A Proposed Optimization Framework for the Routing Protocols in Adhoc networks

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Abstract

Because of recent advancements in wireless communication and networking, it is now much simpler for people to continue cultivating meaningful connections with one another. After the evolution of the IEEE 802.15.4 standard and Mobile IPv6, which is described in IETF RFC 4068, there is a demand for the design of a routing protocol based on the new architecture of wireless networks that can facilitate efficient communication. This is because the design of a routing protocol that is based on the new architecture of wireless networks is required to meet this demand. This desire has surfaced as a direct result of the necessity to design a protocol that is suitable for usage with the recently developed architecture of wireless networks. Wireless sensor networks, abbreviated as WSN for convenience, are one kind of wireless network that might run into problems with its physical layout. Scalability, energy efficiency, and efficient routing throughout the network are the three problems that need to be addressed here. It changes the way sensing operations are performed from those that can only be done on a small scale, in a centralized location, and at a high cost into those that can be done on a large scale, in a dispersed location, and at a lower cost. This is accomplished by combining extremely small battery-powered sensors with wireless networks. There are literally hundreds of different applications for wireless sensor networks that may be utilized to make complex problems easier to handle. When it comes to the great majority of applications for wireless sensor nodes, the key concern of engineers is the conservation of energy in these nodes. This becomes very important because the amount of energy consumption in sensor nodes should be maintained to a minimum in order to maximize the amount of time that a network can continue to function normally. The creation of a routing algorithm that consumes the least amount of energy possible is the major challenge presented by WSN. Clustering techniques are necessary for the maintenance of the network's available energy, and the k means clustering strategy is used during the formation of clusters in wireless sensor networks (WSN). When there is growth in the network and the topology formation changes because of scalability in the network, a new routing technique has been proposed with a k-means clustering algorithm using IPv6. The goal of this technique is to minimize energy consumption among the nodes while also maintaining a balanced distribution of energy use across the network. This was carried out with the goal of using IPv6, which has already been accomplished. The method of routing that has been presented is suitable for implementation in settings that support not only unicast and multicast routing but also any cast and multicast routing as well as multipath routing. This is done so that load balancing may be implemented successfully inside the network. In addition, research has been done to investigate the problem of finding bottleneck nodes within a WSN in order to make the process of energy conservation easier.

Keywords: wireless sensor networks; K-Means Clustering; IPv6; the IEEE 802.15.4; routing technique; multipath routing

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1. Introduction

Because of their widespread use, wireless sensor networks, abbreviated as WSN, have been the subject of much research in ubiquitous computing environments. Wireless sensor networks are made up of a large number of sensor nodes, each of which is outfitted with a CPU, memory, and a kind of wireless communication with a limited range. In practical applications, the sensor nodes are dispersed across the regions of interest, and they are used to collect data from the settings in which they are located. The sensor nodes collaborate with one another in order to send the data that has been detected to the central base station, which is referred to as the sink node [1]. In comparison to Ad-hoc networks, wireless sensor networks are severely limited in their sensor nodes' capacity for memory storage, computation, and the availability of energy sources. These limitations make it difficult for wireless sensor networks to replace ad-hoc networks. Because sensor nodes function with a limited capacity DC source or may be situated such that replacement of its energy source is not feasible, it is widely thought that wireless sensor networks have an energy constraint. The protocols developed for ad hoc networks are not compatible with sensor networks, despite the fact that sensor networks are a subset of ad hoc networks.

In their study, [2] examined the functional requirements of the protocols used in sensor networks and ad hoc networks. They found that sensor networks have a much higher number of nodes than ad hoc networks do. Because of this, sensor networks call for alternative methods that are more scalable. When compared to ad-hoc networks, sensor nodes have a limited power supply, and it is difficult to recharge their power due to the high number of nodes and the environment in which they are installed. Ad-hoc networks [3] do not have this limitation. Therefore, the amount of energy that a WSN uses should be taken into consideration as an essential parameter. As seen in Figure 1, a WSN is made up of autonomous sensor nodes that are dispersed throughout space and work together to monitor the circumstances of the environment or the physical world. After being set up in an ad hoc manner, the nodes interact wirelessly and often arrange themselves into networks on their own. It's possible for a WSN to have as many as a thousand different nodes [4] in it. The data from the source nodes are sent to the nodes at the destination via the intermediary nodes. This destination node is linked to a central gateway, which is also sometimes referred to as a base station. The central gateway establishes a link to the wired world, allowing for the data to be gathered, processed, and evaluated.

1.1 Anycast Routing

Anycast is a communication protocol that may be used to acquire services from one of a plurality of servers that share one address or transmit data to any of those servers. For a variety of reasons, this protocol shows a lot of potential for both wired and wireless networking environments. When identifying a group of receivers, an anycast address is used. When a packet is sent to the anycast address, it is then routed to the recipients in that group who are geographically located closest to the anycast address [5]. This proximity is determined by the routing algorithm. In contrast to a unicast address, which mandates that the message be delivered to a particular recipient, and a multicast address, which mandates that the message be delivered to each and every member of the multicast group, an anycast mandates that the message is delivered to just one member of the anycast group. The destination is determined by the router based on how well it will minimize the total routing distance. Anycast, much like multicast, has a one-to-many link between network addresses and endpoints. However, with anycast, only one of those endpoints is selected at any one moment to receive information from any sender. There is no IPv4 address that is equivalent to the anycast address in IPv6. Multiple interfaces share the address [6] that has been allocated to them. When a packet is sent to an anycast address, it is sent to the interface that has this address in its immediate vicinity. When a packet is sent to an anycast address, it is only sent to one of the anycast groups—specifically, the anycast group that is geographically located closest to the sender

1.2 Unicast Routing

A unicast address specifies a single node. It is essential that the data packet be delivered to the intended recipient when it is transmitted to a unicast address. A unicast address is used to determine the location of a single network interface. IPv6 specifies both the stateful and stateless techniques for the automatic setting of an IP address. Auto-configuration is a process wherein devices on a network address themselves with a link-local unicast address. This is done via a mechanism known as auto-configuration. In the stateless auto-setup method for IPv6, hosts keep an ear out for Router Advertisements (RA), which are regularly broadcast by routers. Router Advertisements (RA) messages are what identify the subnet. These messages come from

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routers that are connected to the network. The host devices will utilize the router that is transmitting the RA signals as their default router. When there is no stricter control over the addresses that the host uses, as long as they are unique and routable, the stateless technique is utilized. When there is a need to determine the precise address allocations for the hosts, the stateful technique is the method that is used. It is possible to utilize both automatic configuration techniques at the same time. The site administrator is able to express his auto-configuration option by setting the necessary fields in the Router Advertisement (RA) messages [7]. There is a difference between IPv4 and IPv6 due to the fact that IPv6 uses several sorts of Unicast Addresses for routing: global unicast, site-local unicast, and multicast.

1.3 Multicast Routing

A group of nodes may be defined by using multicast addresses, and when a packet is sent to a multicast address, it is required to be delivered to each individual member of the group. A multicast address is an identifier that may be used for a group of interfaces since it can be used to identify numerous nodes at the same time. When a message is sent to a multicast address, it is distributed to all of the interfaces that are associated with that address. IPv6 incorporates scoped multicast as an essential component of its design, with the goal of improving protocol performance and reducing protocol overhead [8]. Link-local scoped multicast is used for the purposes of address resolution and router discovery by fundamental IPv6 components such as neighbor discovery (ND). The use of IPv6 addresses allows for communication between devices that is both uninterrupted and constantly linked. Because of these benefits, a new protocol for wireless sensor networks has been developed [9].

1.4 Routing in WSN with Dual Addressing

Dual addressing scheme (DAS) for IPv6 over IEEE 802.15.4 [10] wireless sensor networks combines a global unicast address to cope with association link changes and node mobility. Additionally, it links local addresses to lighten the overhead of the system in order to save energy and resources. A dual addressing scheme was developed by Cisco. Each sensor node in an IPv6-enabled WSN needs to have a global unicast address that can be maintained despite link changes or inter/intra WPAN mobility. Additionally, these nodes need to reduce the number of headers they send in order to make efficient use of the limited resources available to the WSN. DAS employs both link-local addresses, which are formed from the 16-bit short address, and global unicast addresses, which are generated using EUI-64, in order to generate IPv6 addresses that are globally unique while still having a minimal overhead for communication inside intra subnetworks. By combining both of the addressing 26 techniques, it is possible to decrease the amount of overhead in the sensor network, facilitate intra- and inter-subnetwork mobility in the WSN, and access and control each sensor node. Instead of using a separate mesh sub-header in between the MAC and IP headers, DAS is able to offer routing at the network (L3) layer since it is based on dual addressing. This is in contrast to traditional addressing methods. As a result, it is able to avoid providing duplicate address information, which is advantageous in the low-capacity IEEE 802.15.4 frame. DAS may also be used with table-driven routing (TDR), which includes the ad hoc on-demand distance vector (AODV) [11] routing protocol. This is in addition to the utilization of tree routing.
Even if internal routing is accomplished using TDR, address compression may save energy if link local/global IPv6 addresses are produced with DAS and the MAC address translation table is maintained. Although it is anticipated that TDR will incur the large overhead required to search for a path to a gateway when the links are loss and nodes move frequently, TDR has the advantage of achieving a minimum distance path between two random nodes in a wireless network. This is a significant benefit over other path discovery techniques. The gateway is given the ability to translate the global unicast IPv6 address and the link-local IPv6 address that is sent to a sensor node by DAS. These addresses are based on the IEEE 802.15.4 MAC addresses. DAS enables seamless communication by preserving the previously assigned global address, which it does even when link changes or inter/intra-WPAN mobility occurs. Additionally, it helps conserve the limited resources of WSNs in intra-network communication by reducing the address size and the amount of overhead involved. The proposed study has as its goal the development of a hierarchical routing management framework for the purpose of increasing the productivity of wireless sensor networks by using IPv6.

2. Proposed Methodology

In many different applications of wireless sensor networks, a sink node and a large number of many small sensor nodes are often put in the monitoring region in a haphazard manner. Sensor networks have a wide

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range of potential applications, including surveillance in the military, monitoring of the environment and targets, and monitoring of the environment. The development of wireless sensor networks became feasible as a result of technological advancements in wireless communication (WSN)[12]. The Internet Protocol Version 6 (IPv6) describes in further detail a new addressing system that is referred to as an "Anycast address." This address serves as an identification for a group of interfaces. Anycast IPv6 addressing for WSN was a topic of discussion [13]. The goal of sending a data packet is to have it sent to an Anycast address and then have it routed to the "nearest" interface. Roughly speaking, the routing protocols may be arranged into the categories of unicast, broadcast, multicast, and anycast. At the moment, the Anycast technology is being researched extensively in wireless networks. When there are several sinks distributed over a network, the Anycast communications become highly significant. Anycast services were created for use in WSN to facilitate IPv6 routing.

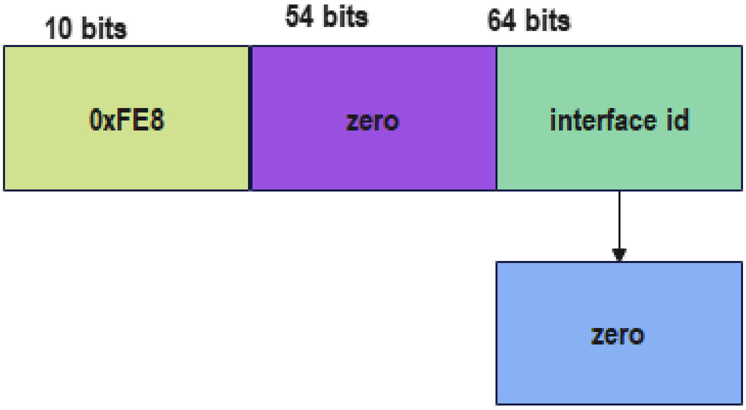

Figure 1: Link-Local Address

Anycast has the potential to become a key paradigm for a wireless sensor network in terms of the resources available, the resilience of the system, and the efficiency of repeated service applications. As the size of the wireless sensor network grows, nodes that are closer to the sink use up their energy supply more quickly than nodes that are farther away. However, a significant number of the IPv6 routing search algorithms that are employed today are unable to adapt to the additional constraints that IPv6 imposes, which has an effect on the performance of WSNs. Connectivity between WSNs [14] and the internet is required in a wide variety of application situations. Despite the fact that WSNs normally do not have IP capabilities, connecting to an IP network makes it simple to monitor sensors located in any part of the globe. The IPv6-enabled extended tree-based routing algorithm significantly improves the inefficient routes created by the present hierarchical routing approach. One way to describe the structure of a sensor network is either as one that is made up of a large number of nodes, each of which is equipped with sensing, processing, and communication capabilities and is placed inside the phenomena itself or extremely near to it.

Figure 2: Layers of protocol

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[15] came up with the idea for a routing method and gave it the name Energy-efficient Routing Algorithm to Prolong Lifetime. Assuming that the sources and the sinks are dispersed throughout the network in a uniform manner, the sources that send the data packet to the "nearest" sink around the area in which the events happen can reduce the hops of packets transmitting, which in turn saves energy, reduces the cost of router table maintenance, and extends the effect of network survival. In wireless sensor networks, there is often something called a sink that collects data from the sensor nodes that are powered by batteries. Because the sensor nodes around the sink use up their energy more quickly than the other nodes, it is necessary to install many sinks in order to extend the lifespan of the network.

Batteries provide electricity for each node in a wireless sensor network (WSN), and it is anticipated that these batteries will not need to be changed for many years. Because of the low cost and compact nature of the sensor nodes, we were only able to fit them with modest batteries that provided a restricted amount of power. To maximize the use of the network and the lifespan of the batteries, it may not be feasible to replace the batteries whenever they run out of power. This is due to the fact that the number of nodes [16] is typically quite high, making it unlikely that it will be possible to recharge the batteries whenever they become depleted. When a sensor node generates data, it is required to transmit that data to any sink that is currently operational. The selection of a sink for each source using arbitrary criteria is one technique for selecting sinks. As a result, there is a need to significantly cut down on the amount of energy that WSNs consume. The following actions are ones that can be made to reduce the amount of energy used by wireless sensor networks due to communication.

(1) In order to plan the nodes' current states (transmitting, receiving, idle, sleep)

(2) Altering the transmission range between the sensing nodes;

(3) Employing effective techniques of data collection and routing

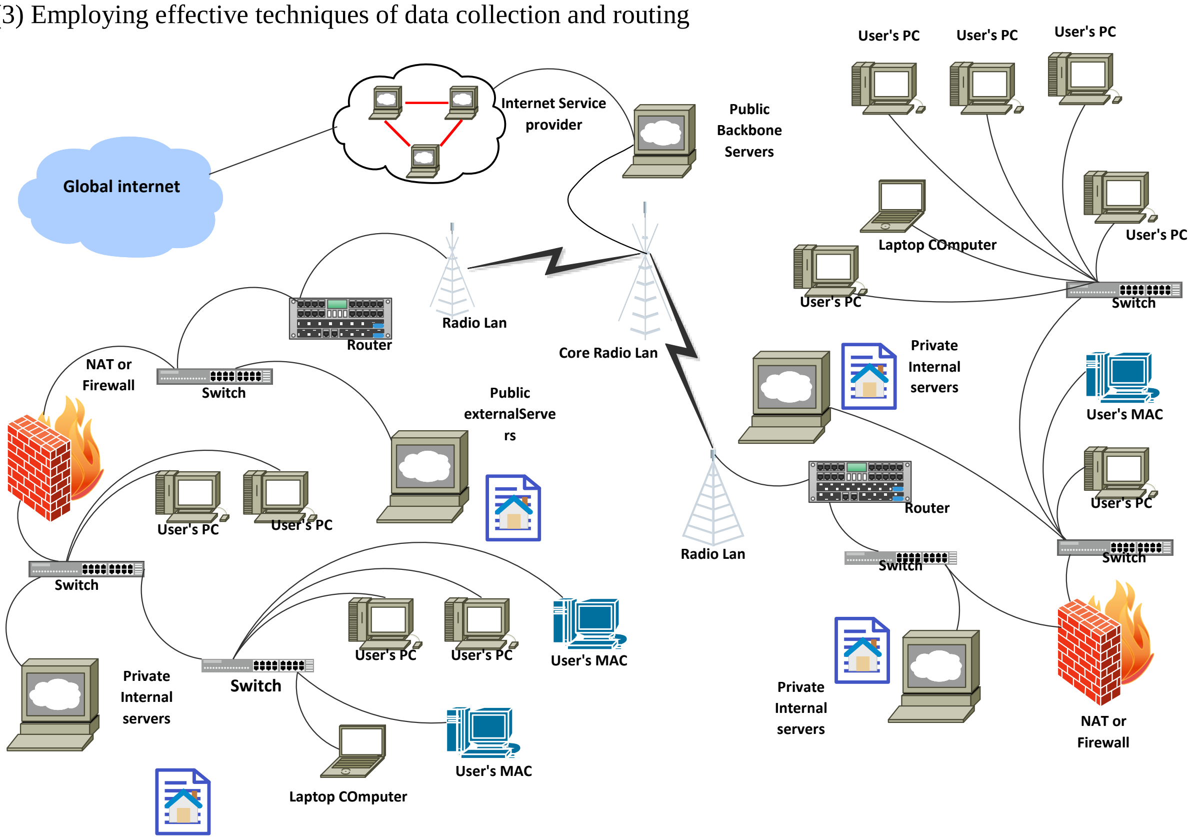

Figure 3: Adhoc Network

(4) Steering clear of any interaction with unwelcome information, such as in the instance of overhearing the routing strategy is implemented at the link layer and it uses the IPv6 Routing protocol, while the IEEE 802.15.4 standard serves as the MAC protocol. FFD (full-function device) and RFD (reduced-function device) are the two types of nodes that are defined by IEEE 802.15.4. (Reduced function device). The method partitioned WSN into many clusters, and when viewed from the standpoint of routing, each cluster

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has three distinct kinds of nodes: gateway nodes, cluster head nodes, and cluster members. Cluster members are RFD nodes since they do not have a routing function, but gateway nodes and cluster head nodes are FFD nodes because they have a routing function. A dual addressing technique, sometimes known as DAS, was presented by [17] for use with IPv6 over IEEE 802.15.4 wireless sensor networks (WSN).

The gateway nodes link the Wireless Sensor Network (WSN) to the IPv6 networks, and the gateway nodes interact with one another and the WSN in a multicast fashion over the IPv6 networks. One PAN consists of a single gateway node that has access to extensive computing resources. Taking into consideration the fact that the WSN architecture and the IPv6 architecture are both fully integrated, the method splits up a single PAN into numerous clusters, with just a single cluster head node present in each cluster. A cluster tree is a kind of tree topology that is formed by one gateway node and many cluster head nodes. The gateway node serves as the tree's root node, while the cluster head nodes serve as the tree's intermediate and leaf nodes.

The process of clustering consists of the following steps:

a. The election of a cluster Head

b. The establishment of inter- and intra-cluster communication

c. The formation of packets

When designing a routing tree, the following responsibilities are taken into consideration: The term "collaborator" refers to a node that identifies the occurrence of an event and then transmits the information it has gathered to the coordinator node. The Coordinator Node is sometimes referred to as the Cluster Head (CH), [18] and it is chosen via the use of an election process. This node is in charge of aggregating the gathered data that is received from other collaborators and sending the results to the sink node. A node that is in the path between the coordinator and the sink node that relays the data to the link is referred to as a relay node. A node that is interested in receiving data from a group of coordinator and collaborator nodes is referred to as a "sink node."
The number of CREPs should be set to 0 and the status of the parent node, as well as CREP, send and received, should be set to NULL. Select the BS as the parent (node), the BS will broadcast CREQ packets while the Sensor will broadcast PREQ packets, and then you will call the election procedure to choose the cluster head (CH). The construction of the tree comes next. Choose the cluster head (CH) that is closest to the sink (BS), and if a node is voted to be the CH, it will connect to the BS and send out requests to the other nodes. If not, the node will join the CH as a leaf in the tree, functioning as the source node.

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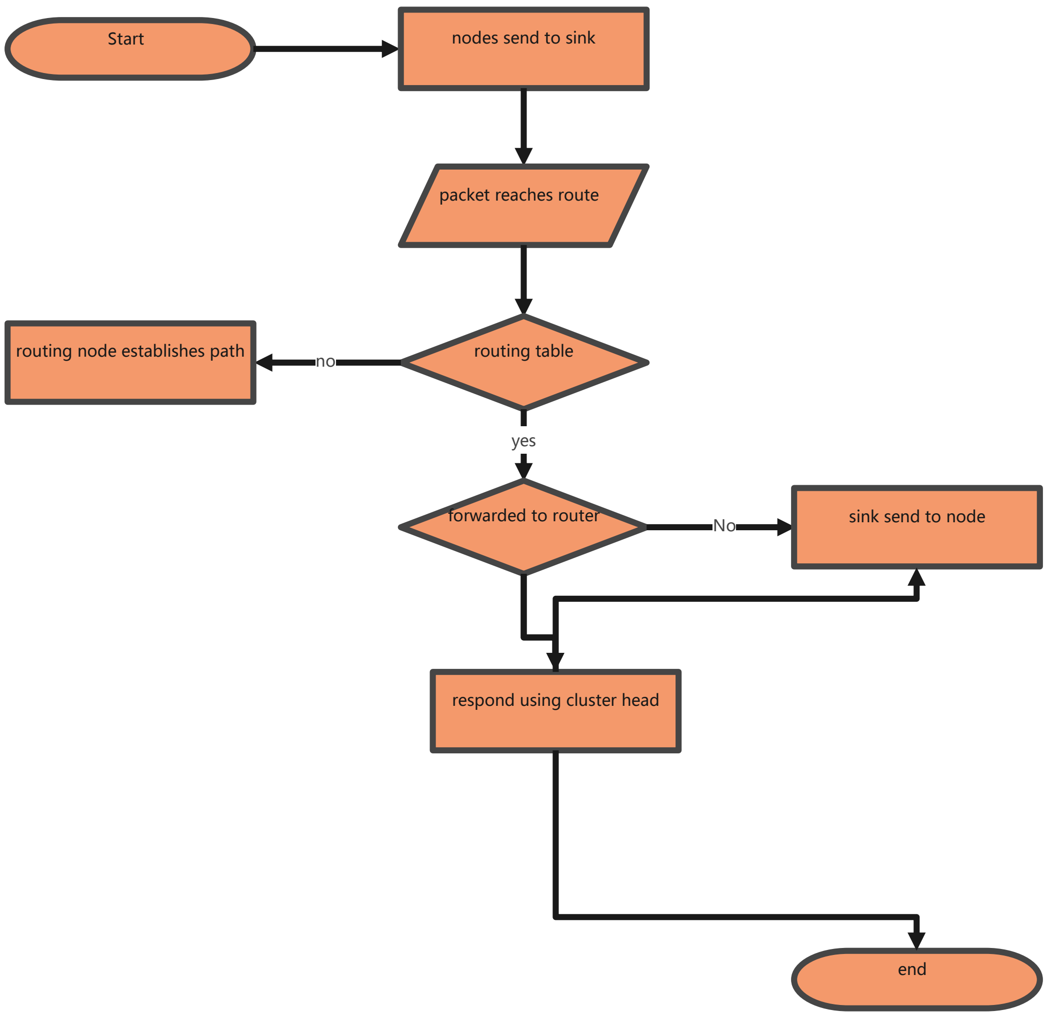

Figure 4: Flow Chart of proposed work

The procedure of Routing is shown in Figure 4. After the selection of cluster heads (CH), the information will be broadcasted in the cluster so that each node can send PREQ to establish a connection with CH; however, in the case of unicast, the broadcast process will only be carried out once in order to minimize the overhead and make the most efficient use of the available resources.

The loss of energy that occurs between transmission and receipt of a signal In the case of unicast routing, there can only be one source of a packet and one destination for it.

In the case of Anycast Routing, there are several destinations; nevertheless, the CH will send the packet to the destination that is geographically closest to the source, and the route will be decided based on this proximity.

Within an anycast group, the destination cluster head kick off the process of routing.

In the case of multicast routing, there are many sources and multiple destinations, and each packet will be sent to every potential destination node by making use of multicast groups.

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Step 6: Rebuild the tree and ensure that the energy factor of each sensor node has been brought up to date. After you have finished one cycle, go to step 7 and repeat steps 3 through 5.

In the case of anycast routing, the process is kicked off by the CH that is being received, and it will be destination sequenced. The solution that has been described makes use of a hybrid approach. Because the generation of the routing table is dynamic and dependent on a variety of parameters, the suggested technique is reactive in nature and follows a source-initiated, destination-sequenced structure. Setup initial energy to each node and calculated energy dissipation of nodes Calculate the latency of the routing Record the number of data packets at the source and destination to find PDR Record the number of nodes alive after each round of transmission in Routing with increasing load Test the scalability by increasing the number of nodes from 100 to 500 in the same routing scenario

Many Routing or Many to Many Routing Is What Multicast Routing Is. The use of 16-bit multicast group IDs is what makes multicast addressing possible. A multicast group is a collection of nodes that are physically separated by a hop distance, registered under the same multicast group ID, and each has its own group ID. nwkGroupIDTable is a property of the NIB that has the following functions: Contains a list of 16-bit group IDs to which the device belongs; (Network Information Base). Within the framework of the pre-existing routing systems, we suggested implementing anycast, unicast, and multicast communication in order to enable the execution of all possible varieties of communication.

3.2 Clustering

Since cluster heads are involved in the routing process, it is imperative that they consume energy in the most effective manner possible. After the formation of the cluster heads, the other nodes fall to sleep in order to preserve energy since they do not participate in the routing process. Following the completion of one cycle, the selection procedure used before will be repeated in order to choose a new cluster head. Since the weighted sum method is used, which gives more weightage to battery power over distance, the actual election process is being carried out while keeping in mind the criteria of energy efficiency. In most cases, the battery that is allotted to each node is depleted with every action of transmission or sleeping. However, the node that has the highest value and is the farthest away from the sink is the one that is given the opportunity to serve as a cluster head. The optimization problem may be solved using the weighted sum approach, which finds a solution by systematically altering weights among the objective conditions in accordance with the constraints that have been supplied. This is the way to attain high performance. When determining the weights to allocate to the battery and the distance from the sink, one must bear in mind the equation that each variable has to satisfactorily solve;

$$\Sigma W_i J_i = 1 \text{ and } W_1 J_1 + W_2 J_2 = 1 \quad (1)$$

Where W1 = Wb refers to the weight that is assigned to the battery of the node, and W2 = Wd refers to the weight that is assigned to the distance; Ji refers to the amount that is multiplied by the weights of the ith component. The scheduling policy is used to determine the best way to transmit the packet from its origin to its final destination. Sleep It is possible to determine when the nodes will wake up by using a technique called a wake up schedule. In order to lengthen the amount of time that sensor nodes are able to function normally, this sleep-wake scheduling is used.

Asynchronous sleep wake up in order to save energy, each node wakes up independently of the nodes that are next to it. This strategy is responsible for achieving a one-of-a-kind balancing of the work performed by the nodes in accordance with the conditions that have been predetermined. The end result of this strategy is the formation of a node that is significantly more powerful than the others in terms of battery and distance. In CBAR, sensors are grouped together into clusters, and one node in each cluster acts as the cluster head. This node is tasked with the job of collecting data, aggregating data, and then transmitting it to a more remote Sink. When access to multiple data sinks is given using an Anycast protocol, the lifetime of heterogeneous

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wireless sensor networks may be improved in environments where there is more than one sink for collecting data.

A network like this is made up of two different kinds of devices: those that are resource-rich (information sinks) and those that are resource-limited (sensors generating new data). In light of the fact that the Anycast routing protocol is used in wireless sensor networks, the purpose of this study is to combine the qualities that are unique to wireless sensor networks with the objective of enhancing the effectiveness of Anycast routing.

The transmission is dependent on the energy of the node as well as the distance between the CH and BS, with the weighting of each node being determined by the following factor.

$$T_c = W_1 * D + W_2 * E_f \qquad (2)$$

where T c denotes the transmission criteria, W 1 and W 2 denote the weight factors, and D denotes the proximity factor based on the provided distances of the node with respect to the BS and CH whose T e will be determined.

Using the following formula, we can calculate how much energy was lost between transmission and reception:

$$E_{T_X}(k,d) = \begin{cases} E_{elec} * k + \xi_{fs} * k * d^2, & d < d_0 \\ E_{elec} * k + \xi_{mp} * d^4, & d \geq d_0 \end{cases} \qquad (3)$$
$$E_{R_X}(k,d) = E_{elec} * k$$

where E Tx is the amount of energy that is consumed by each node, E Rx is the amount of energy that is consumed when receiving a k-bit packet, E eloc is the energy that is dissipated, f s is the free space propagation, _mp is the multiple fading channel parameter, d is the transmission distance, k is the message length, and do is the initial value of d.

Step 5: All of the nodes will send their data within the time that they have been allotted, and then the data will be sent to the BS via CH.

A straightforward combination of the various routing metrics is used to calculate the cost of the route using the following formulae:

$$\phi = \phi' + \Sigma\alpha_i * \text{ metric } c_i$$
$$\phi = \phi' + \alpha_1 * \text{ hop }_i + \alpha_2 * w_i + \alpha_3 * \text{ delay } + \alpha_4 * E_i \qquad (4)$$

.

3. Experimental Analysis

The WSN Simulator is made up of the Following Modules: PHY Protocol; MAC Protocol; Routing Protocol; Application; Event; Medium; Environment; Node; Transceiver; PHY Protocol; Routing Protocol; Application; Layer Event is considered an abstract class since it is responsible for laying the basic basis for the operation of all events. It consists of how an event should function, gives processes to compare events based on their separate start times, and determines if there is some kind of equality across events. Additionally, it consists of an abstract way to fire the event. The term "medium" refers to the means through which the nodes communicate with one another. The functioning of the nodes may be determined using the media. Medium has to be informed about the existence of nodes, their positions relative to one another, as well as other features such as transmission power and receiver sensitivity.

Medium includes details such as the bandwidth and wavelength of the medium being modelled, in addition to a reference to a propagation model that was current throughout the creation process. This model will provide the groundwork for determining the signal intensity that is sent out by nodes and received by other nodes. Environment: The functionality of the environment module is comparable to that of the medium module. The

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environment has a significant role in determining the model's physical features. In the context of a WSN network, the word "physical environment" refers to a variety of factors, such as light, temperature, humidity, sound, optical, coverage area, magnetic field, and so on. The term "node" refers to the individual nodes that make up a sensor network. Because a WSN network is made up of many different sets of nodes, all of which are talking with one another using a specific routing protocol. The hardware and software attributes of the node are included inside the node module. The term "node component" refers to a collection of several components, such as a CPU, transceiver, sensor, energy supply, routing protocol, and applications. This module essentially covers the hardware that is included inside the transceiver of the sensor node.

It addresses the various states of the transceiver, such as Sleep, Standby, Receive, and Transmit, in addition to the behaviour of nodes and the total power consumption level of nodes. It creates events to mark the beginning and finish of each signal that it sends out. Each and every one of these events is communicated with the medium module instance. The PHY Protocol is the layer of the network stack that is implemented in hardware the majority of the time since it is the lowest layer. The physical layer is responsible for providing the following services: altering the state of the transceiver; sensing the carrier; sending and receiving packets; detecting the amount of energy present in network packets; changing the channel on the physical layer to enable multiple channels. MAC Protocol: The MAC protocol layer is the layer of the network stack that sits between the Physical Layer and the Routing Layer. It is almost entirely implemented using software that runs on the CPU of the node. The MAC layer is responsible for the majority of the work that must be done in order for the WSN network to be both reliable and efficient. The following services are within the purview of the MAC layer:
Channel access policies, Scheduling.

Management of Buffers Administration of Errors Transmission and Reception of Packets between Nodes Principal Metrics of Performance: In this part, we will offer the metrics that will allow us to assess the performance of protocols using a multipath routing technique in a WSN. These metrics will serve as the foundation for our evaluation. We concentrate on measurements in order to assess the benefits and burdens associated with such methods. Energy Efficiency: One of the primary design objectives of any routing protocol in a WSN should be to maximize energy efficiency in the network. When evaluating the energy efficiency of multipath routing protocols, one method that may be used is network lifespan, which integrates energy usage in sensing, computing, and communication, in addition to network coverage and connection. On the other hand, the total number of messages broadcast in multipath protocols may also be a relevant statistic to assess energy efficiency. This is because the communication process accounts for the majority of the substantial energy consumption that sensors produce.

Additionally, the load-balancing performance of the evaluation protocol has a significant impact on the energy economy of routing protocols. This is because load balancing helps to prolong the lifespan of sensor networks and prevents the network from being congested. As a result, any measures that can be used to assess load balancing might potentially be utilized for the goal of this endeavour. Data Reliability: One of the most significant benefits of multipath routing protocol over single path routing protocol is reliability. Reliability is one of the most essential advantages. When calculating data reliability, the total number of messages received at the destination node is divided by the total number of messages originating from the source node. This ratio is then multiplied by 100. Data reliability may also be defined as the proportion of data packets that are successfully received by the destination node.

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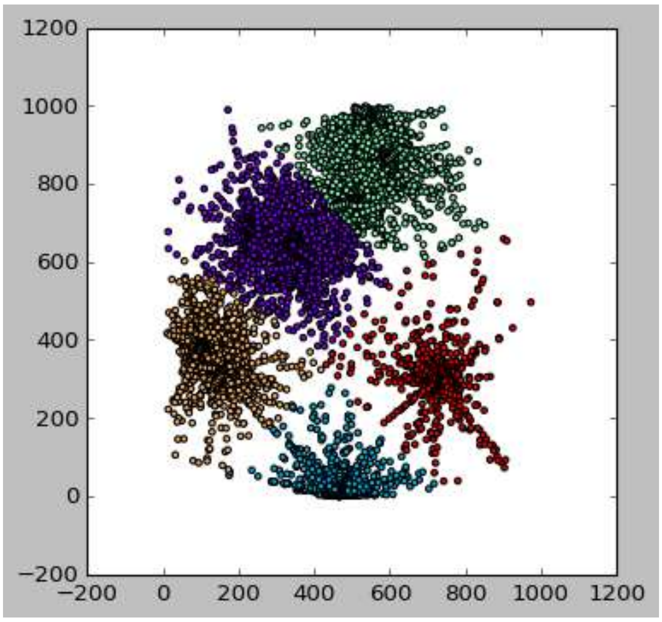

Figure 5: Clustered data

Because the number of pathways detected influences the quantity of data that is transferred, the number of paths discovered may also affect a protocol's dependability. Therefore, the dependability of the data will increase in proportion to the number of pathways found. Path Discovery Takes More Time in Multipath Routing Protocols Path discovery takes more time in multipath routing protocols because it is more difficult to find other routes. The statistic known as route setup time is often used in the process of evaluating the overhead a multipath routing system incurs. The whole length of time that the sink or source node needs in order to determine the pathways that go from the source to the destination node may be referred to as the route setup time.

The time needed to set up a route is reduced according to how well the protocol was designed. Average Delay: Because multipath routing takes into account load balancing and dependability, it is possible that it will take a longer path than single journey routing does. Because of this, the time it takes to transmit a packet from its source to its destination might potentially increase. When determining the overall delay that multipath routing causes, we look at the average delay. Consumption of energy is one of the most critical considerations that must be made during the design phase of autonomous sensor network nodes. All of the designs for the sensor network motes employed duty cycle methods, which meant that unused motes went into sleep mode and would periodically wake up to conserve power. This was done to enhance efficiency. The replacement of batteries is not an option for networks that include thousands of physically implanted nodes that are employed in power-saving technologies such as power-aware computers, energy-aware software, or power management radios. These types of networks are very difficult to maintain. The investigation of WSNs is becoming more active, and the scope of its applications is also expanding.

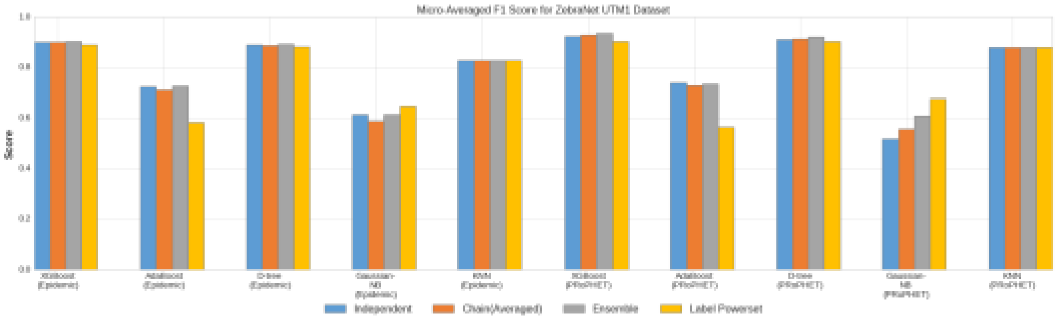

Figure 6: Prediction Score

However, a significant number of the IPv6 routing search algorithms that are employed today are unable to adapt to the additional constraints that IPv6 imposes, which an effect on the performance of WSNs. [19] has presented a revised IPv6-based longest prefix matching routing method as their contribution. The network

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prefixes and the destination addresses are both converted into the decimal system. The Scalable Bloom Filter is used to store the network prefixes, while the segmented storage of the destination addresses helps to minimize the total number of filters. A fair distribution of the address prefixes is what allows for the fast lookup time that is obtained.

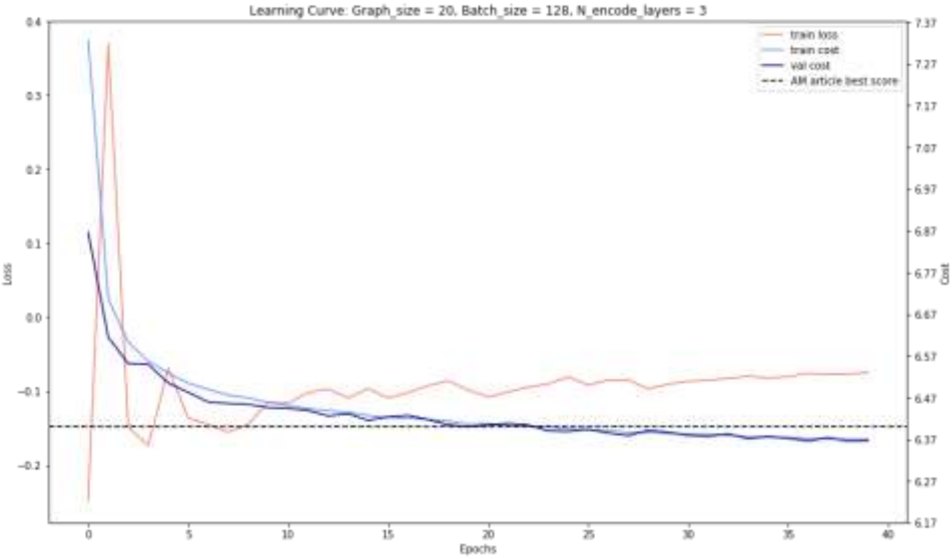

Figure 7: Learning Graph

During our experimental investigation, we made use of the Network Simulator 3 (NS-3), as well as Contiki and Cooja. Many people consider NS-3 to be a discrete-event simulator. Improving the study into different kinds of communication networks was the reason for its creation in the first place. NS-3 is a new simulator that does not support any APIs that were previously used by NS-2. NS-3 is an open-source simulator. All of the applications in NS-3 are written in pure C++, and users have the option of using Python bindings. Even though NS-3 does not provide a Graphical Tool, it is still possible to analyze graphical data by utilizing the free source program NetAnim. NS-3 offers a device model of a basic Ethernet network.

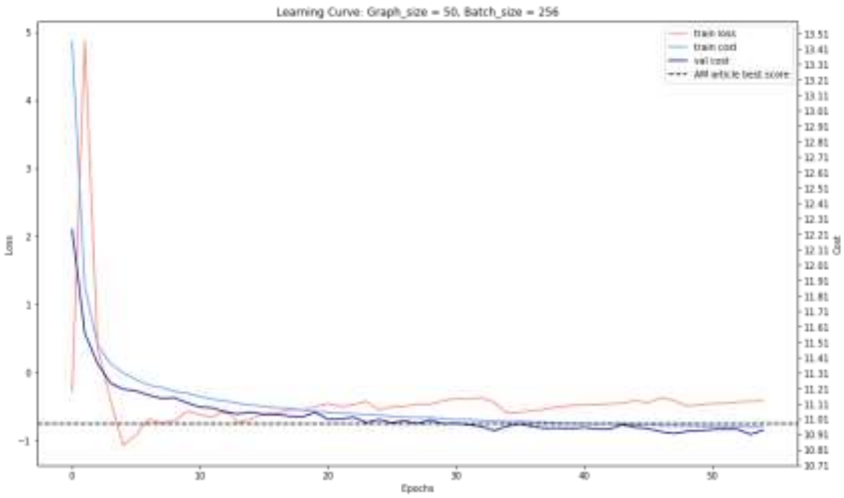

Figure 8: Training Graph

This model utilizes CSMA/CD as the network's protocol scheme, and it employs back-off that increases exponentially in order to compete for the shared transmission medium. When it comes to wireless sensor networks, NS-3 already has a number of modules built in, including 802.15.4, 6LoWPAN, and RPL, among others. The architecture and specifics of NS-3 were detailed in the following figures 3.10 and 3.11, and figures 3.12 and 3.13 presented the sensor node deployment of the simulator.

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6. Conclusion

The fact that the sensor nodes only have a limited amount of energy available served as the impetus for the work that is outlined in the proposal. In the work that has been presented, the protocols for effective routing in WSN have been provided, and evaluations have been carried out by simulating the systems using NS-3 and Contiki/Cooja. Within the confines of this proposed work, an updated version of an energy-efficient cluster-based routing protocol that makes use of IPv6 has been provided. This protocol is based on both the static and mobile sink. In order to improve lifetime, latency, and reliability, the energy-efficient hierarchy-based clustering routing (EEHCR) protocol was designed. This protocol identifies multiple paths between the source and the sink in order to improve lifespan, latency, and reliability. Hierarchical structures were used in order to achieve this goal successfully. When used with wireless sensor networks (WSNs) that make use of IPv6 addressing systems, the protocol supports anycast, unicast, multicast, and multipath routing in its application. When it comes to the transmission of data, there is more than one alternative routing path that may be accessed. In the case that one way is unable to convey the data properly, another path will be used. It is possible for the sensor nodes to enter a condition known as "sleep" in order to save energy if it turns out that they are not required for the route that the data is being transmitted along. It has been brought to everyone's attention that the control packet overhead required for route discovery and maintenance is rather minimal. Because of this, the goal that was set for the improvement in energy efficiency was accomplished with flying colors. In order to reduce the quantity of duplicate data that is sent and the amount of traffic that is present in the network, the cluster-based multipath routing protocol is used. This is done in order to achieve both of these goals. In addition to this, the protocol reduces the strain that is exerted on the sensor nodes and confers more mobility on the sink. In this scenario, it is up to the sink to choose the node that will serve as the cluster head, choose the path that will provide the best possible routing, and keep track of the sensor nodes' current energy levels. It has been constructed as a tree-based routing with node and sinks mobility, and it is able to manage the mobile sink in the network in an efficient way. Additionally, it contains both of these mobility features. In order to gather the data, the sink is now making its way across the network. The formation of the tree is initiated by a sensor node, which subsequently develops into the root node of the tree. Between relay nodes, the connection may move in either direction; however, when traveling between a relay and a non-relay node, the connection can only proceed in one direction.

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