internet of Things (IoT), a neural network train and test module, a neuro-fuzzy inference engine, a neuro-fuzzy rule supervisor, a number of rules, a ground station, a data routing subsystem, a decision supervisor, and a cluster range online management. Working together, these modules more effectively gather data, route it, and make decisions in order to reduce energy use.

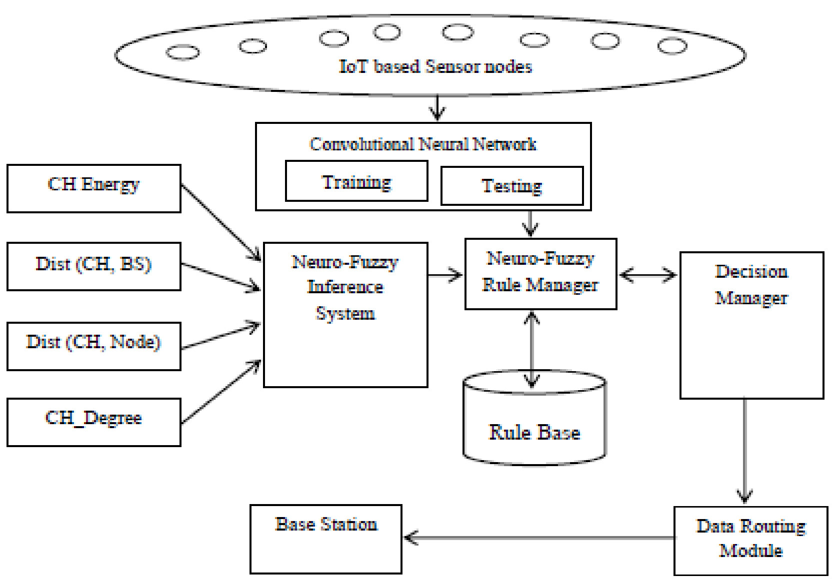

Figure 2. Proposed systems Architecture[42]

In this paper, we provide a cluster-based routing algorithm for efficient energy consumption, which makes use of fuzzy rules and a convolution neural network.

3.1 Proposed Algorithm:

Here are the steps of the routing algorithm that is being proposed:

Step 1: Read the energy levels and location (X_i, Y_i) of sensor nodes Si, i={1,2,…,n}
Step 2: Learn the distances of the nodes from of the base station as well as among themselves by sending HELLO messages to all the nearest neighbors.
Step 3: Invoke the k-means clustering algorithm to divide the data into k distinct groups based on their relative positions.
Step 4: Select the cluster heads for each cluster using the ground station as the coordination, taking into account the nodes' space & power levels.
Step 5: Find the shortest way from every node to a base station via heads of the cluster during route discovery.
Step 6: Using the shortest channel identified in Step 5, have the cluster heads relay data acquired by nodes: as well as using a fuzzy set of rules
Step 7: Get information from the home station.
Step 8: If the nodes' energy levels drop by at least 45%, the operation should be terminated.
Step 9: Ensure that the cluster head has been rotated if required.
Step 10: if true Proceed to Step 4, otherwise continue to Step 6.

As a result of this method, the sensor nodes will regularly update the base station with their data. When less than 5% of the initial energy remains and 45 percent of the nodes have depleted their reserves, the algorithm is stopped.

3.2 Working Procedure:

Using the cluster-based routing proposed in this research for route optimization in WSN, the packets collected by the sensor nodes are sent to the cluster - head either through the cluster members or directly. In order to efficiently route data packets, the cluster's head nodes employ a path detection method & persistently update the path they've discovered. Convolution neural networks were utilized for the network's guidance to account for variables like traffic density, bandwidth, and congestion. In addition, the clustering and path finding procedures in this work are executed using a fuzzy rule - based expert strategy. If a node wants to find the fastest way to send packets to a mobile sink, it will first have sent the packets its own cluster head. Then, the cluster head would then send the messages to the mobile sink. The system is periodically updated, and path detection procedure then employs the rules learned during preparation to optimize routing. In addition, this study efficiently employs fuzzy rules for equally useful creation and also to carry out cluster-based routing, thereby dealing with uncertainty.

4. Results and Discussion:

The NS-2 simulation program was used to run simulations on the suggested cluster formation methodology. Additionally, tests have been performed with a range of network sizes, from 50 nodes to 500 nodes. Over a (500x500) m2 space, these nodes have indeed been set up. In Table 1 we can see the values that have been utilized in this research for the simulation.

Table 1. Description of simulation elements

S.No	**Parameter**	**Description**
1	Total Network Place	500 x 500 m^2
2	Total Hops	500
3	Data sachet volume	1000 bytes
4	Bandwidth	2,4 and 6 Mbps
5	Existing Bandwidth	10MHz-20 MHz
6	MAC Standard	IEEE 802.11
7	Total Simulations	10
8	Transfer Rate	Constant bit rate flow

9	Simulation time	500 sec
10	Data package Production	1 Packet

The results of widespread testing of the suggested algorithm are reported. We ran two separate sets of tests in our simulation and labeled them situation 1 and situation 2, respectively. The sink in situation 1 was located at (100, 100), but in situation 2, it was located at (200, 250). Four input variables, including CH Level Of energy, Distance to BS, Distance to Node, and CH Degree, were used in the development of our inference system. Figure 3 shows the CH energy level variable and its values as they show up in Scenario 1. Low, moderate low, moderate, high minimal, and high are all possible values for this fuzzy set. Numbers below zero and over one hundred are calculated using the trapezoidal membership function, while values in the middle are represented using the triangle membership function.

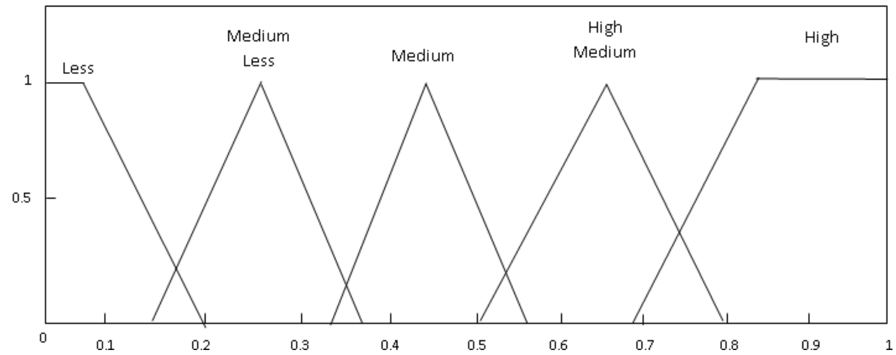

Figure 3. Energy Levels

Lifespan analysis of the network is shown in Figure 4 for both scenarios with a range of node counts.

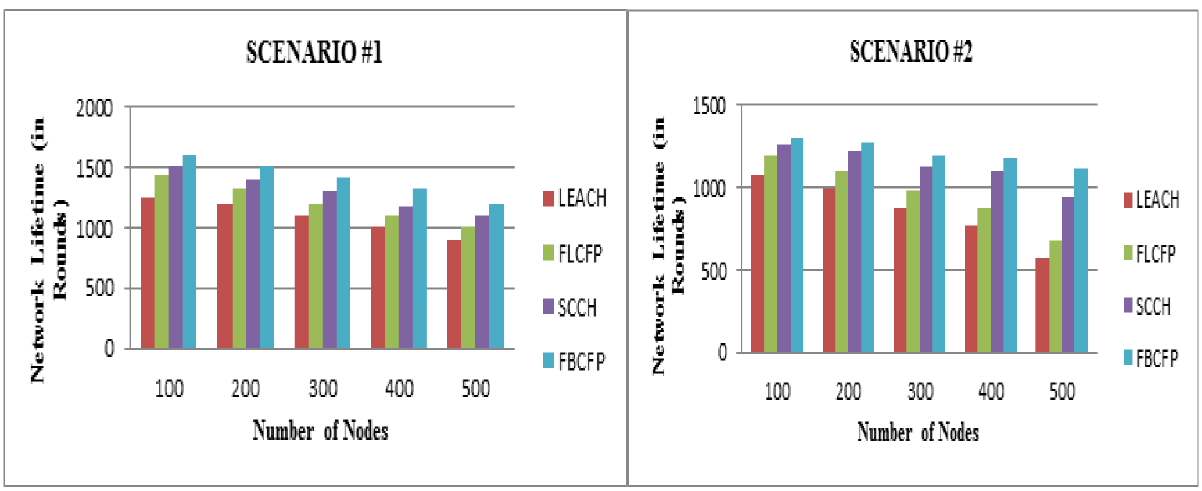

Figure 4.8 Network lifetime Analysis in situation #1 and situation #2

It is clear from this work that the routing algorithm proposed extends the lifetime of the network more so than LEACH, FLCFP, and SCCH. The cluster-forming stage is responsible for this. Each node in our proposed design connects to the CH after taking into account the cluster's present size, its leftover energy, and its distance from the CH. As a result, the CH are able to share the workload, which ultimately helps to prolong the network's lifetime by preventing the first node from dying prematurely. Using the proposed algorithm for routing results in the longest network lifetimes, as measured by the statistical measures used. A comparison using standard deviations is also carried out (SDs).

5.Conclusion:

In this paper, we provide a new cluster-based routing technique for efficient IoT-based sensor network routing. This routing algorithm improves network performance as a whole since it uses neuro-fuzzy rules to carry out precise clustering in order to supply cluster-based routing. This method proposes using energy modeling via the trust & energy manager to efficiently route packets while minimizing energy consumption. This is accomplished through the use of machine learning algorithms embedded into the cluster process for grouping the node of the WSNs. The network's lifetime is lengthened to a greater extent due to the use of a convolution neural network using fuzzy rules for load modification. Additionally, degrees of the CH, the amount of leftover power of the CH, the distance between both the CH or the sink node, and the distance between both the CH and the sensor node were all taken into account during the routing decision-making process. These four elements have been shown to be critical for optimizing energy consumption and extending the lifespan of networks. This work's findings demonstrate that the suggested protocol outperformed LEACH, FLCFP, & SCCH by means of network lifetime thanks to the employment of learned neuro-fuzzy system and cluster-based routing.

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