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Review

A Comprehensive Review on Optimal Cluster Head Selection in WSN-IoT

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ABSTRACT

Nowadays, Wireless Sensor Network (WSN) based Internet of Things (IoT) is a highly developed field that shows a promising area for research because they are economical and simple to manage and maintain. The network comprises a group of sensor nodes that can sense, compute and transmit. In WSN-IoT, energy conservation becomes a significant challenge to extend the network lifetime. So far, numerous efforts have been taken to enhance the routing protocols in the network through the clustering approach, since clustering is considered an effective and appropriate technique transmits the data without any issue. Nevertheless, in the clustering concept, Cluster Head Selection (CHS) is considered a complex process as it has to persuade specific metrics for effective performance. If appropriate clustering is not performed, the network will undergo energy depletion which fails in the network. As a solution to this, suitable techniques for the selection of Cluster Head (CH) play an important role in WSN-IoT. Therefore, this review presents a comprehensive analysis of 85 research papers based on conventional CHS approaches in the WSN-IoT. Additionally, this work analysis numerous approaches based on their categories, and utilized software tools, published years, and performance metrics and are discussed. Here, the categorization of approaches is performed based on optimization algorithms, clustering techniques, Artificial Intelligence techniques, Low-Energy Adaptive Clustering Hierarchy (LEACH) approach, and other approaches. From the analysis, it is clear that conventional approaches prolong the network lifetime as well as reduce energy depletion, but they fail to provide enhanced security, and Quality of Service (QoS), and also they fail to balance the temperature and load of WSN-IoT devices. Subsequently, numerous problems and challenges have been laid down, and finally, concluded that when an optimization algorithm is integrated with the machine learning approach, QoS, security, temperature, and load balance can be attained besides energy efficiency as well as network longevity.

Abbreviation: WSN, Wireless Sensor Network; BOA, Butterfly Optimization Algorithm; CSO, Crow Search Optimization; IoT, Internet of Things; MFO, Moth Flame Optimization; FLC, Fuzzy Logic Controller; QoS, Quality of Service; SSA, Squirrel Search Algorithm; SEA, Stable Election Algorithm; PSO, Particle Swarm Optimization; WBAN, Wireless Body Area Network; DE, Differential Evolution; LEACH, Low Energy Adaptive Clustering Hierarchy; GA, Genetic Algorithm; HQCA, High-Quality Clustering Algorithm; GOA, Grasshopper Optimization Algorithm; MOTCO, MultiObjective Taylor Crow Optimization; ALO, Ant Lion Optimization; FCM, Fuzzy C-Means; GWO, Grey Wolf Optimization; PEGASIS, Power-Efficient Gathering in Sensor Information Systems; FL-AFOA, Fuzzy Logic and Artificial Flora Optimization Algorithm; RE, Residual Energy; MOBSO-DE, Multi-Objective Bee Swam Optimization with DE; SFO, Sailfish Optimizer; EEHCHR, Energy-Efficient Hybrid Clustering and Hierarchical Routing; CSO, Cat Swarm Optimization; DNN, distance to nearby nodes; TCH, Temporary Cluster Head; ROA, Rider Optimization Algorithm; E2E, End to End; SOA, Spider Optimization Algorithm; C-SSA, Cat Salp Swarm Algorithm; FCH, Final Cluster Head; CS, Cuckoo Search; ACO, Ant Colony Optimization; PE, Position Estimation; NE, Nash Equilibrium; UE, User Equipment; ECRRS, Energy Efficient CH Rotation and Relay Node Selection; MDC, Mobile Data Collector; RCSO, Rider-Cat Swarm Optimization; PTA, Preference-based Trust Selection Algorithm; LID, Lower ID; OCE-CHS, Optimized Cluster Establishment and Cluster-Head Selection; AP, Articulation Point; DAAM, Distributed Address Assignment Mechanism; SPNE, Sub-game Perfect NE; C3HA, Cluster Centered Cluster Head Selection Algorithm; DBSCDS, Distance Based Stable Connected Dominating Set; NNs, Neural Networks; CTEEDG, Cluster-Tree-based Energy-Efficient Data Gathering; GH, Grid Head; IEECHS, Improved Energy Efficient CHS; MEACBM, Mobile Energy Aware Cluster Based Multi-hop; SAPSO, Self-Adaptive PSO; DDR, Distributed, and Randomized; DTBS, distance to BS; RCC, Random Competition-based Clustering; EDCHSM, enhanced dynamic CHS method; AI, Artificial Intelligence; GSO, Glowworm Swarm Optimization; CCEF, Cluster Compactness Estimation Factor; WOA, Whale Optimization Algorithm; RSS, Received Signal Strength; iABC, improved Artificial Bee Colony; MWVCP, Minimum Weighted Vertex Cover Problem; Taylor KFCM, Taylor kernel fuzzy C-means; TDMA, Time Division Multiple Access; SADSS, Self Adapting Differential Search Strategies; EEUC, energy-efficient unequal clustering model; AFSA, Artificial Fish Swarm Algorithm; ECH-DUAL, energy-based CH unequal clustering approach; BS, Base Station; HSA, Harmony Search Algorithm; FL-TEEN, Fuzzy logic Threshold-sensitive energy-efficient sensor network.

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1. Introduction

Currently, WSN has emerged as one of the trending research topics. WSN has the ability to track the environment by monitoring and recording the changes that occurred in surrounding areas [1]. Few environmental conditions monitored by the WSN are sound, vibration, pressure, intensity, humidity as well as motion [3]. Basically, the WSN applications are exploited in numerous fields, like bio-medical applications, habitat monitoring systems, military solicitations, and health monitoring systems. The WSN comprises low-power sensor nodes, which are of very low cost. Each and every sensor node is located in a specific region and in a self-organizing way it forms a wireless network. Usually, it can monitor the special environment that humans cannot be able to work in. Nevertheless, the transmission of the data among nodes in an effective way is not quite possible due to various complex factors [4]. The sensor nodes exploit minute batteries, which are difficult to recharge and have minute processing and communication ability [5]. Therefore, the sensor node's energy utilization must be reduced to extend the network lifespan. One of the main constraints to design the WSN is the sensor node's energy. Over the past few years, energy utilization in WSN has gained a lot of popularity from researchers, which paves the way to initiate an area named WSN-IoT [51]. The energy utilization can be minimized at various characteristics, like services, applications, and communication, wherein energy-capable consumption is required. Hence, the minimization of the energy utilization by the sensor nodes is considered a difficult task in the advancement of the large-scale WSN [6].

In recent days, IoT is considered a developing network standard, which gaps in the physical world as well as cyberspace [1]. In contrast with the ad-hoc network, the WSN-IoT application encounters various confront regarding the number of sensor nodes, communication mode, hardware, computational cost, battery power, and so on [54]. Aside from sensing, the sensors exploited in the IoT network are allocated with numerous functionalities and they need to encounter new confronts regarding security, functionalities, and power management. Few of the aforesaid problems are identified by employing several technological changes in prehistoric protocols and strategies exploited in WSN [25]. In designing the WSN-based IoT, the minimization of power utilization is considered the major problem. Many research studies have arisen with numerous concepts to minimize energy utilization and increase the lifetime of the network for suitable resource utilization [61]. Therefore, the cluster head selection is exploited to overcome the issue [7]. The clustering model is considered the important approach to extending the network lifetime in WSN-IoT [45]. Here, the sensor nodes are grouped into clusters, and for each cluster, the sensor nodes will choose the cluster heads. In WSN-IoT, suitable CHS is considered one of the main issues in the clustering-based routing approaches [22]. Moreover, it has been viewed that proper CHS can enhance the performance of the routing approaches regarding the scalability, data delivered, extensive network lifetime, and improved network coverage region. From the particular cluster nodes, the cluster head receives the data and transmits the data to the BS. One of the main challenges in WSN-IoT is to select the most suitable cluster head [10]. The sensor nodes use a large amount of energy while transmitting the data and it affects the network lifespan. To overcome this, the clustering approach is used to present an energy-effective data transmission [12].

For several reasons, the sensor nodes might be unsuccessful, such as battery reduction, transmission connection, instability, the impact of environmental, and hardware part breakdown [32]. It is necessary to recognize the faulty nodes at the correct time. A fault-tolerance method is necessary to improve the lifetime of the network [29]. If the CH node is ruined, another equivalent correctly sensor node will take over the CH accountability to carry on the network operation [35]. Various CHS approaches were presented for WSN-IoT. Many of the CHS approaches concentrate only on energy-efficient CHS [53]. While designing the CHS approach the security feature of CH nodes is not considered. So these approaches must be modeled in the manner of securely selecting CHS by perceiving the good deal hubs and rejecting them of their CH application in WSN-IoT [60]. Several hierarchical routing protocols on the basis of clustering approaches, such as LEACH, SEP, PEGASIS, were presented [2] and [13]. Additionally, meta-heuristic search approaches were identified as a hopeful and suitable solution for an extensive range of applications [10]. Moreover, machine learning approaches minimize the number of data transmissions when using distributive properties of WSN [26]. In WSN, the initial and primary routing protocol, which is carried out on the basis of the traditional hierarchal routing protocols, is LEACH [47]. Here, in each cluster, the adjacent CH is elected by the Multi-hop LEACH within one hop range and presumes that as next-hop and thereby, enhances the energy effectuality. This enhancement is due to the exploitation of reduced energy, especially in large sensor networks [43]. Nevertheless, the main disadvantage of the multi-hop LEACH and some other possible solutions [45], which integrate the clustering and the multi-hop communication, is the Cluster head over the base station leads to high relay traffic and the nodes deplete faster, thus the network lifespan is minimized [8].

a) Motivation

The most important motivation of this paper is to present an intuition to novice researchers regarding the selection of CHs based on various algorithms. Additionally, it aids the researchers to learn the CHS models on the basis of the requirement and enumerating their applications. To present a rapid intuition, a survey of current meta-heuristic-based approaches was performed. During the data transmission, the energy utilization in WSN-IoT should be reduced. Diverse methods are presented to alleviate this issue and concentrated on only one constraint that is energy and unpaid notice to other appropriate constraints, like Quality of Service, distance, trust, connectivity, and so on. Few protocols practice optimal path selection and encounter confront associated while choosing the path and presented the maximum throughput as well as minimum delay. Moreover, improving the lifetime of a WSN by optimal CHS, clustering, and energy-efficient routing by taking into consideration of contradictory parameters is a challenging issue as well as motivation.

Motivated by this, numerous CHS approaches are reported in section 2, recommending diverse models for CHS and its role. Lately, a review of a few optimization models mainly focused on their energy consumption and the lifetime of the network, which, aspire is to explain their features and objectives. Nevertheless to the author's knowledge, no outline of the security, load, and temperature highlighting their CHS has been adopted hitherto. Therefore, efforts have been done to propose a wide review of models presented previously, for CHS in WSN-IoT respecting their evaluation metrics to have an extensive-spread understanding of this work.

To have a comprehensive analysis of these schemes of CH, their essential categorization on a widespread platform raises the following questions, which are stated below:

- Ø Who instigates the CHS?
- Ø Which parameters determine the role of a sensor node?
- Ø Which sensor nodes shall be chosen as CH?
- Ø Whether energy effectual node is essential to choosing the CH?
- Ø Does it necessitate re-initiation of the cluster formation process?

The main objective of this work is to present a comprehensive review of CHS approaches in WSN-IoT. It is performed based on the categorization of approaches, which are exploited to choose the appropriate CH. The current review has been critically reviewed to recognize the problems in conventional studies. From the review, it is clear that conventional approaches improve the lifetime of the network and minimize energy depletion, but did not provide enhanced security, and QoS, and also, fail to balance the temperature and a load of WSN-IoT devices.

From the overall analysis, it is exhibited that numerous studies reviewed have used MATLAB as the execution tool.

The paper is arranged as follows: Section 2 elucidates conventional approaches in the WSN-IoT and section 3 illustrates the system model of WSN-IoT. Section 4 describes the research gaps and issues of CHS in WSN-IoT. Section 5 represents the analysis of CHS approaches regarding implemented software, performance metrics, and Year of publication. Lastly, the conclusion and future work of the paper are presented in section 6. Fig 1 demonstrates the workflow of the paper.

2. System Model

The architectural model of the WSN incorporated into the IoT platform is demonstrated in Fig 2. WSN serves as an abode for numerous sensor nodes that operate concurrently in a spatially distributed manner to look at an occurrence of a few sorts, appropriate to the application in contemplation [1]. Mainly, these nodes comprise power units, microcontrollers, memory units as well as transceivers, which utilize huge power that they exhaust within a restricted period. If the energy depletion is higher for the nodes, then the lifetime of the network is reduced. Therefore, some energy effectual storage is extremely expected. In order to preserve the energy, the appropriate CHS scheme is used. As shown in Fig 2, the sensor nodes are grouped to form clusters. On the basis of the certain electoral model, some senor nodes are chosen as the CHs and the residual nodes act as member nodes. Ultimately, the member nodes are responsible to collect the environmental information, and subsequently, it transmits the data to the CHs, which transmit it to the BS. The latter transfers it to the user through the mobile sink node; ultimately the user makes decisions on the basis of current environmental information.

3. Literature Survey

This section exhibits a comprehensive review of several methods adopted for CHS in WSN-IoT. Fig. 3 exhibits the categorization of CHS approaches in WSN-IoT. Here, various approaches such as optimization algorithms, clustering techniques, Artificial Intelligence techniques, LEACH approach, and other approaches are developed for the CHS. The challenges present in these approaches are considered to motivate the researchers to develop a novel CHS process in WSN-IoT.

a) Categorization of Optimization Algorithms

This section describes the optimization approaches used for the CHS in WSN-IoT. Generally, optimization algorithms are the widespread type of approach which uses a degree of randomness to attain optimal solutions to hard issues.

In 2018, M. Praveen Kumar Reddy and M. Rajasekhara Babu [1], adopted a hybrid approach with both MFO and ALO to enhance the CHS performance amid the IoT platform in WSN–IoT network. The specific experimentation model not only conserves sensor node energy by maintaining the delay and distance but also balances load and temperature and IoT devices to obtain optimal CHS in WSN–IoT network.

A Multi-Objective Based Clustering and SFO algorithm were exploited by Deepak Mehta and Sharad Saxena in 2020 [3]. The proposed algorithm directs to a routing approach in order to maintain energy effectiveness in WSNs. From the multiple objectives, the effectual fitness function was devised based on the selection of CH. Therefore, it aids to reduce energy utilization and the deceased sensor nodes. After the selection of CH, to decide an optimal path to the base station for the transmission of the data, SFO was exploited. In 2021, D. Laxma ReddyPuttamadappa and C.H. N. Suresh [4] planned to recognize an optimal CH for energy-efficiency routing protocol in WSN. Here, the major objective was the CHS, therefore a novel hybrid ACO-GSO approach was proposed. The proposed algorithm was the integration of both the ACO and GSO approaches. Here, the main contribution of the CHS was to minimize the distance between the chosen CH nodes. By exploiting multi objectives such as delay, energy as well as the distance the fitness function was formulated. In 2021, Aparajita Chowdhury and Debashis De [5] worked on an energy-effectual coverage optimization method with the aid of Voronoi-GSO- K-means model. Here, the K-means model, GSO, and Voronoi cell structure improve coverage area with the least amount of active nodes. For effectual sensor deployment, the aforesaid method considers optimal sensing radius computation. By exploiting the sleep-wake model as well as multi-hop transmission, the adopted model enhances the deployed network lifespan by reducing energy utilization.

A novel energy-aware CHS in WSN was developed using hierarchical routing by Rakesh Kumar Yadav and R. P. Mahapatra [8] in 2021. Here, a novel hybrid optimization approach was developed. Furthermore, the election was done by exploiting some aspects such as energy stabilization, distance reduction amid nodes, and delay reduction during the transmission of data. By choosing the appropriate CH, the non-linear objective model obtains the extended lifespan. Here, the hybrid optimization model was named as ROA and CS approach. Finally, the adopted model performance was evaluated and exhibited its superiority over the traditional methods. In 2019, T. Shankar *et al.*, [10] worked on a hybrid HSA and PSO approach for the energy effectual CHS. Here, the adopted model exhibits the maximum search effectuality of HSA and the dynamic ability of PSO, which enhances the sensor nodes' lifetime. At last, performance evaluation of the adopted approach exhibits an enhancement in throughput as well as residual energy. In 2020, Anand Tanwar *et al.*, [11] proposed a model to lessen the utilization of energy per node by modifying the effectual sleep/awake of nodes' scheduling. For the sensor activation, this approach encounters 2 stages like initialization stage, as well as activation stage. Using the initiation of a network, the initialization stage was evolved that was carried out to formulate the network parameters to the sensor. Then, the adopted fractional calculus in the GOA optimization approach was exploited to activate the sensors in each slot in the activation phase.

A SAPSO was adopted by A Shankar *et al.*, [12] in 2017 to resolve the base station positioning issue. This approach was exploited to reduce the

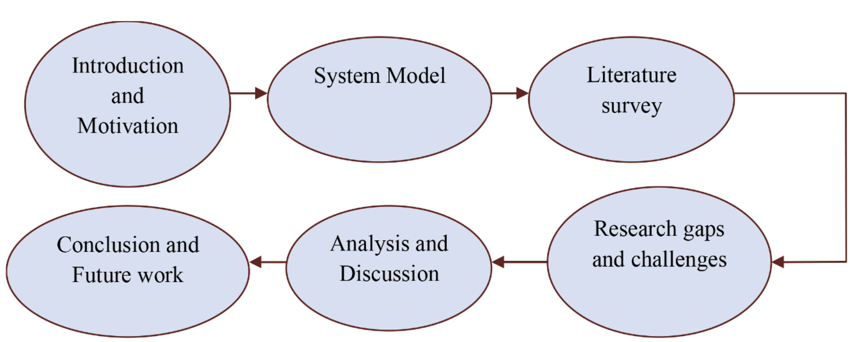

Fig 1. Workflow of the paper

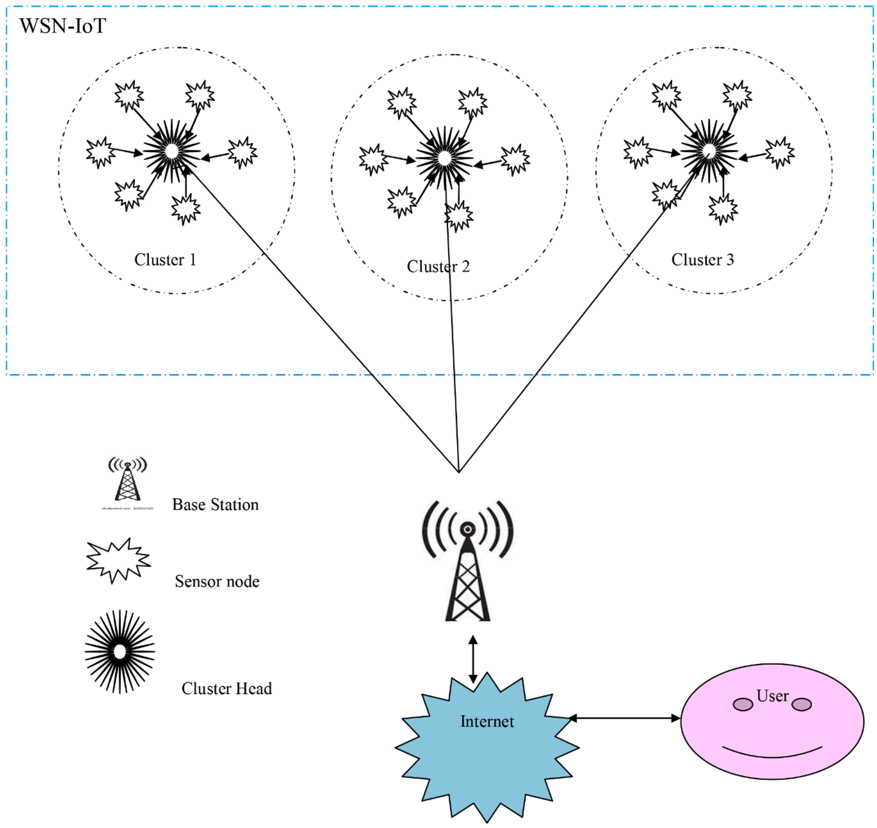

Fig 2. System model of cluster head selection in WSN-IoT

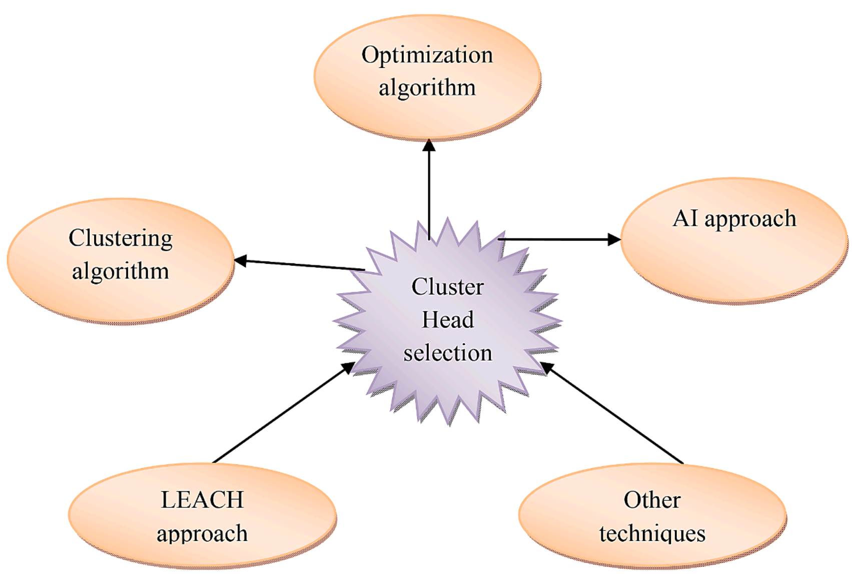

Fig 3. Categorization of CHS techniques in WSN-IoT

distance between the CH and the base station to account for minimizing the energy consumption. In 2020, Prachi Maheshwari Dr *et al.*, [17], worked on the minimization of energy consumption and maximization of a lifetime of the network. In WSN, clustering, and routing approaches, were extensively exploited in order to select an appropriate CH from a group of nodes. Therefore, BOA was utilized to select an optimal CH from a nodes group. Moreover, the route between the base station and CH was recognized by exploiting the ACO. This method chooses the optimal route based on the enduring energy, node degree, and distance.

In 2021, Kim Khanh Le-Ngoc *et al.*, [18], presented a Sugeno-based FLC, which was an effectual distributed multi-level clustering model. This was exploited to systematize WSN into various multi-level clusters. Here, the CHs gather their member's data and transmit that data to sinks. Additionally, in order to optimize the clustering FLC, an enhanced SSA was developed. Therefore, by optimizing FLC its rule-base was reduced and its efficiency in the clustering process was enhanced.

In 2019, A. Vinitha *et al.* [19], addressed confronts in the minimization of energy and presented an energy effectual multi-hop routing in

WSN called Taylor-based C-SSA. It was performed by enhancing C-SSA with the Taylor series. This approach experiences 2 phases to attain the multi-hop routing that involves the CHS and data transmission. At first, by exploiting the LEACH protocol, the energy effectual CH was chosen for the effectual transmission of the data, and then that data transmits to the Base Station via the chosen optimal hop. By employing the adopted Taylor C-SSA model the selection of optimal hop was performed. In addition, by adopting the trust model the security-aware multi-hop routing was done which includes the direct trust, integrity factor, indirect trust, and rate of data forwarding. In 2020, Praveen Kumar Reddy Maddikunta *et al.*, [20] developed a hybrid WOA-MFO approach to choose the optimal CH in order to optimize the aspects such as remaining energy, CH load, temperature, and cost function. Then, the developed model performance was estimated with conventional approaches concerning energy-specific metrics. In 2021, Sathyapriya Loganathan and Jawahar Arumugam [22], worked on the selection of the CH node, which creates the novel cluster. The PSO optimization approach with the metrics of the optimization of clustering coefficient, remaining sensor node's energy, and distance from sink node and the CH to the members was developed to choose the CH sensor node.

A DBSCDS methodology was developed by Ajay Kaushik *et al.,* [24] in 2019, by exploiting a metaheuristic algorithm named GWO to attain a balanced, stable, and energy effectual CDS-based WSN. Additionally, it enhances the cluster-based WSN performance. Netsim Emulator, as well as MATLAB simulation, was exploited to validate the performance of the adopted model. In 2017, Palvinder Singh Mann and Satvir Singh [26], adopted an iABC model with an enhanced solution search formulation to increase the exploitation abilities of conventional meta-heuristic. Furthermore, an enhanced population sampling approach was developed to enhance the global convergence of the adopted meta-heuristic, via the Student's t-distribution that necessitates merely one control parameter to calculate and save; consequently, it maximizes the effectiveness of the adopted meta-heuristic. In 2016, D. Rajendra Prasad *et al.* [27], suggested a hybrid MOBSO-DE for the effectual clustering. The election of the CH process was on the basis of the communication energy and metrics such as energy constraint factors and residual energy. The performance of the adopted model demonstrates that the adopted model was superior to conventional models such as MOBSO and LEACH regarding the network lifespan and packet delivery ratio. In 2019, Anupkumar M. Bongale *et al.*, [30], presented a hybrid CHS for WSN on the basis of firefly and HSA. The main objectives of the adopted protocols were 2 level CHS scheme. Initially, to ascertain the primary set of energy effectual CH nodes HSA was exploited, which are adequately estranged from one another by definite optimal distance. Subsequently, using the firefly algorithm uncertainly selected CH nodes was sophisticated by considering the metrics such as density of cluster, density of node, and energy to be utilized.

In 2021, Rambabu Bandi *et al.* [41] worked on a SADSS-IABCA Algorithm-based CHS model to prolong the network lifetime with enhanced QoS. This adopted model-based CHS model integrated diversified search schemes related to DE with the onlooker and employee bee phase to enhance ABC local searching capability with analysis to eradicate its restrictions of delayed convergence. Additionally, for the effectual election of CHs, the apt election of DE schemes was calculated via the probability-based self-adapting procedure. In 2020, Mohana Bakshi *et al.* [46], worked on an adaptive CHS model based on the GSO method. Numerous conventional algorithms group nodes into clusters comprising a fixed number of nodes. In certain scenarios, that was not appropriate, like, when numerous nodes are dead. For each cluster, the number of nodes was not fixed in an adopted model, and it mechanically changes along with the number of alive nodes in the network that maximizes network lifetime. In 2017, Amit Sarkar and T. Senthil Murugan [49], worked on the Firefly method to maximize the network energy effectuality and the node's lifespan by choosing the optimal CH. Here, a firefly with cyclic randomization was designed to select optimal CH. The performance of the network was maximized in this approach while evaluating other traditional models.

In 2019, M. Sindhuja and K. Selvamani [51], investigated the selection of the CH model to resolve the positioning of base station issue and to balance the energy utilization in IoT. A secured energy effectual approach was necessary in order to expand the survival of the IoT. As, the transmission of data, processing of data, and sensing by sensor nodes requires maximum energy, the sensor node becomes deceased due to the existence of the rechargeable batteries. ALO method was utilized, which was a security constraint CHS method in order to overwhelm aforesaid problems. In 2020, P. Subramanian *et al.* [57], worked on a hybrid GWO and CSO algorithm-based optimal CHS model to enhance the expectation of the network lifetime by considering the reduction of distance among the nodes and energy stabilization and reduction of delay. In order to deal with the issue of premature convergence the proposed model was exploited which stops it from effectually discovering the search space. This proposed hybrid approach in the CHS process maintains the tradeoff amid exploration and exploitation degree in search space. In 2017, M. Praveen Kumar Reddy and M. Rajasekhara Babu [61], intended to develop a hybrid approach by using both GSA and ABC to enhance CHS performance in WSN-based IoT networks. The specific experimentation model not only conserves sensor node energy by maintaining delay as well as distance but also balances the load as well as the temperature of IoT devices to achieve the optimal CHS in WSN based IoT network.

In 2020, Roopali and Rakesh Kumar [63], developed a routing protocol based on a GA for WBAN that was effective regarding the efficiency of energy and lifetime of the network. Here, the adopted model concentrates on Inter-BAN communications. The experimentation outcomes of the adopted protocol were evaluated with earlier known approaches regarding diverse metrics like the lifetime of the network, energy effectuality, packet delivery ratio, throughput, as well as the average delay was exhibited improved performance. In 2019, B. Pitchaimanickam and G. Murugaboopathi [66], worked on a Hybrid model of the Firefly approach with PSO (HFAPSO) to find the optimal CHS in LEACH-C approach. The hybrid approach enhances global search firefly's behavior by exploiting PSO and attaining optimal positioning of CH. The adopted method performance was calculated by exploiting the number of alive nodes, residual energy, and throughput. In 2020, R. Karpaga Priya and S. Venkatanarayanan [67], worked on a Hybrid method of fuzzy logic integrated with the SOA. Moreover, via RSS, a temperature influence was realized and the number of packets received. The adopted model was experimented with in MATLAB and by exploiting the PIC microcontroller as well as Zigbee and was implemented in a hardware testbed. In 2019, Jacob John and Paul Rodrigues [70], developed energy-aware routing by exploiting the optimal CHS process by considering energy as an effectual constraint. The developed approach was exploited to select the optimal CH and it was done by the MOTCO approach, which was an integration of the Taylor series and CSA. The adopted objective model was based on the distance among nodes in the cluster, cluster traffic density, nodes energy, and delay in data packet transmission.

In 2021, Ramakrishnan Anandkumar [71], worked on a Hybrid FL-AFA-based 2-Tier CHS to improve the energy effectiveness and extend the network lifespan. This proposed model attained the CHS in 2 phases, by exploiting FL the selection of TCH and, by exploiting AFA selection of FCH was performed. Initially, the idea of fuzzy logic was deployed over the input parameters of RE, DTBS, and node degree. Next, the advantages of AFA were exploited to calculate the fitness function via the CCEF, DNN, and PE. In 2017, D. Chandirasekaran and T. Jayabarathi [72], developed a protocol by exploiting a novel evolutionary approach named, CSO. It was simulated in real-time to reduce the intra-cluster distances among cluster members and their CHs; also optimizes energy distribution for WSNs. WSN protocol performance was analyzed with the aid of sensor nodes deployed in a field and grouped into clusters. The adopted model novelty was considering the RSS, remaining battery voltage, and intracluster distance of sensor nodes in

CHS with the aid of CSO. In 2016, R. Juliana and P. Uma Maheswari [75], worked on the security models acquired by WSN that directed to resource and exploitation of energy overhead ensuing in earlier energy depletion. Trust and reputation were broadly employed in past studies to identify the misbehaving nodes and therefore enhance the overall network QoS by evading them. In this study, the ABC was presented as a trust model for effectual CHS in a multi-hop WSN. In 2017, K. Vijayalakshmi and P. Anandan [76], worked on the optimal path selection in routing that improves the lifespan of the network and also the effectuality of the network's energy. Several meta-heuristic models chiefly PSO were efficiently exploited however with poor local optima issues it was not appropriate. Hence, the adopted model was based on the PSO and Tabu search approach. Finally, the outcome exhibits the effectiveness of adopted Tabu PSO by improving the number of clusters formed, and the percentage of nodes alive, also exhibits minimization of average E2E delay and average packet loss rate.

In 2019, P. K. Poonguzhali and N. P. Ananthamoorthy [77], modeled a novel routing protocol with optimal parameter selection. Additionally, ACO was exploited for path-based clustering. Moreover, by exploiting the HSA, a minimum density cluster was chosen. To identify the optimal CH, the ACO was integrated with HSA with a minimum routing path with minimized energy utilization. The experimentation of the adopted model was performed over the conventional ACO-Fuzzy, max-min ACO, and ACO regarding several performance measures. In 2016, P. C. Srinivasa Rao *et al.* [78], developed an energy-efficient CHS approach that was based on the PSO named PSO-ECHS. The approach was modeled with an effectual model of fitness function and particle encoding. Several metrics such as sink distance; intra-cluster distance and the remaining energy of sensor nodes were considered for the energy effectiveness of the adopted PSO model. The approach was examined broadly in several cases of WSNs, varying the number of CHs as well as sensor nodes. In 2018, Vinith Chauhan and Surender Soni [79], developed a mobile sink-based energy-aware clustering model to improve network lifespan despite the overwhelming problem of energy holes. At first, the network was partitioned into several rectangular regions and each region consisted of one CH in the adopted model. In order to choose the CHs, the firefly approach was exploited wherein residual energy, distance from a node to sink, and an average node to node distance were the crucial parameters of the procedure. The adopted model performance was evaluated with the conventional models and it was simulated by exploiting the Matlab platform.

In 2016, P. Sengottuvelan and N. Prasath [81], developed an optimized selection of CH by exploiting an enhanced AFSA model. In order to minimize overall network energy utilization, nodes were partitioned into clusters and one node acted as CH and collects the gathered information from other nodes. In the sensor network, clustering was performed to minimize the communication overhead. Thus, network performance, and lifespan, was enhanced. In 2020, M. B. Shyjith *et al.* [82], adopted the RCSO model, which was a combination of both the ROA with CSO. Moreover, by exploiting the multi-objective constraints, the threshold and CH were selected including the energy, distance, and delay. Subsequent to the CHs determination, the transmission of the data initiates from CHs to the BS. Ultimately, residual energies generated from the nodes were updated in the measurement stage. In 2020, Turki Ali Alghamdi [83], attempted to model a new clustering approach with optimal CHS by exploiting 4 main criterions namely delay, energy, security, and distance. Furthermore, to choose optimal CHs, this work presents a novel hybrid approach that integrates the concept of firefly and dragonfly algorithm, called firefly replaced position update in dragonfly (FPU-DA). Table 1 summarizes the comparison analysis of diverse optimization approaches.

a) Categorization of Clustering Algorithms

The categorization of clustering algorithms used in the WSN-IoT for the CHS is elucidated in this sub-section. During the CHS process, the clustering algorithms focused on the complete set of objective which needs to be fundamentally explored.

In 2021, Akhilesh Panchal and Rajat Kumar Singh [2], proposed a novel clustering approach called EEHCHR in WSN. Moreover, by exploiting Euclidean distance parameter, FCM approach, BS position, and node remaining energy, a novel method of hybrid and adaptive clustering were developed for the last practice of the node's energy. Only in a few rounds, the clustering was carried out, and these outcomes in minimization of network energy utilization. By exploiting the energy effectual fitness function, every cluster head was chosen that works adaptively with nodes remaining energy to enhance the selection of the CH process. In 2019, Amir Abbas Baradaran and Keivan Navi [13], developed an approach named HQCA to generate high-quality clusters. During clustering, this proposed model exploits criteria to measure the cluster quality that can enhance inter-cluster and intra-cluster distances therefore it minimizes the error rate. Based on fuzzy logic, optimal CH was elected; under several criteria like minimum energy as well as distance, and remaining energy.

In 2020, Sehar Umbreen *et al.* [15], developed an energy-efficient mobility-based CHS model. The election of CH was based on the dedicated parameters which have an enormous effect on the energy utilization of the sensor. Each node weightage was computed on the base of the node's mobility level, distance to sink, remaining energy, and neighbor's density. In 2017, Eid Rehman, Muhammad Sher, *et al.* [21], developed a secure CHS approach by computing the weight of each node to pact with security chosen by exploiting minimum energy utilization. The node weight was an integration of diverse measures such as the trust metric that supports a secure decision of a CHS regarding this; the node was not appropriate for a malicious one. In 2021, Bilal R. Al-Kaseem *et al.* [23], worked on a novel clustering model named SEA to reduce message swap amid sensor nodes and stop recurrent CHs rotation. Based on MWVCP, a sojourn position determination approach was developed to decide the optimal location for sinks to discontinue and gather the data from CHs. In 2019, K. Sindhanaiselvan *et al.* [42], developed on clustering model to reduce energy utilization through communication from the sender to the receiver, and several parameters wherein evaluated to ascertain the CHS based on the energy utilization since this was directly associated with the network lifetime. The experimentation was performed by exploiting the MATLAB.

In 2007, Zhu Xiaorong and Shen Lianfeng [43], developed a novel static type clustering model named Hausdorff clustering that was based on the sensor node's position and communication effectiveness, and network connectivity. Nevertheless, the CH was rotated in the cluster using a fuzzy logic approach that optimizes the lifetime of the network. In 2017, Mukil Alagirisamy and Chee-Onn Chow [45], worked on the selection of the CH by enhancing the EEUC. This proposed model tentative CH was elected based on node IDs, energy-based timer, remaining energy, and trust value. Here, an ECH-DUAL by exploiting a dual (static and mobile) sink was developed. In 2018, Abdulhamid Zahedi *et al.* [47], worked on clustering algorithms to minimize the transmission of messages and dissipation of energy. Moreover, the reservation was the model by the assist of that the number of communicated messages for the usual implementation of clustering phases and CHS was minimized.

In 2015, KyeDong Jung *et al.* [52], developed the clustering algorithm by exploiting the fuzzy inference system. It was exploited to enhance the adaptability of the CHS using FL-TEEN for wireless multimedia sensor networks. The stochastic election approach cannot assure the presentment of CH. Moreover, as the formation of the cluster was not optimized, the network lifespan was obstructed. The approach was adopted that collects attributes of a sensor node to estimate the probability to be CH in order to enhance this issue. In 2017, M. Narendran and Periyasamy Prakasam [53], recommended an energy effectual CHS in mobile WSNs, estimated and analyzed based on remaining energy and randomized selection of nodes that were not elected as CHs in former rounds. This study works on an RCC scheme that was more stable than

Table 1
Comparison analysis of diverse Optimization Approaches

Authors [citation]	Adopted methodology	Features	Challenges
M. Praveen Kumar Reddy and M. Rajasekhara Babu [1]	Hybrid MFO and ALO approach	It reduces the load, delay as well as the temperature of the SN. It minimizes the energy consumption	It was inappropriate for numerous applications. The security and privacy were not supported.
Deepak Mehta and Sharad Saxena [3]	SFO	It aids to reduce the utilization of energy and also minimizes the number of deceased nodes.	It was not appropriate for time-constrained applications.
D. Laxma ReddyPuttamadappa and C.H. N. Suresh [4]	Hybrid ACO and GSO	Minimizes the distance between the chosen CH.	Difficult to discover the optimal CH nodes.
Aparajita Chowdhury and Debashis De [5]	Voronoi-GSO-K-means approach	It improves the network lifespan by minimizing the energy consumption of Mobile WSN.	It does not exploit s sensible region of mobile sensor nodes.
Rakesh Kumar Yadav and R. P. Mahapatra [8]	CI-ROA	It reduces the distance between nodes, energy stabilization, and minimizes delay during transmission of data.	Overhead and complexity in the formation of cluster phase
T. Shankar *et al.* [10]	Hybrid HSA and PSO algorithm	It employs the high search effectiveness of HSA and also exploits the dynamic ability of PSO.	The adopted model is disadvantaged by several renowned factors of the CH election.
Anand Tanwar *et al.* [11]	Fractional-GOA	It attained maximum energy, throughput, and alive nodes.	Low performance on dense networks
A Shankar *et al.* [12]	SAPSO	It reduces the distance between the BS and CH on account of increasing the energy.	The selection of CH is not appropriate.
Prachi Maheshwari Dr *et al.* [17]	Hybrid BOA and ACO	It chooses the optimal route based on distance, remaining energy and node degree.	The proposed model does not support load and temperature.
Kim Khanh Le-Ngoc *et al.* [18]	Improved SSA	It reduces the average energy of WSN's nodes, retransmission ratio data, and packet loss.	It does not work on the reliability factor in clustering and routing.
A. Vinitha *et al.* [19]	Taylor C-SSA	It exhibits superior convergence.	It does not work on multi-hop routing regarding the high performance.
Praveen Kumar Reddy Maddikunta *et al.* [20]	Hybrid WOA- MFO	Energy utilization is optimum and the temperature generated using the IoT node is balanced.	It does not concentrate on QoS, and network density with multi-objective optimization.
Sathyapriya Loganathan and Jawahar Arumugam [22]	PSO	It maximizes the network lifetime.	Computationally complex.
Ajay Kaushik *et al.* [24]	DBSCDS-GWO	It is exploited to reduce the energy utilization by sensor nodes which are useful for IoT applications.	For time-constrained applications, it is in-applicable.
Palvinder Singh Mann and Satvir Singh [26],	iABC	It consumes the least energy and increases network lifespan.	It requires optimal CH selection.
D. Rajendra Prasad *et al.* [27]	MOBSO-DE	It attains a considerably higher packet delivery ratio and also it improves the delivery ratio.	It requires the run time enhancement of the technique.
Anupkumar M. Bongale *et al.* [30]	Hybrid firefly and HSA	Energy utilization is distributed over the diverse CHs of the network.	Low performance on intracluster data aggregation.
Rambabu Bandi *et al.* [41]	SADSS-IABCA	Enhancement in the percentage of alive nodes, throughput and mean remaining energy.	For CHS it does not balance the energy in the network.
Mohana Bakshi *et al.* [46]	Modified GSO	It minimizes the communication overhead	Difficult for positioning heterogeneous IoT nodes and their effect on clustering.
Amit Sarkar and T. Senthil Murugan [49]	Firefly algorithm	It develops the security constraints and other practical constraints.	The adopted CH on several routing protocols remains an issue.
M. Sindhuja1 and K. Selvamani [51]	ALOP	It is used to attain the objectives such as minimizing the utilization of energy, delay, and distance and maximizing security.	It does not support sensing capabilities in diverse applications.
P. Subramanian *et al.* [57]	HGWCSOA-OCHS	It balances the percentage of alive and deceased sensor nodes. Also, minimizes the utilization of energy, and improves network lifespan.	Low performance of energy balance and network lifetime.
M. Praveen Kumar Reddy and M. Rajasekhara Babu [61]	Hybrid GSA and ABC	It has increased the life expectancy of WSN–IoT network also preserves energy and reduces the delay, distance, and load.	It is complex to estimate the cost function.
Roopali and Rakesh Kumar [63]	Genetic algorithm	Energy savings and improves the network lifetime. Also, it supports ubiquitous health monitoring.	For complex network scenarios, it does not consider node mobility and cross-layer interactions.
B. Pitchaimanickam and G. Murugaboopathi [66]	HFAPSO	It performs better for energy utilization, the lifespan of the network, and the number of alive nodes.	It does not support real-time applications with a large sensor network density.
R. Karpaga Priya and S. Venkatanarayanan [67]	Fuzzy logic and SCO	It considerably minimizes mortality rate of nodes and increases the lifetime of the network.	It does not consider temperature impact on the node, because of environmental factors.
Jacob John1 and Paul Rodrigues [70]	MOTCO	It obtains the throughput and network energy at a maximum value.	Low accuracy calculation.
Ramakrishnan Anandkumar [71]	FL-AFA	It increases the energy, average delay, network lifetime, and packet delivery ratio.	Low performance on the network lifetime
D. Chandirasekaran and T. Jayabarathi [72]	CSO	The computation time is less and fast convergence.	The issue in re-clustering is the effect of the difference in temperature on battery voltage.
R. Juliana and P. Uma Maheswari [75]	ABC algorithm	It considerably enhances the network performance regarding the packet delivery ratio as well as network lifetime.	It does not aid the end-to-end delay.
K. Vijayalakshmi and P. Anandan [76]	Tabu PSO	It exhibits minimization of average E2E delay and average packet loss rate.	It does not work on security.
P. K. Poonguzhali and N. P. Ananthamoorthy [77]	ACO combined with HSA	It enhances the energy efficiency of the network.	Difficult to predict the routing paths.

(*continued on next page*)

Table 1 (*continued*)

Authors [citation]	Adopted methodology	Features	Challenges
P. C. Srinivasa Rao *et al.* [78]	PSO-ECHS	It reduces the total energy utilization and reduces the network lifetime.	Difficult in energy balancing and fault tolerance of WSNs.
Vinith Chauhan and Surender Soni [79]	Firefly optimization algorithm	It enhances network lifespan and packet delivery ratio and reduces packet delay.	It does not aid the congestion control and load balancing.
P. Sengottuvelan and N. Prasath [81]	AFSA	It reduces packet loss and enhances network lifespan.	High computational time
M. B. Shyjith *et al.* [82]	RCSO	It attains maximum energy saving.	It does not work in throughput, as well as the a number of alive nodes.
Turki Ali Alghamdi [83]	FPU-DA	It works on delay, alive nodes, network energy, and risk probability	It can lead to trade-regarding obtaining objectives. Also, increases the computational cost.

the conventional clustering approaches such as LID. In 2021, Ganesh Jayaraman and V. R. Sarma Dhulipala [56], worked on the fuzzy-based energy-effectual CHS approach to increase network lifespan. During cluster formation, the k-means approach was exploited to model a cluster effectually and CH was chosen based on a fuzzy logic system.

In 2020, Susan Augustine and J. P. Ananth [68], introduced a CHS occurrence on the basis of the approach, Taylor KFCM which was an enhancement of the KFCM approach in the Taylor series. By exploiting the selection occurrence adopted model selects the CH, the acceptability factor that was calculated by employing distance, energy, and trust. Conversely, a node was represented as a CH while fitness constraints of minimum distance, maximum energy as well as trust energy were obtained. In 2017, Seyyed Mehdi Hosseini *et al.* [73], suggested an Energy-effectual Fuzzy LEACH, taking into consideration of the base station was Mobile. The novelty of the proposed model was to wisely choose the CHs on the basis of the mobility of the BS as well as its look probability in diverse positions. Therefore, the CHS appropriately as supper CH node can reduce the consumption of energy. Here, Mamdani's fuzzy system was exploited regarding the centrality of a node, remaining energy, mobility of BS, and BS manifestation probability as input variables. In 2019, Deepak Sharma1 and Amol P. Bhondekar [84], considered a multi-heterogeneity WSN case with sensors nodes, which consists of diverse primary energies and diverse requirements of traffic besides solar energy-harvesting abilities. For this case, an enhanced CHS was developed based on traffic, energy, and energy harvesting that uses the effectually the WSN heterogeneities regarding the traffic, energy as well as energy harvesting. In order to emphasize the adopted model's performance, the system was considered non-energy neutral. Table 2 summarizes the comparison analysis of different clustering algorithms.

a) Categorization of Artificial Intelligence Techniques

The Artificial Intelligence techniques in the CHS for the WSN-IoT are described in this section. Artificial Intelligence indicates a computer system's capability to achieve activities, which require human intelligence when imitating human ideas or minds.

In 2018, K. Thangaramya *et al.* [9], developed a new Neuro-Fuzzy Rule-Based Cluster Formation and Routing Protocol to carry out the effectual routing in IoT-WSNs. Here, a simulation experiment was conducted by exploiting the adopted technique it was exhibited that the adopted routing approach presented superior network performance regarding the measures such as consumption of energy, packet delivery ratio as well as a lifetime of the network. In 2016, Vahid Jafarizadeh *et al.* [58], addressed the optimal determination of the CH node issue. In order to solve this issue, Naïve Bayes classifier was exoloited. This was the subset of the data mining approaches. Finally, the experimental analysis demonstrates that the adopted model's effectuality was superior to existing models. In 2018, Rakesh Kumar and Manju Gangwar [80] considered the TDMA-based MAC protocol as the adopted work. Here, the adopted model was endeavored to enhance the conventional BEST MAC protocol by exploiting AI. Here, the back propagation algorithm was exploited as an application of ANN to improve the network's performance. Moreover, 2 performance parameters such as energy effectuality and WSN throughput were considered to prolong network lifespan by exploiting the optimal CHS process. In 2019, Farah Sanhaji *et al.* [85] implemented a developed model for routing protocol on the basis of NNs. The proposed model focused to enhance the performance of clustering. One of the significant factors was the utilization of energy in WSNs. In the NN tool and LEACH routing protocol was developed the criteria of the utilized energy for the procedure of the CHS. Here, the sensor node with the utmost level of energy was chosen as CH. Table 3 summarizes the comparison analysis of different AI algorithms.

a) Categorization of LEACH Algorithms

This section explains the categorization of LEACH algorithms from the several conventional CHS model for WSN-IoT research. Generally, the LEACH represents as a hierarchical protocol, which is well-known for easy and energy saving protocols.

In 2019, Trupti Mayee Behera *et al.,* [14], focused on an effective CHS model that rotates CH position among nodes with superior energy levels when compared with traditional approaches. Here, the approach contemplates initial energy, remaining energy, and an optimum value of CHs to choose the subsequent group of CHs for the network which was appropriate for IoT applications. In 2021, Nitin Kumar *et al.,* [28], developed a new model to extend the network lifespan and also minimization of energy consumption in the WSN. In the geographical environment, the sensor nodes were distributed in a heterogeneous way as well as extended in a highly developed and normal way with maximum as well as minimum energy considerably. Here, each and every SN was arranged in clusters or groups. Each cluster possesses a CH node, and each CH receives data from all SNs and it can communicate to the BS. The SNs were located with primary energy. In contrast to the conventional routing protocols, the lifespan of the network, as well as energy utilization, were considered the important factors. It was attained by selecting appropriate CHs. In 2018, Rahul Priyadarshi *et al.,* [31], developed a model that chooses the CH in 2 phases. In the initial phase, the CHS was performed by professed probability. In the next phase, the CHS was performed by survival time approximation. Finally, the experimental outcomes exhibit that the network the adopted model performance was superior to conventional models regarding the network lifetime and nodes' energy.

In 2015, Payal Khurana Batra and Krishna Kant [37], worked on the LEACH protocol, which pursues a Dynamic DDR approach for clustering. Because of the arbitrariness that occurs in clustering approaches, the number of CHs produced deviates highly from the optimal number. Here, a model was presented that endeavors the arbitrariness available in LEACH's clustering approach. In 2018, Liang Zhao *et al.,* [50], worked on the disadvantages of difficulty to deal with CHS and extreme energy utilization in WSNs. Here, a modified CHS approach based on LEACH i. e., LEACH-M was developed. On the basis of the DAAM of ZigBee, both

Table 2
Comparison analysis of different clustering algorithms

Authors [citation]	Adopted methodology	Features	Challenges
Akhilesh Panchal and Rajat Kumar Singh [2]	EEHCHR	It enhances the overall network lifetime.	Minimum performance on dense networks
Amir Abbas Baradaran and Keivan Navi [13]	HQCA	During the clustering process, high reliability and, low error rate occurs.	The cluster estimation was not performed on the basis of the density, as well as the peripheral density of each node.
Sehar Umbreen *et al.* [15]	EEMCS	By performing re-clustering overcomes the overhead of cluster formation and also saves energy.	It does not support heterogeneous nodes.
Eid Rehman, Muhammad Sher, *et al.* [21]	Energy-Efficient Secure Trust-Based Clustering Approach	The average rate of avoiding malicious nodes as a CH.	For Cluster formation Deficiency in quality solutions.
Bilal R. Al-Kaseem *et al.* [23]	SEA	It is successful in enhancing the lifetime of the network.	Not appropriate for unequal clustering
K. Sindhanaiselvan *et al.* [42]	EBCH	It attempts to prolong network lifespan by minimizing the utilization of energy.	Suggested a multipath routing approach to further improve network lifespan.
Zhu Xiaorong and Shen Lianfeng [43]	Hausdorff clustering	It considerably maximizes the network lifespan.	Inappropriate for large-scale networks
Mukil Alagirisamy and Chee-Onn Chow [45]	EEUC	Total energy utilization and, average energy utilization are less.	Because of its high costs, it is incompatible with high-density networks.
Abdulhamid Zahedi *et al.* [47]	Reservation-based clustering Approach	It minimizes the control messages in the entire network efficiently.	It does not pay attention to the application for the routing protocols.
KyeDong Jung *et al.* [52]	FL-TEEN	It performed an enhancement of performance in the lifetime of sensor node lifetime.	Recommended different fuzzy input functions to improve further energy effectiveness.
M. Narendran and Periyasamy Prakasam [53]	RCC	It discloses the enhanced lifetime of the network throughout information transmission.	For cluster formation, insufficiency in show quality solutions
Ganesh Jayaraman and V. R. Sarma Dhulipala [56]	Fuzzy-based energy-efficient CHS approach	It extends the lifetime of the network	It needs to analyze the efficiency of sensor nodes in a mobility environment.
Susan Augustine and J. P. Ananth [68]	Taylor KFCM	It is precise for clustering and enhances energy effectiveness with a superior lifetime of a network.	It does not work on real experiments.
Seyyed Mehdi Hosseini *et al.* [73]	Energy-effectual Fuzzy LEACH	The computational time is low and increases the network lifetime	It affects environmental noises.
Deepak Sharma1 and Amol P. Bhondekar [84]	EHTEAR	The energy-harvesting is appropriate to realize the realistic WSNs, which are suitable for the IoT arena.	The routing decisions are not performed.

the node's network address and residual energy were considered to optimize the CH threshold formulation. Moreover, the proposed model effectively balances network energy load and considerably enhanced energy effectuality by leveraging a CH competitive model.

In 2019, Xu Xing Ding *et al.,* [64] worked on the LEACH approach, which chooses the CH arbitrarily in WSN. In real-time cases, the proposed model affects the distribution of the clusters for the obstruction shadowing effect. Here, to eradicate the obstruction shadowing effect the logarithmic function was exploited. Here, the appropriate cluster was organized due to the density of the nodes that were elucidated as the value of the new threshold. In 2020, Amine Kardi and Rachid Zagrouba [74] developed a radial CHS model for homogenous WSNs. It aspires to make sure superior load balancing and improve network lifespan. The performance analysis was performed among the LEACH, Multi-Chain-PEGASIS, and Mod_LEACH, protocols, and the adopted model regarding the lifetime of the network, stability/instability periods, and development of the number of CHs was performed in this study. Table 4 summarizes the comparison analysis of different LEACH algorithms.

a) Categorization of other CHS approaches

In this section, the other CHS approaches for the WSN-IoT are described.

In 2021, TriptiSharma *et al.,* [6] worked on soft computing-based CHS models for WSN. Based on the several parameters, the approaches were evaluated that aid the investigators to learn the optimal and suitable soft computing based CHS approach on the word of their requirements and application for further study in this enthusiastically rising field. Subsequent to the analysis of several soft computing approaches it was identified that the soft computing application-based approaches have done the routing approaches highly adaptive, high energy effective with enhancement in the transmission of data as well as stability period. In 2019, Amanjot Singh Toor and A. K. Jain [7], developed a new model on the subject of mobile sensor nodes named MEACBM routing protocol for hierarchical heterogeneous WSNs. Based on a recently developed probability equation the CH was selected, and it chooses merely the SN as CH and it has maximum energy between other SN. Subsequent to the sensor nodes deployment and clusters formation in MEACBM, the entire network area was partitioned into sectors as well as within each sector a mobile SN was positioned that acted as an MDC to collect the information CHs. This approach aids in considerably reducing the energy exploitation of sensor nodes to transfer the data to BS. In 2021, Hyun-Ho Choi *et al.,* [16], worked on the optimal CH with minimum complexity as well as overhead. An asymptotic geometric analysis was performed, which ascertains the optimal CH coordinates in the considered area of the sector. Therefore, a few sensor nodes close to the optimal coordinates required were examined. In 2017, V. Baby Shalini and V. Vasudevan [25], worked on the CH, and from each cluster, non-cluster member nodes will transmit the sensed data to CH. It can forward the information to the end-user. The EDCHSM was developed to deal with CHS which causes the overlapping coverage and unbalanced utilization of energy within the communication of the cluster.

In 2019, Radha Ranganathan *et al.,* [29], modeled a fuzzy-based CH modification to minimize the utilization of energy and network lifespan increases. Using the BS, the Topology between CH was dynamically modeled. The CH that relies on multiple shortest paths was probable to deplete its energy earlier, while the CH acts as an AP. Therefore, the criticality between's centrality and remaining energy as metrics to decide the periodicity of changing the CH was selected. In 2016, Bibudhendu Pati *et al.,* [32] developed a CH selection algorithm called an Energy-effectual algorithm to choose the CH that works with two approaches ECHSA-1 and ECHSA-2. The first approach works with the NE decision of the game theory.

Table 3
Comparison analysis of different AI techniques

Authors [citation]	Adopted methodology	Features	Challenges
K. Thangaramya *et al.* [9]	Neuro-Fuzzy Based Routing model	It maximizes energy utilization and increases network lifespan.	It does not present effectual secure routing.
Vahid Jafarizadeh *et al.* [58]	Naive Bayes	It supports multiple networks without spending more amounts of money and time.	Recommended to add new features to the approach and cause development in a particular application.
Rakesh Kumar and Manju Gangwar [80]	ANN	It saves energy transmission and enhances throughput.	By avoiding collisions, overheads are controlled during communication.
Farah Sanhaji *et al.* [85]	NN	Network lifetime is maximized.	Obtaining an optimal network structure is difficult.

Then, the ECHSA-2 algorithm works based on the SPNE the CH was chosen on the basis of this SPNE decision. In 2018, S. Anthony Jesudurai and A. Senthilkumar [33], worked on the IEECHS protocol -WSN. Here, it was exploited to transmit the received information and it was done by energy effectual routing protocol. In the selection of the CH election process, 2 CHs were elected in an alienated cluster and their work in several functions. By means of this process, the network lifetime was prolonged as well as the consumption of energy was reduced for IoT applications. For data entropy, the adopted model was elucidated on clustering of dual CHs in the technique of data integration.

In 2020, Kalaivanan Karunanithy and Bhanumathi Velusamy [34], developed a CTEEDG protocol to maximize network lifespan and the throughput of WSNs. Fuzzy logic was exploited by the CTEEDG to choose the CH on the basis of information gathered locally. The tree topology was set up amid clusters towards BS in the inter-cluster communication phase. In 2021, Shivshanker. P. Biradar *et al.,* [35], developed a new OCE-CHS algorithm for sensor nodes. It was exploited to manage the ratio of packet success and minimize energy debauchery. It was significantly differentiated from node-based clustering which uses a distributed clustering approach to select CHs based on the current node speed and residual node energy. In 2017, K. Lakshmi Joshitha1 and S. Jayashri [36] worked on 2 approaches to improve the linear iterative regression lifetime on the basis of the clustered network. As the energy of CH depletes below a threshold because of traffic performed, the cluster node of the dead heading node was assigned to a few conventional suitable CHs in the network. In 2018, Huarui Wu *et al.,* [38], proposed ECRRS, which was a novel routing protocol of WSN. The density of network topology, residual node energy, and distance to sink was under consideration in CHS. The proposed model enhances the effectuality of the network energy when performing the equalization of power utilization. An energy threshold of CH was exploited to minimize the CH rotation frequency. In order to fulfill the network connectivity, a relay node selection approach was exploited in large-scale farmland applications and the utilization of power was reduced far end CHs. In 2011, Jinchul Choi and Chaewoo Lee [39], worked on a new energy-based MODE to calculate the consumption of energy in a multi-hop WSN clustered with probabilistic CHS. Subsequently, the optimal probability was determined which increases the network lifespan. Finally, the experimental analysis attained by the proposed Monte Carlo approach exhibits energy consumption from a network was minimized. Additionally, precisely the optimal clustering probability was predicted. In 2019, G. Prabaharan and S. Jayashri [40], developed a new mobile data gathering model in WSN. Here, the soft-computing-based CHS, as well as clustering, was performed. It was based on the fuzzy inference model. The smart CHS, as well as data gathering in vehicular, was performed. It was exploited to minimize energy consumption as well as time. Therefore, by reducing energy consumption, the network lifetime was maximized.

In 2021, Akhilesh Panchal and Rajat Kumar Singh [44], developed an energy effectual model for the selection of the optimum number of CH and GH that expands the lifespan of the network. Initially, an optimum number of clusters expression was given, after that, a novel model was proposed to choose the optimum number of CHs in an energy effectual way. The idea of GH was introduced in an effectual manner that works in a dynamic way to save the CHs energy. In 2014, Devesh Pratap Singh *et al.,* [48], developed a CHS by Randomness with Data Recovery in WSN approach to decide on appropriate CH concerning data recovery within the cluster. The adopted model such as CHSRDR was considered the heterogeneity in power and maintains a cluster of vice-heads based on arbitrariness in the cluster; these vice-heads can act as a head in prospect, while the main head comes to the end of power. In 2013, Shan Lianhai *et al.,* [55], presented a cellular-assisted CHS approach for the WSN. It was considered various metrics to select the optimal UE gateway CH. The information transmission energy cost from a sensor node to a subsequent node was analyzed. It computes the complete energy cost of a system for WSN.

In 2020, Pramod Singh Rathore *et al.,* [59], designed a novel approach to select CH. The aim of the CH was based upon node distance

Table 4
Comparison analysis of different LEACH algorithms

Authors [citation]	Adopted methodology	Features	Challenges
Trupti Mayee Behera *et al.,* [14]	R-LEACH	It enhances the performance of the network for measures like remaining energy and throughput.	It needs to test in diverse realistic cases for a WSN-IoT system.
Kumar, N. *et al* [28]	Gaussian distribution	It maximizes the network lifespan and reduces energy utilization at the time of the transmission data.	It is not appropriate for real-world applications
Rahul Priyadarshi *et al.,* [31]	Advanced-LEACH	It overcomes the energy imbalance, increases information redundancy in the transmission of data, minimizes energy utilization and extends network lifespan.	It lacks security and privacy
Payal Khurana Batra and Krishna Kant [37]	LEACH-MAC	It extends the entire network lifespan protocols.	Suggested heterogeneous networks in order to apply in a real-time environment.
Liang Zhao *et al.,* [50]	LEACH-M	It considered both the residual energy and network address to amend CH threshold formulation.	It does not present a more practical and dependable CHS.
Xu-Xing Ding *et al.,* [64]	LEACH	It prolongs network lifespan	Suggested to expand enormous sensor acquisition cases with obstruction factors.
Amine Kardi and Rachid Zagrouba [74]	Modified -LEACH	It maximizes the lifetime of the network, and stability.	It does not cover throughput and the development of energy utilization in the network.

Table 5
Comparison analysis of other CHS algorithms

Authors [citation]	Adopted methodology	Features	Challenges
TriptiSharma et al., [6]	Soft Computing approaches	It is highly adaptive, and energy effectual with enhancement in a stability period.	Necessitates in the enhancement of network security
Amanjot Singh Toor and A. K. Jain [7]	MEACBM	It minimizes the energy utilization of sensor nodes to transfer the information to the BS	Increases the overhead and threshold-based functions are reduced.
Hyun-Ho Choi *et al.,* [16]	Asymptotic geometric analysis	It maximizes the sensing data rate when minimizing the feedback overhead considerably.	It needs optimal CH selection with low overhead.
V. Baby Shalini and V. Vasudevan [25]	EDCHSM	It overcomes the imbalance of energy exploitation and increases network lifespan.	Recommended the re-division of the observing area subsequent to the death of all redundant nodes in a similar coverage area.
Radha Ranganathan *et al.,* [29]	Fuzzy-based CH amendment	It balances the energy utilization and therefore enhances the s lifetime of the network.	It does not test the mobile case.
Bibudhendu Pati *et al.,* [32]	SPNE	The lifetime of the network is higher.	In the network, some nodes suffer from a reduced amount of battery power.
S. Anthony Jesudurai and A. Senthilkumar [33]	IEECHS-WSN	It has superior network lifetime, throughput, and energy utilization.	Try to improve the simulation by considering more challenging series.
Kalaivanan Karunanithy and Bhanumathi Velusamy [34]	CTEEDG	This protocol generates better outcomes while it is simulated for industrial automation.	Focused on performing real-time experimentation for instance industrial applications using CTEEDG protocol.
Shivshanker. P. Biradar *et al.,* [35]	OCE-CHS	This method managed the energy and it enhances the network scalability.	This method does not experiment in a complete 5G environment.
K. Lakshmi Joshitha1 and S. Jayashri [36]	Secondary cluster head allocation model (SCH)	This approach is superior for the performance enhancement of the network with the lifetime development and throughput enhancement.	This model lessens the issue of coverage hole produced in the network.
Huarui Wu *et al.,* [38]	ECRRS	It enhances energy effectiveness, minimizes the cluster head rotation cost, extends the network lifetime, and balances node energy utilization.	It is difficult to discover the optimal sets of CH nodes
Jinchul Choi and Chaewoo Lee [39]	Monte Carlo method	It ascertains the optimal probability that increases the network lifetime.	Deriving the number of hops is essential for more precise modeling.
G. Prabaharan and S. Jayashri [40]	Soft computing approaches	It ensued in minimum packet loss, high residual energy, and minimum collection delay.	Focused on multiple vehicular assemblies by priority-based collection.
Akhilesh Panchal and Rajat Kumar Singh [44]	EOCGS	It saves dynamically energy of the CHs.	It causes additional complexity.
Devesh Pratap Singh *et al.,* [48]	CHSRDR	It provides a data recovery method.	Suggested on the competent allocation of the task within the cluster.
Shan Lianhai *et al.,* [55]	Cellular-assisted UE	It prolongs the sensor networks lifetime.	It does not consider the sensor nodes' ability to know the positions.
Pramod Singh Rathore *et al.,* [59]	SPSRN	It leads to a nominal reduction of node energy of the source cluster.	Suggested to implement this technique with fuzzy and bio-inspired techniques for enhanced outcomes.
Y. Harold Robinson *et al.,* [60]	MLSEEP	It exhibits the energy effectiveness, computation overhead, and trustworthiness of the network.	Recommended performing a new data aggregation model with private communication security approaches.
Rajkumar Mylsamy and Subramanian Sankaranarayanan [62]	2PTH	This approach forms the foundation for stable communication and trust enabled.	It does not support design trustworthy.
Muhammed Tay and Arafat Senturk [65]	C3HA	It is a highly efficient model for CH selection exploited in WSNs.	Few nodes might overlap in a random distribution of the nodes.
Teng Gao *et al.,* [69]	FAHP	It enhances the energy effectuality and the network lifetime.	To promote robustness the spare CH model must be developed.

as well as node energy. The CHS aspires to minimize the utilization of energy and to prolong network lifespan by set up the shortest path relay node idea. While some sub-cluster nodes were closely loaded, this ensues in more rapid energy utilization, as well as to attain the normal energy reduction; the selected trajectory cluster was started. In 2018, Y. Harold Robinson *et al.,* [60], developed a novel power-aware routing protocol for WSN on basis of the fuzzy logic and threshold rate to enhance the effectuality of energy. In WSN, CH was elected based on every node's probability values that were computed from the remaining energy of every node. To compute the mean energy of the complete network of the present stage, the cumulative remaining node energy was exploited. Here, the fuzzy control uses 3 metrics such as node queue length, the distance from a node to the BS, and node residual energy.

In 2015, Rajkumar Mylsamy and Subramanian Sankaranarayanan [62], developed a preference-based protocol for trust and head selection (2PTH) model for communication privacy from intermediate malicious nodes. A 2PTH approach was an amalgamation of a PTA. To find out routes with trusted nodes, PTA was developed to determine a route without malicious nodes to forward the packets on the basis of the weight assignment to trust parameters. In 2021, Muhammed Tay and Arafat Senturk [65], worked on a clustering model for WSNs to reduce energy consumption. Therefore, the lifetime of the network was increased in the WSNs. The C3HA that was adopted in line with this purpose presents a novel viewpoint to the CHS whilst making a high effectual WSN. This adopted model was evaluated with conventional approaches, it was exhibited that the proposed model was effective regarding speedy and precise CHS.

In 2012, Teng Gao *et al.,* [69], developed a new fuzzy multiple criterion decision-making model. It was exploited to optimize the CHS to model a distributed energy-effectual clustering approach. To choose the optimal CHs, the Fuzzy multiple attribute decision-making was developed considering each and every metric falsely. Following this criterion, by exploiting the fuzzy Integral each node calculates a composite value. Table 5 summarizes the comparison analysis of other CHS algorithms. Fig 4 demonstrates the classification of approaches used in CHS for WSN-IoT.

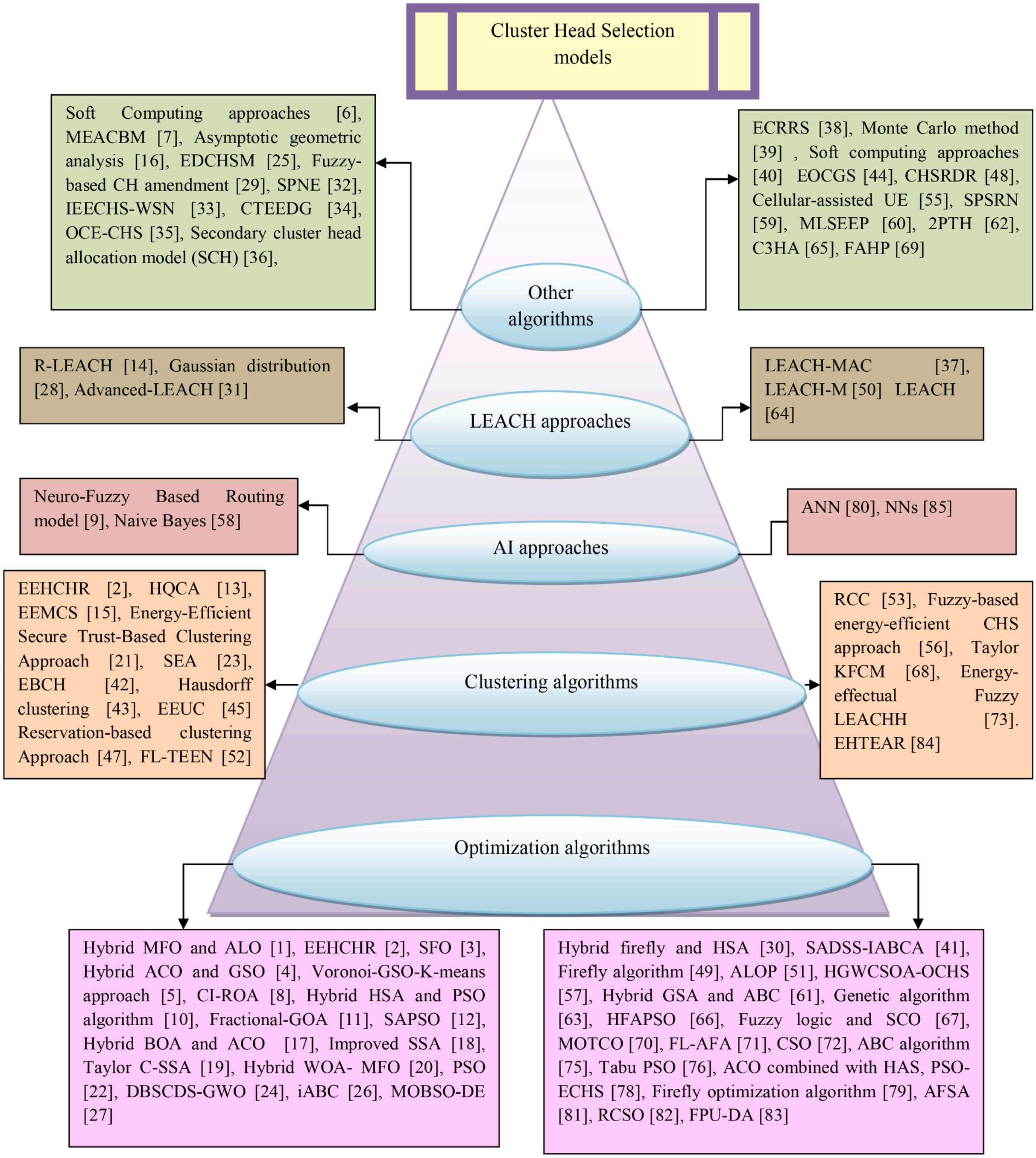

Fig 4. Taxonomy of approaches used for Cluster Head Selection in WSN-IoT

4. Research gaps and challenges

This section demonstrates the research gaps and challenges encountered by the conventional CHS approaches in WSN-IoT. This research is performed systematically by considering the scientific basis in the field of CHS on approaches in WSN-IoT. In addition to the energy conservation, another major challenge faced by the WSN-IoT is restricted resources of computing sensor nodes. Also, the main issue is to conserve the energies by prolonging the network lifespan [1]. To operate the sensor nodes, the batteries, which comprise a fixed energy source, were exploited; therefore, recharging numerous batteries is not practical and is considered a most important problem [4]. One more challenge in WSN-IoT that exists in the literature is the security that lies in between increasing the security as well as reducing resource utilization. Nevertheless, several researchers have dealt with certain solutions, although many of them feel that multiple security challenges must be convened to provide optimal security to WSN. For the last few decades, there is enduring research on the solution to traffic load throughout the network in WSN-IoT that should be reduced. Along with this, the cost of transmission over the network is also a challenge, which should be minimized [15]. In WSN-IoT, the QoS requirement is considered another focal point of novel technologies. Numerous metrics, such as E2E delay, load, throughput, and temperature, are approximately disregarded when selecting the CH in WSN-IoT [17]. Therefore, there is a requirement to consider the aforesaid QoS parameters in cluster-based routing techniques for real-time WSN-IoT applications. Additionally, there are numerous other limitations especially associated with CHS. One such limitation is the distance of the CH from its cluster members and other

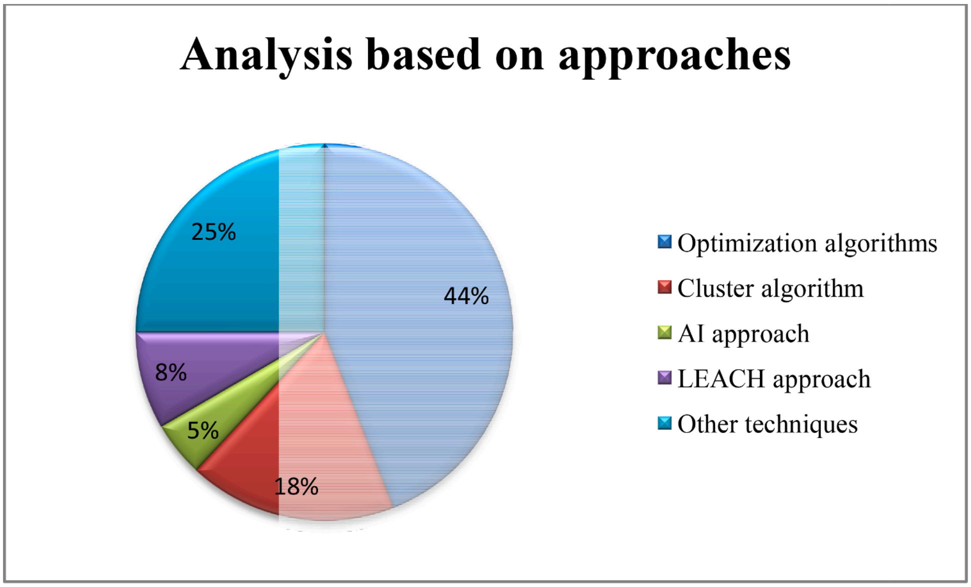

Fig 5. Analysis based on approaches

Table 6
Analysis perform based on publication year

Years	No of published papers
2022	2
2021	16
2020	17
2019	27
2018	7
2017	8
2016	3
2014	1
2013	1
2012	1
2011	1
2007	1

cluster members [33]. In a zone, the location and the CH placement determine the energy utilization of its members. The CH distance from its cluster member is named intra-cluster distance and the CH distance from the members of the other clusters is named inter-cluster distance. The clusters, which possess more intra-cluster distance, utilize maximum energy when compared with the other clusters. The security and privacy of information and network must be equipped with these fundamental principles like authentication, integrity, confidentiality, availability, and authorization. In contrast to the Internet, the WSN-IoT will be used for the most noteworthy global economy. For example, healthcare, transportation, home, smart city, personal and social. Hence, the security and privacy problems are mainly fretful that require to be addressed in WSN-IoT.

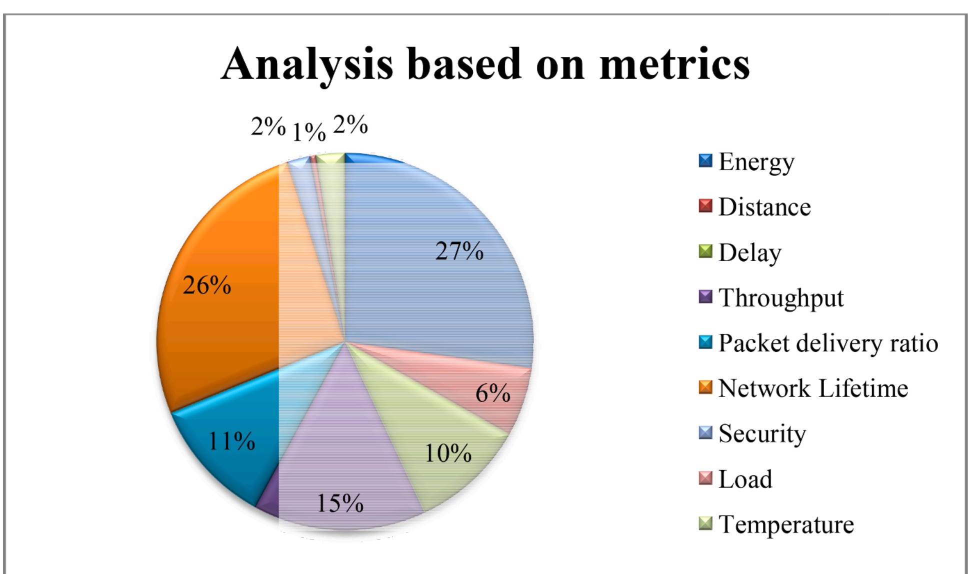

Fig 6. Analysis based on metrics

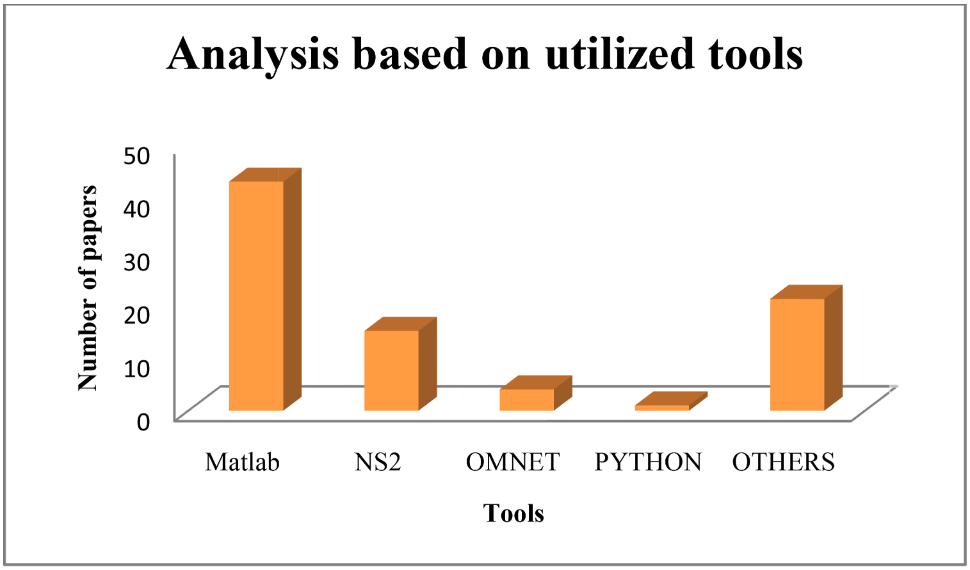

Fig 7. Analysis based on utilized tools

5. Analysis and Discussion

The analysis and discussion of CHS in WSN-IoT are illustrated in this section. Here, by exploiting several research papers, the analysis is done on the basis of the software employed, categorization of techniques, publication year, and performance evaluation metrics.

5.1. Analysis based on Approaches

This section elucidates the analysis by exploiting several CHS approaches in WSN-IoT employed in the existing works. Fig. 5 demonstrates the approaches that exploited CHS approaches in WSN-IoT. From Fig 5, it is clearly evident that 44% of the research papers exploited optimization-based algorithms and 18% of the research developed was based on clustering algorithms. In addition, LEACH approaches were used by 8% of researchers, and 5% of the research work exploited AI-based approaches. Moreover, 25% of the researchers utilized other techniques. From the analysis, it is noted that optimization-based algorithms are the most commonly used approaches for CHS in WSN-IoT.

5.2. Analysis based on Publication Year

This section summarizes the analysis made based on published years. The analysis using the published Year is represented in Table 6. Out of the 85 papers reviewed, it is determined that more number of research papers is published in the Year 2019 and the least number of paper were published in the year 2014, 2013, 2012, 2011, and 2007.

5.3. Analysis based on Metrics

In this section, various metrics that are used for the evaluation of performance taken from the 85 research papers are evaluated. The clear description of the metrics is stated as follows:

(i) **Energy:** Energy is the most important measure to measure the WSN-IoT performance. Initially, the node's energy will be high. If there are no appropriate energy-aware models, the energy starts to decrease. The node's energy decreases speedily which leads to the deprived performance of the complete network.

(ii) **Delay:** From source to destination, the transmission of packets in minimum time improves the performance of the network. Hence, measuring the delay in transmission of packets to the destination is based upon the propagation delay and transmission delay.

(iii) **Temperature:** In both sensor node and CH, the sensor node temperature will augment during the transmission and in receipt of the data from the sensor node to the CH.

(iv) **Load:** In general, the CH maintains the IoT network load. In the cluster, the sensor nodes transmit the data to the CH. The CH transmits the aggregated data to the Base station. The load of the CH must be least to augment the network effectiveness.

(v) **Distance:** By every sensor node, the evaluation of distance from CH is done. Therefore, a node can be managed only by an accurate cluster while the distance from CH of that cluster is minimum.

(vi) **Throughput** It indicates the total data rates transmission over the network within a specific time.

(vii) **Packet delivery ratio:** It defines the ratio of data packets delivered effectively to the base station with a diverse number of nodes.

(viii) **Network lifetime:** Higher the lifetime of the network, the network performance is enhanced.

(ix) **Security:** The security mode chooses the CH, which assures the security demand. Additionally, the WSN-IoT requires security constraints, which transmit the data with suitable authenticity, integrity, reliability, confidentiality, and availability.

Fig. 6 demonstrates the analysis based on those metrics. For the analysis, the evaluation metrics experimented with are found to be energy, delay, network lifetime, distance, throughput, packet delivery ratio, security, temperature, and load. It is noticed that approximately 27% of the research papers used energy as the evaluation metric, 26% of the research papers have used the network lifetime, and 15% of the research papers used throughput as the performance metric. Moreover, 11% of the research papers have used the packet delivery ratio. When 10% of the research papers have utilized the delay, the number of papers that used security and temperature is 2%, and finally, the number of papers employed load as the metric is 1%.

5.4. Analysis based on Implementation Tools

In this section, it is evaluated that the conventional models have experimented on various platforms. The experimentation section aids the researchers in how to model, and simulate outcomes effectually on the particular platform. From Fig 7, it is clearly evident that more number of researchers have efficiently simulated their research on the platform MATLAB. MATLAB is used in 43 research papers, while NS2 simulator is used in 15 research papers. The OMNET simulator is used in 4 research papers, and python is used in 1 paper. There are also papers, i. e., 22 works that were simulated in several other kinds of platforms, such as C, JAVA, dot net, etc.

6. Conclusion and Future work

- Ø In this paper, a systematic way analysis based on several CHS approaches in the WSN-IoT was performed. This paper analysis numerous papers that were collected from 85 research works and collected papers were categorized in terms of various methods, which were categorized based on the optimization algorithms, clustering techniques, Artificial Intelligence techniques, LEACH approach, and other approaches for the CHS.
- Ø The review of conventional models recommends future works for the CHS in the WSN-IoT by taking into consideration of various research gaps and issues. Moreover, the analysis of the review is considered regarding the categorization approaches, utilized implementation tools, publication years, as well as evaluation metrics.
- Ø From this review, it is clear that optimization-based algorithms were commonly exploited in numerous works; and also MATLAB is often employed as the implementation tool in conventional papers.
- Ø Considering the aforesaid literature review, a hybrid approach for CHS can be proposed. We can further enhance the proposed model by presenting the WSN-IoT network in the pervasive healthcare application using the Meta-heuristic optimization algorithm based on Machine learning.
- Ø In WSN-IoT, the major challenge is to choose a suitable CH. Therefore, the CHS techniques can be examined on the basis of different parameters, like trust detection, distance-based selection, energy-based selection, delay, packet loss ratio, transmission load, QoS, and temperature constraints.
- Ø Here, the meta-heuristic optimization algorithm can be used for distance-based selection, energy-based selection, delay, packet loss ratio, and network lifetime. Additionally, the Machine learning algorithm can be exploited for trust detection, transmission load, QoS, and temperature constraint.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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