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A QUALITATIVE STUDY ON UTILIZATION OF ROUTING IN UAV NETWORKS

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ABSTRACT

In recent years, wireless sensor networks, also known as WSNs, have become a popular tool for monitoring the changes and events that occur in our surroundings. When a sensor identifies the occurrence of an event, it generates event packets and sends them to alert the related sinks. This enables system administrators to comprehend the actual state of the monitoring environment and to respond in an appropriate manner. On the other hand, sensors are frequently installed in order to monitor particular occurrences. The transmission of messages between any two nodes in a network is made possible through the use of a decentralized mechanism known as routing. A routing strategy, like all other distributed algorithms, is executed locally on each processor or node that makes up the network. It is the job of the routing daemon that is operating on each node and processor of the network to route incoming messages while making use of the local information that is kept at the node itself. The routing table of the node is the term that is typically used to refer to this local information.

Keywords: Sensor, Network, Nodes, Routing, Wireless.

I. INTRODUCTION

WSNs make use of a variety of sensors in order to identify distinct occurrences. However, there are situations when more than one WSN can co-exist in the same location. For instance, a wireless sensor network (WSN) in a smart building may arrange sensors to detect human movement or body temperature in order to control the on/off status of hallway lights. Another wireless sensor network has been installed inside of this structure in order to monitor the temperature of the inside and regulate the ventilation systems. In addition, if this structure is a hospital, then a large number of sensors are deployed to monitor the physiological status of the patients.

In point of fact, the combination of various co-location WSNs creates a heterogeneous WSN. At the moment, the routing pathways of various WSNs are mutually independent. This indicates that various

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WSNs route their own packets through their own routing paths and sensors. When a sensor receives a packet that is part of another WSN, the sensor discards this packet without first attempting to relay it to the appropriate sink. In point of fact, the routing efficiency will improve if sensors can forward receiving packets for other WSNs. This is because many more sensors in this heterogeneous WSN will be able to relay packets, which will reduce the distance between neighboring sensors and ultimately lead to an increase in the sensor density of the monitoring environment. The less distance that must be travelled, denoted by d, means that less energy must be expended for packet transmission, given that $E = f. (d_2)$.

On the other hand, a sensor will cause a large number of redundant packets of the same one to flow throughout the network if it transmits all of the packets it receives in the direction of their sinks because of wireless broadcasting. This phenomenon, also known as broadcast storm or packet storm, results in the waste of a significant amount of energy due to the transmission of duplicate data that is not essential. In addition, the effectiveness of the monitoring system's problem-solving capabilities will be reduced if sinks are not informed by sensors of an event that has occurred in a timely manner. When assessing the effectiveness of a monitoring WSN, this efficiency is typically a significant component to take into consideration.

II. DESIGN TECHNIQUES FOR ROUTING IN UAV NETWORKS

UAV networks each have their own routing systems due to the fact that they each have their own unique features; nonetheless, several strategies that are common can be used for the transfer of data. On the other hand, an appropriate forwarding method needs to be tailored to the mobility model and the functional context in UAV networks. The choice of relays that are used to convey data is a crucial consideration in order to prevent packet loss. In this part, we will talk about some design strategies that may be used for routing in UAV networks.

1. Delivery Scheme

The various distribution methods such as unicast, broadcast, multicast, and geocast routing a sender and a receiver can communicate directly with one another using a method known as unicast routing. The message distribution strategy known as broadcast routing, which fills the network with information. An approach based on flooding can increase the likelihood of delivery, but it demands a significant amount of bandwidth and overhead. A method that relies on broadcasting is appropriate for networks that are scattered; but, as network density rises, these schemes become less efficient. Similar characteristics may be found in both geocast routing and position-based routing. A multicast routing is utilized by a geocast-based protocol in order to deliver a message to all of the nodes that are located within a particular geographical area. That is to say, it sends the packet from the originating node to all of the nodes that are geographically closest to it within the same region. Maintaining a network organization, such as a tree or mesh structure, is the responsibility of multicast routing. Tree-based protocols are responsible for maintaining a multicast routing tree in order to send data from a source node to a collection of destination nodes. The most significant disadvantage of using a tree-based technique is that, in the event that the topology becomes unstable, the tree will need to be rebuilt. As a direct consequence of this, the routing service experiences frequent interruptions. The topology needs to be maintained, which is a major difficulty in a network with a high degree of activity.

2. Cooperative Routing

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A strategy that has a lot of potential to improve the dependability of communications is called cooperative routing. Nodes participating in cooperative routing provide a hand to one another in the process of information transfer by utilizing the broadcasting protocol. Within the context of cooperative routing, a neighboring node can function as a relay node. The cooperative routing incorporates both direct transmission (DT) and cooperative transmission (CT) connections into its architecture.

3. **Path Discovery**

The Discovery method is utilized whenever the source node is aware of the geographical location of the target destination node. In order to go to the destination, a route request (RREQ) like the one shown in must be transmitted in order to discover all of the available routes leading from the source node to the destination node. When all of the alternative pathways are sent to the target destination, the optimal path is chosen based on a set of conditions that are quite specific. After then, the data transfer takes place along the chosen route. The method of path discovery is utilized in already established routing protocols in UAV networks because to the ease with which it can be carried out. Its advantage is that the packet will be sent via a route with a low cost, which the potential to lessen the amount of time has spent transmitting data as well as the number of errors that occur.

4. **Single Path**

When transmitting data between two communication nodes, the single-path approach is utilized, and in this method, the routing path is determined by employing straightforward routing tables. It is possible to predefine a routing table for a single path in such a way that there are no alternate options available in the event that there are problems with the network. Because of this constraint, using this approach might result in the loss of packets if the route were to become corrupted. Procedures that only take one path at a time Acquire knowledge of the many paths, and then choose the one optimal way to each location.

5. **Multiple Paths**

Multipath routing techniques, as their name suggests, generate many routes between the source and the destination nodes in addition to the primary route. Because there are many different routing pathways in the network, it is difficult to maintain the routing table while using multi-path routing. In the event that there was an issue with the communication nodes, multi-path routing would have multiple options to choose from in order to reach the target. When it comes to protecting against jamming attacks or path failures in UAV networks, multipath routing is a crucial component of the defense strategy. In addition to providing efficient and reliable data transmission, the multipath routing methods also increase the network's resilience when operating in an environment where harmful jammers are present. The intricacy of this approach is the most significant drawback to it. Maintaining a routing path is a difficult and time-consuming process, and even the smallest mistake opens the door to the potential of route loops in the network.

6. **Quorum-Based Routing**

The development of a location service makes use of a method called quorum-based routing. When it comes to position-based routing, the location service and forwarding scheme are both crucial

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components. To discover the current position of a particular node, it is necessary to make use of the location service, during which one of the following four possible strategies may be implemented: some-for-some, some-for-all, all-for-some, or all-for-all. On the other hand, the forwarding strategy may be broken down into three different categories: greedy forwarding, restricted directional flooding, and hierarchical approaches.

7. **Grid-Based Routing**

The network space is partitioned into a hierarchical grid in the routing method known as grid-based. Every node in the local first-order square is responsible for maintaining a database that lists all of the other nodes. A broadcast of the routing table occurs at regular intervals. Each node in the first-order square has both its own unique identifier and the ID of the node that is geographically closest to it. In the first-order square region, the position of each node is periodically broadcasted to the other nodes. It is common practice to regard the position of a node to be the grid's centre. After a node has come within a close proximity to the position, the information about the position will begin to be sent gradually. This ensures that the position information is transmitted to the appropriate node, which is where it is subsequently kept. A grid-based location service requires that all nodes store the information for some other nodes; this method may be categorized as an all-for-some approach since it requires all nodes to store the information for some other nodes.

8. **Store-Carry And Forward**

When a problem in the network causes a disconnect from its next relay node, yet forwarding data is essential, and when it is also not able to transmit data to the next hop because the node is beyond of transmission range, the store-carry-and-forward routing approach is utilized. In this kind of situation, the data is carried by the current packet holding node until it reaches either another node or the node at which it is intended to arrive. The most significant drawback of utilizing this method is the resulting delay. In spite of the fact that this method might not be effective in a FANET setting owing to the frequent topology changes, it can still be utilized successfully in FANETs if the UAV nodes are only scattered in a few locations, in the event that the network has sporadic connectivity, the forwarding node is responsible for transporting data packets until it either connects with another node or reaches its final destination. The store-carry-and-forward routing strategy may be utilized with ferrying unmanned aerial vehicles (UAVs) to take advantage of delay-tolerant networks. The store-carry-and-forward routing approach is used in delay-tolerant routing in UAV networks to ensure good throughput.

9. **Greedy Forwarding**

It is possible that communication between two nodes in a network that contains a large number of UAVs will need the use of greedy forwarding. The reduction of the total number of hops taken by the transmission channel is the fundamental idea underlying this technology. The algorithm behind it selects a relay node that is geographically located in the closest proximity to the node it is intended to reach. A straightforward method of forwarding, greedy forwarding is a progress-based mechanism. A node will send a packet on to the neighboring node in its neighborhood that is located the furthest away from the target node. The method will fail if there is no neighbor node closer to the destination node, at which point the node that is retaining the packet will be referred to as the local minimum. A comparison may be made in the greedy method between the distance that exists between the current node and the target

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node and the distance that exists between the current node and its neighbors. In the past, it has also been used to choose both the forward and the backward nodes. The related local optimum problem with this approach is one of its drawbacks. As a result of this difficulty, it is possible that it will not locate the most effective relay node to get to its destination. Huge overhead is another disadvantage of this method.

10. Prediction

UAV networks make use of a variety of different prediction approaches. The most popular form of prediction is based on the speed, geographical position, and direction of the unmanned aerial vehicles (UAVs) that the source node employs in order to relay data to the subsequent node. In most cases, the estimates that these parameters offer for the subsequent relay node in communication networks are of a satisfactory quality. Figure 1.11 illustrates how a predicted geographical position can be utilized to locate the subsequent relay node in a network. In order to prevent the loss of packets in the communication network, the store-carry-and-forward mechanism is utilized in certain circumstances. Path discovery is used, in addition to its other functions, to locate active communication routes between nodes.

III. ROUTING PROTOCOLS FOR UAV NETWORKS

There have been several different routing methods suggested for UAV networks. For use as test beds in UAV networks, the routing protocols MANET and VANET were selected in the beginning. However, it was determined that the routing protocols developed for MANETs and VANETs are not appropriate for use in UAV networks. This was due to the fact that UAV networks exhibit characteristics that are distinct from those of MANETs and VANETs, such as fast topology changes and high mobility. As a result, new routing protocols tailored specifically for UAV networks have been suggested as of late. UAV routing protocols may be broken down into two distinct categories: those that are based on the network architecture, and those that are based on the data that is being forwarded. The topology-based, position-based, and hierarchical routing protocols are the three separate subcategories that are included in the classification of network architecture-based routing. There are three distinct varieties of routing that are included in topology-based networking: mesh-based, tree-based, and hybrid. A further subdivision of tree-based routing is possible by dividing it into source-rooted and core-rooted based routing. In the multicast routing system known as source-rooted tree routing, the source node serves as the root of all multicast trees and is responsible for the ongoing building and distribution of those trees. Cores are nodes in core-rooted tree routings that have specialized functions such as multicast data dissemination and membership management. Cores are at the centre of the tree. When using a routing method that is based on a mesh structure, data packets are split up and sent to each of the nodes in the mesh. Both the process of constructing a mesh and discovering new routes may be done in two different ways: the broadcasting technique can be used to find new routes, and the core point approach can be used to find new routes. In high mobility networks, the performance of mesh routing is superior to that of tree-based routing, and mesh-based routing offers a variety of different pathways to forward data packets from their source to their destination. Mesh-based routing requires control packets, which adds overhead to the routing process and results in an inefficient use of power. Mesh-based routing also requires control packets in order to maintain and manage the routing topology. When using source-based routing, intermediary nodes are not required to keep their routing information up to current in order for the packet to be sent. The most significant disadvantage of source routing is its increased overhead. Because the routing table for a source route is so lengthy for a big network, each and every packet has to include the full route in its header file. This causes a significant amount of wasted bandwidth on the network. In hop-by-hop routing, the information necessary to reach the destination is sent along from one hop to the next. In the hop-by-hop routing method, when a node gets a packet destined for the destination, it sends the packet on to the next hop that is geographically closest to it and corresponds to the destination node. Both tree-based and mesh-based routing are combined into a single system using hybrid routing protocols. The most significant advantages of hybrid routing are the several routing pathways that it provides. In this part, we will discuss the routing protocols that are applicable for UAV networks. We will comprehensively study topology-based, position-based, hierarchical, deterministic, stochastic, and social network-based routing protocols.

IV. ROUTING SCHEMES FOR HETEROGENEOUS WSN'S

In a WSN, sensor nodes or motes are placed in the region of interest either deterministically or randomly in order to monitor various environmental or physical conditions.

- ✓ **Sensing unit**: sensor node is a battery-powered, wireless device that relays information to an end user via a base station (BS) or sinks. This information can be sent to the user in several ways. The most important elements of sensor nodes are the sensing units, which might include a single sensor or many sensors in various configurations, and analog-to-digital converters (ADC).

- ✓ **Processing unit:** It is responsible for receiving the signal sent by the sensing unit and managing the cooperation of sensor nodes in order to carry out sensing duties. Memory is included in the microprocessor or microcontroller that makes up this component. This device is also responsible for providing intelligent control of the sensor nodes.

- ✓ **Communication or transceiver unit:** This component handles the sending and receiving of data across an RF channel. Additionally, it is responsible for the connection of the nodes to the network.

- ✓ **Power unit:** This component is often made up of a battery. This unit provides the power that is necessary for all of the system's components to function properly, and it does so by supplying it. It's possible that there are some extra units that are dependent on the application. Because of its cheap production cost and low power consumption, the individual modules have been merged into a single, relatively small module.

WSNs provide a number of important design challenges, one of the most crucial being the effective control of power. It is possible to do this through the efficient use of energy at each level of communication, beginning with the capture of data and continuing through its transmission and reception. Clustering-based routing protocols have been shown to have the capacity to make effective use of electricity, according to the research that has been conducted on the topic. Clustering algorithms have shown to be the most effective option for lowering the amount of power that is consumed at the network level. It is a technique for organizing the nodes into clusters, with a cluster head (CH) serving as the leader of each cluster. Instead of transmitting the data straight to the BS, which would need a large amount of power, the sensing nodes instead send it to the closest CH, which also takes on the job of aggregating and grouping the data before sending it to the BS. The low energy adaptive clustering

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hierarchy, often known as LEACH, is a fundamental clustering technique that ensures that energy dissipation is spread out equally among all of the network's nodes. The CH distributes TDMA slots to the member nodes so that they may send their sensed data only within the time period that they have chosen for themselves. Whenever the node is in an idle situation, the radio is turned off. This TDMA scheduling helps conserve energy and lengthens the lifespan of the network. In addition, before transmitting to the BS, the CH fuses the data in order to filter out any unnecessary or duplicated information. In order for sensor networks to endure long-term deployments, they need to be able to resist harsh environments. This is especially important when the networks are deployed in remote geographical places, as is the case when monitoring animals. In order to increase the performance of the network, it has been determined that using a technology known as a hybrid routing methodology is the most effective strategy. On the basis of the geographic distance that separates the sink node from each sensor node, the network has been partitioned into a number of distinct zones. Within the network, there is a relay node that can be periodically refilled when it runs low on power. In a sensor network, relay nodes are a particular subcategory of sensor nodes that are installed to share the burden of other nodes that have been overwhelmed. Because the relay node facilitates the collection of data in an effective manner, which in turn increases the lifespan, the location of the relay ought to be constructed with care displays the employment of a relay node, which is accountable for the collection of data from sensors that have been deployed for the purpose of livestock tracking and the transmission of that data to BS for further processing. The relay nodes ensure that the process of data collection is carried out in a balanced manner while also enhancing the network's lifetime and making it fault resilient. The relay node in the network is responsible for maintaining, supporting, and recovering communication. Instead of establishing clusters and CHs, sensor nodes that are located closer to the base station or relay are able to send their data directly to the base station or relay. To avoid wasting energy on the transmission of data that isn't essential, the LEACH protocol can be implemented locally instead of system-wide. This helps to keep data transmissions to a minimum.

Since the invention of low-power digital circuits and wireless communication technologies, wireless sensor networks (WSNs) have found widespread use in a variety of industries, including target tracking, medical help, urban management, smart homes, and military reconnaissance. WSNs are primarily made up of a base station (BS) and a large number of sensor nodes that are randomly dispersed across the network. The battery is the primary source of power for the sensor node's energy supply. However, the battery power is quite restricted, and it is very difficult to charge or replace the battery when the sensor nodes are put in an environment that is either complicated or hostile. Therefore, increasing the network's energy efficiency is the most significant and crucial objective in the design of WSN routing protocols in order to extend the lifetime of the network.

Designing a routing protocol for WSNs that is based on clustering is the most efficient method for conserving the energy of the sensor nodes and extending the life cycle of the network. This may be accomplished by implementing a clustering-based routing protocol. The purpose of a clustering method is to separate the sensor nodes that are being examined into a number of different areas, often known as clusters. In each cluster, a sensor node is chosen to serve as the leader, also referred to as the cluster head (CH), and the remaining sensor nodes are chosen to serve as members of the cluster. The remaining sensor nodes are tasked with sending their perceived data information to the CH that is geographically closest to them. The CH will then perform data information fusion and send data to the BS. The method of transmission that is used by the CH to send data packets to the BS can either be single-hop or multi-

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hop, and the mode that is used is mostly influenced by the distance that separates the CH and the BS.

Several clustering-based routing protocols, such as Low-Energy Adaptive Clustering Hierarchy (LEACH), Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN), Hybrid Energy-Efficient Distributed Clustering (HEED), and LEACH-centralized (LEACH-C), a novel Battery-Level Aware Clustering family of schemes (BLAC), etc., have been proposed as ways to lengthen the life cycle of a network. These protocols include On the other hand, the majority of clustering routing methods for WSNs have been largely built on networks that are homogenous. Heterogeneous wireless sensor networks, also known as HWSNs, are currently seeing increasing widespread use in practice as a result of improvements in both the resources available at individual nodes and the structure of the network. The HWSNs focus primarily on taking into account the heterogeneity of the energy. Stable Election Protocol (SEP), Modified SEP (M-SEP), Prolong-SEP (P-SEP), an improved version of the Energy Aware Distributed Unequal Clustering Protocol (improved-EADUC), and Distributed Energy-Efficient Clustering Algorithm (DEEC) are some of the routing protocols for HWSNs that take into account the heterogeneity of the nodes' energies. Other protocols include Prolong-SEP (P-SEP).

V. CONCLUSION

In this mechanism, wireless sensor networks that are deployed in the same geographical environment form a heterogeneous sensor network, and sensors relay packets generated by their own wireless sensor network as well as other wireless sensor networks. The paths for the delivery of packets are constantly determined based on the directions in which events are conveyed, as well as the leftover energy of the sensors underneath them and the sensors that surround them. Additionally, in order to conserve delivery energy and efficiently alert the appropriate sinks, those packets that were sent in the same direction by the same sensor are grouped together and treated as a single entity. The findings of the simulation indicate that the EERH is an effective method for extending the lifetime of a heterogeneous WSN.

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