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Recent Advances in Clustering and Energy Efficient Routing in WSN

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ABSTRACT

Multiple technologies are employed in modern sensor network research to improve upon past studies that prioritised efficiency and novelty above cost. This survey fills in the blanks on previous models by providing full information about them. In wireless sensor networks (WSNs), energy management is a primary concern, which is why clustering is employed. Multihop routing in a clustered setting was the primary focus of this investigation. Our research is separated into three distinct areas, each of which is founded on a different methodological tenet: (1) parameter-based, (2) optimization-based, and (3) methodology-based. Several methods were found for this general class, and their idea, parameters, benefits, and drawbacks are discussed in length. Through this effort, we hope to provide readers with the resources they need to further explore potential research topics and create an original model that addresses the limitations of current WSN-based clustering solutions.

Keywords : Clustering, Energy Consumption, Throughput, QoS

I. INTRODUCTION

1.1. Wireless Sensor Networks

A wireless sensor network (WSN) network is characterized as a small-scale gathering for sensor hubs, especially for sensing, monitoring, capturing, and processing the information concerning an application. Therefore, generally, these hubs completely rely on battery backup, storage, data size, computation, and bandwidth [1]. Nowadays, WSN has become unavoidable in daily life; hence, many studies tend to focus on specific application properties [2].

Real-time applications have attracted attention among technocrats and analysts because of the recent breakthroughs in the sensor field. To overcome the difficulties in the sensor field, scientists and technologists have found an answer in the utilization of real-time WSN applications. Real-time sensors have the ability to detect, record, and send feedback immediately to the end client for future processing of all the gathered data. In particular, a real-time application addresses the presentation of basic applications that need limited delay latency. For the current situation, the real-time application involves the extensive application of WSN, which has much potential for applications in different kinds of research. The main advantage of the real-time application is its capability of screening thenvironment very quickly, providing an immediate response to the client, and easily controlling the outside environment. The outside environment is directly linked with the computer framework through multiple sensors, input and output gadgets, and actuators. WSN can empower the network limited delay guarantee, which is fundamental for an end-to-end packet delivery known as real-time WSN [3] as shown in Figure 1.

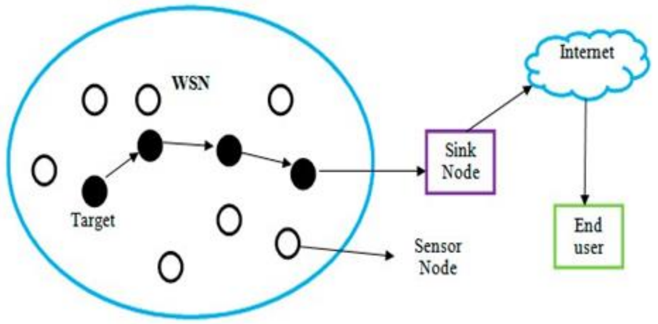

Figure 1. Wireless sensor network (WSN) architecture.

Events in real life can be changed into information, which can be saved, processed, and utilized for future purposes by sensor hubs in a WSN. Every sensor hub is changed in a particular manner as per their condition, for example, if the installation of a sensor node is underground, it should then have transceivers with high power transmission to block attenuation of noisy channels while on the off chance that the sensor is set in a marine situation [4]. At that point, a sensor's external shell/encasement needs to withstand the impact of salty and damp environments and being waterproof would be another significant and advantageous component. Each change in the environment can be monitored by sensors and that information can be sent to the main server in which decision-making processes can happen in real-time. Catastrophic failures can be reduced by the sensor networks via constant and solid monitoring of the environment [5]. Hence, WSN consists completely of sensor hubs and can communicate wirelessly. Sensor node architecture is explained in the next sections [6].

1.1.1. Sensor Node Architecture

Advancements in the field of wireless communication have made improvements in WSN, such as gadgets known as sensor hubs, conceivable. Naturally in WSN, thousands of sensor nodes are utilized for the network because the lifetime of a sensor node basically relies on its battery, and these nodes are inclined to become damaged when they are circulated [7]. Sensors can be properly utilized in places in which it is difficult for a human to handle the environment. Small sensor hubs consist of three primary phases:

1. To receive the data;
2. Processing of data;
3. Data transfer through wireless communication.

Sensor hubs' main advantages are low power, small size, sensing capacity, data transmission through wireless communication, and computation which is shown in Figure 2.

1.1.2. WSN Types

WSNs can be classified into five types depending on the situation for which the network is chosen.

Terrestrial WSN

This type of WSN has many minor hubs, which are randomly deployed in a particular region in which the communication is ad hoc.

Generally, two- or three-dimensional, grid, or optimal placement are utilized to organize these nodes. The main drawback of this type of WSN application is the impact that poor weather conditions, such as snow and rain, have on optical wireless communication interfaces.

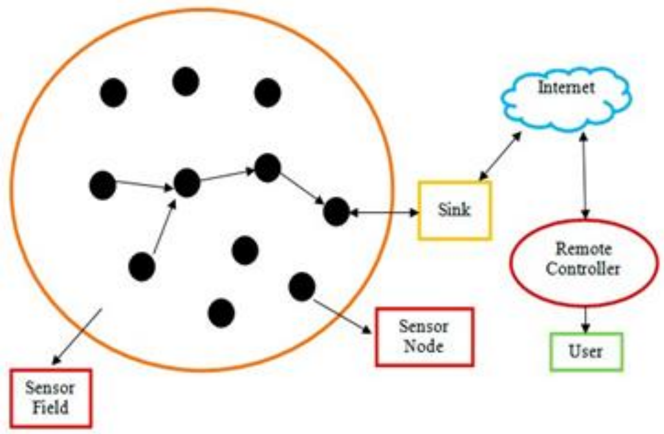

Figure 2. Sensor node architecture.

Underground WSN

In this type of WSN, sensor hubs are placed underground for gathering data about underground conditions. The downside of a WSN is the restricted battery power, since under these types of conditions, it is extremely hard to monitor energy or changes in the environment.

The main drawback of wireless communication is the loss of signal during high potential conditions. To improve WSN reliability, productive routing algorithms are required for explaining the confinement of the WSN's precision during the routing process [8].

Underwater WSN

Underwater WSNs (UWSNs) incorporate expensive sensor hubs for gathering data about underwater conditions; hence, these hubs can be placed directly underwater. Very poor network signals, limited bandwidths, and network delays are some of the restrictions in this type of network [9].

Mobile WSN-

One of the main advantages of a mobile WSN is the automatic changing of the sensor hub's position when the power changes in response to the environment.

These types of hubs are generally attached to the computer for communication. This type of hub can collect data from a wide range of regions or data from other hubs in the network. The primary limitations of this type of WSNs are high maintenance, low navigation, poor coverage of zones, and high accessible status [10].

Multimedia WSN

Multimedia WSN applications have modest sensors, and they can detect, compute, actuate, and communicate. Use of the WSN incorporates home observation, traffic management frameworks, and environmental checking.

These types of WSN devices are interconnected in wireless communication and are capable of recovering video and sound transmissions and scalar sensor information from the earth [11].

1.1.3. WSN-Main Prerequisites

Power Efficiency

WSN utilizes a sensor that results in low power use. The response time is exceptionally quick in view of its constraints.

Reliability

Many techniques are used for power reduction in WSN hubs, which bring about an expansion in the system's lifetime and consistency.

Scalability

WSNs can extend this system to include hubs as required. Its extensions should be easy to manage.

Mobility

Mobility is an essential component of WSN. Since WSN is a remote system, no wire is utilized for this system. This is the reason mobility is a key component of WSN.

1.1.4. WSN-Security Vulnerabilities

WSNs are widely used for intelligent monitoring of many parameters, including vehicular actions on streets, temperature, humidity, passages and structures, water level, pressure, criminal surveillance in streets and alleyways, remote checking on numerous patients, and numerous different other applications [12–14]. As previously described before, each WSN organization is subject to and must be adjusted by considering the nature of the establishment.

At any rate, the main research challenge is real-time communication, which completely relies on an application, such as event-driven, nonstop, and question-driven applications. In these applications, if the data packets are beyond the cut-off, it is viewed as influencing the framework execution and quality [5,15,16].

1.1.5. WSN-IoT

Since the establishment of the IoT model, WSNs have been found to be its critical enabler. In IoT, all the sensor nodes can connect to the internet for sharing and receiving information, whereas in WSNs, there is no direct connection to the internet for the nodes. All nodes in WSN require a mediator to connect to the internet. Significant research has been done in recent years on bridging WSN into IoT. When it comes to bridging IoT and WSN there are plenty of security breaches that need to be addressed and hence there is a great scope of research in this area which has been addressed by some of the notable researchers in their papers [17–19].

1.2. Clustering

WSN consists of a huge number of sensors but has limited battery power. Naturally, WSN hubs can work under harsh and hazardous environmental conditions; however, the battery cannot be recharged or replaced in these situations. Hence, energy conservation is essential for the network. Generally, routing protocols have an immense effect on energy utilization in which energy utilization is considered the main consideration while designing the routing protocol [20].

Cluster-based routing protocols are known to be best in the concept of energy savings for any type of sensor in order to increase the network's lifetime. A group of sensor hubs is generally eluded as clusters. In this group, an extraordinary hub called the cluster head (CH) and member hubs, known as ordinary nodes (ON), are used. The CH can select high energy and is utilized for data collection and transmission of other hubs to the base station (BS) [21]. In this type of protocol, the messages that pass through the system can be decreased [21,22] and the sensed data can be transmitted by sensor hubs to the corresponding CH. The BS can collect data from all of the available CHs in the network via an intermediate CH, which purely relies on the type of WSN architecture that is selected [23]. The CH sensors information after accepting the information from the cluster member; this process is accomplished in order to dispose of repetitive information so that just the outright information is transmitted. This type of transmission is done to spare energy since energy utilization is considered one of the prime factors in WSN selection [24].

Clustering techniques generally increase scalability and significantly reduce radio transmissions [25–28]. A definitive goal of clustering is to offer an answer that maintains dependability among sensors throughout the system's activity [29].

1.2.1. Clustering—Design Challenges

In a large portion of the WSN open-air applications in some critical situations, such as those that are unattended, maintaining the battery is complicated. With this limitation, it is very difficult to extend the lifetime of the network.

Alongside the previously mentioned drawbacks, some different difficulties, which should be satisfactorily addressed while designing clustering algorithms exist, are listed below.

1. For clustering protocols, the number of clusters and formation processes are very essential. Balance among clusters is very important, and at the same time, message exchange during the formation of the clusters must be minimized.
2. The algorithm complexity increases linearly as the network develops.
3. CH selection is very important because it can directly affect the performance of the system.
4. The most ideal hub should be chosen with the goal that the system steadiness period and general network lifetime should be expanded.

5. In most of the strategies, CH choice depends on a few parameters, for example, energy level and hub location.
6. CH will receive the sensed data from the nodes on which the data aggregation process is performed. That process is the reason that these steps form the key structural challenge [27].
7. A clustering algorithm should handle all types of applications because WSNs are completely application dependent.
8. The clustering algorithm design must support defense applications in which data are highly confidential, for example, military applications and health monitoring [26]
9. Variable energy allocation becomes complicated in many of the researches.
10. While applying the clustering model in a larger network it becomes complicated and energy consumption will be gradually increased.
11. Clustering algorithms are combined with many hybrid models to improve the overall performance of the network. During that process interference of the network is also gradually increased.

1.2.2. Benefits of Clustering in WSN

1. Clustering can execute optimized management methodologies in the network.
2. From the sensor level, the topology of the network and communication overhead are managed by clusters because of hub associations with only the CHs.
3. Clustering can maintain the bandwidth for communication, and it can also prevent redundancy of exchange messages [30].

The section organization of this survey is divided into five parts. In Section 2, the earlier survey studies of clustering methodologies are discussed. In Section 3, an overview of routing protocol-based clustering models is discussed. In Section 4, a detailed discussion concerning clustering and clustering techniques in addition to the objectives, comparisons, pros and cons, and evaluation are discussed. In Section 5, the conclusion of the paper is presented.

II. MATERIALS AND METHODS

There are numerous studies in WSNs addressing different subjects, for example, congestion control [31], quality-of-service (QoS) assurance [32], network lifetime maximization techniques, in-network aggregation techniques, and multiobjective optimization in addition to optimization algorithms.
A series of reviews that describe clustering, optimization, and clustering-based multihop routing protocols are presented in the following section.

2.1 Clustering-Based Routing Protocols

Rathi (2012) divided routing protocols into classical and swarm intelligence methods. At the beginning of this review, classification is described as dependent on a few factors, such as energy efficiency, path establishment, complexity in computation, and the structure of the network, among others. At that point, a grouping consisting of five general classes was introduced. For every one of the classic and swarm intelligence techniques, four classes were then introduced: (1) quality-of-service (QoS) awareness, (2) hierarchical, (3) data-centric, and (4) flow of network. At last, every classification was examined and discussed based on a few parameters, such as aggregation of data, location, and energy efficiency. Moreover, standard measurements were then introduced for the simulation [33].
Rostami (2018) contrasted different homogeneous and heterogeneous networks. This overview presented the difficulties of each analyzed protocol and contrasted them based on some clustering parameters, such as CH numbers, cluster counts and objects, complexity, and intercluster communication. When compared with homogeneous networks, the heterogeneous systems appear to provide better performance because they select the CH having high power, while in

homogeneous systems, all hubs have an even operational and processing capability [34].

Abbasi (2007) presented the first overview and assessment of clustering protocols in WSNs. This overview contains two major categories, namely, convergence time and clustering attributes. Convergence time has variable and fixed parts, whereas clustering attributes have clustering-related properties and processes. After summing up the strategies and their significant objectives, as indicated by the proposed order, the techniques were assessed through parameters, such as cluster overlap and stability, rate of convergence, mobility of nodes, and location awareness [35].

Fanian (2016) introduced a study about techniques that were created according to the low-adaptive clustering hierarchy (LEACH) protocol. This survey depended solely on LEACH-based techniques,

which were assessed in terms of balanced clustering, failure recovery, and the original LEACH. Comparisons were made with respect to clustering properties and processes and CH possibilities. At last, these factors were classified with respect to highlights, such as breakdown retrieval capabilities, multilevels, and configurations [36].

A review by Akkaya (2005) surveyed recent routing protocols and discovered classifications for different methods. Based on this survey, three main categorizations, namely location-based, hierarchical, and data-centric were defined. Every routing protocol was depicted and described under a suitable classification. In addition, protocols utilizing contemporary procedures, for example, QoS modeling and network flow, were additionally discussed [37].

Sha (2013) assigned a multipath routing protocol to WSNs, which are mainly infrastructure- and non-infrastructure-based networks. Each and every classification was studied and analyzed. At last, the methods in every classification were contrasted with respect to time for route setup, lifetime, efficiency, load balancing, and reliability [38].

In 2014, Afsar described an architectural perspective of survey clustering-based routing protocols. In the initial stage, clustering characteristics were explained, and after that, categorization of routing protocols was performed. Clustering techniques are generally classified into two categories, namely, equal and unequal sized clustering algorithms. Depending on their objectives, the clustering technique summary was then prepared and presented in this review. Finally, a comparison with respect to clustering features, such as algorithm complexity, cluster count and size, and mobility, is provided [39].

Riaz (2018) studied and presented an overview of clustering algorithms in which it is demonstrated that the major input parameters are initial energy, node degree, and density. During the CH selection process, the CH node should utilize minimum energy from the total energy consumption. Few of these protocols lead to the development of variable cluster sizes and counts, and sometimes, these protocols create a gap that is very close to the base station (BS) and consumes more energy during communication since the hubs take a longer path to arrive at the BS [40].

Pantazis (2013) focused on energy-efficient protocols and introduced a review of routing protocols that classifies the techniques into three general classes: (1) reliable routing, (2) communication model, and (3) topology model. Every technique presented in this overview is discussed based on advantages and disadvantages, robustness, route metric, scalability, periodic message, and mobility [41].

In a review by Ramesh (2011), various clustering methodologies were categorized and described and special attention to their CH selection procedures was emphasized. These methodologies were then contrasted with the necessity of clustering during each round for CH selection, appropriation of group heads over the system, cluster development required after every revolution of CH, balanced cluster creation, and parameters utilized and help highlight the importance of the CH determination technique on the presentation of these plans. The parameter utilization for this correlation was legitimized by thinking about the impacts of CH selection and its role in network energy efficiency [42].

Singh (2015) examined the advantages and impediments of cluster-based routing protocols using various methodologies. In this review, these techniques were classified based on block, grid, and chain. At last, methods were assessed in terms of cluster stability, scalability, energy efficiency, and delivery delay [43].

Arjunan (2019) introduced a study addressing unequal clustering techniques. These techniques were ordered into three main classes: (1) deterministic, (2) pre-set, and (3) probabilistic clustering algorithms. The presented protocols were described by characterization, targets, attributes, demerits, and merits. Deterministic algorithms were utilized for robust and reliable applications. A heuristic methodology was chosen in cases in which an optimal solution was needed for a specific environment.

All mentioned protocols are contrasted with respect to cluster and CH properties [44].

Dehghani (2015) assessed clustering algorithms for energy saving. Every algorithm is described in detail and its advantages and disadvantages were thoroughly examined [45].

In a 2018 review by Sharma, heterogeneous routing algorithms were discussed. This survey describes four general heterogeneity-based classifications (1) computational, (2) energy, (3) link, and (4) different. Hub heterogeneity levels, CH selection, and sink position were the parameters selected for the comparative analysis of routing algorithms [46].

Liu (2012) introduced a study on network routing protocols and sketched out the advantages and goals of clustering techniques. This survey classified clustering attributes into four main classes: (1) cluster qualities, (2) CH attributes, (3) total proceedings of the protocol, and (4) clustering process. Regarding objectives and capabilities, the clustering method summary is presented. At last, the strategies dependent on the parameters that were adopted for every one of the four classifications and different parameters; for example, the stability of the cluster, scalability, and load balancing were compared [47].

Kaur (2017) examined a few clustering strategies that were previously investigated and referenced by considering in which circumstances these protocols would be suitable for use and in which cases productive outcomes would not be achieved. Some of these strategies were viewed based on distinctive clustering parameters, such as cluster development prerequisites, separation of detecting hubs from the BS, and threshold and residual energy in addition to computation of the ideal number of CHs [48].

In a review by Suhail (2017), general classification and scientific categorization of distributed clustering protocols were prepared. This overview additionally analyzed the bunching plans dependent on the stability and overlapping of the cluster, node location, and mobility [49].

Radha (2015) discussed different clustering techniques, for example, centralized, hybrid, and distributed techniques. This discussion could help researchers introduce a novel clustering algorithm that would be mainly focused on improving network lifetime and power factors [50].

Mitra (2012) analyzed the present condition of proposed clustering protocols with emphasis on their capacity and dependability necessities. In WSN, the energy constraints of hubs play a very crucial role in protocol design and implementation. Likewise, QoS measurements, for example, data loss tolerance, delay, and system lifetime uncover dependability issues when structuring recuperation components for clustering schemes. These significant attributes are frequently restricted as one regularly and negatively can affect the other [51].

Santhiya (2013) reviewed WSNs energy-efficient clustering algorithms. The “load-balanced clustering algorithm” was introduced for the balanced energy of clusters in both uniform and nonuniform distributions. Secure communication in clusters is very essential because if the clusters misbehave or are compromised, the entire network link then fails. To overcome this issue, cluster-based certificate disavowal for enrolling and evacuating hub authentications is recognized for dispatching attacks on the area. This process prevents the energy of sensor hubs from becoming exhausted in WSN and shields the sensor hubs from harmful attacks [52].

Dawood (2014) examined the scope of WSN clustering protocols. Moreover, this review subdivided the job of a clustering protocol to improve WSN exhibition. The review also examined the significance of improved QoS energy-based clustering protocols to maximize the battery power of WSN [53].

Kaur discussed different difficulties related to clustering and various strategies or procedures created to overcome these difficulties [54].

In 2014, Kumar reviewed various distinctive leveled clustering WSN algorithms from an energy efficiency perspective and furthermore, described the major ideas of clustering and its characteristics, focal points, impediments of clustering, and different clustering algorithms in its scientific categorization. This overview additionally presents relevant open issues and difficulties in progressive directing or clustering [55].

2.2 Optimization-Based Clustering Mechanisms

Several optimization-based clustering algorithms were developed in earlier days such as ant colony optimization (ACO), artificial bee colony optimization (ABCO), fuzzy logic (FL), genetic algorithm (GA), whale algorithm, particle swarm optimization (PSO), and so on.

Nayyar and Singh (2017) introduced an exhaustive review of ant colony optimization (ACO) for WSNs. This effort reviewed QoS parameters, such as energy utilization, bandwidth, delay, reliability, and data aggregation. Favorable circumstances and hindrances of ACO-based routing protocols for a WEN were further examined [56]. The major advantages of this process are that it can reduce energy consumption and will increase the bandwidth and message success ratio. The disadvantage is that it can increase the network delay.

Gambhir (2018) tried an “artificial bee colony optimization” (ABCO)-based LEACH algorithm with respect to assorted WSN situations by changing the number of rounds and corresponding number of sensor hubs. Many parameters, for example, dead and live hubs per round and packet to the BS per round were considered for execution assessment. Examination of every parameter starting with an ordinary LEACH was also introduced [57]. The major advantages of this process are that it can reduce energy consumption. The disadvantage is that it can increase the interference of the network.

In a review by Sambo (2019), a wide survey of the ongoing progressive methods dependent on computational intelligence (CI) or machine learning (ML) were examined. To accomplish this task, the calculations were grouped for different CL uses, which could be fuzzy logic (FL), genetic algorithm (GA), neural network (NN), reinforcement learning (RL), or swarm intelligence (SI). To assess and analyze these uses, several parameters, such as data aggregation, data delivery rate, and scalability, were selected [58]. The major advantages are that this method helps to increase the network lifetime and the quality of service of the network. Due to the combination of the hybrid model, it can increase the interference of the network.

Wang proposed a whale algorithm-based optimization model for WSN. The mathematical model of hub inclusion in WSN was created to accomplish full inclusion for an area of interest. For the model, switch learning is brought into the first whale swarm streamlining calculation to upgrade the underlying appropriation of the population. This strategy leads to an upgrade in hub searchability and accelerates the global search. The outcome of this work showed that this algorithm could viably improve the inclusion of hubs in WSN and enhance system execution [59]. The major compensation of this process is that it increases the energy efficiency of the network. The disadvantage is that it can increase the network's end-to-end delay.

Hemalatha (2015) surveyed WSNs optimization techniques. This paper analyzed significant research issues regarding the optimization of energy and requirements for WSN optimization. This paper examined steering difficulties and requirements for WSN improvement. All the available optimization techniques are clearly discussed with their advantages and disadvantages [60]. All the available optimization techniques are clearly discussed with their advantages and disadvantages. The most common advantages and disadvantage of the network is that it increases the network lifetime and optimization-based models lead to an increase in the latency of the network.

In a review by Kaur (2015), a top to bottom investigation about power utilization was introduced. This work surveyed many significant methods for conserving power in WSNs. Emphasis was given to artificial intelligence (AI)-based power optimization methods including FL, NN, clustering, and network-based strategies [61]. The major advantage of the model is it can increase the accuracy of the network. The drawback is that it can reduce the precision of the network.

Parwekar's (2018) study addressed difficult issues, such as node maintenance and localization and clustering among others. The fundamental point of optimization strategies is to give the inside solution enough time and furthermore to limit energy utilization along these lines by drawing out the lifetime of the system. This study obviously depicts the utilization of distinctive distributed optimization methods in the field of WSN [62]. The major advantages are that this method helps to increase the network lifetime and the quality of service of the network. Due to the combination of the hybrid model, it can increase the interference of the network.

In 2016, more introduced an energy optimization design by optimizing the system hubs working mode.to optimize the stages of WSN; this study stressed the use of the particle swarm optimization (PSO) technique. When compared to GA, PSO internally utilizes candidate answers to get a feasible answer to get reinforced molecules out of all multitude molecule change streamlined WSN. The PSO calculation is the most helpful strategy to advance the stages for example network coverage, hub position, grouping, and routing and data aggregation [63]. The major advantages of this process are that it can reduce energy consumption and will increase the bandwidth and message success ratio. The disadvantage is that it can increase the network delay.

A review by Sneha, Swathi (2016) examined various optimization methods, such as particle swarm optimization (PSO), artificial bee colony (ABC), ACO, and GA. These methods are used to improve the performances of various parameters, for example, reduced power consumption, optimal path, and target coverage. ACO and ABC yield high achievement rates and longer system lifetimes, especially for a fundamental system but for a thick system, they do not perform well The major advantages are that this method helps to increase the network lifetime and the quality of service of the network. Due to the combination of the hybrid model, it can increase the interference of the network.

Mangat (2012) presented a review on a PSO-based clustering investigation. The fundamental purpose behind picking the PSO technique for clustering is the small number of parameters that should be modified. Single form, with slight varieties, functions admirably in a wide assortment of uses. PSO has been utilized for approaches that can be utilized over a wide scope of uses, for example, image segmentation, design of the system, clustering of web usage data, signal processing, pattern recognition, classification, and multiobjective optimization. The hybridization of PSO with other transformative calculations, such as GA and differential evolution (DE) has been a powerful tool for improving PSO proficiency and precision . The major advantage of the model is it can increase the accuracy of the network. The drawback is that it can reduce the precision of the network.

III. CLUSTER-BASED ROUTING PROTOCOL CLASSIFICATION—OVERVIEW

In this section, clustering is subdivided into three different categories: (1) parameter-based, (2) optimization-based, and (3) methodology-based clustering. First, parameter-based clustering is subdivided into two major classifications, including clustering-based both on primary and secondary parameters. Second, optimization-based clustering is subdivided into classical and hybrid optimization approaches. Finally, methodology-based clustering is subdivided into fuzzy-based and metaheuristic methods as given in Figure 3. All these classifications are thoroughly explained in Section 4.

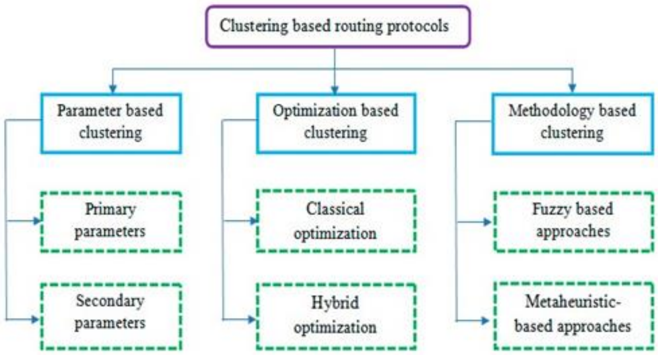

Figure 3. Classification of clustering-based routing protocols.

3.1 Parameter-Based Clustering

3.1.1. Clustering Based on Primary Parameters

The major primary parameters consist of general objectives and clustering strategies for head selection. The major subsections consist of objectives.

Strategy for CH Selection

A short description is given to illustrate the general method for choosing a cluster head based on various strategies, such as those that benefit the crowd. This segment presents noteworthy ways to address the CH choice from the previously mentioned strategies. It is depicted in Figure 4.

Objective

Calculated different directing in addition to techniques containing numerous goals, for example, data aggregation, fault tolerance, scalability, network stability, node connectivity, load balancing, collision avoidance, network coverage, and network lifetime among others are some of the primary goals of calculated different directing. The remainder of the goals are considered optional and are set to help accomplish the principal targets. Optional destinations are of less significance [36].

3.1.2. Clustering Based on Secondary Parameters

In this section, secondary parameters are discussed briefly. The developed clustering model has several features and characteristics. The Figure 5 shows the details about those clustering methods.

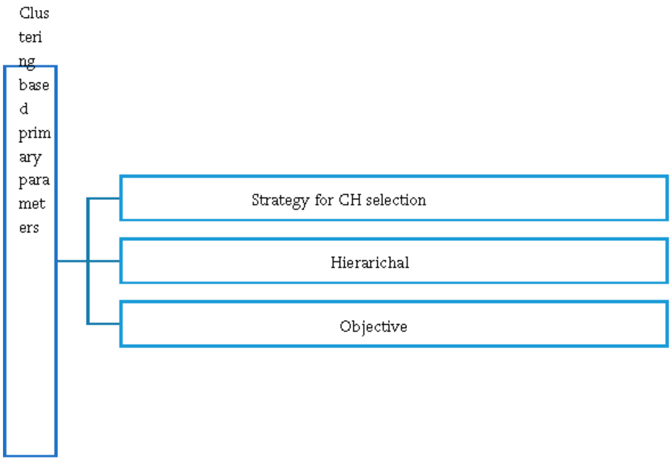

Figure 4. Clustering-based primary parameters.

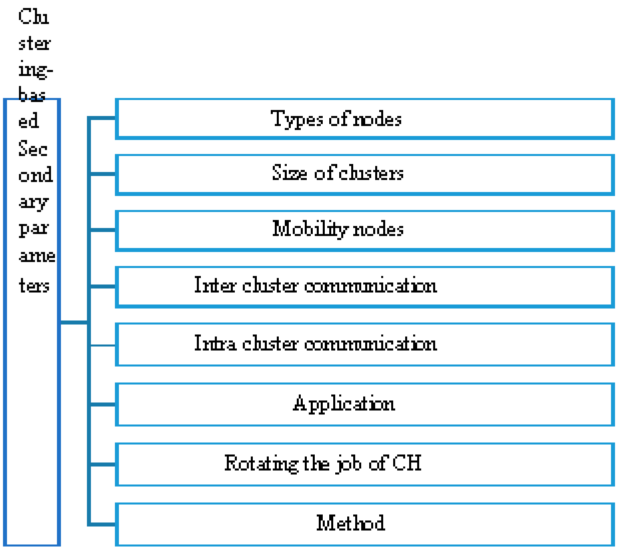

Figure 5. Clustering-based secondary parameters.

Types of Node

Homogeneous and heterogeneous nodes are available for algorithms. CHs are generally chosen from heterogeneous sensor hubs if calculations utilize such hubs.

Cluster Size

Cluster size can be controlled or uncontrolled. This model is used to examine a technique to determine whether the creators focused on controlling cluster size. In general, the coverage area of the cluster is fixed according to the distance from the BS. Clustering algorithm density decides the cluster size for the determination of a range of clusters [41].

Mobility of Nodes

CH and normal nodes may have motion or be motionless. If a motion is available, it would be over a limited range.

Intercluster Communication

CHs and BS can be directly connected by either a one-hop or also by a multihop connection.

Intracluster Communication

Generally, in intracluster communication multihop transmission is employed. That choice is the smarter one for using multihop intracultural communication in which there are few CHs when part hubs are a long way from CHs or when there are more limitations on sensors. Consequently, the parameters were viewed as having the possibility that a single-hop or multinumber of hops could be used for assessment measures [40].

Rotating of the CH

This rule decides if a technique to utilize a system will supplant the hubs and assume the job of a CH. In specific techniques, CHs are occasionally supplanted. In some different techniques, they are supplanted after a predetermined timeframe or when the CH energy level reaches the predetermined limit. With the help of the energy threshold system, this technique, for the most part, attempts to bring system energy utilization together.

Methods

The clustering technique may be centralized or distributed but involves a centralized or hybrid distribution in some strategies.

3.2. Optimization-Based Clustering

Optimization-based clustering is classified into classical and hybrid optimization approaches.

3.2.1. Classical Optimization Approaches

The essential factors for classical optimization approaches are parameters from earlier developed models, including their limitations, utilizations, capabilities, and simulation environments are shown in Figure 6.

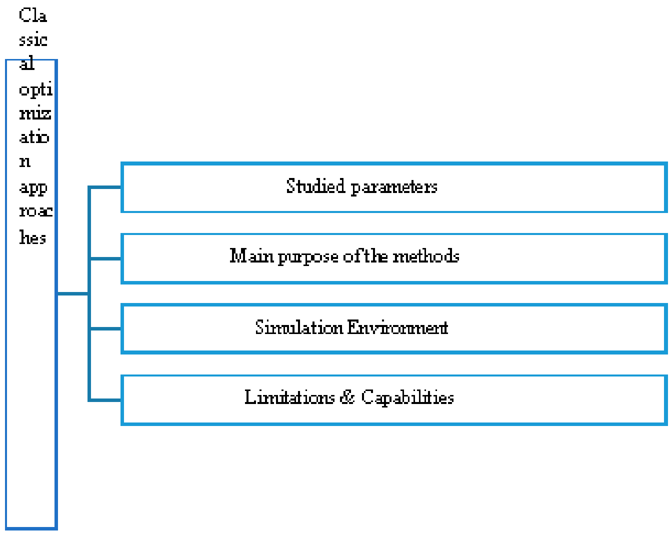

Figure 6. Classical optimization approaches.

3.2.2. Hybrid Optimization Approaches

Fuzzy- and metaheuristic-based methods which is shown in Figure 7 are the major segments of hybrid optimization approaches. The considered elements introduced for attribute inspection of the two strategies consist of capabilities, drawbacks, input and output factors of fuzzy logic, rule evaluation, and setting method, defuzzification, and fuzzy logic utility.

3.3. Methodology-Based Clustering

In this section, methodology-based clustering consists of two sections, namely, fuzzyand metaheuristic-based approaches. The figure provides the factors for both the fuzzy and metaheuristic algorithms.

3.3.1. Fuzzy-Based Approaches

This section provides factors that are used by the fuzzy-based approaches and it is shown in Figure 8.

To portray each attribute of a fuzzy system, a few factors are considered in reviewed protocols, such as the principle of FL, capacities, fuzzy input and output factors, rule evaluation, capabilities, and limitations.

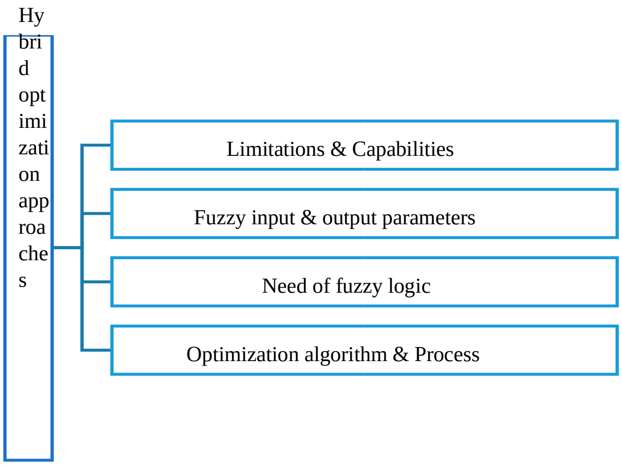

Figure 7. Hybrid optimization approaches.

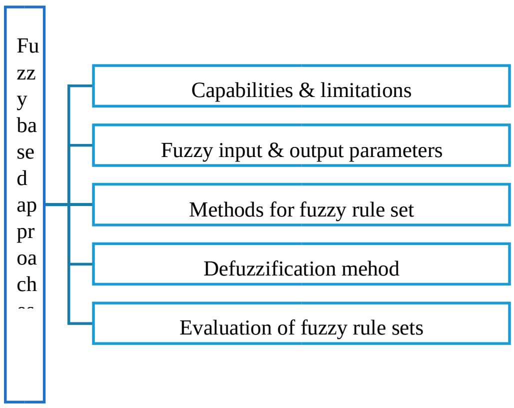

Figure 8. Fuzzy-based approaches.

3.3.2. Metaheuristic-Based Approaches

This section examines the elements measured in metaheuristic-based methodologies that are introduced in this section and shown in Figure 9 for explaining the procedures, such as capabilities, constraints, factors concentrated in the protocols addressing ways to develop optimization algorithms, processes, reasons, and simulation environment, used in the earlier developed works.

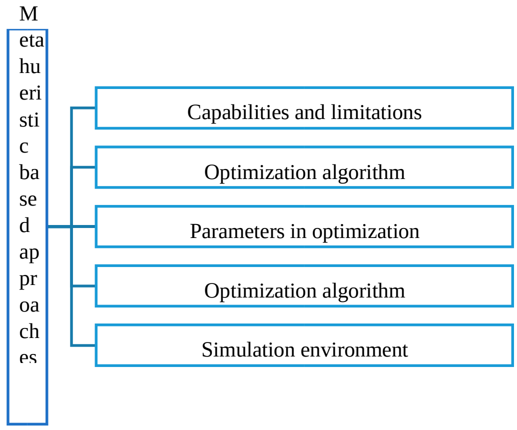

Figure 9. Metaheuristic-based approaches.

IV.ENERGY EFFICIENT ROUTING PROTOCOLS IN WSN

Energy efficiency of a network is a significant concern in wireless sensor network (WSN). These days networks are becoming large, so information gathered is becoming even larger, which all consume a great amount of energy resulting in an early death of a node. Therefore, many energy efficient protocols are developed to lessen the power used in data sampling and collection to extend the lifetime of a network. Following are some energy efficient routing protocols:

1. LEACH "Low-Energy Adaptive Clustering Hierarchy" In this type of hierarchical protocol, most of the nodes communicate to cluster heads (C.H) [1] [8]. It consists of two phases: (i). The Setup Phase: in this phase, the clusters are ordered and then Cluster Head(CH) has been selected. The task of CH is to cumulate, wrapping, and forward the information to the base station (Sink) [2]. (ii). The Study State Phase: in the previous state, the nodes and the CH have been organized, but in the second state of "LEACH", the data is communicated to the base station (Sink). Duration of this phase is longer than the previous state. To minimize the overhead, the duration of this phase has been increased. Each node in the network, contact with the cluster head, and transfer the data to it and after that CH will develop the schedule to

transfer the data of each node to base station [8] [2].

2. PEGASIS "Power-Efficient Gathering in Sensor Information Systems" It is a "chain-bases protocol" and an upgrading of the "LEACH". In "PEGASIS" every node transfers only with a close neighbor to direct and obtain information. It receipts turns communicating to the BS, thus decreasing the quantity of energy consumed per round [9]. The nodes are in this way that a chain should be developed, which can be completed by the sensor nodes along with using an algorithm. On the other hand, the BS can compute this chain and transmission of it to all the sensor nodes. [10]To develop the chain, it is expected that all nodes have universal information of the system and that a greedy algorithm is engaged. Thus, the structure of the chain will begin from the remote node to the nearer node. If a node expires, the chain is rebuilt in the similar method to avoid the lifeless node [11].
3. TEEN "Threshold sensitive Energy Efficient sensor Network protocol" The TEEN is a hierarchical protocol designed for the conditions like sudden changes in the sensed attributes such as temperature. For a reactive network, the first developed Routing protocols On the basis of Functioning mode On the basis of Participation style On the basis of Network structure Proactive Direct communication Data centric Reactive Flat Hierarchical Hybrid Clustering Location-based INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 6, ISSUE 12, DECEMBER 2017 ISSN 2277-8616 94 IJSTR©2017 www.ijstr.org protocol was TEEN [12]. The reduction of the number of transmissions is the purpose of a hard threshold, which is done by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The number of transmissions is reduced by soft threshold by avoiding all the transmissions which might occur when the sensed attribute is changed slightly or not changed. TEEN is well applicable for time important problems and is likewise quite efficient in terms of saving energy and response time. It also allows the user to manage the power utilization and accurateness to suit the application [13].
4. 4.APTEEN "Adaptive Threshold sensitive Energy Efficient Sensor Network" The "APTEEN" is an expansion of "TEEN" and goals at both taking episodic data gatherings and replying to time-critical events. As soon as the BS formulates the clusters, the C.H transmits the features, the values of threshold and schedule of transmission to all nodes.[12] After that, the C.H performs information accumulation, which has as a consequence to preserve power. The main advantage of "APTEEN" in contrast to "TEEN", is that nodes utilize a smaller amount power. on the other hand, the primary disadvantages of APTEEN are the complication and that it results in lengthier deferment times [14].
5. Directed Diffusion Directed diffusion is data-centric routing protocol for collecting and publishing the information in WSNs [15]. It has been developed to address the requirement of data flowing from the sink toward the sensors, i.e. when the sink requests particular information from these sensors. Its main objective is extending the network lifetime by realizing essential energy saving. In order to fulfill this objective, it has to keep the interactions among the nodes within a limited environment by message exchange. A localized interaction that provides multipath delivery is a unique feature of this protocol. This unique feature with the ability of the nodes to respond to the queries of the sink results in considerable energy savings [1] [15]. 6. Energy-Efficient Sensor Routing (EESR) EESR is a flat routing algorithm [16] proposed particularly to decrease the power utilization and data latency, and to give scalability in the WSN.

Mainly, it consists of Gateway, Base Station, Manager Nodes, and Sensor Nodes [17] [18]. Their duties are: Gateway Delivers messages from Manager Nodes or forms other networks to the Base Station, which has extra specification than normal sensor nodes. It sends and receives messages to/from Gateway. Moreover, it sends queries and collects data to/from sensor nodes. Manager Nodes and Sensor Nodes collect data from the environment and send it to each other in 1-Hop distance till the Base Station [16].

V. CONCLUSIONS

Using energy limits on sensor hubs and the features of the clustering model is a potent method for keeping a sensor network's energy efficiency high. The state of the art protocols and algorithms are discussed here. Clustering criteria for these protocols include parameter, optimisation, and approach. Clustering characteristics both primary and secondary factors are taken into account. At this stage, the introduced criteria had been applied to every category of approaches. This evaluation is to provide a different perspective and a jumping off point for investigation tactics by evaluating categorised ways for simple comprehension of gaps in the processes, with the ultimate objective of giving useful data and inspiring researchers. Our long-term goal is to apply these findings to further areas of WSN, including but not limited to: body area networks; wireless sensor networks; sensor networks run on rechargeable batteries; and mobile sink planning.

VI. REFERENCES

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