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Metaheuristics Techniques for Cluster Head Selection in WSN: A Survey

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Abstract— In recent years, Wireless sensor communication is growing expeditiously on the capability to gather information, communicate and transmit data effectively. Clustering is the main objective of improving the network lifespan in Wireless sensor network. It includes selecting the cluster head for each cluster in addition to grouping the nodes into clusters. The cluster head gathers data from the normal nodes in the cluster, and the gathered information is then transmitted to the base station. However, there are many reasons in effect opposing unsteady cluster head selection and dead nodes. The technique for selecting a cluster head takes into factors to consider including residual energy, neighbors' nodes, and the distance between the base station to the regular nodes. In this study, we thoroughly investigated by number of methods of selecting a cluster head and constructing a cluster. Additionally, a quick performance assessment of the techniques' performance is given together with the methods' criteria, advantages, and future directions.

Keywords-Wireless sensor network, Clustering, Cluster head selection, Metaheuristic, Hybrid, Heterogeneous WSN.

I. INTRODUCTION

As a consequence, to their rapid development, wireless sensor networks (WSNs) are being used extensively in many different uses, notably the management of emergencies, RFID systems for the usage of aerial vehicles, and medical devices. Networks of dedicated, widely dispersed wireless sensors that record and monitor environment conditions and convey data gathered to a central point are referred to as wireless sensor networks. A broad range possibility in the area of disaster prevention is made accessible by the wireless sensor network's rapid growth. A reliable wireless sensor network requires the subsequent qualities: conservation of energy, scaling, flexibility, accuracy, and portability. Clustering is one of the primary methods for improving the lifetime of a network in wireless sensor networks. It involves cluster formation by selecting a cluster head for each cluster composed of sensor nodes represented in *Figure 1*. The efficiency of strategies for clustering rely on how the heads of the cluster are distributed through the network.

However, due to improvements in in-depth research on clustering and routing, the issues have recently been investigated by means of objectives, characteristics, and clustering mathematical methods. Study's choice of cluster members in multiple approaches to handling mobility, scalability, as well as additional difficulties is an informative start and might serve to a new study route in the area of wireless sensor networks. Various limitations, applications, advantages and advancement of each method, challenges are considered in this study. A number of investigations are setting proposed methods for reducing node sensor use of energy. Efficiency can be adopted from external sources such as vibrations in the environment, electromagnetic waves, solar energy, mechanical energy, thermal sources. Recent technique represents recharging the nodes with lower energy such as the nodes energy depletion is reduced. Embedded sensor nodes implied in monitoring human activities or application-oriented area like health monitoring, home appliances, etc., The past research is to manage the ideal energy usage of sensor node to increase the network lifespan.

Wireless sensor network planning can be described as structured and round networks. Round network also represented as distributed network. Flat or distributed network is of homogeneous network. The sensor nodes in this network all are of same type like same energy, same size. The nodes are placed randomly in a self- organized area. Network runs the same protocol for data transmission.

Direct contact with in the flat network, node energy depletion happens due to base station-to-node single hop communication. Node death occurs as node forward the information, they're far from the transmission's core in a single rely transmission. Therefore, multi hop transmission is introduced to decrease the long-distance transmission rate. In multi hop transmission the node handles the traffic issues as it transmits data from neighboring nodes instead of transmitting

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its own data. The node death leads to isolates the node from the system. It is defined as a hot spot.

In multi hop communication the disadvantages are follows.

1. Energy consumption is increased due to continuous transmission of data from single node (near to base station) to base station.
2. Traffic in network increased due to forwarding packets through multi hop transmission.
3. End to end delay in data transmission is increased.
4. Scalability is minimum.

LEACH (low-energy adaptive clustering hierarchy) is an energy-efficient communication protocol that was initially developed by Heinzelman et al. [1] in the early 2000s. The power consumption is optimized using an approach to clustering termed LEACH, which selects a small number of CHs based on movement of cluster before other nodes form the cluster by joining the cluster heads. Sent to the relevant CH for aggregation, the data gathered are subsequently communicated to BS from CH [1]. LEACH was a very effective technique that reduced the amount of energy used during the transmission phase, hence extending the network lifetime.

Despite the fact that the approach improved energy efficiency, Long-term problems were encountered with some difficulties. The two primary issues were isolated node and network gaps. The network hole problem is additionally referred to as the spot issue due to the leads the CH present near the BS to exhaust energy quickly than the node distant from the BS in a multi-hop surrounding while much of the information is transmitted to the CH close the BS for data gathering and transmitting to the BS [2][3]. The confined node issue, on the other hand, occurs when nodes avoid joining any clusters and does not have a way to relay information to the BS [4][5]. In order to solve these issues, a few approaches and techniques are performed, include uneven clustering, movable BS, and an effective selection of CH. When clusters near the BS have fewer sensors than clusters distance from the BS, unequal cluster formation occurs. As a result, the load is equal since a CH near to the BS uses less efficiency to interact with other CHs in the cluster and might do this for CHs farther from the BS [6]. To collect the sensor node data from CH, the sink in a mobile BS is regularly moved [7]. Both approaches involve much intension and pace in terms of cluster development and management of memory to record. Consequently, that we continue with the correct CH selection procedure, that has recently produced a lot of work. The spacing from each other members of the cluster (CM), CH, and BS, in addition the enduring efficiency of the node, are utilized in selecting CH. To improve CH election, establish a higher network QoS, and speed convergence, several studies add selection criteria to a metaheuristic algorithm.

Clustering technique is introduced for handling the flat network issues. A major approach for prolonging the system's lifespan in wireless sensor networks is clustering. It includes connecting the nodes with sensors and electing a single node to lead each cluster as its head. The selected cluster head collects the information from all the normal nodes, transmits it to the center station, and receive it from the center station. The performance can be summarized using clustering algorithms that are studied based on works published.

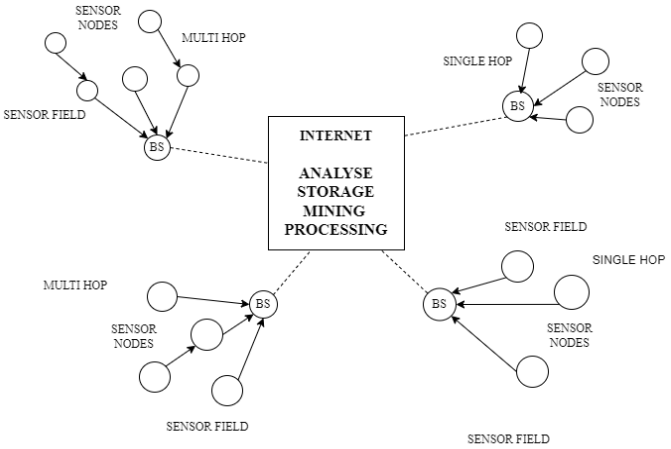

Figure 1 Wireless Sensor Network

Cluster head selection technique concepts with limitations and merits. Related works are discussed in Section II. Reviews on clustering in WSNs are presented in Section III.

In Section IV, Cluster head selection in various methods are discussed. In Section V, metaheuristic techniques are discussed of the numerous methods is presented. Mobility and Multi hop data transmission based numerous methods, Heterogeneity and Hybrid based concept are discussed. Comparative analysis is presented in Section VI with discussion on limitations and future work. Conclusion of the review at Section VII.

II. RELATED WORK

Many studies on the topic of clustering have been presented over the span of the past decade or even more. Several advantages and disadvantages have been observed after review of these articles. A study on choosing cluster heads was released for the method of clustering for WSNs. Three categories—deterministic, adaptive (using fixed parameter and resource adaptive probabilistic models), and mixture metrics—were utilized to classify the cluster leader methods of selection in that study. The amount that the different cluster head selection methods aided in the process, the parameters used, the level of re-clustering and cluster formation required, the evenly and regular dispersion of heads of clusters, and the development of balanced clusters were all taken into regard. Using the LEACH protocol as a basis, presented a review on clustering algorithms.

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The methods were split into several parameters, which then were split into various objectives intended to attain from researcher. The author was aware and addressed unsolved issues identified during network performance analyzation.

The genetic algorithm, neural network, and fuzzy logic strategies of the selection of cluster head method were introduced. In the work it is examined under number of current nonhybrid and hybrid metaheuristic algorithms. The article's hybrid algorithms were split into integrative hybrid and collaborative hybrid. It includes analysis of the benefits and drawbacks of past, current, and future algorithms. The article's inability to explain the way an algorithm operates in a WSN establishing is one of its flaws. A comprehensive evaluation of clustering methods and CH selection is discussed. The study of the area and comparison is beneficial for creating cluster of node method was presented at the outset of this article. The evaluation of the purpose which is used to evaluate the clustering algorithms' accuracy was then addressed. The conventional as well as modern clustering algorithms were utilized to classify the clustering approaches. The time intricacy, benefits and drawbacks of the method have been included in the analysis.

A survey on cluster formation and cluster head selection in mobile ad hoc networks (MANET) was discussed. The LEACH algorithm was compared with the LID approach and the HD algorithm in the paper, the benefits and drawbacks were examined into the framework of selecting CH. A study rely on clustering methods used in energy-efficient WSNs. The batch-based (cluster) and framework-based (grid) hierarchical clustering algorithms were used to classify the techniques and methods. Homogeneous and heterogeneous systems, constitutional or scattered methods, fixed and movable group of nodes, statistical and uncertain methods, and reliable and nonreliable cluster nodes access are the various types of hierarchical clustering approaches. The primary clustering methods are based on movement, clusters coincide, location knowledge, conservation of energy, equal clustering, and cluster stability. In ascending order to provide an improved understanding of the way the clustering protocols evolved over time; the protocols have been reviewed.

In terms of probabilistic and non-probabilistic protocols, another survey of techniques for clustering. The survey's detailed description of each protocol's drawbacks and benefits helped to distinguish their relative importance. According to the clustering objectives, a new study in cluster of node methodologies divided into categories. By statistically evaluating a number of previous literatures that were examined to accomplish certain clustering objectives, this study provides a clear direction for future research on clustering in WSNs.

Review of non-metaheuristic and metaheuristic methods applied to the selection of CH and formation of cluster techniques is given in the current subject at hand. These methods are utilized in a variety of circumstances, covering movement, multi-hop and single-hop information transmission, heterogeneity, and other variables. The implication of the techniques, their restrictions, and future possibilities for thorough grouping of nodes in WSNs are also underlined.

III. CLUSTERING IN WSN

Clustering analysis is based on strategies shown below *Figure 2*. The energy efficiency of WSNs can be increased in part through network clustering. Prior to choosing a few nodes, referred to as the Cluster Heads (CHs), network clustering involves dividing nodes into a number of clusters.

Clustering algorithm consists of two phases startup and reliable phases. Startup phase is also represented as first step in the algorithm. In startup phase clustering grouping of nodes, selection of cluster head is done. In reliable phase data transmission are done. Clustering of two-step process explained as follows.

LEACH stands for Low-Energy Adaptive Clustering Hierarchy. In WSNs, the nodes collaborate in order to detect variations in the physical or environmental circumstances. The gathered and imposed sensed data is analyzed and evaluated at a primary base location known as BS. LEACH uses energy-efficient and low-cost microsensors to provide higher-quality results in huge networks [1]. LEACH arranges itself utilizing flexible grouping, head-cluster movement, and local computing for a level distribution of resources through the entire system. In this study, two presumptions were made: (1) the central station is stable and placed distant among the nodes; and (2) the nodes in the area are uniform and subject to efficiency constraints. Additionally, LEACH-based clustering in heterogeneous and mobile settings has been evaluated. Using a threshold specified by the system suggested breakdown of head of cluster and the quantity of moments a single node occurred as CH, the CHs are chosen first. The newly elected cluster head will then use the CSMA MAC protocol to send an advertisement message to the non-CH nodes so they may determine the grouping relates to that specific node in that cluster. The strongest signal received from a CH is used as the basis for the cluster affiliation decision because it uses a small amount of energy for transmission. A non-CH node might, however, receive two signals of comparable strength from two CHs. In this instance, it will pick one of the two CHs at random to serve as the cluster head. The non-CH node should implement the CSMA MAC protocol to cluster entering message to the CH of its cluster during the cluster setup process. After obtaining the entering message about the nodes in its group, the CH provides a period for every node to communicate through TDMA in form to prevent clashes during the communication stage.

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Clustering algorithm provides advantages comparing with other algorithms. It improves network performance efficient management and better resource utilization.

A. Resource utilization

Efficiency utilization in network is reduced. CDMA and TDMA based method are used. The disruption among grouping of nodes is decreased by CDMA. TDMA is used to allow all nodes to communicate through the whole communication link.

B. Efficient Management

Node death without affecting the network leads to topology change in the network.

C. Network performance

1) ***Network lifespan:*** Methods for clustering reduce node consumption of energy, lengthening the lifespan of the entire system.
2) ***Scalability:*** Increases the network area coverage.
3) ***Load Balancing:*** Equal and even energy distribution is achieved by cluster head rotation.
4) ***Packet delay:*** Information is communicated to the main terminal from typical nodes by the head of the cluster. This reduces the packet delay in result.

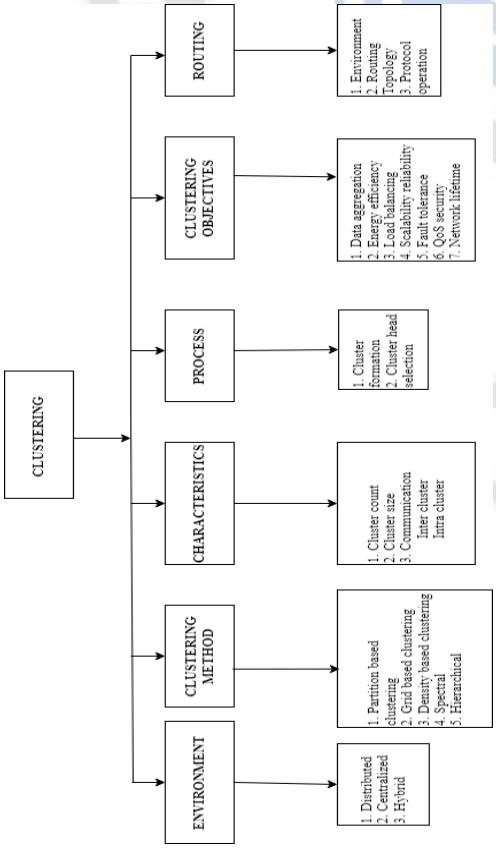

Figure 2 Clustering Of Nodes In Wireless Sensor Network

The most common performance values evaluated in clustering algorithm are system lifespan, ratio of packets received to total delay, throughput, standard deviation, efficiency and energy consumption.

IV. CLUSTER HEAD SELECTION METHODS

Data aggregation and transmission to the main terminal is operated using the selection of the cluster leader. Selection of cluster head plays a major part in ideal energy consumption and increases the network lifespan. Cluster head present near the main terminal exhaust the efficiency led to hotspot issue. Unequal clustering is applied to get rid of hotspot problems. Cluster heads are selected based on an array connected considerations such as the separation of nodes from the cluster leader, the cluster head and the base station, the separation of the nodes and the main terminal, residual energy, node weight, etc. There are five major categories fall under CH selection are: approximate, attribute-based, weighted-probabilistic, optimization-based, and preset. Figure 3 shows the cluster head selection method.

Head of cluster mobility is another method in cluster head selection, Cluster head is fixed, inter and intra cluster connection takes place in the network. When cluster head acts as a mobile, sensors information changes and cluster information monitored frequently. Cluster head moves to different position for better communication in the network. Cluster head plays as relay node to avoid traffic in the sensor node for data aggregation. Sink node based on intended node is another method of cluster head. Cluster head selection method is of different groups attribute based, weighted probabilistic, probabilistic, ideal based. Selection of cluster head of cluster is found using node efficiency, neighbor nodes efficiency, number of hops and neighbor's links.

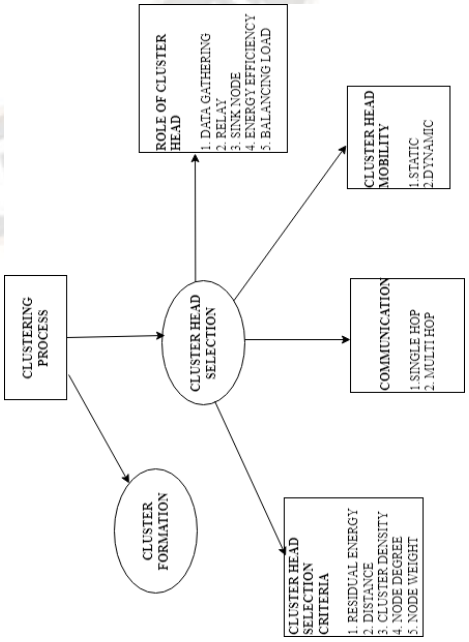

Figure 3 Cluster Head Selection

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V. METAHEURISTIC METHOD

When solving optimization issues, a theory derived from nature or a bio-inspired theory is known as a metaheuristic method. The words "meta" and "heuristic," which together make up the term "metaheuristic," are used to describe high-level methodologies and problem-solving techniques, respectively. For it to get at an ideal solution, the metaheuristic algorithm needs to be prepared to achieve a balance among exploration and exploitation. This will prevent the algorithm from falling into a local optimum too quickly or from having a slow convergence rate. When solving optimization issues, a nonintegral metaheuristic method excludes the algorithmic elements of other techniques. This will be covered in more detail in the section below. Methods are expressed in *Figure 4*. This section examines the utilization of nonintegral metaheuristic method in selection of cluster head by different environmental conditions. The environment situation and associated methods of selection of cluster head are shown in *Figure 3*. [9] Modified LEACH raising the attainment and running order of network routine. The Participation of other factors in clustering protocol increase the network attainment. As a consequence, the clustering technique only takes the factor of energy into effect. [10] CLWPA ideal Cluster head selection is done. Only a imperceptible development was detected in the period of network. [11] Discuss an ideal Genetic Algorithm for Cluster head position agreement for ease hotspot issue with more motility sinks and new positioning strategy. [12] Based on GA, a highly suitable nodes is selected to act as the entire cluster leader. Energy conservation is reduced as the network space increases based on simultaneity and communication.

For network arrangement it mostly depends on homogeneous network. It is based on merging of IoT and WSN. In sensor nodes energy maintenance Cluster head selection plays a major role which improves the lifespan of WSN. To reduce the efficiency usage of nodes many broad research using different clustering method is done. It leads to energy stability and extended lifetime of network. Low energy adaptive clustering hierarchy protocol (LEACH) which is meant as basic cluster formation algorithm, which is established on dynamic Cluster head selection neighboring cluster communication and cooperation, data fusion which improve the entire systems lifespan. LEACH protocol includes the round which is determined in the process of Cluster head selection and information transmitted. In LEACH nodes are arranged into association called cluster and one single sensor node is selected as head of cluster formed. Cluster is managed. Data transmission phase is based on some steps they are communication of data and data merger, and many other path finding performances. LEACH algorithm in which random selection of cluster head increases the usage of efficiency.

Selection of Cluster leader is done without using residual energy. The connection of Cluster head with the network is completely based on the received signal strength. In LEACH by forming cluster and selection of cluster head reduces the information transmission. The distribution of group of nodes head and the cluster head formation in each round will not be agreed to accidental cluster head selection. In LEACH low energy nodes can become cluster head which has high endured energy. The efficiency of this cluster head sensor nodes reduces faster than other nodes. Cluster head backing higher traffic charges than other nodes because of its work to collect information from ordinary nodes and gather them and transfer the information to central node station. Cluster head uses single hop transfer of information to central station which is different for wide area network.

[13] Energy aware distance-based cluster head selection and routing (EADCR). To lengthened the system lifetime of wireless sensor network using FCM (Fuzzy C-means), endured efficiency, Euclidean distance, cluster position. The group of nodes in the EADCR main terminal selects the cluster leader using the fitness function using the FCM approach. Based on the separation from the sensor node and the central node terminal, the area between the sensor node and its head of group, its initial energy, and the residual energy, the fitness function is evaluated. [14] Dynamic cluster algorithm is used to form cluster in network. Based on most significant energy, cluster heads are determined. Ideal route is found by using path-based equalization algorithm (PEABR). To align the mobile nodes path. The issues are minimum number of mobile nodes, cluster head makes energy consumption more and more traffic. [15] FOI-LEACH is a modified routing approach based on LEACH for ground consideration appliance. It is based on endured efficiency, and also regenerate sensor node to choose ideal cluster head to reduce the cluster leader node death earlier and to maximize the system lifespan. This protocol mitigates the problem based on hotspot. [16] Efficient IM-WSN to minimize the computing complication at sink node by reducing the number of hidden results by MLE for received signal. This is accomplished by sum of cluster details other than the last bit, by the approved cluster head, last bit is communicated to the Sensor node. One bit is communicated from each cluster details. Improving the cluster head selection by IM method and increases network lifespan.

[17] In a wireless sensor network, locating nodes, cluster and selection of cluster head, routing, data gathering, and security have all been shown with fuzzy logic, which is based on variation of aspiration. LEACH protocol is developed to LEACHFL which accurately selects the head of group, FL is worn to associate node density, balance energy and distance. [18] Sensor nodes having materialistic data repetitions, cluster head with materialistic and dimensional interaction is discovered by compressed prediction algorithms. By using the cluster head excess energy this algorithm improves the network lifespan. [19] Routing table is placed at cluster head for perfect

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routing. Host may damage cluster head data when secure transmission of data takes place. Wireless sensor network avoids illegal hosts joining the network. Indicators of quality of service are based on outturn, bandwidth, solidity, and end-to-end delay. To improve network lifespan, micro genetic algorithm-based LEACH (GA-LEACH) is used [20]. Cluster head selection is done by Genetic algorithm by using distance from base station and energy level. Relay node is used for transmission of data.[21] Multiple weight LEACH (MW-LEACH). Each group's cluster head is selected using endured efficiency, which minimizes network issues and increases the network's lifespan.

[22] After head of cluster selection, the sensor nodes in the group connects with the cluster based on parameters, like endured energy, unification, movable of nodes, efficiency of nodes and area. Group of nodes form cluster, TDMA is send to the nodes from cluster head for knowing the time schedule for transmitting data. Data transfer from cluster head to sink is done by using CDMA. Code Division Multiple Access is used to omit collision in network.

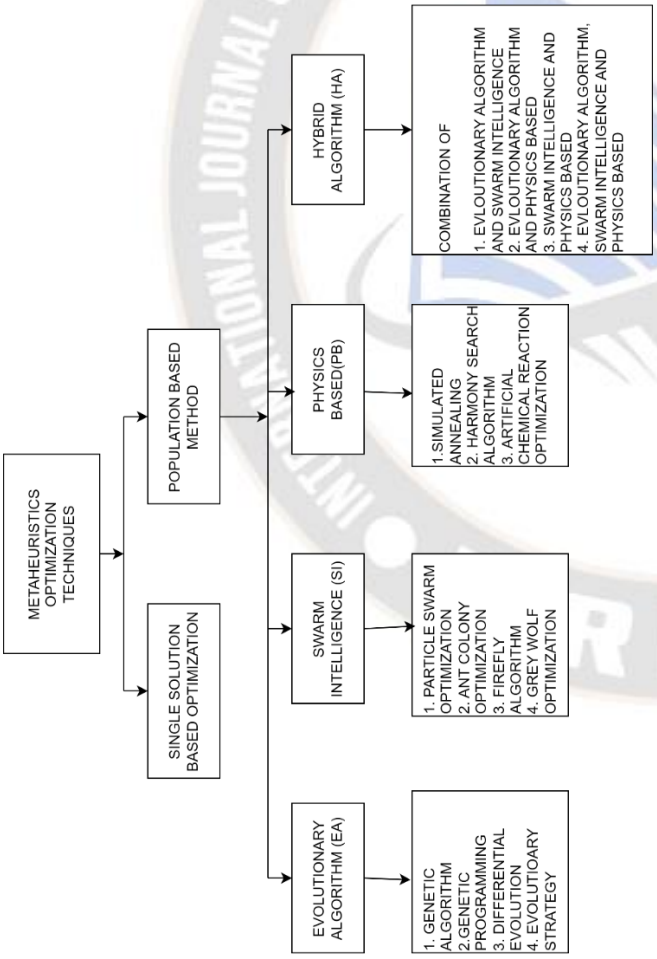

Figure 4 Metaheuristics Optimization Techniques

[23] Data transmission is completed by single hop or multi hop technique. In LEACH sensor nodes present in sleep mode after the transmission of data and back to normal mode when its time slot starts. Random cluster head selection is not guaranteed in each round. Balance energy in nodes is not considered. Sensor nodes with low or high endured energy will become cluster head. LEACH uses single hop for data transmission to sink node, for wide network LEACH is not adaptive. [24] Metaheuristic approach based on clustering protocol (CPMA) in which cluster head selection is completed using Harmony Search algorithm that minimizes the overall loss of energy. It also uses Artificial bee colony algorithm to ideal parameters. [25] FPU-DA algorithm for cluster head selection four parameters latency, efficiency security, distance is used. Cluster head selection is done by dragon fly and firefly algorithm for communication between cluster (inter and intra) and nodes. Imbalanced load of the cluster head.

An efficient selection of cluster head by using improved GWO algorithm is used. It considers parameters like endured energy, average inter cluster distance, sink distance, and balancing factor. The algorithm proposed is EECHIGWO [26] has optimal fitness function for CH selection and improved WSN lifespan using multi hop features. CH selection leads to handle the energy consumption in a balanced method. It supports an established and uniform finding of CHs in every cycle, which start to perform in balanced efficiency usage and reduced SNs from dying early on. The protocol's reliability is analyzed for network stability using the number of nodes which are dead, average efficiency usage, process rounds, the typical throughput, and the network lifetime.

A. MOBILITY

A honeybee algorithm was carried out by the authors [26] for selecting CHs in a mobile WSN (Bee WSN). The CH selection criterion relies on the node's remaining energy along with its degree, speed, and direction. The observer and employed bee types of bees the honeybee algorithm identifies. While the data packets are utilized as bees., the spectator bees are managing items that utilize the standard to find the best appropriate CH. This algorithm is thought to have good exploitation through employed bees and good exploration through observer bees. The simulations revealed that Bee WSN [27] creates more evenly distributed clusters than some other techniques.

Due to frequent topology changes and scalability concerns, mobile WSNs have limits. The authors of [28] suggested a bioinspired approach to clustering using the internet of drone application (BICIoD) to address the problems by dragonfly algorithm (DA). Dragonflies perform in two distinct forms of buzzing action: passive behavior (seeking food) to encourage exploitation and active behavior (migration) that improves the possibility for research. The selection of CH is suggested in the way utilizing drone position, still energy, and connectivity to the BS. DA is then used to handle the newly

formed clusters, where the cluster nodes must adjust to the CHs' movements and follow to them. BICIoD improves other algorithms in phrase of group lifespan, efficiency usage, and transmission charge, based on studies with other algorithms. [29] GAPSO-H algorithm based ideal selection of cluster head and sink motility. Since the nodes were placed randomly exceptional usage of higher energy bodes are not attained. [30] EEWC algorithm based Ideal selection of cluster head is based on strength action. Long distance communication acquires high energy utilization for huge area network when node with mobility (sink) detected at the center of the network. [30] Cluster based WSN uses more energy when gathering data and transferring the gathered data to the sink node or Base station. [32] GEIGOA main objective is to associate differing parameters that use the efficiency of nodes for route finding. Mobility of sink is captured through alteration and nonlinear weight. Sink motility is perfect by initial decision on the minimum efficiency cluster head area to maintain the efficiency of cluster heads. The minimum energy cluster head regions are comprehensible through fitness function. [33] Uneven grouping of nodes minimizes the size, group of nodes nearer to sink node (BS). As the area between the cluster head and base station increases the cluster size also increases. The nearer cluster head has more task for data transmission to base station. Channel overload is minimized by minimizing the cluster (group of nodes) size.

B. MULTIHOP DATA TRANSMISSION

An improved PSO clustering based approach for energy development called EPSO-CEO in a multi form transmission of data setting was proposed by the authors [34]. PSO is a particle-based theory in which location and momentum are modified up until the overall optimum explanation is found. The article talks about centralized clustering with PSO-based cluster creation and CH selection. The CH selection is due to the strength of the sensor node function that includes efficiency and location distance based on PSO, with the cluster leader of the specific cluster being the correct value obtained by PSO. Inter and intra-cluster multi-hop transmission of data applying area and endured energy are precisely covered by the authors as well. The simulation showed that, when compared to other competing approaches, EPSO-CEO execute improved method by lowering efficiency usage and improving structure lifespan.

In, Sengottuvelan and Prasath developed the breeding artificial fish swarm algorithm (BAFSA), another metaheuristic technique [35] for the best CH selection. In BAFSA, which is a modified alternative of AFSA, the explanation is separated at random, and the structure either exhibits effective behavior or a consecutive behavior. The best answers are also generated via a tournament selection. In order to choose the finest CH, the strength activity due to edge-to-edge respite and efficiency is enforced to BAFSA. In identification to certain current path, the expected method indicated excellent reliability with regard to of reduced packet loss and improved structure lifespan in addition to having quick convergence, strong liability strength, and reliable search capabilities.

On the other hand, Mann and Singh developed an additional cluster formation and route-finding strategy for efficiency in utilizing an artificial bee colony (ABC) [36]. In this article, ABC is applied in a fixed, multi-hop setting. Based on a strength of node activity that includes enduring efficiency, the space between CH and BS, and the space from CH to CH as activity, ABC is utilized in CH selection. After that, ABC is utilized to produce optimum routing for the least amount of energy loss during communication. Based on the simulations, it was clear that ABC outperformed other algorithms in charge of packet distribution, efficiency utilization, and throughput.

More research was done on metaheuristic approaches since bioinspired algorithms typically exhibit quick convergence compared to non-metaheuristic methods. A bio-inspired approach called the firefly cluster head selection algorithm (FFCHSA) was placed in [37]. As the article explains about the FFCHSA CH selection in a multi-hop WSN applying a strength action due to efficiency, the pace of loss of packet, and edge-to-edge delay. The simulations demonstrated that the suggested method operates faster PSO and genetic method (GA) in phrase of overall performance.

The author suggested an interacted cluster of nodes and path finding protocol employing cuckoo and harmony search (iCSHS) in WSN when considering the hotspot problem [38]. The article suggests two different algorithms for two different protocols, using harmony search for routing and cuckoo for clustering. To choose the best CH, the node efficiency, node degree, intra-cluster, and CH coverage must be reduced in the equitable action of the modified cuckoo algorithm. Improved harmony search is used in the literature to implement multi-hop data routing, which lowers communication energy usage. The suggested iCSHS outperforms certain current algorithms, according to a simulation entrenched the two distinct scenarios with differing sink locations.

The sampling-based spider monkey optimization and energy-efficient cluster head selection (SSMOECHS) was introduced by the authors [39]. The controversy related with the area-based selection of CH process were solved by this approach. The idea of spider monkey optimization (SMO) is due to the way curious, hungry monkeys may search for food. Note coverage and energy are among the key variables that need to be optimized while identifying the CH using the SMO sampling method. The technique is replicated in both a homogeneous and heterogeneous setting using multi-hop data transmission, indicating how SSMOECHS enhances network lifespan and energy usage.

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A proficient bee colony-clustering technique (PBC-CP) was put forth by Pathak in [40]. The aforementioned method by and the idea of a bee colony are similar, however in the study, it was used in a fixed and multi-hop data communication surroundings due to the fast-seeking aspect of the PBC-CP. The bee colony algorithm uses the strength activity, which is based on enduring efficiency and degree of node, to pick the CH in an effective manner. Comparing PBC-CP against a number of other current protocols, it did well in extending the system lifespan.

To solve the multi-hop WSN environment's energy hole problem, the author suggested a load-equitable clustering of nodes technique employing an improved memetic algorithm [41]. Through the inclusion of these variables in the strength activity of the memetic algorithm, the group leader is selected using degree of nodes, intra-cluster transmission area, and endured efficiency. The memetic algorithm outperformed other current algorithms in terms of energy usage and network longevity, according to performance comparisons with them.[42] Optimized LEACH extend the duration of increased efficiency of energy with lifetime of nodes. Extend the duration of energy efficiency in sensor node tenure. Selection of cluster head is based on efficiency factor it causes problems with load balancing. [43] Swarm intelligence algorithm it decides an ideal solution for routing algorithm which selects ideal Cluster head through the concept of exploitation and exploration. [44] In Swarm intelligence routing algorithms for Cluster head selection it uses the parameters of node density, node location, residual energy, energy usage in network. Most swarm intelligent routing algorithm execute better in utilization or research which leads to periodic selection of cluster head in network.

[45] ACO multi hop routing from group head to base station is handled. Black hole method is used to find the area to deploy wireless sensor nodes. Fitness function of node is used to choose black hole. For selection of ideal cluster head metaheuristic method is used. [46] Multiple weight minimal energy adaptive clustering hierarchy (MW-LEACH). CH selection is done based on high endured efficiency present in the closer cluster. Other factors are evaluated due to the space between regular nodes and the group head.

C. HETEROGENEITY

A network of sensor nodes with a variety of capabilities, such as shifting processing capacity and sensor variety, is also known as a heterogeneity wireless sensor network (heterogeneous WSN). In comparison to homogeneous WSN, heterogeneous WSN installation and topological control are more difficult to manage. In *Figure 4*, a heterogeneous model is presented.

In sensor nodes, resource heterogeneity can take one of three types of heterogeneity: computational, link, and energy. The above analysis of probabilistic CH selection methods requires that all nodes are of identical energy, processing velocity, and communication range. Each established number of rounds defined as the quantity of iterations that all branches perform in the cluster act as CH at least once—each node in the cluster performs the function of CH one time, so as to establish energy balance.

1) Computational Heterogeneity

When a node is computationally heterogeneous, it has more memory and a more efficient microprocessor than an ordinary node. The heterogeneous nodes' considerable computational capabilities enable difficult data process and longer-term data storage.

2) Link Heterogeneity

Link heterogeneity describes a node's ability to communicate over extended distances and with higher bandwidth than a typical node. A more reliable data transfer may be achieved feasible with link heterogeneity.

3) Energy Heterogeneity

When a node is heterogeneous, it either uses line power or a replaceable battery. The most significant sort of resource heterogeneity among the three listed above is energy heterogeneity since both connectivity and functional heterogeneity require more efficiency resources.

4) Heterogeneity's effects on wireless sensor networks include:

Deployment of heterogeneous in wireless sensor network improves the performance of network as follows

I. Network lifetime:

In heterogeneous sensor networks, packet forwarding from the usual nodes to the sink uses less energy on average, resulting in an extended life. Furthermore, it is also known that if heterogeneity is implemented well in a network, the network's response will be tripled and its length will be extended.

II. Networks response time:

Reaction time is shortened as a result of reduced processing delay and waiting time due to computational and network heterogeneity.

III. Performance Evaluation:

- **Network lifespan**: It is the time period spanning after the network of sensors originally started operating and the time the initial live node expired.
- **Per-Round Cluster Head Count:** The rapid measure returns the number of nodes from their cluster's members that would complete information directly towards the source.

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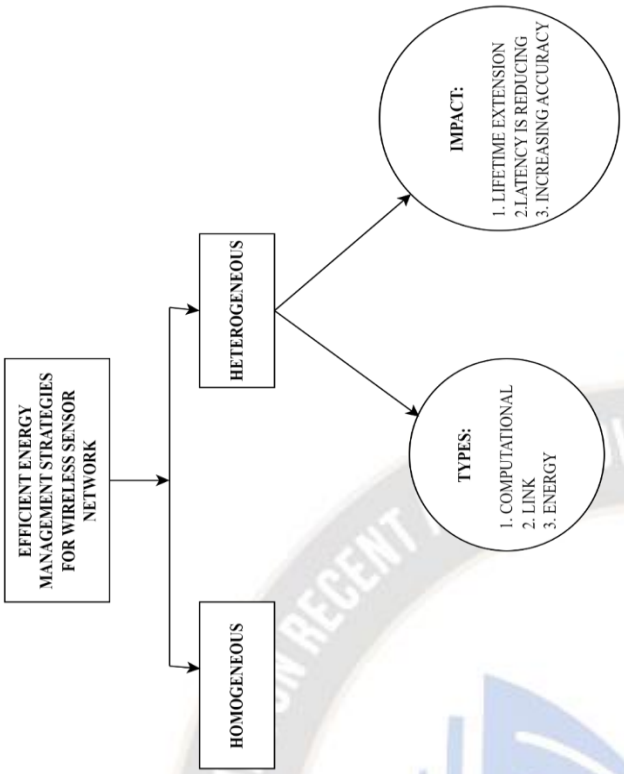

Figure 4 Heterogeneous Model

- **Per-Round Node Count:** The total number of node and the number of instances of each type of node that is still not utilizing nearly each of its energy are included in the initial measurement.
- **Throughput:** This consists of the network's overall data transmission rate in addition to the rates in which cluster leaders and sinks communicate information as well as the rate at each node interchange data with their cluster heads.

The sensing ranges and efficiency usage of the nodes in heterogeneous wireless sensor networks (WSNs) differ. Based on an expected study, a heterogeneous environment significantly improves an application's energy efficiency and predictability by choosing a CH with greater capability. [47] Fitness objective function manages steady state phase for energy heterogeneity and number of cluster head idealization. Node density is not used in fitness function transmission cost is more. The four variants of the technique that the authors proposed in [48] comprised the balanced energy-efficient network integrated super heterogeneous (BEENISH), improved BEENISH (iBEENISH), mobile BEENISH (MBEENISH), and improved mobile BEENISH (iMBEENISH) protocols. The BEENISH selection of CH method is due to the network's average efficiency level and residual efficiency, with ultra super nodes having a higher frequency potential for becoming CHs due to their higher residual energy Wireless Communications & Mobile Computing. The mobile sink feature is available on BEENISH and iBEENISH. According to the simulations, iBEENISH excels BEENISH in terms of throughput and longevity. In addition, it was discovered that mobile sink versions might be effective in attaining their goals, surpassing nonmobile sink versions in regard to efficiency.

In order to utilize in scenarios with different energy the networks, an energy-coverage rate grouping procedure (E-CRCP) was established. In this [49], the entire energy used for transmission is first calculated in order to establish the ideal number of clusters. The CH is selected using the finest percentage of exposure in order to distribute the CHs equally over the network. The requiring energy CH will be replaced by the next communication iteration. In heterogeneous WSNs, E-CRCP minimizes energy consumption, balances network load, and extends system lifespan comparing with other existing protocols.

For heterogeneous WSNs, [50] an energy-efficient approach is introduced by the author. The proposal includes a multicriteria decision-making method known as the TOPSIS methodology basis for a connection to the ideal method for ranking desires. The CH statement section, node affiliation section, CH-acquaintanceship section, and CH-friendship phase are just a few of the stages of this structure. During the CH statement section, information is made available like endured efficiency, power for computation, and repository quantity are greater than the brink values.

Selection of CH method using expectation action was proposed by the author in a work which had just recently published [51]. Advanced and standard nodes were used in this research; advanced nodes had higher levels of energy than normal nodes, generating a heterogeneous environment. To address the issue of energy failure, the CHs are initially chosen using revised threshold values based on distance ratio and weighted energy. Choosing CHs at random is avert. The expectation action is then utilized to maintain the information blend approach's information accuracy. The protocol that is introduced outperforms old protocol in phase of systems lifespan and balance in a heterogeneous environment.

The authors introduced an improved nondominated sorting particle swarm optimizer (INSPSO), a multi objective clustering and routing approach to WSNs [52]. Reducing and increasing objectives are frequently referred to as multiple objectives. To choose the best CH in this article, the entire quantity of remaining electricity must be raised while energy consumption must decrease. Heterogeneous scenarios that include various amounts of network sensors and gateways will be evaluated when evaluating performance. A newly created bioinspired method based on earthworm breeding in description has been introduced: the earthworm optimization algorithm (EWA) [53]. In this method, there are a pair of nodes: basic nodes and advanced nodes. In comparison with ordinary nodes, advanced nodes have greater energy.

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Based on the huge strength expense due efficiency and the area among the CH and the nodes, the best CH is chosen using EWA. There are two distinct methods of replicating in EWA: one contains just one earthworm, while the other comprises an array of parents and offspring. EWA exceeded GA and PSO in phase of respite, throughput, system longevity, and use of power as analyzed with the simulation. The authors of [54] presented a method for determining the ideal CH to minimize energy hole concerns when power core is identified using PSO (EC-PSO). Because the nodes are consistent, the CHs are initially selected by a geometric method. After the first period is used up, the network power turns into heterogeneous, and the PSO proceeds to pursuit for novel sources of energy in the hopes that a node nearby would take over as the CH for the period that follows. After that, a threshold is used to stop forwarding on low-energy nodes. The research shows that EC-PSO exceeds plenty current approaches in terms of power use and network lifespan.

In [55] the author presented an improvement to the distributed energy-efficient clustering (DEEC) approach by utilizing the threshold game theory algorithm (TGDEEC), in order to create an energy-balanced and optimized WSN. Theory is a calculation based on mathematical that simplifies problems involving accord. The article assumes heterogeneous structure with super nodes, regular nodes, and advanced nodes. To determine a threshold, TGDEEC uses a weighted factor that takes into account the power usage of both cluster members and CH. Using the brink and a calculation of the traveled area and efficiency expended, the CH is then chosen. When compared to other algorithms, TGDEEC is recognized to perform better in phase of throughput and structure longevity.

In [56], the author put forth a cluster nodes method using the artificial bee colony algorithm (ABC) and the section-based routing protocol (SBHRA). SBHRA organize a heterogeneous surrounding by dividing the structure into a small portion with three different nodes, namely type-1, type-2, and type-3. Although ABC uses a similar technique to [26], it is implemented in a sectioned and heterogeneous environment in this literature. By using the endured efficiency parameter as a strength function in ABC, CH selection is carried out on the areas of type-2 and type-3 nodes. In comparison with other algorithms, the simulation of SBHRA with ABC for election of cluster head shows an increase in network throughput, stability, and longevity.

By increasing system lifetime and lowering energy usage, INSPSO successfully selected the CH using multiple objective variables. A hybrid a strategy to enhance clustering in WSNs. The combined method takes into account both genetic algorithms (GAs) and particle Known as (GAPSO-H), swarm optimization (PSO), where, in a heterogeneous network, GA is used to choose the best CH and PSO is used to choose the best route path for the sink node with mobility. There are three types of energy heterogeneity deployed: super nodes, advanced nodes, and regular nodes. The strength parameters—endured efficiency, efficiency average, area between sink and node, neighbor's nodes, and efficiency usage rate—make up the fitness function used to choose the best CH. Several current methods were outperformed by the suggested GAPSO-H [29] because it had a longer stability period. On heterogeneous nodes in separate surroundings framework—one with movable sink and the other without—the investigation was conducted. There are four different sorts of nodes in this configuration, namely ultra super nodes, super nodes, advanced nodes, and standard nodes, each with a different beginning capacity.

[57] Energy-Efficient Clustering Approach Using Genetic Algorithm for Heterogeneous Wireless Sensor Networks. It consists of two phases: preparation (setup) and stationary (steady) phase. In preparation phase, the nodes are deployed randomly in heterogeneity level. Genetic algorithm uses parameters shortest space from node to BS, endured efficiency, node degree for selection of cluster head. In steady phase, normal node joins the group due to the CH endured efficiency and area among CH and BS.

[58] distance and energy aware stable election routing protocol (de-sep). It is three level heterogeneous wsn routing protocol. Protocol includes nodes initial energy, live nodes average energy, distance between bs to available nodes. Distance between every node in network to bs for selection of ch. The three key obstacles to establish a cluster strategy for wsns are system stability, longevity optimization, and control of efficiency. In order to decrease the energy consumption at each ch node, the study discussed in this paper concentrated on choosing the modified threshold and suitable ch method. Using energy and distance optimization criteria, this approach selects a ch. To choose the ch, different combinations of energy and sn-bs separation were used. In order to improve the selection of ch and minimize the power usage of distant chs, a three-tier extended energy efficient clustering hierarchy (teeech) [59] method has been established. The group was generated using mfcm, or modified fuzzy-c mean clustering. Various scenarios are examined for determining the balance of energy, network lifespan, resource variation, and network reliability according to the certain number of rounds and the node changes.

D. HYBRID

In order to discover the best answer, the hybrid metaheuristic method combines elements from many algorithms or search strategies [60]. Despite the recent introduction of a variety of new metaheuristic algorithms, some of these algorithms lack the ability to balance between exploration and exploitation. This causes issues like rapid convergence and easy entry into local optimums.

Many algorithms based on metaheuristic include specific actions or approaches to improve the ability to conduct

local search (exploitation) and global search (exploration), as was demonstrated in the nonhybrid section. In hybridization, the same idea is used, but it blends elements from several methods or the methods need to strike a balance between research and extraction skills to recognize the most suitable response.

Mobile ad hoc networks (MANETs) are wireless networks without any foundation using portable, independent, and portable devices that may roam without restriction and have a reputation for self-organizing. Prasad and Balakrishna introduced a revised genetic algorithm applying simulated annealing (SAGA) to enhance longevity and power efficiency in MANETs. Based on the energy value and the CH degree, the CH is selected in this source material. The genetic algorithm has some restrictions, such as a reduced convergence rate and poor local pursuit capacity, although having a greater capacity for global search. The authors propose using SAGA could overcome the restrictions of evolutionary techniques and major combinational optimization problems in MANETs. In comparison with earlier protocols in use, the SAGA method was able to choose CHs from the simulations that performed better.

[61] EeTMFO/GA a secure and energy efficient Cluster head selection in WSN. Hybrid cluster-based connectivity in WSN is optimal. For the ideal Cluster head selecting and sink motility in the transfer of data, a hybrid GA and PSO algorithm is required, that asks for improvement due to the cluster head's remaining energy. [62] For reducing the periodic selection of Cluster head which consumes energy in network. Hybrid swarm intelligent routing algorithm is executed in which one is dominant in achieving increased exploration other in attaining increased exploitation.

[63] Hybrid method ease the unwanted usage of energy in sensor node. It neglects nodes with lowest fitness as Cluster head. Numerous hybrid swarm intelligent routing techniques are being utilized in recent years to maintain constant energy supply and increase longevity. [64] (HCRO-MBFSA) is a hybrid chemical optimization reaction method and bacterial foraging pursuit technique. The cluster generation and cluster head selection technique are based on chemical reaction optimization. A modified bacterial foraging pursuit method is used to route traffic between the source and the destination. It displays minimized network delay as when analyzed with other cluster head choices. This approach implements a multi-hop routing system that is energy efficient. Ideal cluster head selection is done using modified chemical reaction. Ideal routing path is found using modified bacterial reaction. The limitations in this algorithm are increased cost consumption and reduced packet delivery ratio.

[65] Cluster head selection utilizing a combined firefly and modified artificial bee colony optimization method increases minimized inter-cluster distance, decreased respite, and greater power balance, all of which lengthen the lifespan of networks. Firefly algorithm is to renovate location of sensor nodes for ideal cluster head selection. Integrated algorithm may announce the action of choosing the wrong ideal sensor nodes during cluster head selection. Modified ABC algorithm for choosing ideal route between sink node and cluster head by balancing between exploration and exploitation in transmission of data. The execution of this algorithm based on cluster head selection which increases network lifespan and energy stability and reducing the network suspension. This method has difficulties in inter-node separation, low throughput enhancement, and a high computational cost.

[66] Particle Swarm Optimization based algorithm using a fitness function to choose cluster head and to transmit data through the secured path. Based on the specification of repair factor, consistency factor, delay, and energy, fitness function is established. Utilizing fitness values, the optimum path is completed using a hybrid of the Particle Swarm Optimization and Water Wave Optimization methods. This supports the reduced delay and reduced distance. Route maintenance is based on data packets transmitted through selected path or rerouting is needed.

When compared to the baseline swarm-intelligent cluster head selection approaches, cluster head selection is an admirable achievement in phase of mean residue power, the number of alive nodes, coverage, and energy balancing index. High computational complexity and this algorithm's ability to function successfully in a network with a small number of nodes are its drawbacks.

[67] Multi weight chicken swarm based genetic algorithm (MWCSGA) which increases network lifespan by introducing energy efficient cluster. Integrates Genetic algorithm with to select the ideal cluster head based on clustering which involves inter- and intra-cluster transmission, use the multi-weight chicken swarm optimization method. Using power consumption variables, the clustering model shows the space among the cluster head and the base station as well as the space among sensor nodes and the cluster head. Self-sufficient sensor nodes are taken into account, increasing network pace, packet delivery ratio, packet drop, end-to-end delay, and energy usage. The challenge in an extensive system and an increased population is resistance delays.

[68] Cluster head selection is based on the tunicate swarm butterfly optimization algorithm hybrid (TSBOA). Network lifetime improves by establishing a equity between power efficiency and path reliability. The hotspot problem is addressed by this technique, which enhances data transfer between sensor nodes. To avoid unintended energy reduction, a hybrid method is applied for better cluster head selection. To choose the best cluster head and establish routes connecting specific path and sink node, the approach uses fitness functions that include latency, link lifetime, predicted energy, sensor node

energy consumption, intra and inter cluster distance. In compared with baseline cluster head selection, TSBOA-based cluster head selection improves performance using mean throughput and residue energy. High computing expenses brought on by the use of the deep long short-term memory classifying a position are an issue.

[69] Hybrid group teaching optimization and modified African buffalo algorithm (HGTO-MABA). Hybrid clustering was introduced to handle between exploitation and exploration which increases the energy stability and network lifespan. Selection of the cluster head using a better method. To regulate the most effective route for information transmission, it takes into consideration residual energy, the space among the cluster and the sensor nodes, and also the space among the base station and the cluster head. This algorithm increases throughput, constant residual energy and network lifespan. [70] Modified rider optimization algorithm (ROA) with Simplified swarm optimization (SSO). Selection of CH is done by kernel- fuzzy c means (kernel FCM). Ideal cluster head is chosen based on acceptability values. [71] GA based chicken swarm optimization (CSO-GA) it follows fitness function calculation based on rotation value and cluster head selection reduces the energy usage. [72] Hybrid firefly algorithm with particle swarm optimization (HFAPSO) for cluster head selection LEACH-C algorithm uses residual energy and node distance. HFAPSO performs in real time for wider network. It performs ideal clustering and ideal route path.

Kumar and Kumar in [73] presented a novel combination ABCACO conduct which combines the artificial bee colony (ABC) algorithm and the ant colony optimization (ACO) algorithm. The ant colony algorithm is based on how ants find food and communicate with one another by leaving pheromone trails. In order to solve the squared optimization problem, the field is divided into subregions in this work, with ABC being utilized for CH selection and ACO for optimization. route-finding in a multi hop WSN setting. Using a fitness function that includes variables like communication energy and node-to-BS distance, the CH selection procedure is accomplished. A subcluster head (SCH) additionally gets chosen using the function of fitness for every subregion element in order to connect with nodes and the CH. The authors also covered the use of the suggested technique for real-time fire detection. ABCACO was able to narrow the distance between devices and improve network durability, strength, and efficiency in terms of a few prior algorithms.

IoT network disaster management using energy-efficient cluster head selection and routing (ECHSR). By changing the sink sites, the suggested method was tested in a forest fire simulation, where ECHSR outperformed certain related approaches [74]. This literature introduces an improved hybrid harmony search algorithm (HSA) and particle swarm optimization (PSO) for CH selection. Later, an improved tree encoding PSO-based multi hop routing system is adopted for information transfer. The efficiency criterion, cluster proximity, and network coverage are all employed to assess a strength action in order to select the most effective CH for the suggested algorithm's CH selection. An adaptive weighted sum (AWS) method is utilized to assess the fitness function to be able to have the best result for the multi objective optimization problem (MOOP).

The primary goal of many WSN research studies is to extend network lifetime, which prompted The most effective CH and assistance CH (HCH) in a multi-hop environment by employing the grey wolf optimization (GWO) and discrete particle swarm optimization (D-PSO) techniques, as laid out by the authors of [75]. HCH is chosen in order to balance energy dissipation and lessen the stress on the CH. The GWO selects a CH according to an arbitrary number and remaining energy, while the D-PSO selects a CH dependent on proximity and core. The CH and HCH are chosen by processing these inputs concurrently. When compared to existing algorithms, the suggested E-LEACH used less power and improved network lifespan.

New study suggests the application of a multi weighted chicken swarm based genetic algorithm (MWCSGA) for cost-effective cluster in multi hop WSNs [76]. The chicken swarm optimization (CSO) incorporates the GA's crossover and methods for evolution. The effective CH is determined upon evaluating its energy consumption, space from the BS, and length from the node through the assessment of the fitness function. To conserve energy, various weights for node localization and remaining energy are also applied before identifying the CH. The numerical results indicate that in phase of energy efficiency, edge-to-edge latency, throughput, and packet delivery ratio, MWCSGA surpasses several current modern methods.

Because ABC can produce optimal answers, several researchers have combined it with other methods to produce the finest possible ideal result. Therefore, columnist developed a combination clustered method based on a metaheuristic

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Table 1 wireless sensor network cluster head selection comparison analysis

Paper (year)	Objectives	Selection Parameters	Sensor Network	Advantages	Limitations
YSGA (2020)	Improve the network lifespan. Decrease energy consumption.	Distance between the CH to base station and Residual energy	Homogeneous	YSGA improves the system's unit design and illustrates how it improves the algorithm's potential while balancing its research and extraction skills in order get the ideal cluster head allocation while reducing the transmission distance. Role changing and region controller shifting have been included to the system to improve it.	YSGA also have the drawbacks of rapid completion and an inclination to get imprisoned in specific optima when reviewed as a separate algorithm. CHs can quickly evaporate if they're faraway from the BS. The protocol's delayed processing might be liable for an essential problem in the suggested method.
SSA (2020)	Increased energy efficiency.	Node energy and Distance between nodes	Homogeneous	Analyzes trade-offs between global search limitations and exploration exploitation.	Focuses on energy conservation during periods of low network energy. Less rounds are applied when PSO performs better than SSO.
NCHR (2021)	Improved network lifespan.	Residual energy and Hop count, Dynamic topology and Node heterogeneity	Both	The recommended strategy has the capacity of overcoming CH failures in addition to changes in topology and nodes heterogeneity. The proposed method goes under use in a testbed setting.	The nodes' energy usage may rise as a result of calculating the CH rotation's parameters.
IEECP (2020)	Increasing network lifespan	Ratio from the original power and Power consumed	Homogeneous	A particular hold to a scheduled method paired for selection of CH is used for power savings. Reducing the price of travel by creating balanced clusters using a modified fuzzy C-means strategy.	The complexity of the entire technique may increase if additional functions and CHs are used, likewise the execution time can be prolonged.
DCoCH (2020)	Increased network lifespan	Number of neighbouring nodes and remaining energy, Intracluster communnication cost	Homogeneous	The application of time-based clustering ensures that the desired parameters are selected as CHs. To avoid collisions, time-division multiple access (TDMA) and code-division multiple access (CDMA) are used.	The difficult process of altering coefficients might cause problems with the stability of the system. For disperate need, the coefficients requisite be accurately established.

TABLE 1 CONTINUED

TGDEEC (2020) [53]	Decreased energy waste.Energy stability	Distance and Residual energy	Heterogeneous	By eliminating nodes that are unsuited for use as cluster heads, the threshold protects an improper cluster head from getting identified.	Because specific nodes consume excessive energy initially, the simulation results are unstable.
Threshold CH	Improve network lifetime.	Distance from Base station and Residual Energy	Heterogeneous	For acquiring accurate information, the trust function-based data fusion method is	The algorithm can be enhanced further while maintaining a

selection (2021) [49]				applied. The proposed technique removes chance from the CH selection process.	concentrate on related to energy issues.
FEECA (2020)	Prolong network lifetime	Average distance of BS, Communication quality, and Residual energy	Homogeneous	A horizontal channel separation that reduces the network's stress. Researchers analyze the most appropriate settings for the inconsistent reasoning method. The discussion of path data for ideal routing.	Setting the ideal conditions could be challenging and have a negative impact on scalability.
DRELEACH (2021)	Energy usage should be reduced. Increase the life of the network.	Node degree and Residual energy	Homogeneous	The necessary calculations are localized using a variable range, which results in less processing.	There may be increased energy usage due to the numerous calculations required to calculate the nodes' energy.
LEACHABF (2020)	Equitable energy. Extend network lifespan.	Total energy used in network, Sink and node distance, Cluster distance	Homogeneous	In order to provide better solutions and increase the accuracy with which the optimal result may be discovered within the field of solutions, ABF creatively combines the combination of convergence service and variability service with genetic techniques. The computationally complex nature of the method is further explored.	The inclusion of three additional approaches could make the algorithm challenging overall. LEACH-ABF challenges to converge in multimodal issues.

TABLE 1 CONTINUED

PBC-CP (2020) [39]	Improving network lifespan.	Residual energy and Node degree	Homogeneous	The search method can be set up so that honeybee exploitation and exploration can both be done simultaneously. Packet collision is avoided by using TDMA.	ABC is renowned for its drawbacks, notably avoiding the authentic solution, due to its large step sizes and preference for research over extraction.
Memetic algorithm (2020)	Load balancing done effectively.	Remain vitality, Nodal level, and Intracluster distance to communication	Homogeneous	The use of unequal clustering may result in additional expenses. In comparison to GA, there was no noticeable shift in performance.	Energy hole issue is discussed.
CNNMR (2021)[7]	The objective is to extend the lifespan of the network while minimizing energy use.	Cluster distance and Residual energy	Homogeneous	To reduce the performance of the various cluster heads, a sink node is used. The problem of a power scarcity is addressed in this paper.	The deployment of mobile base stations without energy shortages provide diffcult problem. The CNNMR technique exhibits higher energy consumption during its beginning stages in comparison to both CMR and FESRA techniques.
EEMCS (2020)	Minimize energy use. Extend the longevity of Wireless Sensor Networks (WSNs).	Remaining energy, movement, the base station's separation, and the number of neighbours	Homogeneous	The evaluation and discussion of the technique of reclustering events are the primary subjects of the paper. Differing system dimensions and different amounts of nodes are employed for the purpose of evaluation.	Due to the possible effect they have on the whole system, determining the ideal weight for every aspect in the CH selection procedure can be difficult.

TABLE 1 CONTINUED					
CMBCH (2020)	The objective is to minimize the delay in communication. Minimize energy use.	Leftover vitality and the division among CH and the remaining nodes	Homogeneous	Working together with CM and CH leads to a reduction of communication delay, improvement of data security, reduction of full data loss, and enhancement of network efficiency.	Expensive and possibly lowering CM capacity are two distinct concerns of the CM and selection of CH method. The existence of 3 break regions restricts the system's possible expansion.
Optimized LEACH (2020) [40]	Prolong energy efficiency with lifespan of network	Node degree and energy, distance between BS and node	Homogeneous	Extend the duration of energy efficiency in sensor node tenure.	The selection of cluster heads depends on the power factor, resulting in load imbalances.
EEWC (2020) [29]	Modifies the steady state phase to improve network performance	Number of cluster heads for optimization, size and distance	Homogeneous	The selection among the ideal Cluster head relies on fitness function.	When a node that acts as a sink appears in the network's center, communicating across distances needs an immense quantity of energy.

approach (CPMA), which integrates the artificial bee colony (ABC) algorithm and harmony search algorithm (HSA) in a single-hop network. The CH is chosen due to Harmony Search Algorithm [77], which takes into account the projected power distribution ratio as well as the total cost of efficiency. On the other hand, the fitness function utilizes ABC to change the weight influence and CH proportion to try to choose the best CH. CPMA was able to boost throughput and extend network lifetime in simulations using a variety of BS locations.

Energy efficient cluster base routing method using Firefly algorithm and Ant Colony optimization (EECRAIFA) [78]. This algorithm is used in finding optimal Cluster head. Self-organizing map neural networks are incorporated, and the network's nodes are used for pre-clustering. Formation of cluster and Selection of cluster head are both incorporated in the Firefly algorithm. Ant colonies are used as a method of optimization for inter-cluster path. Inter-cluster communication is using a periodic control technique to improve network throughput.

[79] Ideal cluster head selection are performed in different forms are Structure cluster head, ideal head of cluster, unequal head of cluster, Dynamic cluster head selection, CH selection is calculated using parameters residual energy, node density, distance and weight. Swarm intelligence approach is using Decision making approach (DMA). LSO works in Exploitation phase by giving coverage in the accelerated network. LSO maximizes the number of nodes drop in the loop. GSO provides solution in every round.

Hybrid grey wolf optimizer-based sunflower optimization (HGWFO) [80]. In GWO wolf concept is used where leader wolf is a female and other wolf are male which are represented by ‘α’. Male wolf decides when to walk, when to hunt, where to sleep and all function of team. In SFO radiation technique is used, where the plant is placed to get the sunlight better. In selection of CH distance and energy are used to choose the ideal CH.

VI. COMPARISON AND ANALYSIS

In this section, we will be discussing the betterment of algorithms, limitations, parameters used for finding their performance in network. Clustering in WSN is discussed with CH selection using metaheuristic methods. A detailed comparison of metaheuristic methods in selection criteria, sensor node type (Homogeneous or Heterogeneous), advantages, limitations, etc., These comparisons are provided in Tables 1 and 2, respectively.

TABLE 2 HYBRID METHODS FOR CH SELECTION					
Paper (year)	**Objectives**	**Selection Parameters**	**Sensor Network**	**Advantages**	**Limitations**
HGWSFO (2020) [78]	Improving network lifespan	Energy and Distance	Homogeneous	The GWO algorithm's coefficient vectors increase exploitation efficiency. Analyzes the way exploration and exploitation are measured alongside each other. The worldwide search is handled by the SFO algorithm based on plants' differing step intervals.	When viewed as a different algorithm, the grey wolf algorithm is capable of reaching the optimal location while the sunflower algorithm could experience slow convergence. The suggested method is more challenging.
HFAPSO (2020) [67]	Reducing the energy consumption.	Average distance and Energy	Homogeneous	The trade-off between computational expense and network longevity is one that HFAPSO makes a concerted effort to resolve. The designed HFAPSO has an affordable computational cost.	In comparison to nonhybrid methods, the proposed algorithm's temporal complexity will increase. PSO and firefly could both achieve local maxima.
FPU-DA (2020) [25]	Improve energy efficiency. Increase network lifespan.	Security, delay, distance and Energy	Homogeneous	For the ideal CH selection, it makes sure that there is a balance between exploration and exploitation.	The initialization step and the amount of iterations need to be done in a trade-off between accomplishing the goals at an acceptable computing cost and achieving them. At short iterations, the cost function is high.
GAPSO-H (2020) [28]	Increases energy consumption and network lifespan.	Energy Consumption Rate (ECR), Energy, Node degree, Average energy	Heterogeneous	GAPSO-H deals with the hot-spot issue. It is discovered that GAPSO-H is computationally optimized. Emphasizes striking a balance between international and local searches.	The complex nature of the process can be raised through the use of nodes with different levels of energy. The sink's mobility could make it costly.

TABLE 2 CONTINUED					
CPMA (2020) [72]	Increased network lifetime. Improved energy efficiency.	Energy distribution ratio and Total energy cost	Heterogeneous	It utilize the offline Artificial Bee Colony (ABC) algorithm to increase its key parameters. For selection of CH, the online Harmony Search (HS) algorithm is used.	A single hop can result in the CH being farther from the BS using more energy. When parameters are tuned incorrectly or with excessive effort, the algorithm's performance may suffer. The CPMA has an instead long process time.
ECHSR (2020) [69]	Decrease energy consumption. Improve energy efficiency.	Network Coverage, Cluster closeness and Energy efficiency criterion	Homogeneous	For improved routing, the approach also uses improved tree encoding and updated data packets.The adaptive weighted sum (AWS) methods can be used as an analytical framework for minimizing optimization expenditures. It has been suggested the multicriteria decision making (MCDM) methods have applications for solving MOOP.	PSO is restricted by high-dimensional optimization. HSA has a disadvantage of becoming regionally constrained. If AWS is used, the procedure could grow more complicated.

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E-LEACH (2020) [70]	Enhance the vitality of the nodes. Prolong the lifespan of the system.	Unique quantity and remaining energy are selected using GWO. D-PSO selects input based on distance and centrality	Homogeneous	In order to reduce processing time, the optimization methods GWO and D-PSO are executed simultaneously. Packet loss can be reduced with dynamic fuzzy-based transmission.	The energy required to execute the algorithms might increase if there are further algorithms used. If the cluster number are not fixed, the arrangement of CH and HCH may indirectly constrain scalability.
MWCSGA (2021) [62]	Decrease energy consumption. Improve the lifespan of the network.	Separate nodes from each other CH, The distinction across CH and BS, Utilization of energy	Homogeneous	In error tolerance second CH is selected. The selection of CH is improved by the application of genetic techniques. Uniform clustering with multi weight model is used to reduce energy efficiency.	The method is divided into six sections, which increases the overall complexity. Because GA is slow to converge, there is a chance of communication delays.

TABLE 2 CONTINUED

HCRO-MBFSA (2020) [59]	Chemical reaction optimization method for formation of cluster and selection of cluster head		Homogeneous	Ideal routing path is found using modified bacterial reaction. Decreased network delay	Decreased packet delivery ratio and raised energy consumption.
HGTO-MABA(2021) [64]	Improves the system's existence and its reliability	To determine the most efficient route for information distribution, evaluate residual energy, The journey among the main station and the cluster head as well as the spacing among the sensor nodes and the whole cluster.	Homogeneous	Increases throughput, Constant residual energy and Network lifespan.	Developing CH selection approach and Performance analysis is done.
EECRAIFA (2022) [74]	Increase the network lifespan	Node angle, Distance and Node energy. Selection of next hop for transmission.	Homogeneous	Increases throughput, Balance network energy usage and Network lifespan.	Balance network energy consumption, network lifetime improvement, increase throughput.

VII CONCLUSION

Clustering in WSNs has recently received greater attention by increasing the ratio of packet delivery and higher energy utilization, Adaptive low-energy clustering. The initial clustering protocol was hierarchy (LEACH). Introduced protocol rise to the concept of establishment of various approaches of cluster formation currently in use. Clustering involves several steps, with selecting the group leader as one of the most important steps. The cluster head (CH) is the member that collects the information from the remaining nodes in the cluster. It rapidly receives data then transfer to the BS. Consequently, failing to select the best node as a leader may lead to adequate performance of the entire network to collapse. In addition, formation of cluster is decisive aspect in grouping nodes, where efficient formation of cluster can increase longevity and power efficiency. In this paper, we discussed on methods and formation of clustering in WSN and also the CH selection in an optimal way. It is characterized by using metaheuristic method for better performance in network. The method further includes Mobility, Multi hop transmission, Heterogeneity and Hybrid method. A brief discussion on the CH selection with analyzing its performance to increase network lifetime is performed in this work which helps to analyze convinced application.

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