International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

Research Challenges of Improved Cluster Chain Power-Efficient Routing Using Natural Computing Methods for Wireless Sensor Network

Ritesh Yadav[1], SapnaJain[2]
[1,2]Department of Computer Science, Mata Raj Kaur Institute Of Engineering and Technology, Indira Gandhi University, Meerpur, Haryana, India
[1]riteshyadav728@gmail.com, rite2sapna@gmail.com

Abstract: Wireless Sensor Networks (WSNs) primarily operate on batteries, making energy conservation crucial, especially in routing processes. Efficient routing in WSNs is challenging due to the network's distinct attributes. Among various routing protocols, CCPAR is noteworthy as it utilizes a chain between cluster heads to relay data to the base station. This research delves into nature-inspired techniques for energy-efficient routing in WSNs. It introduces the Moth-Dolphin Optimization Algorithm, capitalizing on the communication between moths to enhance routing performance. This innovative method combines the navigational skills of moths and the communicative attributes of dolphins. When benchmarked against other optimization methods, the Moth-Dolphin algorithm offers favorable results. The study then applies this algorithm to improve CCPAR routing, aiming for reduced energy consumption. The modified routing's effectiveness is evaluated against other top-tier algorithms, considering factors like energy consumption, throughput, network longevity, and delay.

***Keywords**: Energy consumption, Wireless sensor network, routing protocol, CCPAR, Moth-Dolphin Optimization Algorithm*

1 INTRODUCTION

This discussion centers on the core principles of Wireless Sensor Networks (WSN) and their applications and challenges. WSNs use sensors to monitor environmental variables like humidity, temperature, and pollution [1]. These data are sent to a central location for analysis. Due to technological advancements, sensors are increasingly used in various sectors, including monitoring water levels, military surveillance, and fire detection [2]. The data collection from these sensors is typically tree-based, cluster-based, or chain-based [3,4].

Routing, crucial in WSNs, manages data transfer between sensor nodes and a base station that processes this data. Various protocols are employed, with the primary objectives being the extension of network lifespan and delay reduction [5-8]. However, factors like energy consumption, node mobility, and connectivity pose challenges to these networks. Depending on their use, routing protocols are categorized into three: task-specific, environment-specific, and general. Examples include underwater networks for the environment-specific category and multimedia systems for task-specific applications [9-12].

As illustrated in Figure 1[13], both the wireless sensor network and the conventional system comprise standard elements such as sensor nodes (which act as sources or sinks/actuators), gateways, internet, and satellite connections [13, 14]. The prevalent structure is typically based on the OSI architecture model. Further details will be provided in the subsequent subsections.

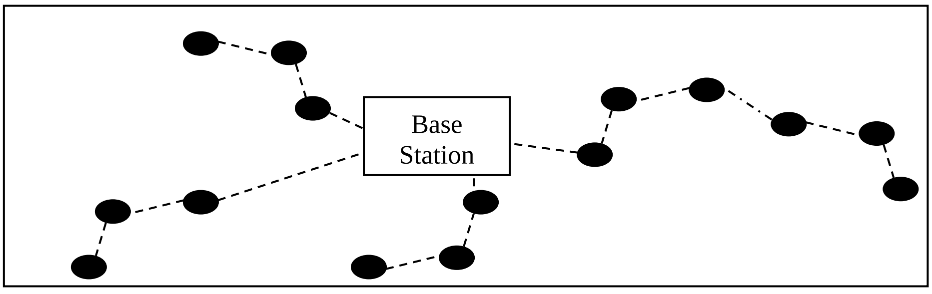

Fig. 1 Depiction of the sensor network and its core infrastructure [13].

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

Sensor nodes collect and process data from various sensors, with a design focused on battery conservation and improved performance. These nodes are essential for detection and data transmission [15]. Depending on system requirements, nodes can perform calculations and either relay processed data to nearby nodes or send it unchanged to the task manager. Within the sensor field, a node can serve as a source, detecting and sharing information about the environment, or as a sink/actuator [17,18] shown in the Figure 2 [19].

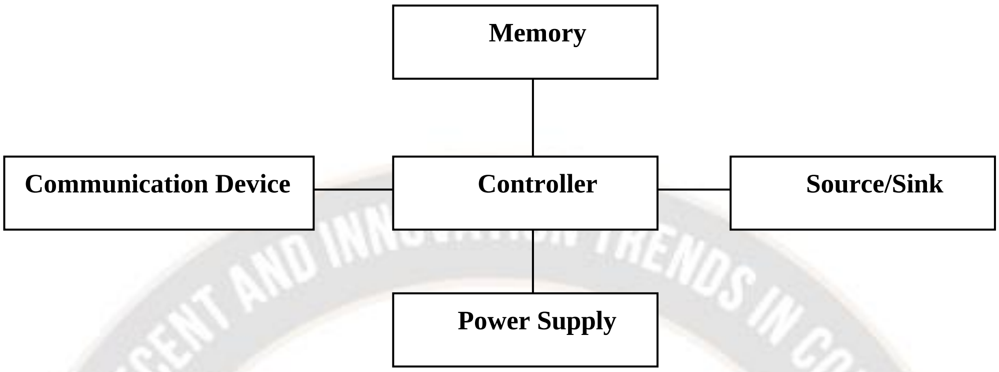

Fig. 2: Summary of hardware elements in a sensor node

Gateways allow researchers or internet users to interact within the network. They facilitate internet access by connecting multiple networks and managing data forwarding based on protocols. Gateways can also filter data, implying that they can incorporate firewalls to guard against potential threats or viruses. Serving as protocol converters, gateways link different networks, ensuring network continuity. They can function at any layer of the OSI Model [15].

The WSN structure comprises five primary layers and three cross layers. Typically, sensor networks utilize the five layers: application, transport, network, data link, and physical layer. Additionally, the architecture integrates three cross planes: task management, mobility management, and power management. Together, these layers and cross planes function to establish the network, enabling the sensors to work collaboratively and optimizing network efficiency.

2 LITERATURE SURVEY

Here we have included studies conducted by various research scholars on Wireless Sensor Network (WSN), focusing on its routing protocols and the application of natural computing techniques for routing.

[1] Lee et al. (2011) analyzed how effective data collection is crucial in WSNs. The study highlights subterranean ant colony optimization as a commonly employed technique for network routing. They introduced a heuristic approach using Ant Colony Optimization (ACO) to conserve energy in WSN routing. The paper also detailed three variations of ACO and their relevance to WSN routing, suggesting that ACO can enhance network longevity while conserving energy.

[2] Heo et al. (2009) addressed the importance of efficient node deployment in WSN, noting that it can cut costs and boost network detection capabilities. They proposed an ACO-based strategy for effective node deployment to enhance network monitoring and coverage.

[3] Wang et al. (2017) proposed a two-phase method to select cluster heads. Initially, factors like node concentration, energy level, and centrality are considered. The selected cluster heads then collect and compress data before sending it to the base station.

[4] Xie et al. (2013) introduced the PEBACH approach, primarily for periodic data collection. It selects the cluster head based on energy levels and distance factors, addressing the challenges of enlarging network size and conserving energy.

[5] Kumari and Prachi (2015) introduced an online packet-forwarding method to decrease network traffic. Their work also enhanced the existing LEACH algorithm using Fuzzy Logic processors to manage cluster heads efficiently.

[6] Singh et al. (2012) emphasized the significance of energy conservation in cluster heads. They proposed LEACH-FL, an improved selection criteria over the standard LEACH protocol, which showed reduced energy consumption in experiments.

[7] Mehra et al. (2018) described a method to determine the optimal number of clusters in a WSN using fuzzy c-means clustering, considering factors like node degree and energy consumption.

[8] Varshney et al. (2018) introduced an energy-efficient LEACH-C variant. This method chooses cluster heads

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

based on optimal energy consumption calculations, enhancing the network's longevity.

[9] Al-Karaki and Kamal (2004) focused on selecting the best cluster head based on proximity to the centroid and energy levels. Their experiments showed an increase in network lifespan and improved coverage. In WSNs, the primary goal is to extend node lifetimes while minimizing energy consumption. Siew et al. and Purohit et al. discussed factors and strategies to achieve these objectives. Sharma et al. introduced the master cluster head concept, which consolidates data before sending it to the base station, conserving energy.

[10] Karlof and Wagner (2003) proposed methods to improve node localization by reducing positioning errors using the ACO-based mobile anchor localization algorithm.

[11] Akyildiz et al. (2002) introduced a PSO-based strategy for efficient energy localization. Static sensors first communicate their data to a mobile destination, which then estimates their position and distance, improving location accuracy.

[12] Yick, J., Mukherjee, B., and Ghosal, D. (2008): In this paper, the authors conducted a survey of wireless sensor networks (WSNs) and discussed various enhancement methods that incorporate evolutionary models. These models are used to achieve similar behavior in different areas of WSN optimization, and the paper also references other works that utilize evolutionary models in various optimization areas.

Gao, T., Greenspan, D., Welsh, M., Juang, R. R., and Alm, A. (2006) [13], The authors introduced a centralized cluster-based protocol and a meta-heuristic method for wireless sensor networks, specifically a real-time clustering protocol called Harmony. This protocol minimizes the distance between cluster heads and cluster nodes to reduce energy consumption, making it suitable for surveillance and building environments.

Ammari, H. M. (2016)[14This paper focuses on reliability and energy efficiency in multi-hop wireless sensor networks (WSNs). It presents the REC+ protocol, a reliable and energy-efficient chain-group-based routing protocol that optimizes cluster head placement, reliability, and cluster size without requiring additional error control approaches.

3 UNDERSTANDING CLUSTERING IN WSN

In WSN, clustering refers to organizing sensor nodes into distinct groups based on certain criteria, known as virtual groups. Different groups may have specific rules or functions tailored to their requirements and application needs. Each cluster has a designated cluster head, which is the primary communication point for nodes, either directly or through a multi-hop mechanism. The cluster head is responsible for transmitting aggregated data to the main collection point, either directly or via other cluster heads. Implementing clusters enhances network stability by promoting data consolidation, which reduces redundancy, cuts overheads, and conserves energy [9, 25, 26]. Figure 3 presents a typical sensor network structure.

Sensor Node: This is the core component of WSN. Its roles vary and can include tasks like primary sensing, data storage, routing, and data processing.

Cluster-heads (CHs): Acting as the leaders of their respective clusters, CHs collect, filter, and forward aggregated data to its destination.

Base Station: This entity functions as an administrative or decision-making hub. It serves as the communication bridge between the sensor network and the end user.

End User: Data from a sensor network can serve a wide array of applications [9]. Specific applications might access network data via the internet, through mobile devices or PCs. In query-based sensor networks, data retrieval starts with a query, initiated by the end user [26, 27, 28].

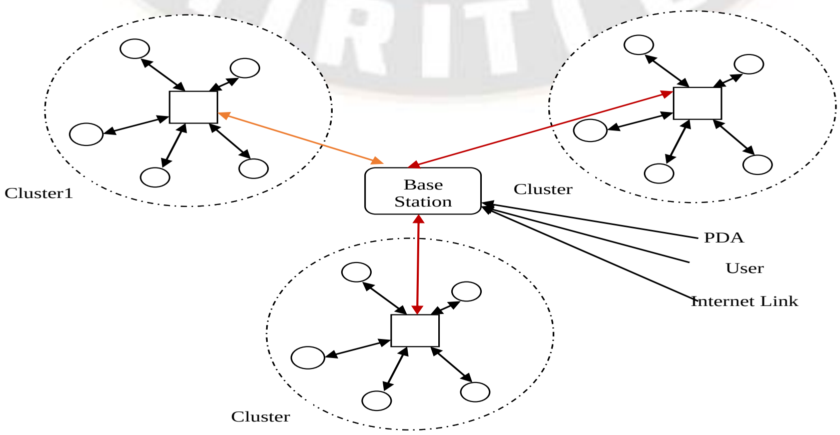

Fig. 3 Basic Structure of Sensor Network

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 9
***Article Received:** 25 July 2023 **Revised:** 12 September 2023 **Accepted:** 30 September 2023*

Clusters in networks consist of nodes organized logically to reduce complexity and enhance performance across various network types [30] and clustering types [31] like; Well-Isolated Clusters: Comprised of points where each point within the cluster is closer to others in the same cluster than to any outside it.Center-Based Clusters: Defined by objects that are closer to a cluster's center, usually a centroid or medoid, than to any other cluster's center.Contiguous Clusters: Made up of points where each one is closer to at least one other within the same cluster than to any outside it.Density-Based Clusters: These are regions with high point density separated by low-density areas. They are used when clusters are irregular or intertwined and when there's noise or anomalies.

Clustering is a technique to group similar objects or data points based on specific rules or relationships. In the context of Wireless Sensor Networks (WSNs), clustering helps to minimize energy consumption by limiting the number of nodes involved in long-distance communication to a base station. The data is divided into clusters, each containing similar objects, simplifying the data's representation at the expense of some detail.

Critical considerations in clustering methods include:

- Number of Clusters: The choice and arrangement of Cluster Heads (CHs) can lead to a variable or predetermined number of clusters, affecting the efficiency of the routing protocol.
- Intra-Cluster Communication: Initial approaches often used direct (one-hop) communication between sensors and their CHs. However, multi-hop communication within clusters is increasingly common, especially when the sensor range is limited or the network is extensive.
- Mobility of Nodes and CHs: Stationary nodes and CHs generally lead to stable clusters. If nodes or CHs are mobile, clusters must be dynamically maintained, adding complexity.
- Types and Roles of Nodes: CHs may have more computational and communication resources in heterogeneous networks than other nodes. All nodes have similar capabilities in homogeneous networks, and only a subset becomes CHs.
- Overlapping: Some protocols consider node overlap between clusters for various reasons, such as better routing efficiency, although many protocols aim for minimal or no overlap.

Figure 4 [32] illustrates the categorization of clustering algorithms into four primary types:

1. Distinct Clustering: In this category, each data point is a member of only one cluster, with K-means serving as a notable example.
2. Intersecting Clustering: Here, data points may be part of multiple clusters.
3. Hierarchical Clustering: This type encompasses agglomerative (bottom-up) and divisive (top-down) techniques.
4. Stochastic Clustering: This employs a probabilistic method, often starting with initial probabilities designated for potential cluster heads.

In the context of Wireless Sensor Networks (WSNs), clustering is frequently employed for tasks like hierarchical routing, data gathering, network administration, conserving energy, and equitable energy distribution.

The benefits of clustering methods include efficient data summarization, minimized data transmission and communication overhead, reduced latency, balanced workload, simplified network governance, and enhanced network stability and efficiency.On the flip side, the drawbacks involve the requirement for additional hardware and infrastructure, elevated maintenance efforts due to the dynamic nature of the setup, increased costs, and multiple security vulnerabilities.

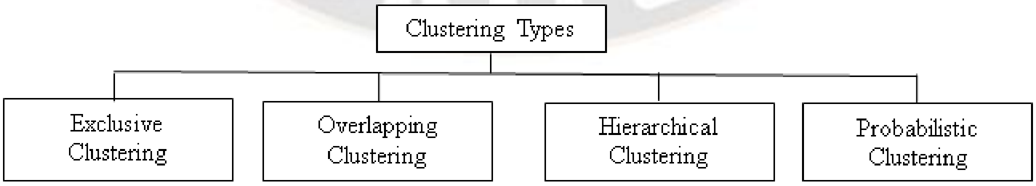

Fig. 4 Categorization of Clustering Methods

4 ROUTING PROTOCOLS

Routing involves a set of guidelines for choosing the best path to move data within a single network or between multiple networks. It is usually a straightforward process based on routing protocols or tables, often set by an administrator. Two main types of routing are used depending on the network's needs: static routing for smaller, simpler networks with pre-defined routes and dynamic routing for larger, more complex networks with frequently changing topologies. Dynamic routing is particularly prevalent on the internet. In the context of Wireless Sensor Networks (WSNs), different applications have specific requirements, and three types of algorithms are employed to meet these needs, shown in Figure 5 [35].

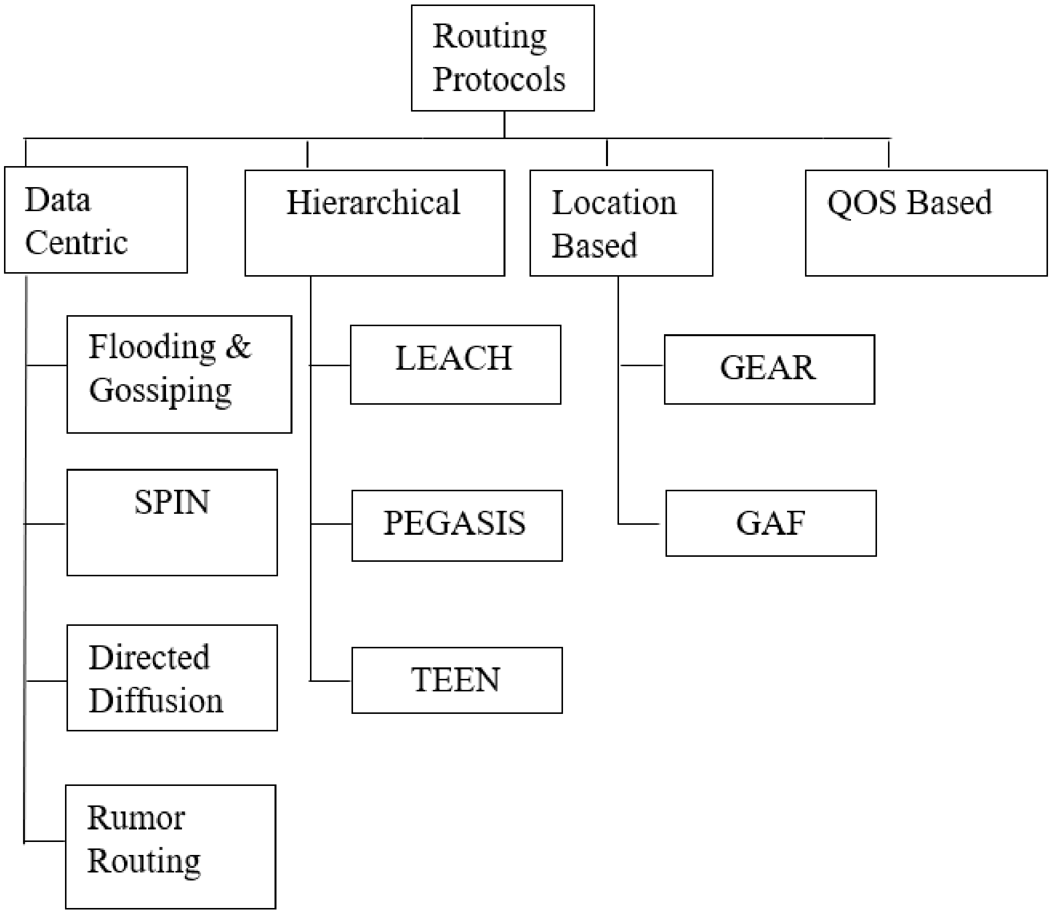

Fig.5 Routing Protocols Types

Attribute-based or Data-centric Routing Protocols in WSNs- In WSNs, sensor nodes often lack global identification because they are randomly deployed. Data-centric algorithms select specific sensor nodes responsible for forwarding data to address this. These selected nodes also perform data aggregation to optimize the data transmission process. Various protocols and conventions are studied under this category to improve the efficiency of data routing.

- Flooding and Gossiping: Flooding broadcasts data to all neighbors, but is not energy-efficient and creates redundancy. Gossiping is a refined version that sends data to one neighbor at a time but is slow.
- Sensor Protocol for Information by means of Negotiation (SPIN): Focuses on data-centric routing with negotiation and resource adaptation features. It aggregates data at intermediate nodes before sending it to the sink.
- Directed Diffusion: Uses named data and interest queries for communication. It maintains local interest caches to avoid loops.
- Rumor Routing: Aims for energy efficiency and creates paths when events occur. It uses agents to discover routes.

Hierarchical Routing Protocols-This routing protocol organizes the network into hierarchical levels for easier management. The network is first divided into clusters and then into regions containing sensor nodes. This hierarchical structure simplifies implementation and enhances the effectiveness of network management.

- Low-Energy Adaptive Clustering Hierarchy (LEACH): Focuses on energy efficiency through clustering and uses TDMA for communication scheduling. It has limitations like random cluster head selection and limited coverage.
- Power-Efficient Gathering in Sensor Information Systems(PEGASIS): Uses a chain-based approach where nodes transmit data to their closest neighbors, eventually reaching the base station. It is energy-efficient but complex.

- Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN): Suitable for time-critical applications, it uses soft threshold values for accuracy and energy efficiency.

Location-Based Routing (Geographic Protocol)-These routing algorithms utilize the positions of the nodes for operation. They primarily function within a designated, virtually defined area or region. The algorithms rely on local information and are typically executed on a single node.

- Geographic and Energy Aware Routing(GEAR): Uses geographical location and energy awareness for routing. It restricts the number of interests to save energy.
- Geographic Adaptive Fidelity(GAF) and HGAF: Focus on battery conservation by selecting only a few active nodes for communication.

QoS-based Routing-The main aim of QoS routing [41, 46] is to provide the best network services and there are various parameters to determine and aims to provide optimal network services based on parameters like delay, jitter, loss, scalability, reliability, power efficiency, and mobility.

5 NATURAL COMPUTING

Natural Computing is a field of research that draws inspiration from nature to solve technical problems. It is particularly interesting for optimizing algorithms in Wireless Sensor Networks (WSNs).

- Genetic Algorithm (GA): Inspired by natural selection, GA is used for high-end solutions to search problems. It employs operators like mutation, crossover, and selection, focusing on a fitness function to optimize solutions. The algorithm evolves a population of candidate solutions over generations.
- Ant Colony Optimization (ACO): Based on ant behavior, this algorithm finds optimal paths in a graph. Ants lay down pheromones to guide each other, and this concept is simulated to find optimal solutions in various problems.
- Particle Swarm Optimization (PSO): Inspired by bird flocking behavior, PSO is used for optimization problems. Birds, or particles in the algorithm, adjust their positions based on their neighbors' positions, aiming to find the optimal solution over time.
- Moth Flame Optimization Algorithms (MFOA): This algorithm is inspired by the moth's behavior of using moonlight for navigation. Moths either move in a straight line or spiral depending on their distance to the moon. In MFOA, the moth's position is evaluated using an objective function, and the algorithm aims to find the global optimum.

These algorithms have been applied in various domains, including WSNs, for optimizing network performance. They offer a blend of simplicity, low computational cost, and effectiveness.

6 ISSUES AND CHALLENGES IN WSN

Communication networks can be categorized into several types, such as cellular networks, adhoc networks, sensor networks, and mesh networks, among others. Many of these networks rely on underlying infrastructures. Numerous definitions have been provided by researchers for wireless sensor networks (WSN). Based on observations, WSN is a unique subset of adhoc networks. Its purpose is to establish a foundation for wireless communication, utilize tools to monitor the physical environment or infrastructure, and then use this gathered information for decision-making and distribution as needed [6,20].

Node Deployment: Node deployment is essential for a strong network, ensuring its longevity and reducing redundancy. The optimal placement of nodes, especially in contexts like traffic monitoring, is challenging due to various influencing factors. Nodes can be statically or dynamically deployed. Static deployment remains fixed, with deterministic methods targeting specific areas and random methods used for riskier environments like forests. Conversely, dynamic deployment aims for optimal node density. Setting up node deployment in WSN is a detailed and time-consuming process.

Energy Considerations: The application of WSN spans sectors like commercial, medical, and military. A primary challenge in WSN is power consumption, as sensor nodes often rely on their own power resources for operations. Hence, a network's longevity is tied to the sensors' power usage. Researchers have identified alternative power sources, such as energy harvesting from environmental vibrations, suitable for low-power sensors [6].

Data Delivery Models: In WSN, different data delivery models are used depending on the application. These include the continuous model, where data is sent regularly; the event-driven and query-driven models, where transmission is based on events or queries; and the hybrid model, which merges features of the other models. Selecting the most suitable model for efficient data delivery in WSN can be challenging, with a key goal being to minimize data transmission delays [20].

Data Aggregation/Fusion: Data aggregation in WSN is a technique aimed at reducing data redundancy. It involves collecting information and processing it into a condensed form suitable for statistical evaluation. However, implementing this method in wireless sensor networks can be challenging. Inadequate management of data aggregation can negatively impact metrics like energy, accuracy, and security [24].

Collision Avoidance: It is maintenance of system and used to avid the collision in unit that used to carry the data e.g. packet, frame etc. The overall lifetime of network can be can increased by collision avoidance. There are various protocols/access methods are used to ensure the collision avoidance in the WSN's [21, 23].

Location Identification: Localization in WSN is crucial. WSNs have diverse applications like target tracking and remote location monitoring where pinpointing a location is essential. Precise location identification is key to the successful use of WSNs.

Gathering Information: One of the primary functions in wireless sensor networks is data gathering. Raw data collection without aggregation from various sensors defines data gathering. For optimal accuracy, energy conservation, and improved reliability, this process presents challenges and needs meticulous execution to enhance the network's lifespan.

Resilience to Failures:WSNs must be resilient to various disruptions. Sensor nodes, deployed in varying environments, can face challenges like energy constraints or issues specific to applications such as battlefield surveillance or traffic management. They might encounter hardware malfunctions, energy depletion, and communication disruptions.

Expandability: Scalability refers to a network or system's adaptability in areas like administration, functionality, geography, and workload. This trait greatly influences routing protocols and their application.

Network Adaptability: Network needs and purposes evolve over time and serve varied applications. Given that networks lack a fixed structure, they face challenges in adapting dynamically to demands. The frequent changes necessitate maintaining consistent data transmission among sensors, preventing potential network issues.

Communication Medium: WSNs predominantly utilize wireless mediums such as Bluetooth. It's favored for its interference-free and sturdy nature. However, several factors, like energy levels and environmental conditions, influence its performance. Secure communication remains a significant concern in WSNs.

Performance Metrics: "Quality of Service" gauges a network's overall efficacy. While its interpretation varies, in computer networking, it often pertains to mechanisms like traffic prioritization. It facilitates application prioritization, and its metrics in computer networks include factors like packet loss, bit rate, and transmission delays.

7 CONCLUSION

Wireless Sensor Networks (WSNs) are primarily powered by batteries, making energy conservation essential, especially for routing. This research highlights the CCPAR routing protocol, which uses a chain between cluster heads to transmit data. The study introduces the Moth-Dolphin Optimization Algorithm to enhance routing efficiency by combining the moth's navigational skills with dolphin's communicative traits. WSNs employ sensors to monitor environmental factors like humidity and temperature. These sensors, which have grown in importance due to technological advancements, are utilized in sectors like military surveillance and fire detection. Routing, a pivotal aspect of WSNs, ensures effective data transfer between sensor nodes and the central processing base. Various routing protocols exist, each with its challenges.

Natural Computing aims to derive computational methods from nature. In the WSN context, techniques such as Genetic Algorithms, Ant Colony Optimization, and Particle Swarm Optimization have been explored for optimizing performance. WSNs have various challenges to tackle. Key among them are optimal node deployment, energy conservation, data aggregation, collision avoidance, accurate location identification, resilience to failures, scalability, network adaptability, choice of communication medium, and maintaining quality of service. Essentially, this comprehensive research discusses the principles, methodologies, challenges, and potential solutions in the realm of WSNs.

REFERENCES

[1] Lee, J.W.,Choi, B.S., and Lee, J.J., (2011), "Energy-Efficient Coverage of Wireless Sensor Networks Using Ant Colony Optimization with Three Types of Pheromones,"*IEEE Transactions on Industrial Informatics*, **7**(3), pp. 419–427.

[2] Heo, J., Hong, J., and Cho, Y., (2009) "EARQ: Energy Aware Routing for Real-time and Reliable Communication in Wireless Industrial Sensor Networks," *IEEE Transactions on Industrial Informatics'*, **5**(1), pp. 3–11.

[3] Wang, J., Cao, Y., Li, B., Kim, H.J., and Lee, S., (2017), "Particle Swarm Optimization Based Clustering Algorithm with Mobile Sink for WSNs," *Future Generation Computer Systems*, **1**(76), pp. 452-457.

[4] Xie, D., Zhou, Q., Liu, J., Li, B., and Yuan, X., (2013), "A Chain-Based Data Gathering Protocol Under Compressive Sensing Framework for Wireless Sensor Networks,"*International Conference on*

Computational and Information Sciences, pp. 1479-1482.

[5] Kumari, J., and Prachi, (2015), “A Comprehensive Survey of Routing Protocols in Wireless Sensor Networks,”*2nd International Conference on Computing for Sustainable Global Development (INDIACom)*, **16**(4), pp. 325–330.

[6] Singh, N., Dua, R., and Mathur, V., (2012), “Wireless Sensor Networks: Architecture, Protocols, Simulator Tool,” *International Journal of Advanced Research in Computer Science and Software Engineering*, **2**(5), pp. 229-233.

[7] Mehra, P.S., Doja, M.N., andAlam, B., (2018), “Fuzzy Based Enhanced Cluster Head Selection (FBECS) for WSN,”*Journal of King Saud University-Science*, https://doi.org/10.1016/j.jksus.2018.04.031

[8] Varshney, S., Kumar, C., andSwaroop, A., (2018), “Leach Based Hierarchical Routing Protocol for Monitoring of Over-ground Pipelines Using Linear Wireless Sensor Network,” *Procedia Computer Science*, **125**, pp. 208-214.

[9] Al-Karaki, J.N., and Kamal, A.E., (2004),“Routing Techniques in Wireless Sensor Networks: A Survey,” *IEEE wireless communications*, **11**(6), pp. 6-28.

[10] Karlof, C., and Wagner, D., (2003),“Secure Routing in Wireless Sensor Networks: Attacks and Countermeasures,” *Proc. 1st IEEE International Workshop on Sensor Network Protocols and Applications,IEEE*, Anchorage, AK, USA,pp. 113-127.

[11] Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., and Cayirci, E., (2002), “Wireless sensor networks: a survey,” *Computer networks*, **38**(4), pp. 393-422.

[12] Yick, J., Mukherjee, B., and Ghosal, D., (2008),“Wireless Sensor Network Survey,” *Computer Networks*, **52**(12), pp. 2292–2330.

[13] Simon, G., Maroti, M., Ledeczi, A., Balogh, G., Kusy, B., Nadas, A.,and Frampton, K., (2004), “Sensor Network-Based Countersniper System,” *Proc. 2ndInternational Conference on Embedded Networked Sensor Systems*, pp. 1-12.

[14] Gao, T., Greenspan, D., Welsh, M., Juang, R. R., and Alm, A., (2006), “Vital Signs Monitoring and Patient Tracking Over a Wireless Network,” *Proc. 27th Annual International Conference on Engineering in Medicine and Biology Society*, pp. 102-105.

[15] Ammari, H. M., (2016), “A Unified Framework for K-Coverage and Data Collection in Heterogeneous Wireless Sensor Networks,” *Journal of Parallel and Distributed Computing*, **89**, pp. 37–49.

[16] Sims, M., Goldman, C. V., and Lesser, V., (2003), “Self-Organization through Bottom-Up Coalition Formation,” *Proc. 2nd International Joint Conference on Autonomous Agents and Multiagent Systems*, pp. 867–874.

[17] Shi, L., and Fapojuwo, A. O., (2010), “TDMA Scheduling with Optimized Energy Efficiency and Minimum Delay in Clustered Wireless Sensor Networks,”*IEEE Transactions on Mobile Computing*, **9**(7), pp. 927–940.

[18] Hempstead, M., Tripathi, N., Mauro, P., Wei, G. Y., and Brooks, D., (2005), “An Ultra Low Power System Architecture for Sensor Network Applications,”*Proc. 32ndInternational Symposium on Computer Architecture (ISCA’05),* IEEE Computer Society Washington, DC, USA, **33**(2), pp. 208–219.

[19] Akyildiz, I. F., Su, w., Sankarasubramaniam, Y., and Cayirci, E.,(2002), “A Survey on Sensor Networks,” *IEEE Communications Magazine*, **40**(8), pp. 102–105. doi: 10.1109/MCOM.2002.1024422.

[20] Sarma, H. K. D., Kar, A., and Mall, R., (2011), “Energy Efficient Routing Protocol for Wireless Sensor Networks with Node and Sink Mobility,” *IEEE Sensors Applications Symposium*, pp. 239–243. doi: 10.1109/SAS.2011.5739777.

[21] Tang, L., Sun, Y., Gurewitz, O., and Johnson, D. B., (2011), “PW-MAC: An Energy-Efficient Predictive-Wakeup MAC Protocol for Wireless Sensor Networks,” *Proc. 30th IEEE International Conference on Computer Communications, INFOCOM’11*, pp. 1305–1313. doi: 10.1109/INFCOM.2011.5934913.

[22] Somani, N. A., and Patel, Y., (2012), “Zigbee : A Low Power Wireless Technology for Industrial,” *International Journal of Control Theory and Computer Modelling*, pp. 27–33. doi: 10.5121/ijctcm.2012.2303.

[23] Dutta, P., Dawson-Haggerty, S., Chen, Y., Liang, C. J. M., andTerzis, A., (2010), “Design and Evaluation of a Versatile and Efficient Receiver-Initiated link layer for low-Power Wireless,” *Proc. 8th ACM Conference on Embedded Networked Sensor Systems - SenSys’10,* pp. 1-14. doi: 10.1145/1869983.1869985.

[24] Pantazis, N. A., Nikolidakis, S. A., and Vergados, D. D., (2013), “Energy-Efficient Routing Protocols in Wireless Sensor Networks: A Survey,”*IEEE Communications Surveys and Tutorials*, **15**(2), pp.

551–591. doi: 10.1109/SURV.2012.062612.00084.

[25] Bandyopadhyay, S., and Coyle, E. J., (2003), “An Energy Efficient Hierarchical Clustering Algorithm for Wireless Sensor Networks,” *Proc. 22nd Annual Joint Conference of the IEEE Computer and Communications-Infocom’03,* **3**(C), pp.1713–1723. doi: 10.1109/INFCOM.2003.1209194

[26] Younis, O., Krunz, M., and Ramasubramanian, S., (2006), “Node Clustering in Wireless Sensor Networks: Recent Developments and Deployment Challenges,”*IEEE Network*, **20**(3), pp. 20–25. doi: 10.1109/MNET.2006.1637928.

[27] Abbasi, A. A., and Younis, M., (2007), “A Survey on Clustering Algorithms for Wireless Sensor Networks,” *Computer Communications*, **30**(14-15), pp. 2826–2841. doi: 10.1016/j.comcom.2007. 05.024.

[28] Sohrabi, K., Gao, J., Ailawadhi, V., and Pottie, G. J., (2000), “Protocols for Self-Organization of a Wireless Sensor Network,” *IEEE Personal Communications*, **7**(5), 16-27.doi: 10.1109/98.878532.

[29] Boyinbode, O., Le, H., Mbogho, A., Takizawa, M., andPoliah, R., (2010), “A Survey on Clustering Algorithms for Wireless Sensor Networks,” *13th International Conference on Network-Based Information Systems (NBIS, 2010)*, pp. 259-268. doi: 10.1109/NBiS.2010.59.

[30] Khan, M. A., (2012), “Multiple Parameter Based Clustering (MPC): Prospective Analysis for Effective Clustering in Wireless Sensor Network (WSN) Using K-Means Algorithm,” *Wireless Sensor Network*, **4**(1), pp. 18–24. doi: 10.4236/wsn.2012.41003.

[31] Rai, P., and Singh, S., (2010), “A Survey of Clustering Techniques,” *International Journal of Computer Applications*, **7**(12), pp. 1–5. doi: 10.5120/1326-1808.

[32] Ghiasi, S., Srivastava, A., Yang, X., and Sarrafzadeh, M., (2002), “Optimal Energy Aware Clustering in Sensor Networks,” Sensors, 2(7), pp. 258–269. doi: 10.3390/s20700258.