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A Deep Overview on Heuristic Algorithms for MWSN

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ABSTRACT: Latest progresses in wireless telecommunications have caused the advent of mobile wireless sensor networks (MWSN). The sensor nodes forming these networks, in addition to being low cost and having limited battery life, are also mobile. Due to the sceptical features of these networks, many applications have been created for them. It can be used for rescue operations in the affected areas, surveillance, surveillance and surveillance systems. It is used to send traffic signals. According to the requirements of the mentioned applications and considering that the wireless sensor nodes Movable equipment that has energy constraints and energy conserving is a substantial tool in its design. The sensor nodes may travel independently and connect with each other thanks to the MWSN, which eliminates the requirement for a centralized control. These networks can outperform static wireless sensor networks because they have a longer lifetime of the network, lower power usage, more available bandwidth, and superior targeted capabilities. The routing procedure in a mobile network is often difficult, and it becomes even more so in MWSN since the sensor nodes are low-energy, low-cost mobile gadgets with limited resources. Modern research has resulted in the development of a number of effective routing methods for MWSNs, but many issues remain unsolved, such as preserving network access, lowering energy consumption, and ensuring proper sensing coverage, to name a few. The advanced routing protocols in the MWSN are presented in this study, which solves numerous routing difficulties. The routing protocols are classified according to their communication network, information status, power proficiency, and movement. The classification described here covers the fundamental elements of several published ideas in the literature for effective routing in MWSN and also provides insight into possible improvements to current routing protocols.

KEYWORDS: Heuristic Algorithm, Mobile Wireless Sensor Network, Cross layer Routing

I. INTRODUCTION

A mobile wireless sensor system (MWSN) is made up of sensor nodes that can move across the network [1]. A sensor node is a piece of equipment with three fundamental modules: a sensing component that collects data from the physical environment, a processing component that processes and stores data locally, and a wireless communication component that transmits data [2]. According to initial study, including mobility into a WSN is beneficial [3]. Sensor nodes can be equipped with mobilizers to change their places [4], or the sensors can be designed to self-incite using spirals [5] or swivels [6], or they can be coupled to trailers such as automobiles, mammals, or robotics [7]. The atmosphere (water or air) in which the sensor nodes are positioned can cause them to move [8]. According to recent studies, MWSN outperform static WSN because they provide the following benefits [2]. Fig. 1 shows the design of MWSN. The sensor nodes are dispersed throughout the network at random. These nodes are interconnected and can interact with one another as well as the mobile agents. The mobile agents are able to gather sensed data and transmitting it to the stationary network of Access Points. They can move anywhere, at any time. The decision of other distinctive attributes like connectivity, MAC level protocols, and physical traits reflects the dynamic topology of the MWSN. Owing to hardware breakdown or energy depletion in a static WSN, an earlier linked network can degrade into a collection of unconnected subnetworks, however with MWSN, the nodes can be used to rearrange the network. After initial implementation, mobile sensors can be repositioned to reach the required density need and close energy gaps in the network [9-11]. Mobility can help you save energy while communicating. When compared to static WSN, MWSN has larger channel capacity. MWSN can accomplish data fidelity by minimising the number of hops, which lowers the probability of error. The habitat of migrating birds is being monitored by a bunch of ornithologists, a mobile worker (might be a robot or a human) armed with sensor(s) accumulating and transferring data to the base station about



agricultural sector, smart city, e-voting, smart transportation system, fire crews looking to move through a burning house, and so on are just a few of the applications where a MWSN can be used [12]. However, implementing mobility in a WSN is difficult due to frequent path breakdown caused by channel fading, shading, interfere, node movement, and node breakdown. Frequent position changes from a moving node can deplete the sensor node's battery source and enhance the likelihood of crashes. As a result, factors such as node mobility, bandwidth constraints, and restricted resources, among others, must be considered when constructing MWSN. Routing is the process of transferring a data packet from one location to another. In a sensor network, the route taken by each message intended for the sink is critical to the network's longevity. Sensor nodes have a finite amount of energy, so reducing energy usage is critical in a MWSN [13].

II. RELATED WORK

In a WSN, the combination of movement and resource utilization poses substantial routing issues [14]. Because of the extremely vibrant nature of the MWSN and the constant changes in network architecture and networking devices caused by mobile nodes or link failures, routing is a serious problem [15]. Mobile sensor nodes have inadequate power dispensation and storing capabilities. Because of the vibrant character of the network configuration, several nodes will run out of energy and fall out of the network, causing the network to divide. Many scholars have developed various routing protocols based on various criteria and design challenges. The network structure, status of info, movement, and power saving strategies can all be used to classify MWSN routing protocols. They are further classified as Direct Communication Routing, Flat-based Routing, and Hierarchical Routing based on the network topology. A sensor node provides data directly to the sink in direct communication routing. If the network region is big, the sensor node's power drains rapidly, and the number of collisions grows as well. As a result, in a MWSN, direct communication routing is rarely utilized. All nodes in the flat based routing system have the same capability [16]. Hierarchical protocols automatically combine network nodes into partitions called clusters, which are then aggregated into bigger divisions known as super clusters, and etc. The data is aggregated by the cluster heads, which reduces the amount of data and saves energy [17]. Cluster chiefs are in charge of making control decisions for cluster members [18].

III. ROUTING METHODOLOGY

Because these networks have no fixed topology, one of the most difficult tasks is routing information from its origin to its terminus. In general, these routing procedures are inspired by two areas: wireless sensor networks (WSNs) and MANETs. The essential capability is provided by WSN routing protocols, because they're unable to manage the higher frequencies of dynamic topology. MANET routing methods, on the other hand, can manage network mobility, but they're built for two-way communications, which isn't always necessary in sensor networks. MWSN-specific protocols are often multi-hop and occasionally modifications of conventional protocols. (ADSR), for instance, is a MWSN modification of the wireless mesh network protocol. ADSR calculates the angle between the transmitting node, probable relaying sensors, and the central station using position information. Next, it is utilized to ensure that packets are routed to the central station at all times. In addition, the LEACH protocol for sensor network has been converted to (LEACH-Mobile) for Mobile WSNs [19]. Another common routing method is to use locate data from a GPS component connected to the sensors. This may be observed in protocols like (ZBR) that employs location details to keep nodes informed about their cluster. GOR [20] is a flat rules that splits the network region into nets and then employs the site details to optimally transmit data as far as feasible within every hop. Multi-hop protocols appear to be a suitable route for MWSN routing protocols since they enable a strong method for routing. The query oriented (DCBM) is such a protocol [21]. Additionally, (RASeR) [22] and (LASeR) [23] are two protocols created precisely for speedy MWSN applications including UAVs. They both use multipath moving, that is made possible by a mechanism known as "blind forwarding which merely permits the conveying node to disseminate a message to its vicinity, it is then up to the reception nodes to regulate if they should forward or reject the message. A network-wide gradient measure is used to assess whether or not to forward a packet, with the values of the sending and reception sensors being assessed to evaluate which is closest to the central station. The fundamental distinction amid RASeR and LASeR is how they keep track of their gradient measures: RASeR sends out tiny beacon packets on a regular basis, in which nodes transmit their existing gradient. LASeR, on the other hand, relies on existing geographic region details on the movable sensor that is probably the truth in numerous applications.

Current routing protocols are classified as flat, hierarchical, or location-centered routing protocols depending on their routing architecture. Similarly, there are two types of hierarchical based routing: conventional and optimized

hierarchical oriented routing. In addition, path formation determines the path from the origin to destination using different types of routing (proactive, reactive, hybrid) [24-25]. Fig 2 depicts a classification of MWSN based routing protocols.

IV. HIERARCHICAL ROUTING PROTOCOLS

LEACH is among the most widely used dynamic clustering techniques for hierarchical topology sensor networks. It is specifically built for scattered environments and requires no globally network information. The sensor chooses the cluster head (CH) as per the acquired signal intensity and the threshold values, and the cluster is formed. For data transmission, the cycle or topology updates interval is used, that is separated into set time intervals of fixed intervals. Because all sensors of a network has an equivalent chance of acting as a CH by picking an arbitrary integer between 0 and 1, sensor nodes gradually expire [26]. Even though dynamic clustering extends the lifespan, fixed LEACH is ineffective for huge MWSN; consequently, LEACH with movement should be examined for vibrant networks. For mobile sensor networks, LEACH variations [27, 28] are describes below:

- A. T-LEACH: T-LEACH [29], like LEACH, creates a hierarchical topology for huge, vibrant, and unevenly disseminated movable sensor networks. To balance the network's energy depletion and increase the packet delivery rate, it employs a tree topology, an energy depletion method, and a multi-hop transmits technique. The topology generation and topology maintaining stages of T-LEACH are applied in two stages. The topology building process creates a data aggregation tree, a cluster organization, and a multi-hop broadcast method initially. Second, the topology maintenance phase builds a stable network using the multi-hop transfer's technique, member node mobile response rate, and cluster mobile response rate. When equated to LEACH and CBR, movable LEACH, the T-LEACH protocol can effectually found and preserve the topology organization of vigorous and unevenly disseminated huge MWSNs in regard of packet delivery ratio (PDR) and average power depletion according to results obtained.
- B. Mobile LEACH: It is [27] a movement oriented protocol for WSN. The static LEACH operations and mobile LEACH operations are extremely analogous. However, the mobile LEACH permits for the insertion of movable sensors with non-CHs during the setup stage, as well as the rearrangement of the cluster to consume the least amount of energy. The CH provides a time slot to all of the sensors in its cluster after the cluster is formed. The cluster members switch off the radio but when it is broadcasting to limit the power consumption of the individual sensors. According to the results of the experiments, Mobile LEACH outperforms LEACH in terms of lowering data packet loss for movable nodes. However, as opposed to LEACH, Mobile LEACH has the drawback of increasing undesired power consumption. For enhancing the lifespan of the movable LEACH for mobile sensor networks, authors in [30] developed mobility based LEACH protocols. All mobile sensors can interact straight with the BS in mobile mono-hop LEACH that is ideal for a small inside setting. However, the transportable multi-hop LEACH is intended to assist some wide range outside applications. The introduced protocols boost the effectiveness of mixed movable sensor networks in regard of network lifespan, communicated packet rate, adjournment, and PDR, according to simulation results.
- C. LEACH-ME: The transportable multi-hop LEACH is intended to assists some huge outdoor applications. The introduced protocols boost the effectiveness of heterogeneous MWSNs in regard of network lifespan, number of packets transmitted, deferment, and PDR, according to simulation results [28]. LEACH-ME also keeps track of information about sensor nodes like the node's job, movement feature, cluster members listing, and TDMA scheduling. Even the sensor keeps track of all information; the movement feature is a significant aspect in deciding which cluster head to use. Let's say the movement feature is regulated by the total transitions and the concept of remoteness. Every CH can build a group of cluster members with the least amount of node mobility using this information. LEACH-ME also guarantees that clusters are spread as evenly as possible while cluster heads are on the move. With respect to mobility factor, simulation findings reveal that LEACH-ME outperforms mobile LEACH in context of average effective communiqué, standardized efficiency, computing and energy overhead.

V. MOVABLE SINK-ORIENTED ROUTING PROTOCOL

The [31] method is used for lengthening the life of cluster-based WSN. When equated to far away sensors the nearby sensors to the sink must typically send a significant amount of messages, and they may quickly deplete their remaining power. This is referred to as a "hotspot" challenge. To evade such difficulties, the identifying section is made up of clusters, which extends the network's lifespan. The movable sink is used rather than the non-movable sink in MSRP, and it goes to each cluster to assemble the sensed information and upload it to the CH. The movable sink now takes the CHs' remaining energy information and goes on to the higher energy CHs.

The setup and the steady state phases are the two phases of the MSRP protocol. The entire network is segregated into clusters during the setup phase, and the movable sink promotes its site to CHs by dissemination the beacon message for the registering procedure. It's also broken down into three phases: initialization, movable sink announcement, and registration of CH. The steady state phase begins once the setup step is completed. Throughout the steady-state stage, the sink collects information and sends it to the registered CH, who then gathers data from the cluster members. Then it's broken down into 3 stages: TDMA scheduling, sink forwarding, and sink movement. The mobile sink goes to all CHs in a network often based on the cluster head's remaining energy and collects data from them. The MSRP minimizes power depletion amid movable sensors and overcomes the energy holes issue by modifying the mobile sink's one-hop neighboring nodes, according to simulation results. Fig.3 shows an instance of mobile sink centered routing protocols.

VI. MOBILITY ADAPTABLE CROSS-LAYER ROUTING

The MSRP minimizes power depletion amid movable sensors and overcomes the energy holes issue by modifying the mobile sink's one-hop neighboring sensors, according to simulation results. The development of a single layer protocol will not be able to give optimal solutions for large-scale MWSNs. As a result, the authors created the MACRO technique that unifies 5 OSI suggestion levels into an all-in-one protocol, including application, transport, network, MAC, and physical layers. Path detection, message progressing, and path managing procedures are all part of the MACRO protocol design, which ensures dependable quality links in the face of frequent topological changes. It also decreases node breakdown, unsolicited control packet flooding, and severe MWSN congestion. Because of the larger number of movable sensors and regular topology variations, the route finding process in huge MWSN may instigate significant latency. In context of PDR and end-to-end packet delay, the experimental outcomes show that MACRO outclasses the conventional CBR-mobile and LEACH-mobile. Fig. 4 shows an instance of cross layer routing in WMSN.

VII. ENERGY MANAGING PROCEDURE IN A WSN WITH MORE THAN ONE BASE STATION

The method [32] has been recommended to increase the MWSNs' enduring power usage and data transmission eminence. The operation of this method for power management in MWSNs with numerous movable sinks is divided into two phases: (i) locate closed tour of all mobile sink's i.e., the length of each mobile sink's closed tour is nearly identical. (ii) On the found closed tour, conclude the stopover positions of all mobile sinks. Then, for the mobile sink, create a routing tree rooted at every stopover site and the location's s stopover time. There are two kinds of wireless transmission ports on every movable sink Limited-power wireless connection: interact with sensor nodes in a sensor network; large capacity wireless interface: interact with a 3rd network for the aim of distant data transmission. EMMS energy management procedures, like LEACH, are divided into cycles. Every cycle contains construction of a routing tree, calculating sojourn times at every sojourn position, and collecting and transmitting sensory data. The routing tree creation step starts a routing tree at every sojourn place on the mobile sink's closed tour based on the sensor nodes' leftover energy. The sojourn time calculation then begins by calculating the members of the created tree and estimating a sojourn time at every sojourn place on each sink's closed tour. The sensor nodes convey their perceived data to the movable sink through the established routing tree in the data collecting and recognizing data transmission stage and the mobile sink communicates the recognized data to the distant observing center. The movable sink receives remaining power information about the sensors in the neighbor group at the termination of the data transmission step and then moves on to its following sojourn spot. The experimental outcomes show that the proposed method greatly enhances the MWSN's remaining power utilization and data communication excellence.

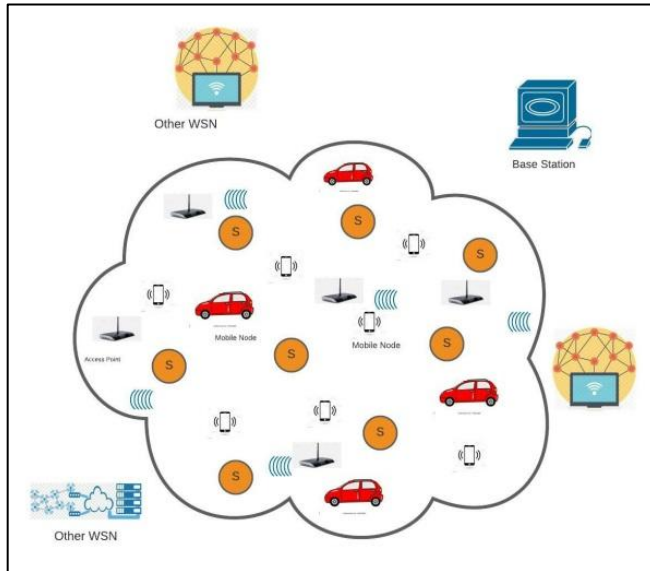


Fig 1: Mobile Wireless Sensor Network

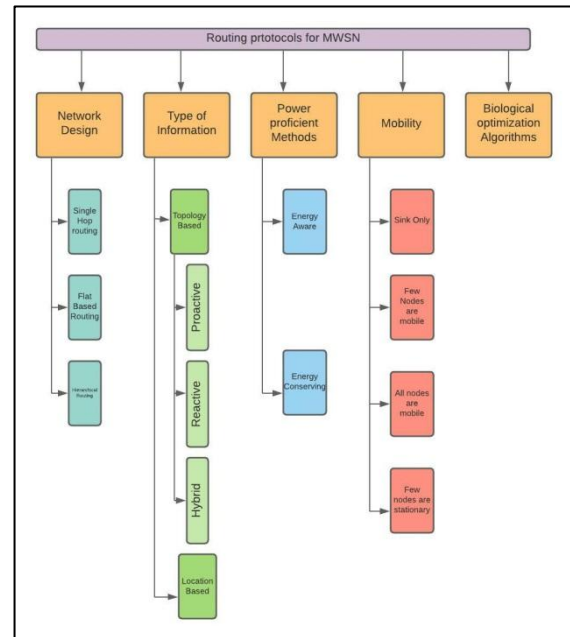


Fig 2: Classification of Routing Protocols of MWSN

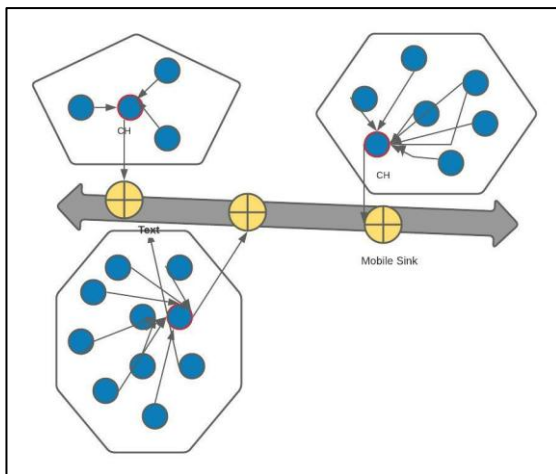


Fig 3. Mobile Sink Centred Clustering in MWSN

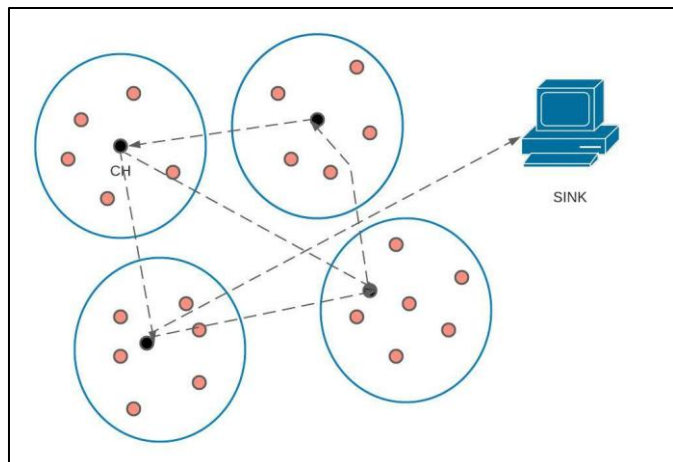


Fig 4. An instance of cross layer routing in WMSN

VIII. MASSIVE MWSNS DATA COLLECTION USING ARTIFICIAL BEE COLONIES

Authors in [33] suggested the ABC procedure, which analyses 3 “bee” assemblies in the “colony” (i.e., bystanders, scouts, and employed bees). To find the best path, the ABC procedure uses a populace of bees, with every bee representing a place in the search domain. An employed bee is one that continuously awaits on the “dance” section to select a honey source in an bystander, arbitrarily hunts a scout, and returns to the formerly stayed honey source. Let's say that the location of the honey sources is a potential solution to the optimization puzzle. Additionally, the quantity of “nectar” produced by a honey source is connected to the eminence (i.e., fitness) of the linked issue. Also, the employed bees are represented by the 1st part of the ABC procedure, while the observer bees are represented by the 2nd part. The functioning of the ABC algorithm is broken into 4 key stages: initialized, population renewal, bee source assortment, and population removal are all steps in the process. Authors in [34] developed an optimization-oriented ABC procedure that leverages the movable BS to determine the best moving route and the best routing path for data collection onto the movable sensor nodes of huge Mobile WSNs. In addition, the ABC method is meant to look into the mobile sink's data delay from three perspectives: data gathering optimization, mobile route stretch reduction, and network consistency

optimization. Each round of the ABC procedure functioning includes a preliminary stage and a data gathering stage, similar to LEACH. The movable sink employs information of network topology in the early phase to find the optimum clusters of the best CH nodes and to create a routing tree amongst the CH nodes.

The data gathering phase begins after the initial phase is completed. Each CH collects the sensed data from their cluster members at this point. The movable BS then sends a quick response to the CH, which gathers the data. In addition, the movable sink determines and selects the subsequent cluster head location based on existing network atmosphere factors and mobility, which aids in determining the quickest path to each CH. When compared to the random walk and ant colony procedures, simulation findings demonstrate that the ABC algorithm may successfully improve various measures of Mobile WSNs like data collecting competence, enduring power usage, and dependability, as well as extend the lifespan of the MWSNs.

IX. MOBILITY-CENTERED CLUSTERING PROCEDURE

To increase the efficiency of Mobile WSNs, authors in [34] designed a motion oriented clustering procedure. On each round, the procedure's process includes a setup phase and a steady phase stage, like LEACH. All sensor nodes have an uniform opportunity to select the CH during the setup phase relied upon the threshold value (i.e., remaining power and movement). It also takes connection period into account during the cluster creation process, resulting in a more dependable path being built depending on the constancy or accessibility of every connection amid cluster members and the CH.

X. TREE TECHNIQUE FOR DATA GATHERING WITHOUT A CLUSTER

To offer dependable assured complete communication for huge Mobile WSNs, authors have designed a CIDT architecture [35]. CIDT is a hybrid logical scheme methodology that employs intra-cluster communication and DCT communication for cluster and tree topologies, correspondingly. For large scale mobile WSNs, the protocol design aids in improving QoS metrics such as data gathering, power depletion, latency, Packet Deliver Ratio, throughput, and network longevity. Here, each sensor node selects the CH with the fastest linking time, and the CH then gathers the cluster members' information messages in a designated time slot. Following CH selection, the BS begins the DCT to designate one-hop neighbor DCN or present DCN, that selects one-hop neighbor DCN or another CH with high coverage distance, highest linking time, and minimal network traffic. Set-up and steady-state phases make up the protocol operation. A sensor chooses itself as a cluster leader among them during the setup phase relied upon its threshold value (i.e., flag, remaining power, and movement). During cluster creation, the cluster member also links with the one-hop CH depending on the assessed linking time, RSS, and connection sturdiness.

The base station then initiates DCT communication to build a data gathering tree that picks the DC node to cover the complete CH. For this round, the Data Collection Node does not contribute in sensing; instead, it collects sensed data and sums data packets from the one-hop CH and the DC Node, then onward the data packet to the sink via DCT. Every round, different cluster leaders and DCNs are designated to guarantee that the network's lifetime is consistently disseminated. The DCN maintains communication with the CH even while the sensor nodes are in high mobility, and CIDT does not need to change the tree structure for that round. Furthermore, by forwarding data with DCT, CIDT minimizes power usages, failure of link, overall delay, and cluster head traffic. In a sink, minor complexity is required to produce a tree structure that decreases cluster head energy consumption. CIDT also aids in the reduction of recurrent cluster creation and the maintenance of a cluster for an extended period of time. At the steady state stage, every cluster member transmits its collected data to the CH throughout its allotted time period, and the CH groups the data and transmits it to the central station through midway CHs using the DSSS approach.

XI. VELOCITY CONSERVATION OF ENERGY AND LINK KNOWLEDGE IN A CLUSTER-TREE

VELCT [31] is an energy-efficient routing strategy based on a hybrid topology (cluster + tree) that has been specifically intended to increase the network efficiency, data gathering, and longevity of huge MWSNs. VELCT is a CIDT upgrade that successfully addresses prevailing network topology concerns like remaining power usages, coverage issues, critical node existence, movement, and network lifespan. The data collecting tree is built using the planned VELCT system (DCT). Established on the location of the CH, certain sensor nodes in a network have been allocated as the data collecting node and do not contribute in sensing on this specific cycle in DCT. The goal of the DCN contemplation in this case is to collect the cluster head's data packets and deliver them to the central station. Due to the optimal use of the DCT, the VELCT procedure decreases remaining power depletion and lessens overall delay and traffic in CHs in huge Mobile WSNs. The VELCT algorithm's main advantages are that it reduces the cluster

head's residual energy consumption, builds a simple tree design, avoids recurrent cluster creation, and keeps the cluster for a long period. The power of the proposed protocol is that it creates a simple tree design of CHs that preserves the cluster for a long period, reducing power depletion and control packets operating cost, and thus evading the blockage issue at the CH level and recurrent clustering in a mobile environment. When matched with power proficient data gathering protocol relied upon tree structure, CREEC, CTDGA, MBC, and CIDT in a high movement atmosphere, experimental outcomes show that proposed procedure can provide improved efficiency in context of power usages, throughput, interruption, and Packet Delivery Ratio with condensed network traffic.

XII. CONCLUSION

One of the most challenging topics in recent years has been routing in a MWSN. MWSN routing has seen a promising evolution as a result of recent research advances. We have offered a wide survey of the most recent routing methods recommended in the literature for Mobile WSN in this study. We categorised them according to their network topology, information status, movement, and power proficiency. These routing protocols each have their own set of advantages and disadvantages, and the majority of them are application specific. We also discovered that combining an energy-aware routing strategy with an energy-saving method at the cross-layer level will result in an effective solution for power proficient routing in Mobile WSN. The agility of sensor nodes aids in the reduction of concerns such as routing holes, hot spots, and energy-hole problems, among others. We covered the majority of the existing MWSN literature, including mobile sensors design, movement, topography, and routing protocols. However, there is still potential for improvement in terms of efficient node finding and transmission scheduling.

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