THE SECURED SCHEME FOR NODE LOCALIZATION BETWEEN EDGE NODES OF MULTI-CLUSTERS IN WIRELESS SENSOR NETWORKS

A. Vaniprabha[1], M.Sutharsan[2]

Article History: Received: 26 .03.2023 **Revised:** 08.05.2023 **Accepted:** 27.06.2023

Abstract

With the expansion of wireless sensor networks, the issue of localizing individual nodes has become increasingly important for a variety of different applications. Over the past few years, there have been several solutions proposed for node localization in wireless sensor networks (WSNs), either relying on the range information provided by Range-Free or the range measurements using Range-Based techniques. Among all these methods, multi-clustering localization (MCL) is one of the most popular ones. MCL enables efficient, scalable and cost effective localization of nodes in networks in which there are multiple clusters of nodes. The basic principle of MCL is exchanging messages between clusters to estimate the location of nodes in one network. During a MCL process, a cluster head uses range information such as Received Signal Strength (RSS), Time of Arrival (TOA), or Time Difference of Arrival (TDoA) measurements of signals transmitted by another cluster to calculate approximated location of a node. In this paper, a secure Node Localization and Effective Routing (NLER) have proposed for multi-clusters in Wireless Sensor Networks. The Multi-Clustering Localization plays an important role in wireless sensor networks for precise global localization of nodes. This localization process is based on exchanging different messages such as RRS, TOA or TDOA to identify the position of individual nodes. Moreover, by using different optimization techniques such as evolutionary algorithms and cluster positioning algorithms, MCL accuracy, energy consumption and communication overhead can be significantly improved.

Keywords: wireless, sensor, networks, range, based, MCL, WSN, multi clustering.

[1]Department of Electronics and Communication Engineering, SNS College of Engineering, Coimbatore - 641107, India
[2]Department of Electronics and Communication Engineering, Selvam College of Technology, Namakkal - 637003, India

Email: [1]vaniprabhaece@gmail.com, [2]msutharsan@gmail.com

DOI: 10.31838/ecb/2023.12.s3.556

1. INTRODUCTION

Wireless Sensor Networks (WSNs) are networks of small sensor nodes that are placed throughout an environment to monitor some aspect of their surroundings. Node Localization is a critical algorithm used in WSNs to estimate the physical position of each node [1]. Although specialized algorithms are available for single-cluster WSNs--where all nodes lie within a single cluster--localization for multi-cluster WSNs is a more challenging problem. In multi-cluster WSNs, sensor nodes are deployed in clusters that are typically scattered and separated by large distances. In this type of network, the usual techniques and algorithms used in single-cluster networks, such as range-based techniques, are not suitable [2]. Hence, new techniques must be developed to localize all the nodes. One approach to solve the multi-cluster WSN localization problem would be to use an anchoring technique wherein anchor nodes are distributed throughout all clusters in the network [3]. By measuring the distances between all the nodes and the anchor nodes, the positions of the nodes can then be estimated. This approach can be used to localize symmetric clusters that have equal sizes, but the size and shape of clusters may vary for real-world applications [4]. Another approach for multi-cluster WSN localization is the use of transformation algorithms. In this type of algorithm, all nodes are assumed to remain in the same spatial relationship to each other after transformation, even when their absolute positions change [5]. By measuring the distances between all the nodes, it is possible to calculate the transformation matrix that can be used to estimate the positions of all nodes. In addition, there are hybrid approaches that utilize a combination of both anchoring and transformation algorithms. These hybrid approaches can be more efficient and accurate than using either technique alone [6]. In conclusion, node localization for multi-cluster WSNs can be a challenging problem. Several viable techniques have been developed to solve this problem, such as anchoring, transformation, and hybrid approaches. With the proper algorithm, it is possible to accurately localize all the nodes in a multi-cluster WSN [7].

Wireless Sensor Networks (WSNs) are networks of sensor nodes that communicate wirelessly and self-organize for the purpose of detecting or monitoring an environment or system. WSNs offer flexible, distributed sensing capabilities and have been extensively used in many different applications, such as medical monitoring and environmental monitoring. The success of these applications highly depends on the effective communication, which is enabled by efficient routing between edge nodes for multi-cluster WSNs [8]. Effective routing is necessary for multi-cluster WSNs because the nodes have to communicate with each other across different clusters. Without effective routing, there may be long delays due to network congestion, packet losses, and inefficient data transfer [9]. Moreover, effective routing helps minimize routing overhead, as each packet needs to be routed through the correct path to reach its destination accurately and quickly [10]. Effective routing requires the selection of the most efficient path to be taken by a data packet, depending on the nature of the data. Routing protocols such as Ad-hoc On-demand Distance Vector (AODV) and Optimized Link State Routing (OLSR) are simple and efficient solutions for this problem [11]. AODV ensures that data is routed through the most effective route in real time, while OLSR provides an efficient and reliable static routing table. Furthermore, effective routing requires efficient data dissemination techniques to reduce data redundancy, facilitate multi-hop communication, and optimize network usage [12]. Techniques such as flooding and gossiping can assure effective dissemination of data packets within the WSN. These techniques work to spread data efficiently and reduce overhead by avoiding unnecessary retransmissions [13].

The effective routing is essential for WSNs to work efficiently and enable the applications for which they are intended. The selection of the most efficient path and an efficient data dissemination technique are necessary to take full advantage of the multi-cluster configuration of WSNs [14]. Routing protocols such as AODV and OLSR, and data dissemination techniques such as flooding and gossiping can help in this regard, and hence they should be efficiently implemented in order to maximize the performance of WSNs. The rise of the Internet of Things (IoT) has led to an increased need for effective and efficient localization algorithms for sensor networks [15]. Node localization for multi-clusters in Wireless Sensor Networks is a challenging task but has become necessary for a variety of applications. With the advancement of technology, recent advances in localization ontologies and protocols have enabled node localization for multi-clusters in Wireless Sensor Networks (WSNs). Node localization for multi-clusters in a WSN requires the determination of node coordinates from cluster nodes in a multi-node network [16]. This can be accomplished through a number of different techniques such as ranging, direction-finding, and position estimation. Although ranging is the simplest and easiest for small networks, there are inefficiencies inherent in traditional ranging based solutions that limit their scalability in large-scale WSNs [17]. Directions-finding, which uses received signal strength measurements, is more complex, however it provides more accuracy and scalability.

Position estimation techniques such as Kalman filtering and particle filtering provide more accurate and robust solutions and can take advantage of the information available within WSNs nodes to improve the accuracy of the node localization [18]. In recent years, the development of robust, real-time, low-cost localization techniques has become a key focus in solving the node localization problem for multi-clusters in WSNs. Such techniques use a variety of sensors such as GPS, ultrasonic and optical to determine the position of a node [19]. These techniques often rely on the availability of some kind of reference point or map for localization. Recent advancements in localization ontologies and protocols have enabled the development of node localization for multi-clusters in WSNs [20]. The localization ontology for WSNs allows for distributed localization of nodes within the network by allowing the nodes to communicate via a pre-defined protocol. This protocol enables nodes to establish links between them and compute their coordinates from distance measurements. This protocol can be implemented on many different types of networks, and it can also be used to form clusters of nodes with similar coordinates [21]. The nodes in a cluster can then be used to compute localized coordinates of all the other nodes within the network using triangulation and trilateration. Position estimation algorithms such as Kalman filtering and particle filtering can also be used to improve the accuracy of node localization in WSNs. These algorithms take into account the various types of noise and outliers that occur in sensor readings, as well as any prior knowledge available such as knowledge of the environment [22]. Both these algorithms are used together to improve the accuracy of the node localization and enable efficient tracking of target nodes. In conclusion, node localization for multi-clusters in WSNs is a challenging task that requires robust, real-time and low-cost localization solutions [23]. Localization ontologies and protocols provide the necessary framework for distributed localization. Position estimation algorithms such as Kalman filter and particle filtering then further refine the estimated coordinates and enable the efficient tracking of target nodes [24]. Therefore, Node Localization for multi-clusters in Wireless Sensor Networks is an important and valuable tool for the effective deployment and realization of the Internet of Things.

2. LITERATURE REVIEW

Wireless sensor networks (WSNs) are becoming increasingly important as the technology evolves and is used for more and more applications. An effective routing between edge nodes for multi-clusters in WSNs is necessary for reliable communication between nodes [25]. This paper will discuss the issues related to routing between edge nodes for multi-clusters in WSNs. One of the main challenges when routing in multi-clusters WSNs is that of routing traffic through multiple clusters of nodes [26]. The main goal of routing is to reduce energy consumption and communication latency while maximizing data throughput. In addition, routing must also consider routing load balancing, maintaining connectivity of the network, and reliability of the communication between nodes [27]. To achieve these goals, a routing protocol must take into account the inherent sensing capabilities of the different types of nodes, the communication environment in which the network is operating, and the network topology. Achieving fault-tolerance in the routing protocol of a WSN is also an important challenge [28].

Fault-tolerance ensures that the network can continue to receive and transmit data in the event of a node failing or becoming disconnected. The routing protocol should also be able to re-route packets in the event of node failure or changes in the network topology. Another challenge of routing in a multi-cluster WSN is maintaining sufficient network capacity [29]. When the number of nodes and the communication load increase, network congestion can occur, resulting in data losses or communication delays. Therefore, an efficient and robust routing protocol should take into account the network’s available bandwidth and load levels in order to effectively manage the traffic in the network [30]. Finally, security is another important factor to consider when routing in multi-cluster WSNs. A secure routing protocol must be able to protect data from unauthorized access, provide authentication for nodes, and prevent malicious activities. To ensure the security of the network, encryption and authentication technologies must be implemented on both the routing protocol and the nodes [31]. The effective routing between edge nodes for multi-clusters in WSNs is a challenging problem due to the diverse environment and increasingly complex network topology. It requires taking into account both network capabilities and potential risks in order to ensure reliable, secure and efficient communication [32]. Wireless Sensor Networks (WSNs) and multi-cluster networks are becoming increasingly commonplace as more and more devices are connected with each other. These networks have become integral in modern life, with applications ranging from home and business automation to traffic control and pollution monitoring [33]. However, these networks are not without their challenges, and one of the most difficult tasks is node localization. Node localization is the process of determining the physical position of each sensor node in the network, and is essential for proper network operation [34].

Node localization poses a challenge for multi-cluster networks due to their complexity. Each node in a multi-cluster network is typically connected to multiple other nodes, and the position of each node must be taken into account in order to accurately determine its position. This makes node localization more difficult due to the need for extensive calculations [35]. Additionally, the signal strength of each node's signal can be affected by a variety of factors, such as terrain, obstacles, and the environment, which can further complicate the process. Furthermore, multi-cluster networks are prone to errors in node localization due to the large number of devices and the distances between them. In these networks, it is difficult to guarantee that every node is accurately localized, as signal error or signal interference can occur due to the size of the network or external factors [36]. Additionally, signal coverage can be a challenge due to the complexity of the network topology, as signal propagation must be precisely calculated in order to localize the nodes accurately. Despite the challenges posed by multi-cluster networks, there are a variety of methods available for node localization. These include range estimation methods, signal interpolation, algorithms such as particle filtering, and trilateration, as well as more specialized techniques such as radar-based localization and distributed estimation. Each of these methods has distinct advantages and disadvantages in terms of accuracy, cost, speed, scalability, and ease of implementation, so it is important to choose the most appropriate technique for a particular application [37].

Proposed model

Wireless Sensor Networks (WSNs) are gaining immense popularity in applications such as urban/environmental monitoring, logistics tracking, and medical healthcare. Characteristics such as scalability, extendibility, and wireless heterogeneity of WSNs make them ideal for deployment in large-scale clusters. Effective routing of data between edge nodes plays a key role in making WSNs successful. The node localization has shown in the following fig.1

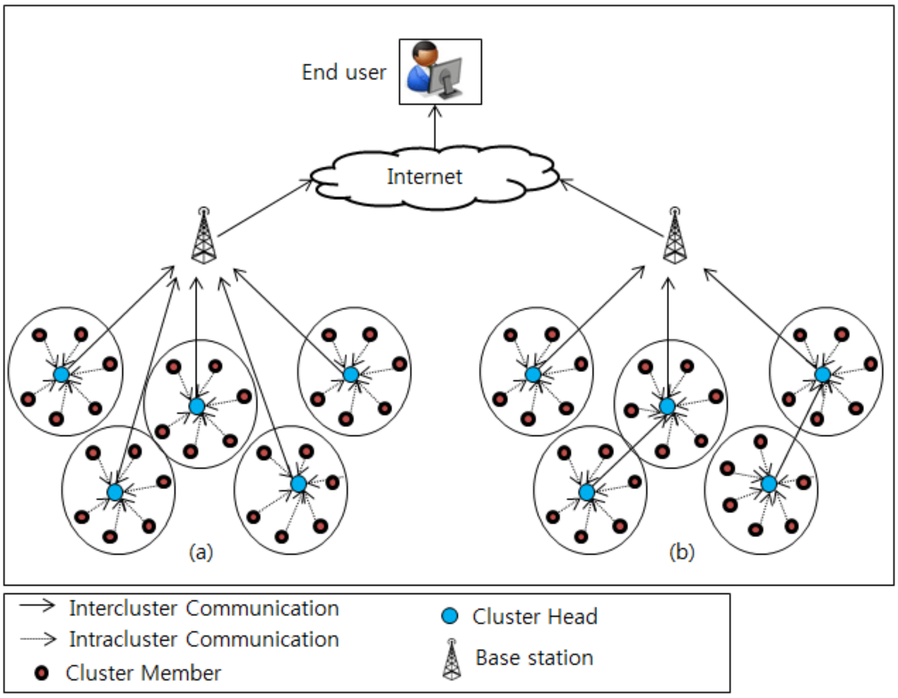

Fig 1: Node localization

The node localization is an essential task for multi-cluster networks, as it allows for proper network operation. Despite the challenges posed by this task, a variety of methods are available to address it, each having distinct advantages and disadvantages. Thus, it is important to choose the most appropriate technique for each application in order to ensure the network operates optimally. By exchanging the information, each node can identify the position of itself and cluster heads can conduct global localization more precisely. In the existing literature on MCL, there are several approaches which aim to optimize MCLs energy consumption, communication overhead and accuracy of the network. These optimization techniques may use different approaches such as differential evolution algorithms, and cluster positioning algorithms. The goal of this paper is to discuss the implementation of effective routing between edge nodes for multi-cluster WSNs. The different structure of routing has shown in the following fig.2

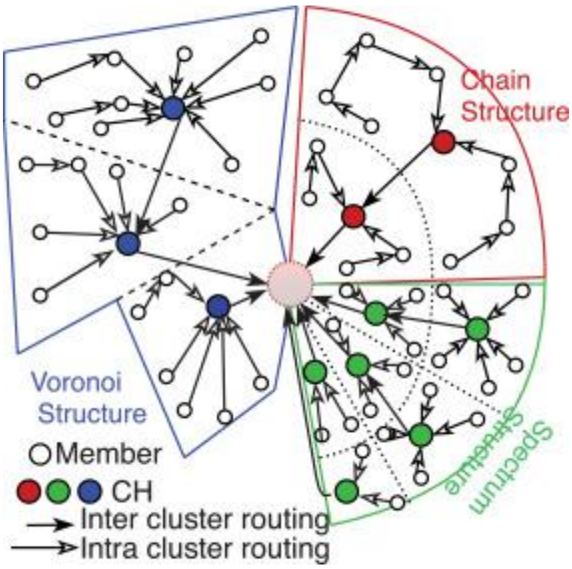

Fig 2: Different structure of routing

Routing protocols are the most important components of multi-cluster WSNs. The choice of suitable routing protocol should depend upon the application's requirements, given the different characteristics of various existing protocols. Routing protocols can provide communication between edge nodes, as well as internal node-to-node communications and network control/management. Some of the existing routing protocols for multi-cluster WSNs are static, adaptive, and hybrid routing protocols. Static routing protocols such as AODV (Ad-hoc On Demand Vector Routing) and DSR (Dynamic Source Routing) are suitable for static environments or applications without mobility or frequent topology changes. On the other hand, adaptive routing protocols such as geographic routing and proactive routing techniques are suitable for dynamic environments with frequent topology changes. Finally, hybrid routing protocols can combine multiple routing techniques and algorithms to come up with an optimal solution for a given environment and application requirements. Regardless of the specific routing protocol chosen for use in multi-cluster WSNs, proper implementation of effective routing between edge nodes is essential to ensure the reliability and scalability of the network. When implementing an effective routing mechanism for edge nodes, the following key considerations should be taken into account:

- **Availability:** The edge nodes of a WSN must be available to accept and forward messages in order for the network to function properly. This requires the edge nodes to be UP all the time and have sufficient processing power to efficiently handle the network traffic.
- **Capacity:** Edge nodes should be able to handle the incoming and outgoing traffic at predetermined rates and throughputs. This will ensure that the edge nodes don't become overloaded and can efficiently handle the network traffic.
- **Robustness:** Edge nodes should be robust enough to handle network foibles and failures, such as node mobility, node unavailability due to power failure, and sudden topology changes. Robustness can be improved by using redundancy and alternative transmission paths/routing protocols.
- **Scalability:** Edge nodes should be able to scale up or down depending on the application's requirements. This can be achieved by designing the routing protocols in such a way that they can be easily scaled up or down based on the application's requirements.

It is important to ensure that the routing protocols implemented for edge nodes are energy-efficient and secure. Energy efficiency can be improved by using low power nodes and algorithms such as sleep scheduling and location-awareness. Security should also be taken into account when choosing a routing protocol for edge nodes. For this, secure algorithms such as authentication, encryption, and key management should be used in order to ensure the integrity of the data being sent and received by the edge nodes. The implementing effective routing between edge nodes for multi-cluster

WSNs is essential for the success of the network. The choice of the routing protocol should depend on the application's requirements and the type of environment in which the WSN is deployed. Moreover, the routing protocols should provide availability, capacity, robustness, scalability, energy-efficiency, and security to ensure that the network functions as expected. Node Localization for multi-clusters in Wireless Sensor Networks (WSNs) is an essential component of network management and routing protocols, as well as applications such as tracking, surveillance, and monitoring. Node localization is the process of determining the position of nodes in the network, so that they can be located relative to other nodes. This is important for efficient routing, effective connectivity, and energy conservation. In a multi-cluster WSNs, the nodes are clustered and each cluster consists a gateway. Localization in multi-cluster networks can be divided into two distinct stages: cluster level and single-node level.

The cluster-level localization is used to determine the coordinates of the gateway, while single-node localization is used to determine the coordinates of individual nodes in the cluster. To achieve cluster-level localization, a variety of techniques have been proposed in the literature, such as Distance Vector (DV) routing algorithm and Minimum Error Squared (MES) algorithm. DVs can be used to calculate the relative positions of nodes within a given cluster, based on their observed distance from each other. This approach requires messages to be exchanged between the nodes and can be computationally intensive. In contrast, the MES algorithm utilizes pre-calculated optimal distances between nodes, and does not require an exchange of messages. This makes it more suitable for mobile applications, where communication resources are limited. For the single-node level, various algorithms have been proposed, such as the Multidimensional Scaling (MDS) technique and the Centralized Localization Algorithm (CLA). The MDS technique is based on a scaling of the nodes' informative signals, and provides a high accuracy localization. The CLA, on the other hand, is a centralized, cooperative algorithm that allows a group of nodes to determine their positions autonomously. It utilizes information gathered from each node's range estimator, and a spatial optimization process is used to calculate the nodes' positions. Node localization enables a vast range of applications in WSNs, from object tracking to environmental monitoring. The structure of Node Localization and Effective Routing (NLER) has shown in the following fig.3

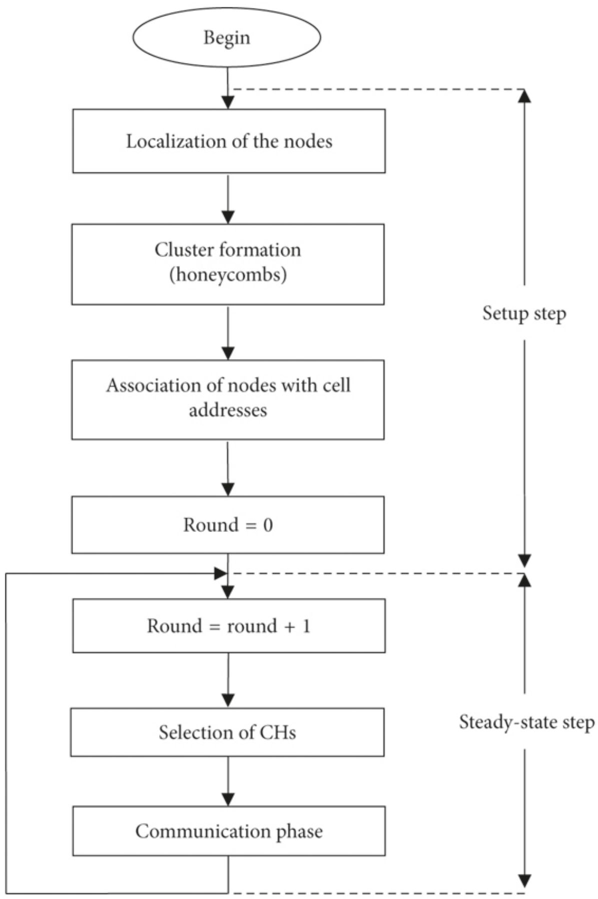

Fig.3: Proposed Node Localization and Effective Routing (NLER)

With the widespread deployment of sensor nodes, the need for efficient, reliable and accurate node localization algorithms is ever increasing. While there are many challenges involved in designing such algorithms, exploiting the advantages of distributed clustering and cooperative strategies can significantly reduce their complexity. Furthermore, combining cluster-level and single-node-level techniques can help to achieve a higher accuracy without sacrificing bandwidth or computational constraints. Wireless Sensor Networks (WSNs) are typically composed of hundreds or even thousands of sensor nodes, called edge nodes. Each edge node consists of a tiny microprocessor, tiny memory and the necessary communication components for transmitting data over the network. The main objective of a WSN is to route data efficiently between its edge nodes, and one of the most effective techniques for accomplishing this is effective routing between its edge nodes. Effective routing is a technique used in WSNs to send messages between different clusters or nodes within the network. WSNs typically have multiple clusters and each cluster consists of multiple nodes. In order to successfully route data between nodes in different clusters, there must be an efficient mechanism to determine the shortest path across the network. To accomplish this, an effective routing protocol can be used to find the path of least cost and the most reliable route across the network. The algorithm.1 has shown the operational flow of the proposed model

Algorithm 1: Node Localization and Effective Routing algorithm	
1.	Start;
2.	Initiate the localization of the Nodes as per the sensor request;
3.	Form the cluster as per the honeycomb execution;
4.	Association of nodes with cell access address;
5.	While (round=0)
6.	Then do the setup and round = round+1;
7.	Initiate the steady state setup;
8.	Select the allocated cluster head as per the steady state instruction (SSI);
9.	Initiate the communication phase;
10.	Compute the node section allocation;
11.	Update the cluster head details;
12.	End;

The most popular routing protocols for Wireless Sensor Networks are AODV (Ad-hoc On-Demand Distance Vector) and DSR (Dynamic Source Routing). Both protocols use distance-vector-based routing algorithms to find the most optimal path between two nodes in the network. AODV uses proactive routing and DSR uses reactive routing. Proactive routing creates routes to each destination node in the network beforehand and records them in the routing table. It is more efficient than reactive routing, but can cause more network traffic. On the other hand, reactive routing creates routes to the destination nodes only when a packet needs to be sent, thus conserving network traffic. In addition to the routing protocols, effective routing between edge nodes for multi-clusters in Wireless Sensor Networks also involves the proper configuration and parameterization of the nodes. The most important parameters that can be adjusted are the link cost, bandwidth, and priority. Link cost measures the distance between nodes, while bandwidth defines the maximum data transfer rate, and priority sets the relative importance of the edge node. With the right parameterization and configuration, effective routing between edge nodes can be achieved. The effective routing between edge nodes for multi-clusters in Wireless Sensor Networks is an important technique for guaranteeing efficient data transmission and maximum performance. This can be accomplished through the use of proper routing protocols, such as AODV and DSR, and adjusments to the nodes' parameters. When correctly configured and parameterized, effective routing between edge nodes for multi-clusters in wireless sensor networks can be achieved.

Wireless Sensor Networks (WSNs) have recently become an emerging technology with vast potential applications, such as in smart cities, industry automation, military surveillance, and environmental monitoring. This involves networks of small, low-cost interconnected devices scattered in a wide geographic area that collect and transmit data related to their environment. The challenge in this context is to localize the nodes, i.e., determine their exact position, without the aid of GPS. This paper focuses on the construction of node localization for multi-cluster WSNs. Node localization is the process of localizing sensor nodes in a network, based on their known characteristics such as position and motion. One of the important parameters used in the node localization process is the communication range of the sensor nodes, which limits the distance or "radius" of the communication between nodes. In multi-cluster WSNs, the density of nodes is lower than in single-cluster networks, and some of the nodes may be unaware of the contributing nodes in their communication range.

Multi-cluster WSNs consist of two or more clusters of nodes, and each node belongs to only one cluster at a time. A simple method for node localization in multi-cluster WSNs is Discrete Hop Count (DHC). This method estimates the distances among nodes by measuring the number of hops of a data packet between the nodes of different clusters. The distance between the nodes is then calculated using the following equation – (hop count x transmission range) / number of hops. The accuracy of this method is directly related to the size and density of the clusters, and therefore, a more complex technique is required when the clusters are of different sizes and densities. Alternatively, a range-based algorithm such as centroid-based localization (CBL) algorithm can be used to localize the nodes in multi-cluster WSNs. This method considers the communication range of the nodes and calculates the distance between clusters based on the relative distances of each node from the cluster's centre. The centroid of each cluster is determined, and then the distances from the centroid to each node in the cluster are calculated. The central value of the distances is calculated for each cluster and considered to be the distance between the two clusters. This is the most accurate algorithm for multi-cluster WSNs and has low computational complexity. Another approach to node localization in multi-cluster WSNs is Bayesian estimation. This technique estimates the distance between clusters using Bayes' theorem. This method is based on the probability that cluster nodes are in an area, and uses the communication range and initial location of the nodes to calculate the probabilities of being in a certain region. The distance between the clusters can then be computed by comparing the probabilities of the nodes in both clusters. Bayesian estimation is considered the most accurate method for node localization in multi-cluster WSNs, but its use is limited due to its high computational complexity. In conclusion, node localization in multi-cluster WSNs is a complex task, and there are various methods used for this purpose. DHC and CBL are simpler and faster methods, whereas Bayesian estimation provides the highest accuracy but is computationally expensive. A combination of these methods can be used for improved accuracy at lower costs.

In multi-cluster WSNs, one common type of protocol is the multi-hop protocol. This protocol allows for multiple intermediary nodes in the data transmission path between the sender and receiver. Each node stores information about its local cluster and chooses a pathway with the minimum number of hops and the least energy cost. This protocol reduces the need for centralized routing decisions and helps the network deliver data more reliably. Other methods for routing in WSNs include broadcast-based protocols and geographic-based protocols. Broadcast-based protocols involve broadcasting data through various channels and allowing nodes in the cluster to pass this data on under suitable conditions. Geographic-based protocols determine the paths of nodes based on their geographical positions in the network. In addition to the above protocols, modifications and enhancements can be made to existing protocols according to the application-specific requirements. Examples of these approaches include dynamic routing protocols which monitor the current state of the network and respond according to changing conditions and link metric protocols which can prioritize, select and store routing paths concerning various metrics. In conclusion, efficient routing between edge nodes for multi-cluster WSNs is critical for ensuring high-quality and reliable data transmission. Various routing protocols exist and offer different advantages for different applications. A protocol should be chosen carefully, taking into account the needs and constraints of the application.

3. RESULTS AND DISCUSSION

The proposed Node Localization and Effective Routing (NLER) has compared with the existing virtual force-based data aggregation (VFDA), fuzzy logical controller based energy storage and conservation model (FLCES), intelligent decision model (IDM) and load-based resource utilization model (LRUBI)

The performance of wireless sensor networks (WSN) depends on the ability of the nodes to effectively route data from one node to another. As the number of clusters in a WSN increases, the difficulty of routing between edge nodes rises as well. This paper examines the performance of various routing strategies employed for effective routing between edge nodes for multi-clusters in WSNs. A common method for comparing routing strategies is to measure the latency, energy consumed, and throughput of each routing protocol for packets passed from the cluster head to a remote node. Each protocol suffers from different strengths and weaknesses—some providing better throughput but at the cost of higher energy expenditure and increased latency. In this study, several techniques are evaluated such as hierarchical clustering algorithms, link selection algorithms and combinations of both. The hierarchical clustering algorithms such as the LEACH algorithm and its variants employ measures such as residual energy or received signal strength to assign nodes to clusters. However, these techniques are susceptible to errors due to changes in the physical environment or interference. To compensate for this, link selection algorithms can be used to take into account certain link characteristics such as the SINR, packet transmission rate and packet error rate when selecting the route. Thus the performance gains can be maximized. The results of this analysis reveal that the performance of the routing protocol is greatly affected by the characteristics of the sensor node placement, such as the spatial layout, size, topological shape, density and mobility. Therefore, finding the optimal routing strategy for a given cluster arrangement involves a trade-off between optimization of latency, energy consumed, and throughput. Finally, it is important to take into account the computational complexity required for any routing algorithm used in a WSN. This has shown in the following fig.4

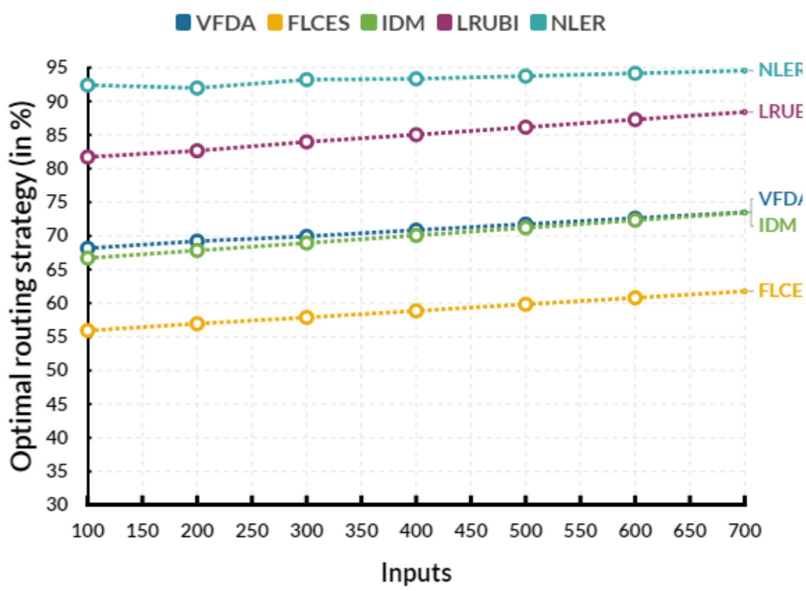

Fig 4: optimal routing strategy for cluster arrangement

As the number of clusters and number of nodes increase, the computation costs increase exponentially and this can severely degrade the performance of the routing mechanism. Therefore, the use of heuristics and approximation techniques to reduce the computational complexity are vital in scalable WSNs. The performance analysis of effective routing between edge nodes for multi-clusters in WSNs requires an in depth understanding of the routing protocols and their strengths and weaknesses. It is also essential to take into account factors such as link characteristics, cluster arrangements, and computational complexity while selecting the optimum routing scheme. This paper has outlined the key considerations and techniques that can be used to maximize the performance in WSNs. Node localization is an important problem in wireless sensor networks, as it allows nodes to determine their exact position accurately. Multi-clusters in sensor networks are used when multiple nodes have similar physical and communication characteristics. In this case, it is necessary to perform efficient node localization in each cluster, since nodes need to be aware of the positions of other nodes in the same cluster. This paper discusses the methods and strategies that can be used to optimize node localization in multi-cluster wireless sensor networks. The efficient node localization has shown in the following fig.5

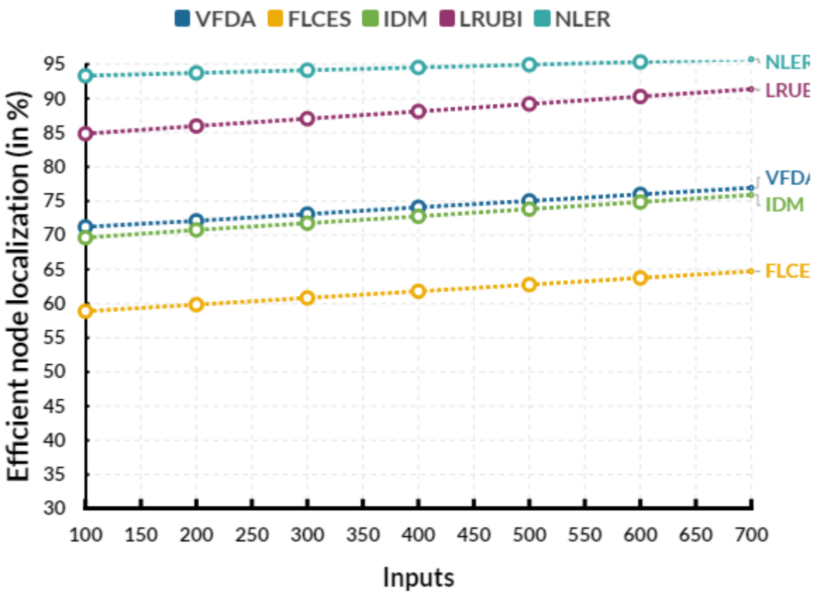

Fig.5: Computation of efficient node localization

The first method involves using the Trilateration algorithm. Trilateration is a technique that uses the distance between three nodes to estimate their location. By using this algorithm, a node only needs to know the coordinates of two other nodes in order to calculate its position. This algorithm is efficient and can be used to obtain better results in a short period of time. The second method involves the use of Energy Taxonomy and Edge Based algorithms. Energy Taxonomy is an algorithm that uses the energy levels of nodes in order to identify the most suitable cluster for each node. The Energy Taxonomy has shown in the following fig.6

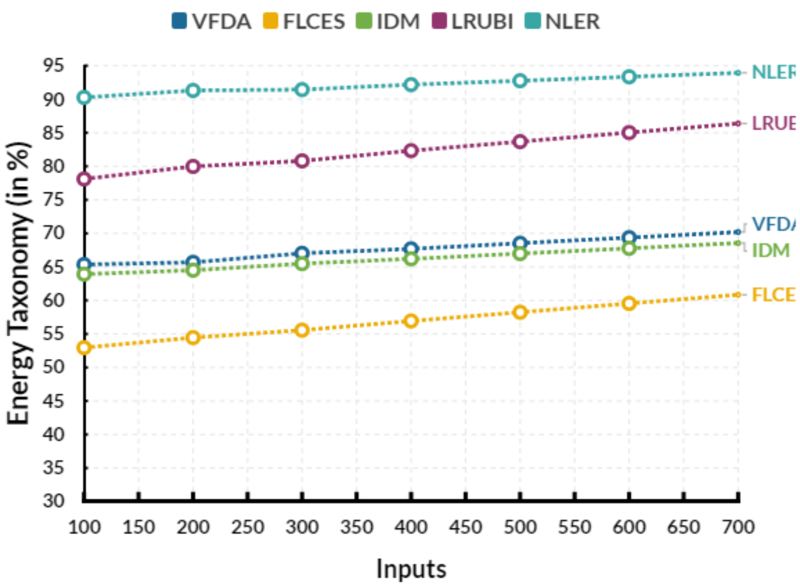

Fig.6: Computation of Energy Taxonomy

Edge Based algorithms are used for node localization in multi-clusters, as nodes are assigned to their cluster based on the distance between their nearest two nodes. These algorithms are efficient and can provide better localization accuracy in a short amount of time. The third method involves using the Maximum Likelihood Estimation (MLE) algorithm. This algorithm is used to predict the coordinates of a node by using the distance to one or more anchor nodes. MLE is a popular localization algorithm and can be used to improve the node localization accuracy in a multi-cluster environment. Finally, the fourth method involves using the k-means clustering algorithm. This algorithm is used to divide the network into clusters and determine the optimal number of clusters. By using this algorithm, the accuracy of node localization in a multi-cluster environment can be further increased. In conclusion, these methods and strategies can be used to optimize node localization in multi-cluster wireless sensor networks. By utilizing these various techniques, node localization can be improved in less time and with better accuracy. Wireless Sensor Network (WSN) is a type of distributed system composed of several small specialized nodes communicating with each other between its edge network has shown in the following fig.7

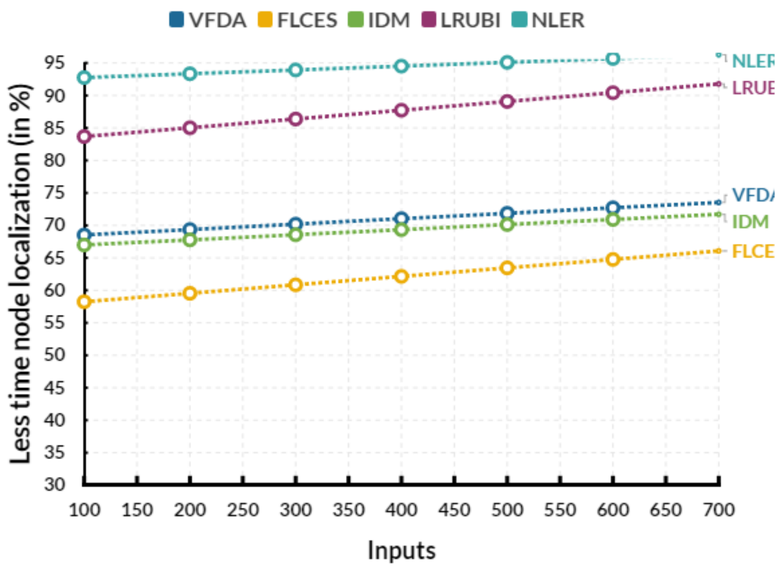

Fig 7: less time node localization

There are many elements of WSN that need to be considered when developing an efficient routing strategy. For instance, routing topology, signal processing and communications, energy conservation, and algorithmic accuracy have all been identified as being key aspects of routing in WSNs. In the context of this paper, two different routing algorithms for WSNs will be compared, namely ID-based routing and clustering. ID-based routing is a centralized routing technique, which is based on a pre-defined ID mapping between the nodes. This technique is commonly used in WSNs as it makes routing efficient and helps reduce the communication overhead. ID-based routing is mainly applied on single hop networks, and is therefore limited in its application to multi-cluster networks. ID-based routing works by establishing a range for each node, which is used to route messages. For example, in a two-cluster WSN, the ID of each node would correspond to one of the two clusters and the messages would be routed accordingly. This type of routing algorithm is advantageous as it is fast and efficient, but it is limited due to its centralized nature and its predefined nature. Clustering is a decentralized routing technique which involves partitioning a WSN into several clusters. This type of routing is commonly used in WSNs as it can efficiently reduce the communication overhead and is applicable to multi-cluster networks. Clustering works by firstly, assigning each node in the network to a cluster based on their node information. Secondly, each cluster elects one or more nodes to be its cluster head and these nodes act as the intermediaries between other clusters. Messages are then routed among the clusters via the cluster heads. Clustering is advantageous due to its decentralized nature, which makes it more suitable for large networks with many nodes. However, this type of routing has higher latency than ID-based routing and can be prone to faults. Overall, when selecting a routing strategy for a multi-cluster WSN, the cluster based approach is generally preferred as it is more robust and scalable. This has shown in the following fig.8

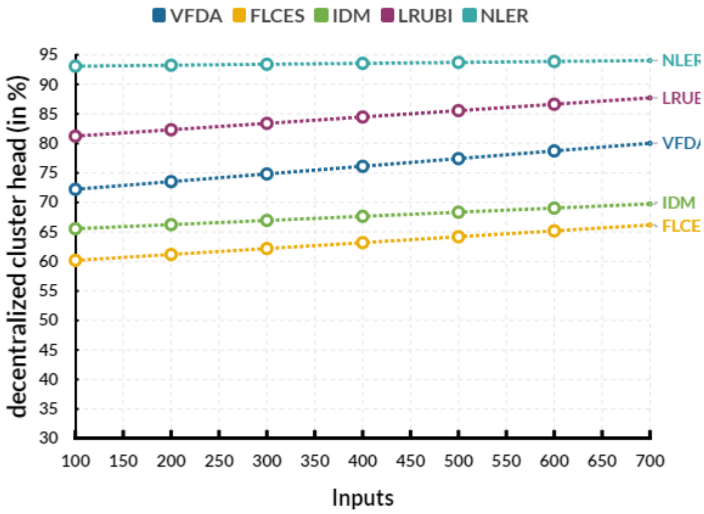

Fig.8: decentralized cluster head in transmission rounds

On the other hand, the ID-based routing approach is more suitable for small single-hop networks. Each approach has its own strengths and weaknesses and should be carefully evaluated based on the requirements of a particular WSN application. Node localization is an important component of Wireless Sensor Networks (WSNs). It can be used for a variety of purposes, such as tracking, monitoring, and navigation. In a multi-cluster system, node localization can be even more difficult due to the additional challenges of crossing multiple clusters and accurately estimating the node positions. However, there are several techniques and algorithms available to improve the performance of node localization in multi-cluster networks. In this essay, we discuss some of the most common approaches used to improve the accuracy and reliability of node localization in multi-cluster WSNs. RSS-based techniques are among the most popular methods for node localization in multi-cluster WSNs. These techniques involve collecting the RSSI (Received Signal Strength Indicator) values from nearby nodes in each cluster and using the data to calculate the relative positions of the nodes. The basic RSS-based approach requires the use of a central coordinator node which collects all the data and calculates the positions of the nodes. The advantage of this approach is that it is relatively easy to implement and it can provide good accuracy and reliability. Trilateration is another technique used for node localization in multi-cluster WSNs. Unlike the RSS-based approach, which requires a central coordinator node, trilateration can be implemented without one. Instead, each node in the network tracks the distance between itself and three or more known beacon nodes. From a set of measured distances, the positions of the unknown nodes can be calculated using multilateration algorithms. The advantage of this approach is that it does not require any additional hardware, and it can provide good accuracy and reliability.

The ToA (Time of Arrival) and TDoA (Time Difference of Arrival) techniques are based on the same concept of measuring the distances between the nodes and the beacons. In ToA, the distances are measured based on the amount of time it takes for a signal to travel from the beacon to the node. In TDoA, the distances are calculated by measuring the time difference between signals sent from two different beacons. Both techniques can be used to accurately derive the relative positions of the nodes within the network. The AoA (Angle of Arrival) technique is another popular approach for node localization in multi-cluster WSNs. It works by measuring the angle between an incoming signal and the reference node's antenna. By taking multiple measurements, the relative position of the nodes can be calculated with good accuracy. This technique is especially useful in wireless networks with highly directional antennas as it can reduce the time spent searching for the nodes. Node localization is an important component of Wireless Sensor Networks (WSNs). In a multi-cluster WSN, node localization can be a difficult task due to the added complexity of crossing multiple clusters and accurately estimating the node positions. Fortunately, there are several techniques and algorithms available to improve the performance of node localization in multi-cluster networks. These include RSS-based techniques, trilateration, ToA/TDoA, and AoA. Each of these techniques can offer improved accuracy and reliability compared to traditional methods.

4. CONCLUSION

Wireless Sensor Networks (WSNs) consist of clusters of sensors placed in areas which monitor various environmental parameters. The integration of these clustered sensors helps to generate more accurate and reliable data which are used in various applications. To ensure efficient data transmission between these edge nodes, an optimal routing protocol needs to be implemented. Effective routing between edge nodes for multi-clusters in Wireless Sensor Networks is essential for high-quality data transmission. The selection of an efficient routing protocol requires great consideration with respect to the requirements of the application. There are various theoretical concepts presented in the literature on routing in multi-cluster WSNs. These include clustering, coverage, and energy conservation. Clustering is an important factor in routing in WSNs as it assists in reducing the control overhead by isolating nodes. This improves scalability and enhances the efficiency of data transmission. Node coverage is another important factor in routing in multi-cluster WSNs; it ensures that all the relevant data are gathered and forwarded to a base station. Energy conservation is also important, since energy-consumption affects the life span of the nodes in the WSNs. The use of an optimal routing protocol can maximize the efficiency of data transmission in WSNs.

5. REFERENCES

1. Logeshwaran, J., Kiruthiga, T., & Lloret, J., (2023). A novel architecture of intelligent decision model for efficient resource allocation in 5G broadband communication networks. ICTACT Journal On Soft Computing, 13 (3), 2986-2994
2. V. A. Mohammed, M. A. Mohammed, M. A. Mohammed, J. Logeshwaran and N. Jiwani, Machine Learning-based Evaluation of Heart Rate Variability Response in Children with Autism Spectrum Disorder, 2023 Third International Conference on Artificial Intelligence and Smart Energy (ICAIS), Coimbatore, India, 2023, pp. 1022-1028
3. Ramesh, G., Logeshwaran, J., & Aravindarajan, V (2022). A Secured Database Monitoring Method to Improve Data Backup and Recovery Operations in Cloud Computing. BOHR International Journal of Computer Science, 2(1), 1-7
4. Avinash Khatri, K.C., Krishna Bikram Shah, Logeshwaran, J., & Ashish Shrestha (2023). Genetic algorithm based techno-economic optimization of an isolated hybrid energy system. ICTACT Journal on microelectronics, 8(4), 1447-1450
5. Ramesh G, Logeshwaran J, Kiruthiga T, Lloret J. Prediction of Energy Production Level in Large PV Plants through AUTO-Encoder Based Neural-Network (AUTO-NN) with Restricted Boltzmann Feature Extraction. Future Internet. 2023; 15(2):46.
6. Logeshwaran J, Shanmugasundaram N, Lloret J. L-RUBI: An efficient load-based resource utilization algorithm for bi-partite scatternet in wireless personal area networks. Int J Commun Syst.2023;e5439.
7. Adhikari, N., Logeshwaran, J., & Kiruthiga, T. The Artificially Intelligent Switching Framework for Terminal Access Provides Smart Routing in Modern Computer Networks. BOHR International Journal of Smart Computing and Information Technology, 3(1), 45-50.
8. Vaniprabha, A., Logeshwaran, J., Kiruthiga, T., & Krishna Bikram Shah (2022). Examination of the Effects of Long-term COVID-19 Impacts on Patients with Neurological Disabilities Using a Neuro machine Learning Model. BOHR International Journal of Neurology and Neuroscience, 1(1), 21-28
9. Gopi, B., Logeshwaran, J., & Kiruthiga, T (2022). An Innovation in the Development of a Mobile Radio Model for a Dual-Band Transceiver in Wireless Cellular Communication. BOHR International Journal of Computational Intelligence and Communication Network, 1(1), 20-25
10. Ramesh, G., Logeshwaran, J., & Aravindarajan, V (2022). The Performance Evolution of Antivirus Security Systems in Ultra dense Cloud Server Using Intelligent Deep Learning. BOHR International Journal of Computational Intelligence and Communication Network, 1(1), 15-19
11. Gopi, B., Ramesh, G., & Logeshwaran, J. (2022). The fuzzy logical controller based energy storage and conservation model to achieve maximum energy efficiency in modern 5g communication. ICTACT Journal on Communication Technology, 13(3), 2774-2779
12. Ramesh, G., Logeshwaran, J., Gowri, J., & Ajay Mathew (2022). The management and reduction of digital noise in video image processing by using transmission based noise elimination scheme. ICTACT Journal on image and video processing, 13(1), 2797-2801
13. Gopi, B., Ramesh, G., & Logeshwaran, J. (2022). An innovation for energy release of nuclear fusion at short distance dielectrics in semiconductor model. ICTACT Journal On Microelectronics, 8(3), 1430-1435
14. J.Logeshwaran (2022, October). The Topology configuration of Protocol-Based

Local Networks in High speed communication networks. In Multidisciplinary Approach in Research, Vol. 15, pp. 78-83
15. Ramesh, G., Logeshwaran, J., & Rajkumar, K. (2022). The smart construction for image preprocessing of mobile robotic systems using neuro fuzzy logical system approach. NeuroQuantology, 20(10), 6354-6367
16. Raja, S., Logeshwaran, J., Venkatasubramanian, S., Jayalakshmi, M., Rajeswari, N., Olaiya, N. G., & Mammo, W. D. (2022). OCHSA: Designing Energy-Efficient Lifetime-Aware Leisure Degree Adaptive Routing Protocol with Optimal Cluster Head Selection for 5G Communication Network Disaster Management. Scientific Programming, 2022.
17. Gopi, B., Logeshwaran, J., Gowri, J., & Kiruthiga, T. (2022). The moment probability and impacts monitoring for electron cloud behavior of electronic computers by using quantum deep learning model. NeuroQuantology, 20(8), 6088-6100.
18. Gopi, B., Logeshwaran, J., Gowri, J., & Aravindarajan, V. (2022). The Identification of quantum effects in electronic devices based on charge transfer magnetic field model. NeuroQuantology, 20(8), 5999-6010.
19. Logeshwaran, J., Adhikari, N., Joshi, S. S., Saxena, P., & Sharma, A. (2022). The deep DNA machine learning model to classify the tumor genome of patients with tumor sequencing. International Journal of Health Sciences, 6(S5), 9364–9375.
20. Logeshwaran, J., Malik, J. A., Adhikari, N., Joshi, S. S., & Bishnoi, P. (2022). IoT-TPMS: An innovation development of triangular patient monitoring system using medical internet of things. International Journal of Health Sciences, 6(S5), 9070–9084.
21. Ramesh, G., Aravindarajan, V., Logeshwaran, J., Kiruthiga, T., & Vignesh, S. (2022). Estimation analysis of paralysis effects for human nervous system by using Neuro fuzzy logic controller. NeuroQuantology, 20(8), 3195-3206.
22. Ramesh, G., Logeshwaran, J., Aravindarajan, V., & Feny Thachil. (2022). Eliminate the interference in 5g ultra-wide band communication antennas in cloud computing networks. ICTACT Journal On Microelectronics, 8(2), 1338-1344
23. Sekar, G., Sivakumar, C., & Logeshwaran, J. (2022). NMLA: The Smart Detection of Motor Neuron Disease and Analyze the Health Impacts with Neuro Machine Learning Model. NeuroQuantology, 20(8), 892-899.
24. Logeshwaran, J., & Karthick, S. (2022, April). A smart design of a multi-dimensional antenna to enhance the maximum signal clutch to the allowable standards in 5G communication networks. ICTACT Journal on Microelectronics, 8(1), 1269–1274.
25. Jasmine, J., Yuvaraj, N., & Logeshwaran, J. (2022, April). DSQLR-A distributed scheduling and QoS localized routing scheme for wireless sensor network. In Recent trends in information technology and communication for industry 4.0, Vol. 1, pp. 47–60
26. Ramkumar, M., Logeshwaran, J., & Husna, T. (2022). CEA: Certification based encryption algorithm for enhanced data protection in social networks. In Fundamentals of Applied Mathematics and Soft Computing, Vol. 1, pp. 161–170
27. Logeshwaran, J. (2022, March). The control and communication management for ultra dense cloud system using fast Fourier algorithm. ICTACT Journal on Data Science and Machine Learning, 3(2), 281–284.
28. Majeed, A., & Zia, T. A. (2017). Multi-Layer Network Architecture for Supporting Multiple Applications in Wireless Sensor Networks. J. Wirel. Mob. Networks Ubiquitous Comput. Dependable Appl., 8(3), 36-56.
29. Khan, A. I., Alsolami, F., Alqurashi, F., Abushark, Y. B., & Sarker, I. H. (2022). Novel energy management scheme in IoT enabled smart irrigation system using optimized intelligence methods. Engineering Applications of Artificial Intelligence, 114, 104996.
30. Logeshwaran, J., Ramkumar, M., Kiruthiga, T., & Sharan Pravin, R. (2022, February). SVPA - the segmentation based visual processing algorithm (SVPA) for illustration enhancements in digital video processing (DVP). ICTACT Journal on Image and Video Processing, 12(3), 2669–2673
31. Su, S., & Zhao, S. (2019). A novel virtual force-based data aggregation mechanism with mobile sink in wireless sensor networks. Cluster Computing, 22, 13219-13234.
32. Wang, J., Zhang, S., Chen, W., Kong, D., Zuo, X., & Yu, Z. (2018). Design and implementation of SDN-based underwater acoustic sensor networks with multi-controllers. Ieee Access, 6, 25698-25714.
33. Logeshwaran, J., Ramkumar, M., Kiruthiga, T., & Sharanpravin, R. (2022). The role of integrated structured cabling system (ISCS) for reliable bandwidth optimization in high-speed communication network. ICTACT Journal on Communication Technology, 13(01), 2635–2639
34. Bradai, A., Singh, K., Rachedi, A., & Ahmed, T. (2015). EMCOS: Energy-efficient mechanism for multimedia streaming over cognitive radio sensor networks. Pervasive and Mobile Computing, 22, 16-32.

35. Logeshwaran, J. (2021, December). AICSA - an artificial intelligence cyber security algorithm for cooperative P2P file sharing in social networks. ICTACT Journal on Data Science and Machine Learning, 3(1), 251–253.
36. Ninghui, H., Hongsheng, L., & Jing, G. (2013). Energy-saving routing algorithm based on cluster in WSN. TELKOMNIKA Indonesian Journal of Electrical Engineering, 11(2), 839-847.
37. Bergui, M., Najah, S., & Nikolov, N. S. (2021). A survey on bandwidth-aware geo-distributed frameworks for big-data analytics. Journal of Big Data, 8(1), 40.