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Research Article

Predictive Model Techniques with Energy Efficiency for IoT-Based Data Transmission in Wireless Sensor Networks

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Wireless sensor networks are limited by the vast majority of goods with limited resources. Power consumption, network longevity, throughput, routing, and network security are only a few of the research issues that have not yet been addressed in sensor networks based on the Internet of Things. Prior to becoming widely deployed, sensor networks built on the Internet of Things must overcome a variety of technological obstacles as well as general and specific hazards. In order to address the aforementioned problems, this research sought to improve rogue node detection, reduce packet latency/packet loss, increase throughput, and lengthen network lifetime. Wireless energy harvesting is suggested in the proposed three-layer cluster-based wireless sensor network routing protocol to extend the energy lifespan of the network. For the purpose of recognising and blacklisting risky sensor node behaviour, a three-tier clustering architecture with an integrated security mechanism is suggested. This clustering approach is cost-based, and the sink node selects the cluster and grid heads based on the cost function's value. With its seemingly endless potential across a wide range of industries, including intelligent transportation, the Internet of Things (IoT) has gained prominence recently. To analyse the nodes and clustering strategies in IoT, the suggested method PSO is applied. A plethora of new services, programmes, electrical devices with integrated sensors, and protocols have been produced as a result of the Internet of Things' explosive growth in popularity.

1. Introduction

The Internet of Things enables physical things to interact with one another and share crucial information while making choices and carrying out crucial tasks, giving them the ability to see, hear, think, and perform important actions. Wireless sensor networks are essential because they act as a permanent layer for the Internet of Things. Applications for the Internet of Things that use wireless sensor networks are the majority. Link quality estimators based on hardware are also used to evaluate the effectiveness of connections and improve routing efficiency. Finally, a variety of tests were performed to evaluate the efficiency of the recommended approach. Most of its rivals perform better than it in terms of network lifetime, throughput, average energy consumption, and packet latency, including enhanced three-layer hybrid clustering mechanisms, energy aware multihop routing, Artificial Bee Colony-SD, and unequal clustering based on fuzzy logic [1–5].

The wireless sensor network is crucial to the Internet of Things (WSN). It is essential to the whole IoT system. WSN is crucial for the growth and development of the Internet of Things because it enables low-cost devices with limited resources to access game-changing applications. Tens of thousands of sensors are used, and they interact with one another wirelessly. Due to advancements in sensor technology, low-cost, small-scale wireless sensors that may be used in small- to large-scale appliances are now readily accessible. Many sensor nodes that can perceive, transmit, and analyse data make up a typical WSN. WSNs may monitor critical environmental variables for smart agriculture, including humidity, temperature, light, and pressure, as well as for secure and dependable communication, military applications, medical care, a variety of industries, traffic surveillance, and more. Before being embraced and propagated, WSNs must overcome significant risks and technical challenges [6–10].

WSNs have particular difficulties in addition to the aforementioned fundamental concerns, which have drawn the attention of numerous researchers. Major research issues for the WSN include issues with power consumption, network speed, network durability, wireless routing algorithms, and network security. Energy consumption is a significant issue in WSN communication. Energy efficiency is a crucial factor that impacts the network's overall performance and increases its lifespan. One of the most crucial factors for assessing the efficiency of WSN routing protocols is the energy level (EL) of WSNs. Energy consumption, residual energy, total energy, and other important metrics and attributes should all be taken into account when computing the cost function in WSN routing [11–15].

Every communication system has traditionally relied heavily on routing. Academics have long battled with finding efficient, secure, and low-cost ways to deliver packets to their intended recipients. The researchers are faced with a difficult task while creating the routing algorithm because of sensor resource restrictions such low energy, limited processing, and short communication range. Numerous attempts have been made and are still being made in this area to identify the best solutions. For load balancing and other factors including scalability, lifetime maximisation, and energy savings, clustering is a network separation technique. It is a very effective and efficient way to increase the lifespan of WSNs while also altering how well the network performs overall [16–20].

Due to the major network connection and power consumption concerns, mobile wireless sensor networks (WSN) and the Internet of Things (IoT) are attracting a lot of academic attention. This article introduces a method that considers properties like network probability, the recognised area of each node, and the radius of the whole identified region. The area of interest carries out free-space propagation. The network connection, long-term communication sustainability, and highest energy efficiency are all guaranteed by this method. It was shown that the probability theory may be used to construct a mathematical network model. Using this method, it has been feasible to investigate and assess how sensor node changes relate to distance from the detecting area. As a consequence, a connection has been made between the indicated area and a network's communication radius. Additionally, a cutting-edge technique has been created to lower energy use and maintain connection by enhancing the connectivity function. Notably, since they include resource-constrained nodes, IoT-based WSN topologies need greater energy optimization than any other network. The effectiveness of the suggested approach's mathematical network structure is further shown via a simulation graphic. When the radius is 100, the suggested approach uses around 40% less energy on average than the LEACH, ZTR, and DSR current methods.

The majority of WSN's constraints stem from the fact that they are resource-constrained objects. Sensors in public space WSNs are regularly subjected to harsh or hostile environmental conditions, such as high temperature, humidity, pressure, dust, rain, snow, and other elements that affect WSN performance, necessitating the use of robust and resilient sensor nodes. Limited resources, limited communication capability, stability, fault tolerance, bandwidth, mobility, result precision, availability, trust, accountability, heterogeneity, integration, uncontrollable environment, technology, and denial of service attacks are some of the other issues and future challenges for WSNs (DoS) [21–26].

The present volume of data produced by the Internet of Things system is growing as a result of the growth of IoT technology, and these data are continually communicated to the data centre. The standard Internet of Things system's poor data processing and analysis cannot manage so many data streams. Additionally, the IoT smart device has a resource-limited characteristic that must be taken into consideration while processing data. The Internet of Things can handle real-time data streams by using the innovative architecture ApproxECIoT (Approximate Edge Computing Internet of Things), and ApproxECIoT was proposed in this work. To handle streams of real-time data, it employs a self-adjusting stratified sampling technique. While staying inside the allotted memory limit, the method modifies the sample stratum sizes in accordance with each stratum's variation. When resources are few, this helps to increase the accuracy of the computation results. Finally, utilising both synthetic and real-world datasets, experimental research was conducted. The findings demonstrate that ApproxECIoT can still provide highly accurate computation results while employing memory resources akin to simple random sampling. When the sampling ratio is 10% for synthetic data streams, the accuracy loss of ApproxECIoT is decreased by 99.8% compared to SRS and CalculIoT and by 89.6% compared to CalculIoT. While ApproxECIoT does not function well when utilising the actual data stream from a wireless sensor network, its accuracy loss falls more than that of other frameworks as the sampling ratio rises.

The wireless sensor network (WSN) has been a busy study topic over the last several years since it is a significant component of industrial application (IA). It is particularly crucial to develop a routing strategy for WSNs in order to properly send sensing data to the receiver given the constrained energy and communication capabilities of sensor nodes. In this article, a Forward Aware Factor with Energy Balanced Routing Method (FAF-EBRM) is suggested. The next-hop node in FAF-EBRM is chosen in accordance with the forward energy density and link weight awareness. Additionally, a spontaneous rebuilding method for local topology is created. When LEACH and EEUC are compared to FAF-EBRM in the tests, the findings demonstrate that FAF-EBRM performs better because it balances energy consumption, extends function lifespan, and ensures excellent QoS of WSN.

In this paper, we propose an innovative unequal clustering routing protocol (UCNPD, which stands for Unequal Clustering based on Network Partition & Distance) for wireless sensor networks (WSN) of mobile education (such as mobile learning), in order to maintain better and lower energy consumption, reduce the energy hole, and prolong the network life cycle. We divide the network area depending on the distance from each node to the base station (BS) in the design model of this protocol because we know that all network node data travels to the BS via nodes close to the BS, and that nodes in this region would use more energy. These node components are responsible for connecting to the BS, and the rest of the nodes adhere to the optimal clustering routing service protocol, which elects the cluster head using a timing mechanism. Cluster rebuilding uses less energy as a result. Additionally, we create uneven clusters by choosing various competing radii, which helps balance the network's energy use. In order to balance and decrease energy consumption, we took into account the degrees of node, the distances to BS, and the energy of the cluster head while choosing the message route. The results of the simulations show that the protocol can effectively slow down the rate of node mortality, extend the network lifespan, and balance the energy consumption of every node.

The collision of tags, which reduces the effectiveness of the RFID system, is one of the major issues that has to be resolved. ALOHA-type algorithms and QT are the most widely used anticollision algorithms at the moment. However, these techniques function well when there are few and static tags to read. However, the effectiveness of recognition is relatively poor when there are a lot of moving tags to read. In this research, a brand-new method for mapping correlation of ID for RFID anticollision has been suggested as a solution. By mapping the correlation of ID, this strategy may improve tag associations to the point where tags can convey their own IDs in response to certain trigger situations, making multitree searching more effective. The approach may significantly minimise the number of times the reader reads and writes to a tag's ID when there are not a lot of tags by substituting the temporary ID for the true ID. When reading slots in dynamic ALOHA-type applications, the reader may pinpoint the positions of the empty slots based on the binary pulse's position, preventing the efficiency loss brought on by reading empty slots. Studies have indicated that using this technique may significantly increase the system's recognition effectiveness.

The area spectral efficiency (ASE) of downlink cellular networks would eventually drop to zero as base station (BS) density goes toward infinity, according to very recent research, if the absolute height difference between the BS antenna and user equipment antenna is greater than zero. The ASE crash is the name given to such an occurrence. We go through this problem one again by thinking about cellular network BS antenna downtilt optimization. In order to boost received signal strength and/or reduce intercell interference power, antenna pattern adjustments are often used to alter the direction of vertical beamforming. In terms of coverage probability and ASE, this article focuses on examining the connection between the BS antenna downtilt and the downlink network performance. Our findings lead to the intriguing discovery that there is a best antenna downtilt to get the highest coverage probability for each BS density. For such an ideal antenna downtilt, which depends on the BS density, numerically solvable formulas are developed. Our numerical findings demonstrate that the network performance may be greatly enhanced by implementing the optimum antenna downtilt, and as a consequence, the ASE crash can be postponed by almost an order of magnitude in terms of the BS density. Additionally, given a certain BS density, our findings provide recommendations on how to determine the ideal downtilt angle to enhance network performance [27–33].

Wireless sensor networks (WSN) that are restricted by the Internet of Things (IoT) have seen dramatic advancements recently. In order to achieve seamless connection, coordinated phenomena like increasing resource usage and providing efficient services are urgently required. IoT devices are often used in distant locations and have a short battery life. Therefore, a short battery life restricts the usage of networks in particular circumstances. Since the present methods of employing WSNs cannot be directly applied to the IoT owing to protocol difficulties, SLAs (service level agreements), scalability concerns, and complexity levels, novel concepts are needed to create energy-efficient ways for the IoT. The Enhanced Multitier Energy-Efficient Clustering Protocol integrated with the Internet of Things (EMEECP-IOT) suggested in this article is based on the heterogeneous wireless sensor networks (HWSN) method and is intended to address these problems. Regarding criteria like network stability, packets received, average throughput, standard deviation (SD), and residual energy, the suggested technique has been contrasted with the existing and conventional protocols. According on the simulation findings, the suggested EMEECP-IoT-based HWSN approach performs noticeably better than the current technique. Numerous performance indicators demonstrate that the proposed EMEECP-IOT increases network lifespan by 35% and reduces energy usage by 21%. For WSN and IoT-focused applications, this suggested technique may be used to reduce energy consumption and improve network lifespan.

The interplay of various factors, such as vehicle-to-infrastructure (V2I) communications, vehicle-to-vehicle (V2V) communications, vehicle density and mobility, and cooperation between vehicles and infrastructure, determines the capacity of vehicular networks with infrastructure support, making it both an intriguing and difficult problem. In this study, we take into account a typical delay-tolerant application scenario with download requests for a subset of cars known as Vehicles of Interest (VoIs). The distribution of the files to the VoIs is aided by other vehicles without download requests since each VoI downloads a unique huge file from the Internet. The usage of V2I and V2V communications, vehicle mobility, and collaboration between infrastructure and vehicles is all explored as part of a cooperative communication strategy that aims to increase the capacity of vehicular networks. A closed-form expression of the achievable capacity is obtained after the development of an analytical framework to model the data dissemination process using this strategy. This expression shows the relationship between the achievable capacity and the major performance-impacting parameters, such as the interinfrastructure distance, radio ranges of infrastructure and vehicles, sensing range of vehicles, transmission rates of V2I and V2V communications, vehicular density, and proportion of VoIs. The suggested cooperative communication technique greatly increases the capacity of vehicle networks, particularly when the fraction of VoIs is low, according to numerical results. Our findings provide recommendations for the best positioning of a vehicular network infrastructure and the creation of a cooperative communication plan to increase capacity.

The spread of Internet-capable gadgets has increased during the last ten years. The Internet of Things (IoT), which connects an increasing number of disparate physical devices, is becoming more and more ingrained in daily life. The primary goal of the IoT is to increase the usefulness of the Internet by connecting a sizable number of smart devices in integrated and linked heterogeneous networks. As a result, this essay provides a succinct overview of the development and history of the Internet. It then introduces the IoT before listing a number of application fields and supporting technologies. The study discusses the connection between WSNs and the IoT and reveals the wireless sensor network (WSN) as one of the crucial components in IoT applications. The goal of this study is to create energy-efficient WSNs that support the IoT. This research evaluates the literature that highlights the most relevant strategies for decreasing the energy fatigue of IoT and WSNs after identifying the causes of energy waste. We also point out any gaps in the body of knowledge on strategies for energy conservation that might be investigated and taken into account in next efforts. The report provides a nearly full and current picture of IoT in the energy sector. It offers an overview and suggestions for a wide variety of energy-efficient techniques put out in the literature, assisting and assisting future studies. Please be aware that the paper is based on the summary of the doctoral thesis and is an expanded version of that work. This article will provide academics with an introduction to the fundamental concepts of networks, WSNs, and IoT applications.

Due to node mobility and energy depletion during mobile edge computing, connection failure occurs, shortening the network lifespan in the mobile ad hoc network. The single-path protocols' necessity to redo the route discovery process when a route fails causes a significant increase in network latency. The multipath routing protocol is thus suggested in order to reduce the expense of route finding. In this paper, we introduce an LLECP-AOMDV routing protocol for mobile edge computing that is based on connection lifespan and energy consumption prediction. The energy grading approach is used during route finding. When a node's energy falls below a certain level, it stops taking part in route finding. The path is chosen during the routing selection phase based on the lifespan of the route connection and the route's minimal energy usage. We assess the outcomes of the comparisons based on performance parameters like as energy usage, packet delivery rate, and end-to-end latency. The result demonstrates that the proposed LLECP-AOMDV is superior to the other three protocols under the majority of network performance indicators and parameters, increasing network lifespan, decreasing node energy consumption, and lowering average end-to-end latency. The protocol is highly helpful for edge computing on mobile devices [34–38].

2. Cluster-Based Sensor Networks Using IOT

The classification of CLHs and MNs as hierarchical or cluster-based routing protocols depends on important factors including residual energy and distance to the sink node (SN). The CLH duty rotates based on the node's rank. The node's ranking is based on changes in critical variables. Data from cluster members (CMs) are gathered, aggregated, and sent to the base station (BS) or sensor node by the cluster head (SN). Block cluster-based routing protocols, grid cluster-based routing protocols, and chain cluster-based routing protocols are only a few examples of the many sizes and forms of cluster-based routing protocols. Additionally, cluster-based WSN is divided into two-tier (two layers) and three-tier (three layers) hierarchies, as shown in Figure 1.

2.1. Cluster Head Approaches in PSO. Neighboring nodes in ABE-AODV may share their available bandwidth, which is assessed locally through Hello messages. Each node computes its medium occupancy ratio locally every second and adds it to a Hello packet. The maximum available bandwidth will be used to translate these statistics into link assessments. The accuracy of bandwidth assessment is determined by the value of which is considered as a sample time. The higher the number, the more steady the readings will be, disguising any sudden changes in the medium load. However, to allow for quick reactions to long-term load fluctuations and node mobility, the number of nodes should be reduced. Hello-based techniques incur overhead dependent on the frequency of Hello emissions. Hello packet emission frequency should ideally be tailored to node mobility and/or flow dynamics. A fixed value of 1 second is used to accomplish successful comparisons in ABE-AODV. In the same way, all of the protocols being compared will be configured to send one information frame per second.

AODV has been extensively upgraded to become an ABE-based QoS protocol. In the future, it will evolve into a multilayer routing mechanism. The routing layer is responsible for finding QoS routes that fit application expectations based on the MAC layer information. The goal of the route discovery procedure is to find a path between the sender and receiver that fulfils the application's bandwidth requirements. As a result, depending on the status of the network, two flows with the same source and destination may follow different paths. Every mobile node receiving an RREQ performs an admission check by comparing the bandwidth demand in the RREQ packet to the projected available bandwidth on the connection where the RREQ was received. If

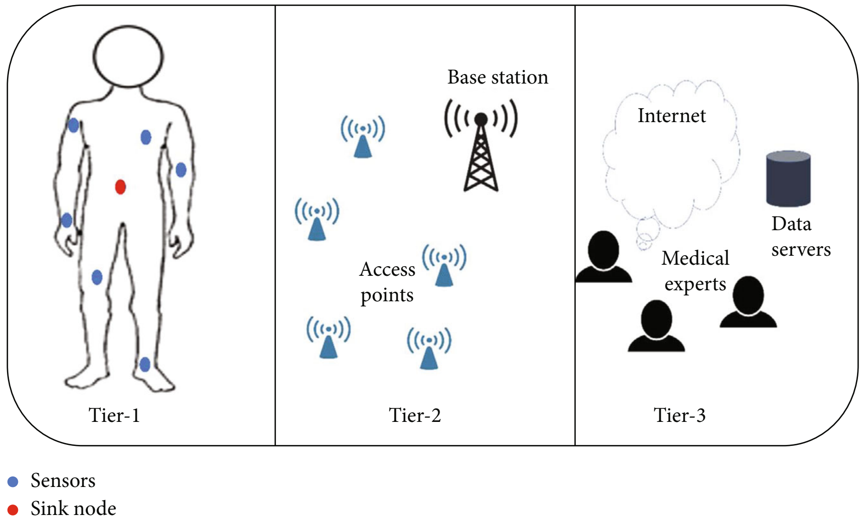

Figure 1: Cluster-based wireless sensor networks.

the check succeeds, the node modifies the route with its own address and sends the RREQ; if it fails, the message is simply discarded. The admission control is conducted on the receiver side rather than the sender side in this phase, which differs from the previous protocols outlined. The fact that each ABE node tracks the available bandwidths of its incoming connections proves this. Finally, if a first RREQ is received, the destination sends the request's originator a unicast route reply (RREP) over the reverse way.

The method is used to tackle the issue of outlier identification in WSNs in this research. They provide an algorithm framework for recognising technique-based WSN-specific methods. Several detection strategies as well as node attributes are explained by the suggested strategy. Based on detection approaches, the different sensor nodes are compared for detection. This article describes how to use WSN devices to perform dynamic power monitoring and diagnostics for signal collection, processing, and transmission. The supervisory controller collects and transmits data to the responsible nodes according to the stated methodology. The DPM protocol is utilised for sensor nodes to extend the lifespan of a wireless sensor network; this suggested that study examines the PSO algorithm's history and current status.

Particle swarm optimization (PSO) is effective in discovering issues when the fault detection technique fails and the nodes are large. Each node should be seen as a particle moving at a velocity dictated by the P_{best} and V values that have been optimised (t). The P_{best} and G_{best} values are used to help improve network detection algorithms for problematic nodes. When compared to other methodologies, the PSO methodology is utilised to locate failing nodes quickly. PSO has the following benefits when compared to other traditional algorithms such as

(i) Simple hardware/software implementation

(ii) Check the network's availability based on the parameters

(iii) Check the parameters in the real, integer, and binary domains

The architecture of WSN is seen in Figure 2. When used in conjunction with link reliability assessment approaches, power management techniques may assist to improve a connection's dependability. The MAC protocol increases transmission power to lower the likelihood of receiving false data when it determines that connection dependability has dropped below a certain threshold. Using the least amount of energy possible, nodes expend energy while communicating at a certain transmission power because some connections have a high chance of succeeding. In order to maintain link reliability while using less energy, the transmission management algorithm may cut transmission power. The possibility to reuse media has increased.

When nodes communicate at exactly the right power needed to establish a successful connection, the signal range is no greater than it was intended to be. As a consequence, fewer network collisions will occur since only nodes with equivalent space requirements will contend for access to the medium. Collisions will be less frequent, improving network utilisation and reducing wait times. A statistic for assessing signal intensity at a transceiver's input port is the RSSI (received signal intensity indicator). RSSI readings are used to assess signal strength and medium noise while receiving incoming data. Sensitivity is the smallest energy power that a transceiver needs to be able to correctly identify and decode data. If a transmission is received at a power level below this threshold, data corruption will happen. Computing RSSI data from the radio requires a reference voltage, which is the battery voltage. Therefore, in order to translate any RSSI value into actual reception power, the voltage present at the moment of receiving must be known.

PSO explanation is as follows:

Y is the representation of T in the new basis:

$$Y = \mathrm{PT} \tag{1}$$

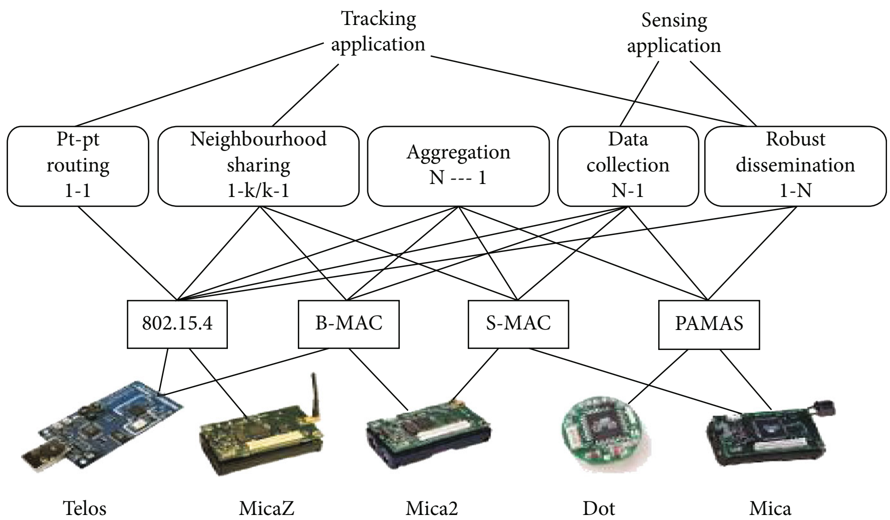

FIGURE 2: Architecture of WSN.

R is the covariance matrix in the new basis:

$$Ry = \frac{1}{n-1} \mathrm{YY}T. \tag{2}$$

Covariance matrix is defined as follows:

(i) Matrix defined: $S = \mathrm{TT}'$

(ii) S is symmetric

(iii) Symmetric matrix is used to calculate by an orthogonal matrix of its eigenvectors

$$\begin{aligned} \mathrm{Ry} &= \frac{1}{n-1} \mathrm{YY}T = \frac{1}{n-1} (\mathrm{PT})(\mathrm{PXT}) \\ &= \frac{1}{n-1} \mathrm{PXTPXT}. \end{aligned} \tag{3}$$

Subspace techniques to tackle numerous statistical issues have been established in array signal processing channel estimation and code-division multiple access (CDMA) communications. Subspace techniques on the same matrices use space decomposition based on EVD, each feasible node solution, which has locations ($T_{i,j}$) and is computed using the PSO method ($S_{i,j}$). In the swarm solution set, each solution set is included. Each solution in the WSN network is utilized to create random numbers using the approach. The technique maintains the far best ($F_{\mathrm{best}i,j}$) and whole best ($H_{\mathrm{best}i,j}$) solutions for each solution and the swarm, respectively. As demonstrated in (4) and (5), the method is utilized to calculate the solution and location of each node (5).

$$\begin{aligned} X_{i,j}(t+1) = {} & \mathrm{ME}_{i,j}(t) + D_1 Q_1 \left(F_{\mathrm{best}i,j} - T_{i,j}(t) \right) \\ & + D_2 Q_2 \left(H_{\mathrm{best}i,j} - T_{i,j}(t) \right), \end{aligned} \tag{4}$$

$$T_{i,j}(t+1) = T_{i,j}(t) + X_{i,j}(t+1), \tag{5}$$

where i and j are the solution and position of th network indexes, respectively. T is the number of iterations, $X_{i,j}(t)$ is the solution of the i-$^{\mathrm{th}}$ and j-$^{\mathrm{th}}$ index of the particle in the swarm, and $T_{i,j}$ is the position of the particle in the swarm (t). Q1 and Q2 generate random numbers that are evenly distributed between the 0 and 1 range. The acceleration numbers are D1 and D2. The inertial weight is denoted by the letter M. For each solution, the PSO implementation strategy is as follows:

(1) For each method, a random number with the right dimensional characteristic was created

(2) The formula was used to compute each particle

(3) If the current solution's success is greater than $F_{\mathrm{best}i}$, $F_{\mathrm{best}j}$ is chosen as the current solution

(4) To see whether $G_{\mathrm{best}i,j}$ is a better solution than the one now in use, the current particle is utilised

(5) Using (1) and (2), determine the particle's solution and location

(6) Repeat steps 2–5 until the maximum number of iterations has been reached

$M = \mathrm{tmax} - \mathrm{t}/\mathrm{tmax}$ is the inertial weight.

The current and maximum iteration numbers are indicated by the letters t and $t$max. Inertial weight is denoted by M. To determine whether a particle is local or global, the parameters D1 and D2 are employed in solution space. In all cases, the PSO technique is utilised to determine the iteration when the means of constants D1 and D2 are both equal to 2.

RGGs, in which RGG vertices represent network nodes and edges indicate direct connections between nodes, are a well-researched and practical model for massive networks, such as sensor networks. This suggests that the transmission ranges and characteristics of all wireless nodes are the same.

In the actual world, heterogeneous wireless networks do exist, with devices that have wildly different capabilities. The positioning of nodes, which heavily depends on the sensor deployment strategy, determines a WSN's connectivity. Given that sensors may be arranged in any manner, one of the most fundamental problems in a wireless sensor network is the coverage issue. In this research, a dynamic random geometric network is used to link and cover hybrid WSNs.

The concept of a dominating set from graph theory is used in dominating-set-based routing. A subset is said to be dominant if every vertex in it is next to at least one other vertex in the subset. This approach's fundamental idea is to limit routing and searching to a subgraph deriving from the dominating set. To facilitate routing inside the induced network of just dominant nodes, the dominating set should also be connected. Gateway hosts that are not a part of a dominant set are referred to as nongateway hosts. Connected dominating-set-based routing's main advantage is that it makes routing in a more compact subnetwork created by the linked dominating set easier. As a result, only gateway hosts are needed to store routing information. Recently, a publication proposed HRGG, a new graph model for hybrid WSN based on RGG. The NSM metric is used in the model (nearest sink node). A connection must fulfil the requirements listed below in order to be functional.

$$D(n, \mathrm{Bn}) < = \mathrm{Tr}(n). \tag{6}$$

n represents the data-sending node. According to the model, in order to send the data, n must locate the closest base station or strong node. Allow Bn to operate as a powerful node or other kind of base station. The network is linked if the distance between nodes n and Bn is less than or equal to node n's transmission range.

(1) The node and base station are moving in different directions

(2) The node and base station are both travelling in the same direction

(3) The BS leaves the node, which remains stationary

(4) The BS as well as the node has been repaired

It is tough to solve the coverage issue with hybrid WSN. To check if each subregion is k-covered or not, divide all subareas by the detecting regions of all n sensors (i.e., n circles). Because the circles may divide as many as O (n2) subregions, keeping track of them all is a tough and time-consuming task in geometry. Due to the transient nature of the nodes, determining these subregions may be challenging. To exemplify a basic technique, the HRGG model is employed. When one node detects an event, all nodes in the vicinity are likely to observe it as well. As long as the node has a strong node in its own zone, it should be enough. If a sink node is close by, it checks the route table before retiring to sleep. Because the data will be noticed by the base station or strong node, the base station or strong node will be anticipated to deliver it, conserving energy for the other nodes. When no strong node is present, the node looks for a neighbour to relay the data to. Coverage may be available if the following criteria are met:

(1) A BS's region contains at least one dominating graph

(2) A forwarding node is present—node n may connect with any other node

Otherwise, the node must wait "t" seconds before updating the route database. This cycle continues until a new node emerges in the area. The connection and coverage aspects of hybrid WSNs are investigated using a dynamic RGG model in this research. Connectivity is established by a single dominating dominant set, whereas coverage is determined by transmission range and node scheduling. It is advised that regions be separated into mutually exclusive groups depending on the presence of sink nodes to save network energy. In addition, the simulation findings indicate that the suggested strategy is both energy-efficient and feasible.

2.2. WSN Energy Efficiency. Wireless sensor network (WSN) energy efficiency is a widely debated topic among academics. For energy-efficient data collection in sensor networks, a number of technologies have been developed. Tree-based approaches and clustering methods are the two sorts of protocols. Clustering is better suited for real-time applications and has a considerably higher scalability factor than its predecessor. This article discusses the significance of clustering as well as the elements that influence it. Numerous clustering algorithms and their expansions to date are addressed in this article, as well as a clustering strategy based on the minimum spanning tree (MST) and shortest route notion, as well as its benefits and drawbacks.

ATPC offers a lightweight transmission power management solution in a pairwise manner as a solid step toward in situ topology control in sensor networks. This fine-grained customization finds a compromise between computation and local memory (for example, the requirement for a table at each node) and communication, which consumes much more energy. RSSI/LQI and connection quality are linked in our in situ tests. We created a model to forecast the optimum transmission power necessary to attain a satisfactory packet reception ratio as a result of these data. However, it points in the right direction for further research towards sensor systems that may be used in real-world circumstances. ATPC seems to operate well with TDMA protocols, according to our findings. ATPC may be effective on a low-density network if accidents and congestion are rare. Due to feedback control's well-known capacity to deal with stochastic disturbances, this is the case. ATPC's effectiveness may be hampered by conflicting transmissions and interferences. The capture effect, on the other hand, reduces ATPC's collision and interference effects. Because a packet may be received even though there are overlapping radio signals as a result of simultaneous transmission, utilising the RSSI/LQI of such a packet may lead ATPC to become unstable. RSSI/LQI for packets detected by packet collision is not regarded as input for ATPC when such procedures are used. As a result, in a CSMA network, ATPC is intended to filter out collision and interference-related noise.

In freshly formed clusters, the cluster head is picked from the node with the greatest energy level, and the next CH node is chosen from the node with the second highest energy level. The following CH nodes were chosen to ensure the cluster's stability. After the cluster head is chosen, it creates and distributes a TDMA schedule to the rest of the cluster. When data is delivered over long distances between the cluster head and the sink node, multihop data transmission is employed to limit the amount of energy lost. Data from cluster heads that are close to the sink node is sent directly to the sink node, but data from cluster heads that are far away is sent through the shortest multihop route. Transmission is divided into the following phases:

(1) Using the distance metric, construct a proximity matrix including the distance between the CH and the sink, as well as the distance between the CHs

(2) Building a super cluster out of MST

(3) Determine which route between each CH and the sink is the shortest

(4) Locate the node that is the most important (the one with the most paths)

(5) Designate that node as the super cluster head node, and aggregation will occur there

(6) Copy the assembled information to the sink node

Some of the advantages of the suggested algorithms are as follows:

(1) When compared to earlier methodologies, scalability is improved

(2) A node leader is chosen in order to prevent fault tolerance

(3) All nodes are considered in the MST approach

(4) Aggregation minimises redundancy

(5) Certain factors, such as route cost and distance, impact cluster formation; by altering cluster formation parameters, cluster efficiency may be enhanced

(6) Cluster efficacy differs

(7) Mobility is not taken into account at all

This method makes advantage of the assumption of a static network. This research investigates current wireless sensor network clustering methods as well as a novel technique that focuses on energy-efficient data transmission between cluster heads and sink nodes. To discover clusters and the shortest data transmission route, we advised using the MST technique. Our future efforts will be focused on the following:

(1) Node importance (NI), a fundamental statistic that determines node connectedness, is used to choose cluster heads

(2) During the cluster formation phase, using genetic algorithms (GA) to save energy

(3) Modifying the data transmission phase to meet the needs of time-sensitive applications

When building and managing wireless sensor networks, there are various obstacles to overcome (WSNs). Because energy is a finite resource in WSNs, one of the most difficult tasks is figuring out how to make the best use of the minimal energy available to extend the network's life. The status of energy consumption should be checked on a regular basis once the network has been installed. With the goal of extending network durability, we propose coverage and link aware neural network-based energy-efficient routing in WSN. The issue is characterised as LP with coverage and connectivity aware limitations in the suggested solution. Adaptive learning in neural networks, coverage, and connection-aware routing with data transfer is all suggested for cluster head selection. The number of living nodes, packet delivery %, and node residual energy of the proposed system is compared to those of current systems. The proposed technique seems to be appropriate for a broad range of WSN applications, based on the simulation data.

A crucial feature of wireless sensor networks is effective information processing. In this article, we examine the time complexity, message complexity (the total number of messages used by all nodes), and energy cost complexity (the total amount of energy used by all nodes for transmitting messages) of some tasks, such as data collection (sending all nodes' raw data to a sink), data aggregation (calculating all nodes' data in aggregate form), and queries for a multihop wireless sensor network with n nodes. For the majority of the tasks examined in this article, we first establish a (asymptotically matching) lower bound on the complexity of the best approaches before proposing effective distributed algorithms to address these issues. The difficulty of data collecting, algebraic data aggregation, and data selection in WSNs is examined in this research in terms of time, message, and energy costs. Prior to presenting effective methods that reach asymptotically optimum time complexity and message complexity, we first investigate lower limits of the complexities for these issues. Many intriguing problems are yet unanswered. When each node will provide a data stream, one has to build efficient algorithms. The second problem is determining the optimum approach where the precision of the data item that is discovered is not a requirement, i.e., when the obtained answer might include some relative or additive mistakes. Additionally, we must create effective algorithms and improved lower limits for energy costs in order to do comprehensive data processing. Studying the time complexity and message complexity for additional holistic inquiries, such as the most frequent things and the

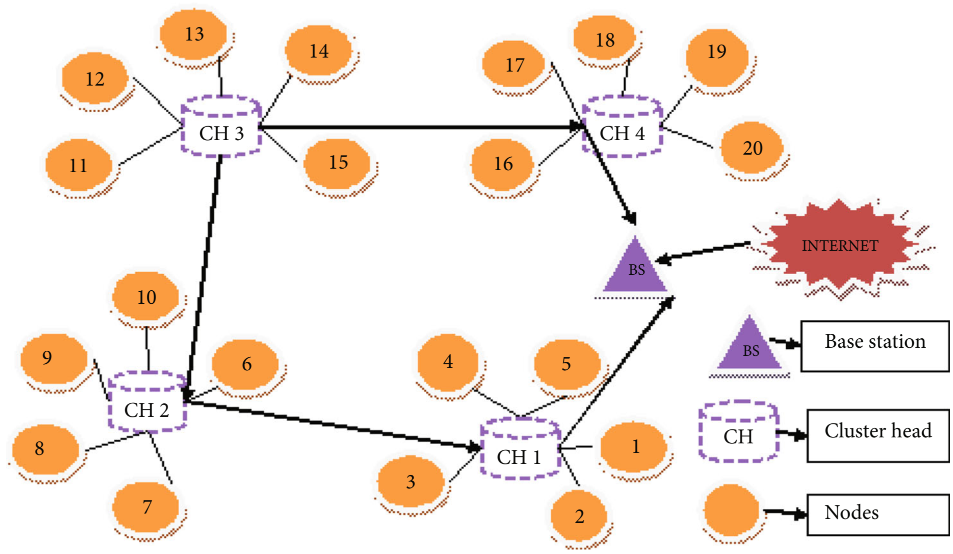

Figure 3: Proposed work for WSN using IoT.

number of different items, is a further issue. Studying lower constraints on complexity and creating effective algorithms to answer these queries when the communication lines are unreliable are the final but not the least crucial steps.

3. Results and Discussion

A sensor field is a network of homogenous, energy-constrained sensor nodes that is randomly spread. Sensor nodes were originally powered by full-capacity batteries. Each sensor gathers data that is typically correlated with data collected by other sensors in its area, and then sends it to the BS through the Cluster Head (CH) for review or decision-making. We'll pretend that all of the sensors have the same period and that CH is chosen. Each fixed cluster has a CH node that is picked on a regular basis to enable communication to and from the cluster. The cost of a connection between two nodes Si and S j is equal to the amount of energy consumed by these nodes to successfully send and receive one data packet. A suitable routing metric is required to build a coverage and connectivity aware connection between two sensors, which will drive the growth of the link between the sensors. We developed an energy-conscious routing system that employs a range of suboptimal paths in order to extend the network's lifespan. The whole network is divided into many discrete subregions. Based on the routing metric supplied in equation and the stated limitations, an effective cover set is generated from these subregions. The routing metric and residual energy of sensors are used to group them together. After each round, the energy of each sensor is updated.

3.1. Cluster Head Approaches. The stages of the proposed solution to the aforementioned optimization challenge are as follows:

(1) A number of CHs have been divided

(2) Using a PSO to choose the cluster leader

(3) Selecting the most efficient path

(4) Data transmission through multiple paths

(5) A number of subregions have been created

(6) A method of dividing a network into subregions while maintaining coverage and connectivity

The next stage is to pick the CH among the participating nodes to balance energy consumption once the whole region has been partitioned into separate sections. Throughout the years, several election mechanisms for CHs have been developed, with many of them favouring evenly spread clusters with constant average cluster sizes. However, we provide a one-of-a-kind neural network-based coverage and connection-aware clustering method. The routing cost measure presented in equation may be used to choose the cluster head nodes. The network's most densely inhabited regions will be flooded with CH nodes, while the underserved areas would be left in the dark. As seen in Figure 3, high-cost sensors in poorly covered areas will be forced to make costly data transfers to distant CH nodes, reducing their lifespan even more.

Once the route selection procedure is accomplished, this phase focuses mostly on multipath data transfer. The best path is one that uses the least amount of energy while covering the greatest ground. However, under the previously described protocols, there is a risk that once the best route is found, it utilised for all communications. Taking the quickest route depletes the energy of the nodes along the way, which might lead to network split. As a solution to this challenge, we suggest multipath data transfer via many pathways. These routes are selected using a probability proportional to the amount of energy used on each journey. It continually analyses along several routes, and the best paths are adequately chosen, thanks to probabilistic route selection.

Coverage and connection-aware neural network-based routing for wireless sensor networks are discussed in this paper. The LP is a limited-edition release. A neural network with adaptive learning is suggested as a method for selecting CH. The weight of the neurons is determined by the network's nodes' remaining energy. A coverage-aware routing measure is also added to help choose the optimum route among those that are available. After the routes have been found and one of them has been selected, the data is delivered using the specified measure. In terms of mean residual energy, percent of surviving nodes, packet delivery fraction, and network coverage, the suggested approach outperforms PEACH and LEACH. According to the statistics collected, the suggested technique is quite successful at delivering more than 95% of packets to their intended destinations while simultaneously increasing network coverage. Although the number of live nodes decreases as network coverage expands, this decrease is less than in other systems. As a result, the suggested system might be used to a variety of coverage and connection situations.

The quality of radio communication between low-power sensor devices changes dramatically with time and environment, according to extensive empirical tests documented in this article. According to this study, previous topology management solutions that concentrated on static transmission power, transmission range, and link quality may be ineffective in the real world. Online transmission power regulation that responds to external changes is required to meet this challenge. ATPC, a lightweight adaptive transmission power control technique for wireless sensor networks, is described in this article. Each ATPC node creates a model for each of its neighbours, defining how transmission power and connection quality are linked. This concept uses a feedback-based transmission power management technique to dynamically maintain individual link quality across time. This study makes a substantial intellectual contribution by proposing a unique pairwise transmission power management approach that differs greatly from current node-level or network-level power control strategies. In addition, unlike most previous modelling efforts, the ATPC design is based on significant field testing of link quality dynamics in a variety of locations and over a long length of time. The real-world findings show that (1) ATPC saves more energy with fine tuning capabilities and pair wise modification, and (2) ATPC is durable even when the environment changes over time with online administration.

The most energy-intensive event in wireless sensor networks is communication, and medium access control (MAC) techniques regulate energy use on network components during communication (WSNs). Reduced transmission power is one method of energy conservation. Two methods for altering transmission power in WSNs are discussed in this article. The first system adjusts dynamically based on information exchange between nodes, while the second determines the appropriate transmission power based on signal attenuation on the link. The suggested algorithms were built and tested, and the results were compared to B-MAC, the Mica Motes 2 platform's standard MAC protocol. According to the findings, transmission power regulation is a good way to reduce energy usage while only lowering packet delivery rates a bit. When comparing B-MAC and suggested transmission power management techniques for node lengths of 5 m, the proposed transmission power management approaches utilise 27 percent less energy. Sensor nodes' communication is the most energy-intensive operation they conduct. As a result, in wireless sensor network medium access control protocols, energy-saving techniques must be used (WSNs).

One such method is transmission power control, which has not been employed in WSNs owing to sensor node constraints. Two WSN transmission control mechanisms are suggested and assessed in this research using experiments and simulations. These methods enable the creation of new protocols that extend the lifespan and performance of networks by changing transmission power to use the least amount of energy while maintaining excellent communication quality. Transmission power management, according to the research, is a sensible strategy for conserving energy while only affecting packet delivery rates by a little amount. To prevent frequent transmission power changes, we want to improve the transmission power algorithms shown in Figure 4. Using various preamble lengths and preamble identification techniques, according to the findings, may aid in reducing packet losses. Finally, to increase transmission power calculation performance in MAC protocols that use channel reservation, the transmission power management mechanism must be examined, with an emphasis on RTS and CTS signals. Transmission power management provides many benefits in the functioning of WSNs, including more reliable connections, lower-cost communication, and higher medium reuse.

In wireless sensor networks, clustering techniques use graph theory to find the shortest route. This article's modules are divided into four sections. The following are a few of them:

(1) Calculation of distance

(2) Calculation of energy

(3) Locating the shortest path

(4) Acknowledgement information

The E and F coordinates of each node in a cluster network are calculated using the same algorithm that estimates the distance of all other nodes from each cluster.

$$D = \left\{ \left\{E_2 - E_1\right\}^2 + \left\{F_2 - F_1\right\}^2 \right\}^{1/2}, \tag{7}$$

where D is the distance from (E_2, E_1) and (F_2, F_1) is also called as Euclidean distance.

The energy can be calculated by using the formula

$$E = A_{\text{int}} - \left(\left(B_t * C_{\text{tx}} \right) + \left(B_r * C_{\text{rx}} \right) \right), \tag{8}$$

where A_{int} is the initial energy level of each clusters, B_t is the number of packets transmitted by the node, B_r is the number of packets received by the node, C_{tx} is the transmission

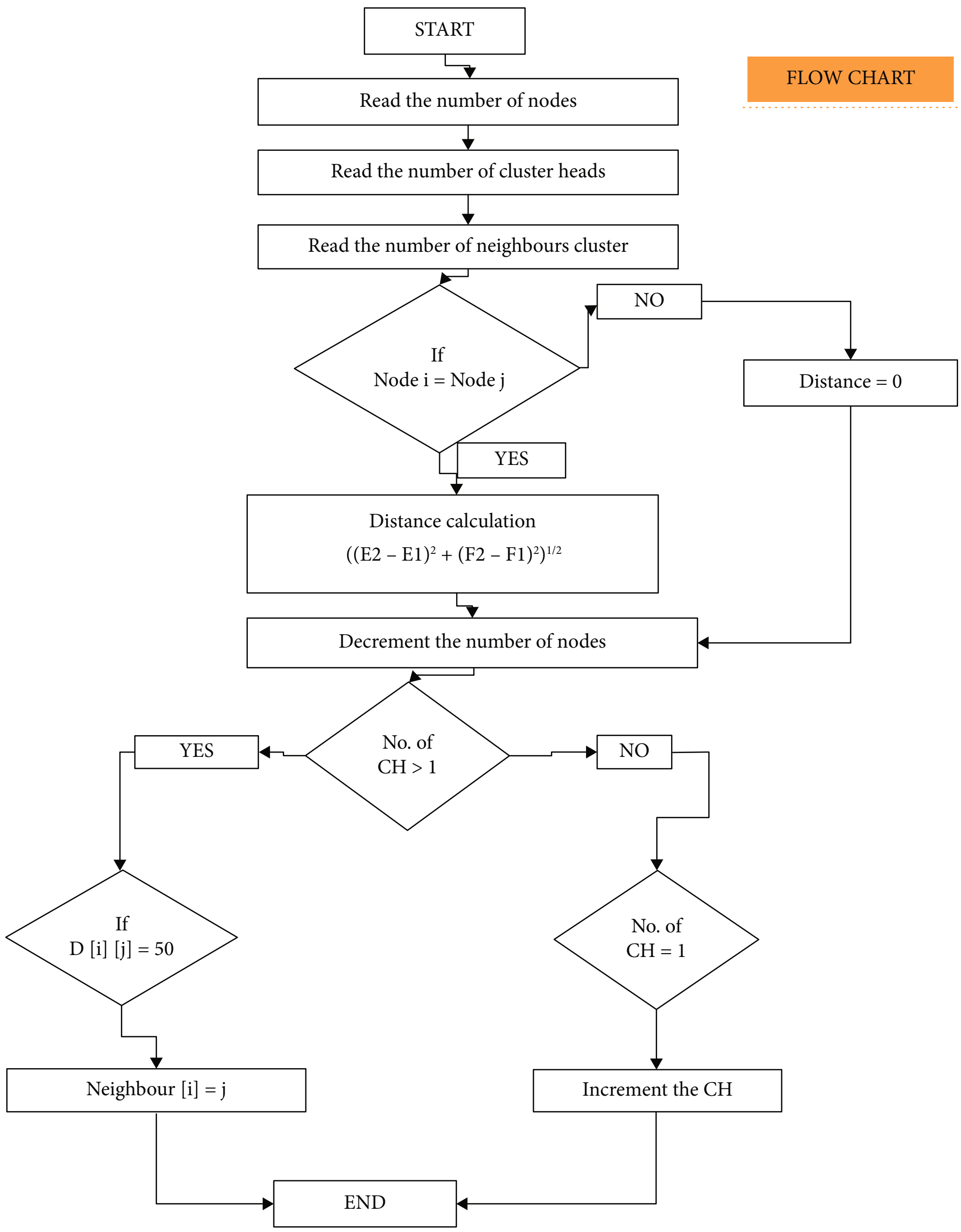

Figure 4: Flow chart of transmission power algorithm.

energy to transmit of each packet, and C_{rx} is the total energy consumed while receiving each packet.

The distance and energy calculations are aimed at determining the quickest and most energy-efficient route to transport data from the cluster head to the base station while also extending the network's life. $D[i, j]$ denotes the shortest path computation of two vertices using graph representations i and j.

(1) $D[i, j] \geq 0$

(2) $D[i, j] \leq 0$

(3) $D[i, j] = 0$

Table 1: Decision-making network structure.

Nodes	Acknowledgement
10	1
20	1
30	0
40	0
50	1
60	1
70	0

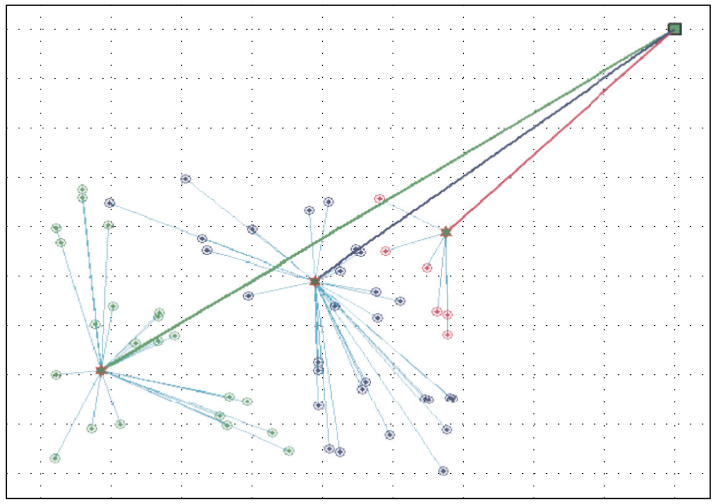

Figure 5: Cluster heads in network.

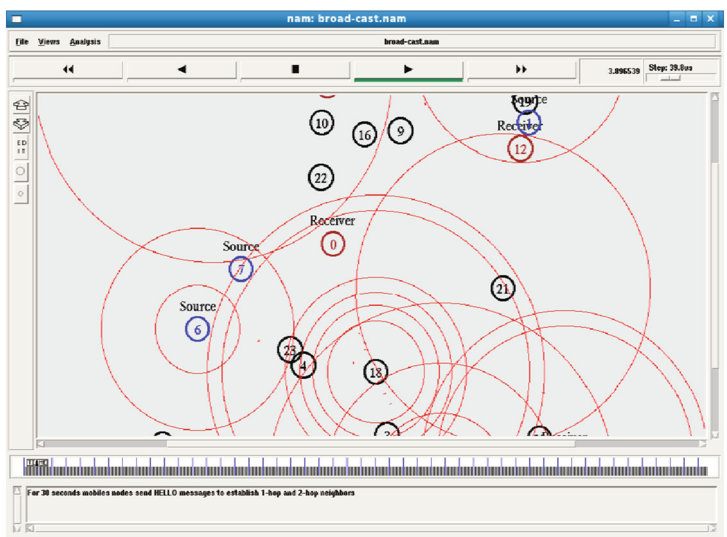

Figure 6: WSN sensing network.

The information is to transfer from one location to another. The station's headquarters, as mentioned in Table 1, the data was successfully received; consequently, send the acknowledgement.

1-the information that has been received (best node)

0-there has been no data received (worst node)

NS2 is used to demonstrate the efficiency of our transmission power strategy. Figure 5 illustrates how the transmission power strategy is utilized to choose cluster heads based on critical factors such the shortest route and power. The WSN sensing network's findings are shown in Figure 6. The results of neighbor node identification are shown in Figure 7. Figure 8 depicts the performance of the distance computation in the networks. Figure 9 depicts the networks' distance-based local level computation performance.

The PSO technique is used to assess the energy efficiency of the optimum node for process data transmitted across the network is shown in Table 2. When the number of malicious nodes increases, more lawful packets are lost, resulting in enhanced network performance. Once data has been successfully delivered to the sink, the number of packets is received. The proposed solutions boost the network's throughput.

Authentication is required for any IoT-based application, and impersonating attacks are a common occurrence. All sensor nodes transmit data to the server over wireless media in IoT-based automation systems that employ WSNs. Because an attacker may easily inject messages into the system, the destination node must ensure that any data used in a decision-making process comes from the correct source node. Authentication allows the destination node to double-check that the data was sent from the correct source node. It refers to a system's capacity to verify a user's identification and establish confidence in a third party.

Third-party trust is defined as the implicit trust between the source and destination nodes of an IoT-based

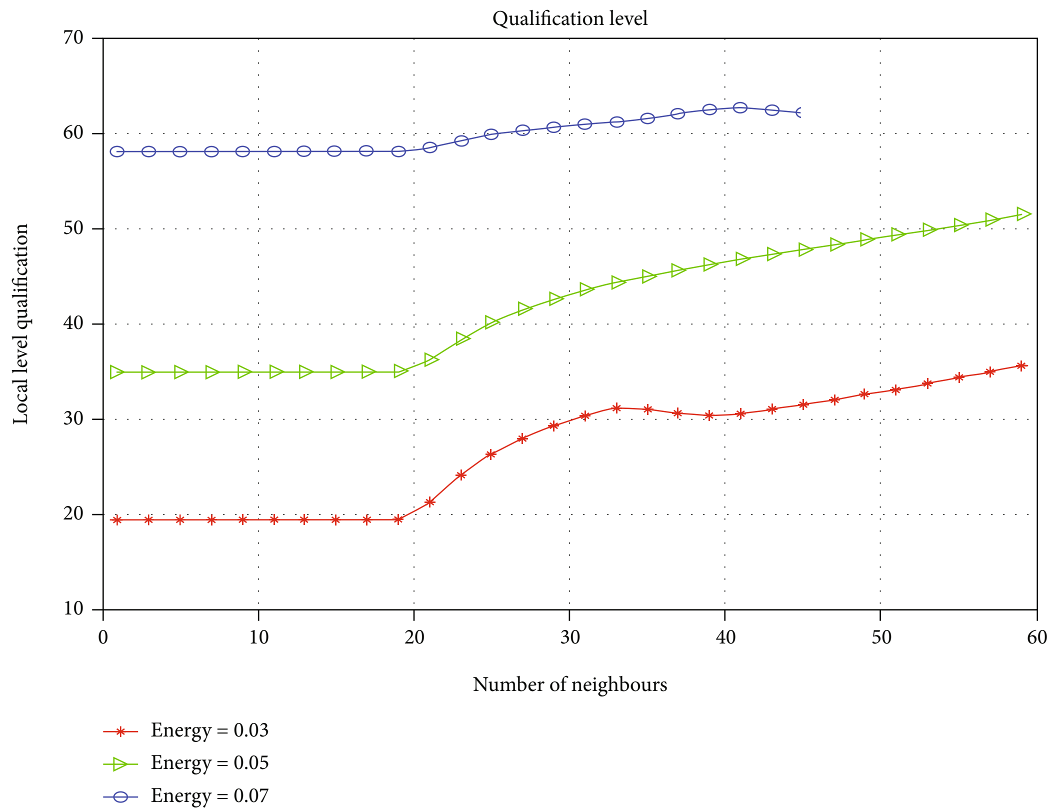

Figure 7: Analysis of neighbor node.

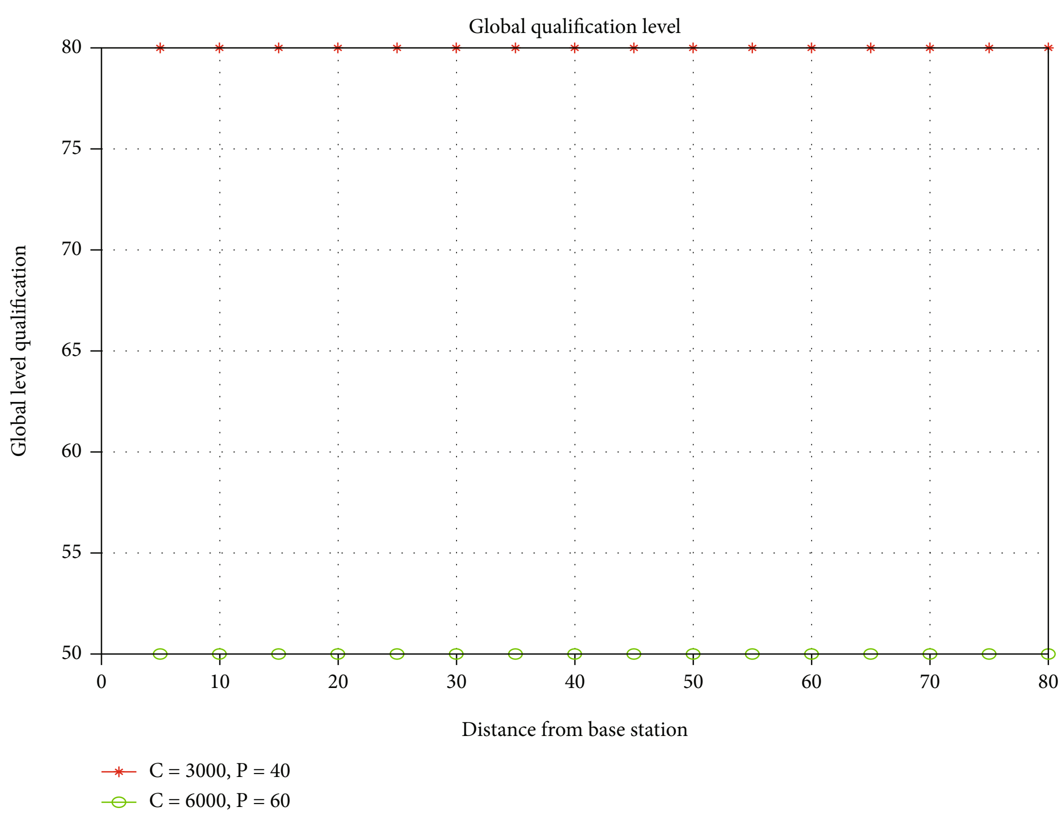

Figure 8: Analysis of distance of various nodes.

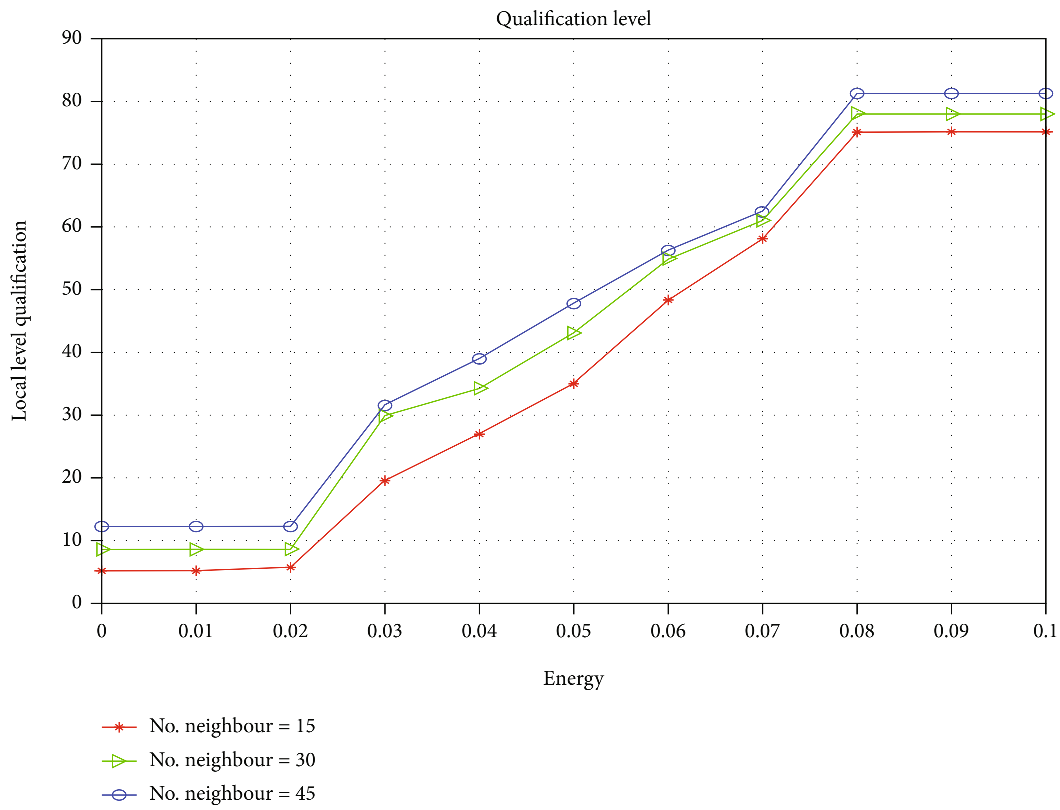

FIGURE 9: Analysis of distance of various nodes based on PSO.

TABLE 2: General parameters for simulations.

Parameters	Values
Hello interval	1 sec
Size of the packet	1500 bytes
Capacity of the medium	3 Mb/s or 12 Mb/s
Communication range	350 m
Carrier sensing	450 m
Communication range	180 m
Carrier sensing range	380 m
Size of the grid	1000 m * 1000 m
C (number of retransmissions)	6

application despite the fact that they have not yet established communication channels for data transmission. An attacker might intercept data while it is being sent from source to destination and replay it later using older keys to deceive the coordinator. The term “data freshness” refers to the fact that the information is up to date and cannot be reproduced. The original data in WSNs must be kept hidden from inquisitive eyes. The original information of the source node should not be shared with nearby or even external networks through a WSN.

Sensor nodes collect and communicate specified data to the server in IoT-based smart home applications. An attacker might potentially listen in on data transfers and get access to sensitive data. This eavesdropping phenomenon might do a lot of harm since the opponent could utilise the data for a variety of illicit reasons. As a result, confidentiality guarantees that only authorized individuals have access to the data. Ensure that all sensor nodes in the system fulfil the privacy rules and assist them in managing their own data is a major challenge. The source location must be known precisely in most WSN-based applications. Due to a lack of sophisticated monitoring techniques, the attacker may be able to convey false information about the source location by asserting inaccurate signal strengths. Monitoring the real source node for data transfer necessitates secure localization. Integrity, in addition to secrecy and privacy, is a crucial security element in WSN data transport. By adding fake information bits into the sent message, an attacker may always change the meaning of the information.

The data is now ready to be transferred to the target node and changed. As a result, an integrity mechanism is required to prevent unauthorised access to the original data. This functionality ensures that legitimate sensor nodes in the network have prompt access to system resources. The necessary nodes must have access to network resources in IoT-based applications. It is necessary to first identify each person and equipment in order to implement security rules and keep prospective attackers out. As a result, noncompliant sensor nodes must be turned off or have their network access restricted. Network access control is the name of this approach (NAC). To design a safe IoT-based system, all of the aforementioned security needs must be met, as

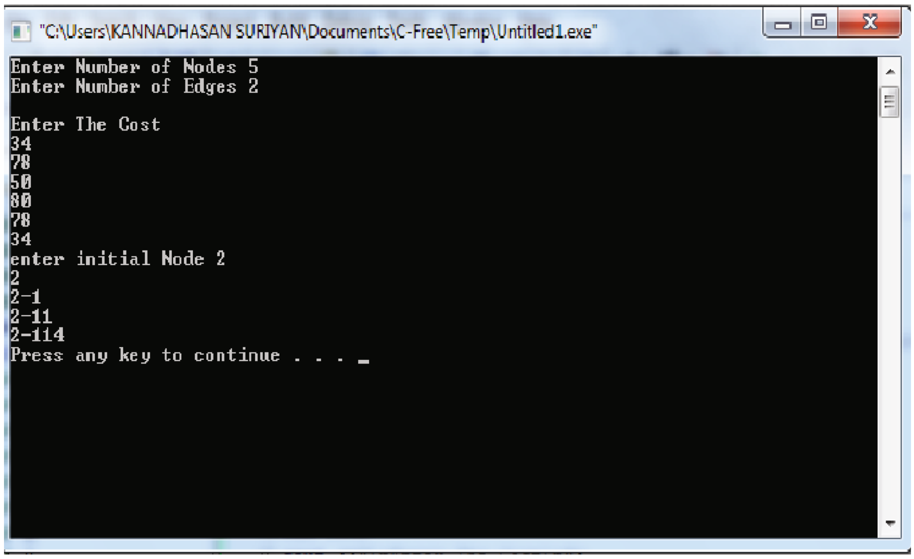

Figure 10: Neighbour node identification.

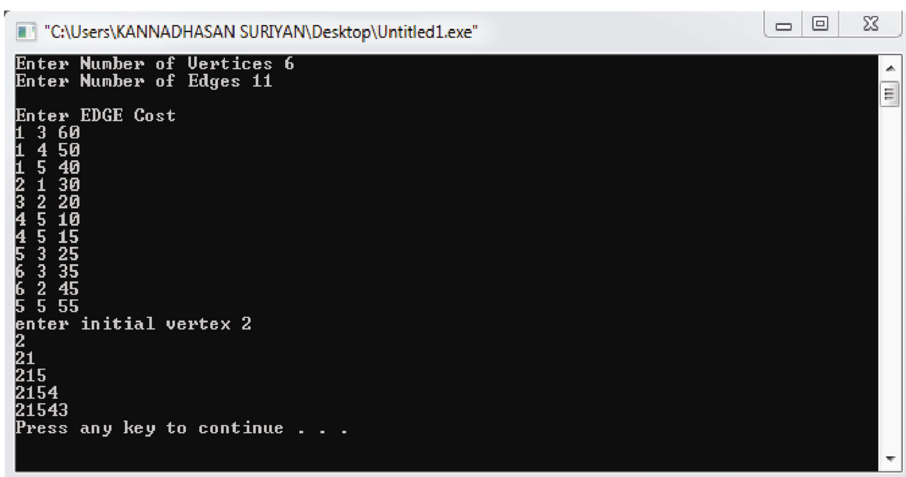

Figure 11: Distance calculation.

well as the ability to withstand a variety of security threats such as replaying, data tampering, impersonation, and eavesdropping.

The data generated by the source node is encrypted using an encryption algorithm. It is critical to transform source data into encrypted text such that the intended recipient may comprehend it. The encryption approaches investigated in this paper were MD4, MD5, SHA-1, HMAC, DES, AES, RC4, blowfish, security algorithms for WSNs, and the proposed TBSA. Similar current encryption techniques utilized more energy than the proposed TBSA, according to the research, since they need additional overheads and complicated procedures to encrypt the original data. The TBSA algorithm was created with wireless sensor nodes in mind. Due to the restricted resources of sensor nodes in WSNs, such as memory, power supply, and data processing capabilities, the TBSA encryption technique is being evaluated as a feasible option for delivering energy-efficient security for IoT-based applications.

The data is now ready to be transferred to the destination node for processing. As a result, an integrity mechanism is necessary to prevent external assaults on the original data. This functionality ensures that legitimate sensor nodes in the network have timely access to system resources. Network resources must be made accessible to the relevant nodes in IoT-based applications. It is critical to first identify each person and device in order to develop security rules and keep prospective attackers out. As a result, noncompliant sensor nodes must be decommissioned or have their network access restricted. Network access control is the term for this approach (NAC). To design a safe IoT-based system, all of the aforementioned security needs must be met, as well as the ability to withstand multiple security threats such as replaying, data tampering, impersonation, and eavesdropping, among others. Figure 10 shows the neighbour node identification.

The data generated by the source node is encrypted using an encryption technique. It is critical to transform source data into encrypted text before sending it to the target recipient. The encryption approaches studied in this research included MD4, MD5, SHA-1, HMAC, DES, AES, RC4, blowfish, security algorithms for WSNs, and the recommended TBSA. Similar current encryption techniques utilized more energy than the suggested TBSA, according to the research, since they need additional overheads and complicated procedures to encrypt the original data. The TBSA algorithm was created to transmit data between wireless sensor nodes in applications. The TBSA encryption technique is being explored as a feasible option for delivering energy-efficient security for IoT-based applications since sensor nodes in WSNs have limited resources such as memory, power supply, and data processing capabilities. Figure 11 shows the distance calculation.

4. Conclusion

This research provides a new clustering technique for each node as well as for the cluster's overall potential. The proposed system of clustering approach utilising transmission power technique is based on graph theory to lengthen the lifetime of the whole sensor network. The qualifying sensor nodes are selected based on their power levels and related to the number of nodes in the transmission zone. The efficiency of the proposed model is tested and analysed in NS2, and the results show that when employing this strategy, sensor nodes consume much less power and stay in the network for much longer. The proposed transmission power technique system is intended to prolong the sensor network's life. The qualifying sensor nodes are selected based on their power levels and related to the number of nodes in the transmission zone. The efficiency of the proposed model is tested and analysed in C++, and the results show that when employing this strategy, sensor nodes consume much less power and stay in the network for much longer.

The efficacy of the proposed model is assessed using NS-2, as shown by the preceding results. Sensor nodes use far less electricity and stay in networks for much longer. The mobility of each node in transporting power from the source to the destination node determines the quickest path in a network. In the future, clustering algorithms will be used to determine the shortest path in a network using fuzzy logic. A novel approach is provided for calculating the available bandwidth between two neighbouring nodes, and, by extension, along a route. This method is used in conjunction with channel monitoring to estimate each node's medium occupancy, which includes distant emissions, a probabilistic combination of these values to account for node synchronization, the calculation of the collision probability between each pair of nodes, and the impact estimation of variable overhead. The results seem to be promising in both fixed and mobile networks. These scenarios recognize that the most important part of developing a QoS system is estimating available resources across the network, not the routing process. The delay metric may also be examined at the same time.

Abbreviations

IoT: Internet of Things
WSN: Wireless sensor networks
EL: Energy level
MN: Member node
SN: Sink node
BS: Base station
CLHs: Cluster head
QoS: Quality of service
AODV: Ad hoc on-demand distance vector
MAC: Medium access control
RSSi: Received signal intensity indicator
CDMA: Code division multiple access
LEACH: Low-energy adaptive clustering hierarchy
PEACH: Power-efficient adaptive clustering hierarchy.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Authors' Contributions

R. Bharathi contributed to the design, analysis, writing, and implementation. S. Kannadhasan contributed to the writing, result analysis, mathematical implementation, and algorithm. B. Padminidevi contributed to the algorithm implementation and analysis. M.S. Maharajan contributed to the result analysis and design. R. Nagarajan contributed to the writing, survey, implementation, and result analysis. Mahtab Mashuq Tonmoy contributed to Results and Discussion.

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