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Non-Metaheuristic Clustering Algorithms for Energy-Efficient Cooperative Communication in Wireless Sensor Networks: A Comparative Study

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Abstract
Wireless Sensor Networks (WSNs) are now considered a vital technology that enables the gathering and distribution of data in various applications, such as environmental monitoring and industrial automation. Nevertheless, the finite energy resources of sensor nodes pose significant obstacles to the long-term viability and effectiveness of these networks. Researchers have developed and studied various non-meta algorithms to improve energy efficiency, data transfer, and network lifespan. These efforts contribute to enhancing cooperative communication modules. This analysis conducts a detailed examination and comparative evaluation of different well-known clustering methods in the field of Wireless Sensor Networks (WSNs), providing significant insights for improving cooperative communication. Our purpose is to provide a comprehensive perspective on the contributions of these algorithms to improving energy efficiency in WSNs. This will be achieved by examining their practical implementations, underlying mathematical principles, strengths, shortcomings, real-world applications, and potential for further improvement.
Keywords: Wireless Sensor Network, Energy-Efficient, Non-Metaheuristic, Clustering Algorithm.

1. INTRODUCTION

Cooperative communication in wireless communications pertains to the collaborative efforts of numerous wireless devices to enhance the communication quality between them. Cooperative communication is necessary because of the constraints inherent in conventional wireless communication. Cooperative communication in wireless communications entails the cooperation among several wireless devices to enhance the overall network performance. It entails the exchange of information, resources, and processing skills across different devices to overcome diverse obstacles and attain enhanced efficiency, dependability, and coverage. Cooperative communication is necessary for several reasons.

Cooperative communication in wireless networks is an effective method to address different obstacles and improve the performance, dependability, and efficiency of contemporary wireless communication systems. It is essential for fully harnessing the capabilities of wireless technology in many applications, such as cellular networks, ad-hoc networks, and the Internet of Things (IoT). In summary, collaborative communication is crucial for enhancing the effectiveness, dependability, and productivity of wireless communication systems. It facilitates the collaboration of devices to surpass the constraints of conventional wireless communication, consequently improving the user experience and enabling the development of novel applications and services.

Within the domain of Wireless Sensor Networks (WSNs), the network's foundation is composed of complex electro-mechanical elements known as sensor nodes. These nodes create links via RF waves with highly efficient receivers called base stations (BSs). Communication inside these networks can occur through either single-hop or multi-hop transmission. Sensor networks can be classified into two main types based on their functionality: proactive networks and reactive networks. Proactive networks function in a passive manner, making them well-suited for activities involving data aggregation. In these tasks, nodes gather and transmit data at regular intervals. In contrast to passive networks, reactive networks motivate sensor nodes to respond promptly only to changes in relevant parameters of interest. Reactive networks are very useful in situations that require timely responses. Collaborative interactions among sensor nodes have emerged as an effective approach to prolong the lifespan of sensor networks.

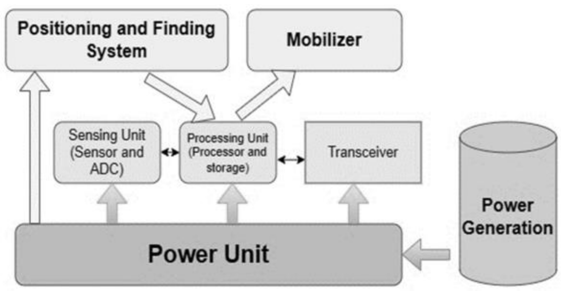

Figure.1 A typical set-up of Sensor within an WSN

2. CLUSTERING AND ITS FEATURES

Clustering is a useful approach to reduce communication expenses and save energy resources in Wireless Sensor Networks (WSNs). This method entails the arrangement of sensors into clusters, with the selected cluster head being solely responsible for transmitting consolidated data [6]. It appears as a hierarchical network structure, where higher-level nodes, like cluster chiefs, have increased duties that set them apart from the nodes at lower levels in the hierarchy [5][6]. The hierarchical notion is similar to that of a hierarchical network, where cluster heads are located at higher levels. The cluster heads are responsible for collecting sensory qualities from the member nodes located at lower levels. Afterwards, the cluster heads perform data aggregation by combining the sensory information and sending the combined data to either higher-level cluster heads or directly to the base station, which may act as the sink node [5][6].

3. DIFFERENT NON-META CLUSTERING ALGORITHMIC EXPLORATION AND THEIR COMPARATIVE ANALYSIS

3.1 Low-Energy Adaptive Clustering Hierarchy (LEACH)

The Low-Energy Adaptive Clustering Hierarchy (LEACH) protocol, introduced by Heinzelman et al. [1], is an innovative approach to provide energy-efficient communication in wireless sensor networks (WSNs). LEACH offers notable energy conservation and extends the lifespan of the network. However, it does have several drawbacks, including the requirement for regular re-election of cluster heads and the possibility of uneven energy distribution caused by probabilistic selection. Despite the difficulties faced, LEACH's innovative methodology has served as a source of inspiration for further investigation, resulting in the development of improved versions such as LEACH-C [2] and LEACH-V [3]. These adaptations have successfully tackled some of the limitations of the original protocol.

Implementation: LEACH utilises a hierarchical clustering methodology in which nodes autonomously form clusters, with each cluster being led by a cluster head (CH). CHs have the responsibility of collecting and delivering data to the sink.

Mathematical Approach: The process of selecting CHs entails nodes determining a probability threshold based on their energy levels using the probabilistic method. Nodes that surpass this criterion are designated as Cluster Heads (CHs) for a specific round.

Improvement Needs: Implementing more advanced CH (Cluster Head) selection procedures could effectively mitigate energy imbalances and minimise the overhead imposed by frequent re-elections.

3.2 Power-Efficient Gathering in Sensor Information Systems (PEGASIS)

PEGASIS focuses on the crucial issue of energy optimisation in wireless sensor networks. The authors of this research study introduce a new hierarchical data aggregation protocol called PEGASIS. The protocol is specifically designed to extend the total lifespan of the network by greatly reducing energy usage during data transfer. The protocol utilises a chain-based topology, where sensors are arranged in a linear manner, and data is relayed sequentially from one sensor to another until it reaches a specified sink node. PEGASIS implements a dynamic switching mechanism that interchanges between two gearbox modes: short-range and long-range. This flexibility aids in reducing energy disparities and extending the network's uptime. Moreover, PEGASIS enhances the process of data fusion by enabling intermediate nodes to consolidate information prior to delivering it to the sink, hence minimising unnecessary data transmission and preserving energy. The simulation findings clearly indicate that PEGASIS outperforms existing protocols in terms of energy efficiency, network longevity, and data transfer dependability. PEGASIS implements a communication paradigm based on chains, in which nodes transmit data to their closest neighbours. The final node transfers consolidated data to the sink.

Mathematical Approach: The algorithm is mainly designed based on the linear chain topology. Every node transmits data to the subsequent node in a pre-established order.

Use cases: PEGASIS is suitable for linear deployments, such as the surveillance of rivers, pipelines, and roadways, where data must follow a defined route.

Improvement Opportunities: The integration of PEGASIS with other algorithms can effectively mitigate communication delays and improve the overall resilience.

3.3 Sensor Protocols for Information via Negotiation (SPIN)

SPIN presents an innovative method for sharing data by utilising a cluster-based architecture. Clusters consist of sensors, and inside each cluster, a coordinator oversees the negotiating process. Prior to data transmission, sensors engage in a negotiation process to ascertain the node that should initiate the transmission of its data, taking into consideration elements like as energy levels and the urgency of the data. This collaborative procedure aids in minimising crashes and minimising energy inefficiency.

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Implementation: SPIN employs a data-centric communication paradigm, wherein nodes solicit particular data qualities from their neighbouring nodes.
Mathematical Approach: Nodes initiate requests for certain data properties. Adjacent nodes react with pertinent information, enhancing communication efficiency.
Use cases: SPIN is particularly useful in situations where there is a strong relationship between data points, such as in the fields of habitat monitoring and environmental tracking.
Areas for improvement: The efficiency and scalability could be enhanced through the use of adaptive negotiation tactics and revised query-response systems.

3.4 Directed Diffusion

The Directed Diffusion technique for clustering in wireless sensor networks is an innovative methodology that aims to improve communication efficiency and conserve energy. This novel methodology, explicated in scholarly literature, seeks to enhance the distribution and consolidation of data inside sensor networks by using the intrinsic features of the network structure and data-centric interactions. Directed Diffusion utilises a communication paradigm based on gradients, where data is transmitted from the source node to the sink node along a directed path created by a network of sensor nodes. Directed Diffusion differs from conventional flooding-based techniques by prioritising controlled data propagation, hence minimising superfluous data redundancy and decreasing energy consumption. The network is partitioned into clusters, where each cluster consists of a source node that initiates data dissemination, and a group of follower nodes that forward and consolidate the data. The simulation findings highlight the efficacy of the strategy in reducing energy usage and extending the lifespan of the network. Directed Diffusion efficiently manages data flow in wireless sensor networks by carefully distributing and consolidating information. This approach effectively minimises congestion, prevents data transmission conflicts, and tackles the energy limitations that are inherent in such networks.
Implementation: Directed Diffusion creates gradients to represent data interests, and nodes transmit data along paths with rising gradients.
Mathematical Approach: Every node in the system maintains an interest gradient that directs the propagation of data.
Nodes adapt the gradients according to the data they receive.
Enhancements Required: It is important to implement sophisticated loop prevention systems and optimise gradient adjustment procedures.

3.5 Dynamic Medium Access Control (DMAC)

Dynamic Medium Access Control (DMAC) is a significant development in wireless sensor networks that improves the effectiveness of clustering by resolving its complexities. DMAC presents an innovative method for designing Medium Access Control (MAC) protocols, specifically customised for clustered sensor networks. This approach functions by adaptively modifying the size of the contention window in response to the fluctuating traffic loads within the clusters. Through this approach, DMAC effectively reduces collisions and contention, leading to enhanced channel utilisation and decreased energy consumption. The protocol effortlessly integrates with clustering algorithms, harmonising with the hierarchical arrangement of sensor nodes into clusters supervised by cluster chiefs. The key feature of DMAC is its capacity to adjust to the ever-changing conditions of sensor network environments. The protocol adjusts its parameters in response to changing network conditions, ensuring efficient data transfer while also conserving energy. DMAC achieves optimal energy economy and data delivery reliability by synchronising contention window adaptation with cluster scheduling.
The implementation of DMAC involves the utilisation of a duty cycle mechanism, in which nodes rotate between active and sleep states in order to minimise collisions.
Mathematical Approach: Nodes coordinate their sleep-wake cycles in order to minimise collisions and reduce instances of idle listening.
Improvement Needs: The efficiency should be enhanced by implementing more advanced duty cycle adjustment algorithms that can effectively handle dynamic variations in traffic.

3.6 Routing Protocol for Low-Power and Lossy Networks (RPL)

RPL (Routing Protocol for Low-Power and Lossy Networks) presents an essential approach to clustering in sensor networks through the optimisation of routing algorithms. RPL is specifically tailored for environments with limited resources. It utilises a hierarchical structure to organise nodes into clusters, which improves the efficiency of the network. This protocol demonstrates high efficiency in situations characterised by low-power and lossy communication lines, which are commonly found in sensor networks. RPL utilises a hierarchical method, in which nodes are allocated ranks according to their proximity to the root node. This facilitates the creation of a directed acyclic graph (DAG) that allows for efficient distribution of data. Cluster heads are essential in RPL's clustering method as they enable communication within clusters and forward data to the root node. Through adherence to the RPL protocol, sensor networks can attain efficient clustering, optimised routing, and decreased energy consumption.

Use cases: RPL is well-suited for situations where there is limited connectivity and a high frequency of data loss, such as monitoring vital infrastructure.

Areas for improvement: Refining the criteria for selecting parents and dynamically adapting the structure of the Directed Acyclic Graph (DAG) could enhance performance.

3.7 Geographical Adaptive Fidelity (GAF)

The Geographic Adaptive Fidelity (GAF) method brings about a significant change in clustering inside sensor networks by utilising a geographic-oriented strategy. GAF utilises location data to establish clusters, wherein nodes in close proximity come together to form clusters, facilitating effective local communication. Nodes that possess greater fidelity serve as cluster heads, ensuring superior accuracy of data and transmitting information to sink nodes. This dynamic clustering methodology improves network efficiency, diminishes energy usage, and adapts to evolving network topologies. The utilisation of geographic attributes by GAF guarantees flexible and expandable clustering, rendering it appropriate for a range of applications, such as environmental monitoring and precision agriculture.

Implementation: GAF incorporates location-based data transfer, adjusting data accuracy according to the distance between nodes and the sink.

Mathematical Approach: Nodes establish data accuracy thresholds according to their distance from the sink. The accuracy of data reduces as the distance increases.

Applications: GAF is suitable for situations where there are different requirements for data accuracy in different geographical regions. Improvement Needs: The accuracy could be enhanced with the implementation of dynamic adjustment of fidelity levels and the utilisation of efficient aggregation approaches.

3.8 Stable Election Protocol (SEP)

The Stable Election Protocol (SEP) introduces a mechanism that effectively selects stable cluster heads in energy-constrained contexts, making it a significant improvement in wireless sensor networks. SEP, which stands for Smart Energy Protocol, is a system that aims to prolong the lifespan of networks and improve their energy efficiency. It achieves this through the use of a dynamic clustering strategy. The network is partitioned into rounds by SEP, wherein each round commences with nodes declaring their energy levels. Nodes with greater energy reserves are considered as potential candidates for selection as cluster heads, whereas nodes with lower energy levels choose to join clusters that are led by these stable cluster heads. This biphasic procedure guarantees that cluster heads are evenly distributed throughout the network and maintain a consistent balance in terms of energy consumption. After selecting cluster heads, SEP utilises a threshold-based method to ensure their stability. In the event that the energy level of a cluster head falls below a predetermined threshold, a re-election procedure occurs to ensure that new nodes with higher energy levels assume the position of the cluster head. The relevance of SEP is its capacity to extend the lifespan of a network by uniformly spreading energy usage among nodes and minimising the overhead caused by frequent re-elections.

Mathematical Approach: Nodes that have energy levels higher than a certain threshold choose themselves as Cluster Heads (CHs) in order to maintain the stability of the network.

Improvement Needs: Performance in dynamic networks could be enhanced with the implementation of more robust stability criteria and adaptive techniques for CH (Cluster Head) selection.

3.9 Threshold-sensitive Energy Efficient sensor Network protocol (TEEN)

The TEEN protocol is a significant breakthrough in wireless sensor networks, with a primary emphasis on energy efficiency and real-time data transmission. The novel architecture of TEEN is suitable for applications that need frequent data updates while still preserving energy in sensor nodes. TEEN presents a methodology for data transfer that relies on a threshold-based technique. Nodes establish a threshold value by evaluating the importance of the data they sense. Additionally, TEEN employs a sleep-wake cycle to further optimise energy conservation. Nodes transition between active and sleep states depending on the importance of their data and the threshold values. Implementing duty cycle decreases the frequency of transmission, hence extending the operational lifespan of the network. TEEN is especially useful in applications involving the monitoring of dynamic phenomena or surroundings with intermittent events.

Mathematical Method: Nodes regularly observe data and send it when values above a certain limit.

Improvement Needs: The accuracy of event detection could be enhanced by implementing adaptive threshold adjustment procedures.

3.10 Base Station Controlled Dynamic Clustering Protocol (BCDCP)

The Base Station Controlled Dynamic Clustering Protocol (BCDCP) is an advanced approach in wireless sensor

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networks that effectively tackles the issues of energy efficiency and network administration. The BCDCP algorithm employs a hierarchical clustering method that prioritises the optimisation of energy conservation and communication efficiency. BCDCP's expertise in energy management and network optimisation renders it well-suited for applications such as environmental monitoring, precision agriculture, and smart cities. BCDCP's incorporation of base station control, dynamic cluster formation, and adaptive management establishes it as a noteworthy advancement in the field of sensor networks, effectively tackling key obstacles related to energy efficiency and limited resources.

Implementation: BCDCP utilises base station-controlled dynamic clustering, in which the base station is responsible for selecting cluster heads (CHs).

Mathematical Approach: The base station starts the process of forming clusters, reducing the additional workload related to selecting Distributed CH.

Use cases: BCDCP is suitable for situations that require centralised control capabilities and efficient communication between base stations.

Improvement Required: The scalability of BCDCP could be enhanced by using decentralised control techniques while ensuring efficient clustering.

Table 1: Comparative analysis of different non-meta clustering techniques

Algorithm	Implementation	Mathematical Approach	Advantages	Disadvantages	Applications
	Clustering-based	Probability based CH selection	Balanced energy consumption,	Frequent cluster reformation	Environmental monitoring, Precision agriculture
			prolongs network lifetime	potential overhead	Habitat surveillance,
LEACH			Distributed CH selection		
PEGASIS	Chain-based data aggregation	Linear chain topology,	Significant energy reduction through	Potential communication delays	Linear deployments (rivers, roads),
		sequential data transmission	minimized transmission distances	in case of chain disruption	Linear monitoring scenarios
SPIN	Data-centric communication	Queryresponse mechanism,	Reduced unnecessary data transmission,	Overhead due to queryresponse exchanges	Correlated data scenarios
		negotiation	energy conservation		Habitat monitoring
Directed Diffusion	Data-centric communication	Gradientbased data propagation	Efficient data routing, adaptation to dynamic conditions	Potential gradient loop formation without loop prevention	Dynamic environments,
					Mobile tracking applications
DMAC	Duty cycle mechanism	Periodic sleep-wake cycles,	Collisions and idle listening minimized,	Synchronization overhead, particularly	Bursty data scenarios,
		dynamic adjustment	adaptive to varying data rates	in dense networks	Intermittent transmissions
RPL	Directed Acyclic Graph (DAG)	Objective function-based parent	Efficient routing, adaptability to	DAG construction and maintenance	Sparse connectivity scenarios,
Algorithm	Implementation	Mathematical Approach	Advantages	Disadvantages	Applications
		selection	changing link conditions	complexity	Critical infrastructure monitoring
GAF	Location-based data transmission	Data fidelity thresholds based on	Energy-efficient data transmission	Defining fidelity thresholds and	Varying data accuracy requirements,
		node-sink distance	based on distance	handling aggregated data at the sink	Large geographical areas
SEP	Clustering with stable CHs	Stability criteria-based CH selection	Improved energy balance,	Energy overhead due to broadcasting	Stability-critical applications,
			prolonged network stability	of energy levels	Long-term monitoring
TEEN	Threshold-based data reporting	Data sampling and transmission	Reduced energy consumption through	Potential missed events due to threshold	Infrequent but significant events,
		based on threshold crossing	selective data transmission	values not being crossed	Intrusion detection
BCDCP	Base stationcontr	Centralized control-	Efficient clustering, energy	Centralized control introduces	Scenarios with

	olled clustering	based cluster	distribution		centralized control,
		formation	optimization, reduced overhead	single points of failure	Efficient base station communication

7. CONCLUSION

To summarise, this research has undertaken a thorough examination and comparative analysis of non-meta-algorithms used to enhance energy efficiency in Wireless Sensor Networks, resulting in enhanced cooperative communication. Every algorithm has its own unique combination of benefits and drawbacks, making them suitable for specific application scenarios. When choosing an algorithm, it is important to evaluate the characteristics of the network, the requirements of the application, and the desired energy-saving objectives. Additional research and innovation are necessary to refine these algorithms, overcome challenges, and advance the progress of energy-efficient sensor networks, as wireless sensor networks (WSNs) continue to evolve and be utilised in various industries. This paper serves as a great resource for researchers, practitioners, and decision-makers who wish to gain insights into the field of energy-efficient algorithms in wireless sensor networks (WSNs):

REFERENCES

[1] Tripathi, N., Sharma, K.K. (2022). Distributed and Hierarchical Clustering Techniques Comparison in Wireless Camera Sensor Networks. In: Kaiser, M.S., Bandyopadhyay, A., Ray, K., Singh, R., Nagar, V. (eds) Proceedings of Trends in Electronics and Health Informatics. Lecture Notes in Networks and Systems, vol 376. Springer, Singapore. https://doi.org/10.1007/978-981-16-8826-3_33

[2] L. Xie and X. Zhang, "3D clustering-based camera wireless sensor networks for maximizing lifespan with Minimum coverage rate constraint," in Proc. IEEE GLOBECOM, Atlanta, GA, USA, Dec. 2013, pp. 298–303.

[3] J. Wang and X. Zhang, "AQ-DBPSK/DS-CDMA based energy-efficient and interference- mitigation scheme for 3D clustered WCSNs with minimum coverage rate constraint," in Proc. IEEE MILCOM, Baltimore, MD, USA, Oct. 2014, pp. 305–310.

[4] A. Del Coso, U. Spagnolini, and C. Ibars, "Cooperative distributed MIMO channels in wireless sensor networks, IEEE J. Sel. Areas Commun., vol. 25, no. 2, pp. 402–414, Feb. 2007.

[5] J. Wang and X. Zhang, "Cooperative MIMO-OFDM based multi-hop 3D clustered wireless camera sensor networks," in Proc. IEEE Wireless Commun. Network Conf. (WCNC), New Orleans, LA, USA, Mar. 2015, pp. 1350–1355.

[6] Aria Nosratinia ET. AL. Cooperative Communication in Wireless Networks, "IEEE Communications Magazine October 2004".

[7] Jigisha Parmar et. al. "Study of Wireless Sensor Networks Using Leach-Teen and Apteen Routing Protocols" International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064".

[8] H. Kiwan et.al. "Hierarchical networks: Routing and clustering (A concise survey)" "2013 26th IEEE Canadian Conference of Electrical and Computer Engineering (CCECE) ".

[9] Neha Rathi et. al. "A REVIEW ON ROUTING PROTOCOLS FOR APPLICATION IN WIRELESS SENSOR NETWORKS", "International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.5, September 2012".

[10] Payal Jain et. al. "The Comparison between Leach Protocol and Pegasis Protocol based on Lifetime of Wireless Sensor Networks", "International Journal of Computer Science and Mobile Computing, Vol.6 Issue.12, December- 2017, pg. 15-19 ".

[11] Kirichek, R., Paramonov, A., Koucheryavy, A.: Flying ubiquitous sensor networks as a queening system. In: Proceedings, International Conference on Advanced Communication Technology, ICACT 2015, Phoenix Park, Korea, July 01–03, 2015

[12] Attarzadeh, N., Mehrani, M.: A New Three-Dimensional Clustering Method for Wireless Sensor Networks. Global Journal of Computer Science and Technology 11(6), April 2011. version 1.0

[13] Hooggar, M., Mehrani, M., Attarzadeh, N., Azimifar, M.: An Energy Efficient Three-Dimensional Coverage Method for Wireless Sensor Networks. Journal of Academic and Applied Studies 3(3), March 2013.

[14] Abakumov, P., Koucheryavy, A.: The cluster head selection algorithm in the 3D USN. In: Proceedings, International Conference on Advanced Communication Technology, ICACT 2014, Phoenix Park, Korea.

[15] Dang Thanh Hai, Le Hoang Son, Vinh Trong Le", Novel Fuzzy Clustering Scheme for 3D Wireless Sensor Networks" , "Applied Soft Computing Journal

[16] C.-Y. Chong and S. Kumar, "Sensor networks: evolution, opportunities, and challenges," Proceedings of the IEEE, vol. 91, no. 8, pp. 1247–1256, Aug 2003.

[17] I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "Wireless sensor networks: a survey," Computer Networks, vol. 38, no.4, pp. 393 – 422, 2002.

[18] S. Murugesan, "Harnessing green it: Principles and practices," IT Professional, vol. 10, no. 1, pp. 24–33, Jan. 2008.

[19] L. Xu, D. Delaney, G. O'Hare, and R. Collier, "The impact of transmission power control in wireless sensor networks," in Network Computing and Applications (NCA), 2013 12th IEEE International Symposium on, 2013, pp. 255–258.

[20] A. D. Amis, R. Prakash, T. H. Vuong, and D. T. Huynh, "Maxmin d-cluster formation in wireless ad hoc networks, in INFOCOM 2000. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings. IEEE, vol. 1. IEEE, 2000, pp. 32–41.

[21] M. R. Brust, H. Frey, and S. Roth kugel, "Adaptive multi-hop Clustering in mobile networks," in Proceedings of the 4th international conference on mobile technology, applications, and systems and the 1st international symposium on Computer human interaction in mobile technology. ACM, 2007, pp. 132–138.

[22] D. Baker and A. Ephremides, "The architectural organization of a mobile radio network via a distributed algorithm, IEEE Transactions on communications, vol. 29, no. 11, pp. 1694–1701, 1981.

[23] L. M. C. Arboleda and N. Nasser, "Comparison of clustering algorithms and protocols for wireless sensor networks in 2006 Canadian Conference on Electrical and Computer Engineering, May 2006, pp. 1787–1792.
[24] O. Younis, M. Krunz, and S. Ramasubramanian, "Node clustering in wireless sensor networks: recent developments and deployment challenges," IEEE Network, vol. 20, no. 3, pp. 20–25, May 2006.
[25] A. A. Abbasi and M. Younis, "A survey on clustering algorithms for wireless sensor networks," Computer Communications, vol. 30, 2007.
[26] P. Kumarawadu, D. J. Dechene, M. Luccini, and A. Sauer, "Algorithms for node clustering in wireless sensor networks: A survey," in 2008 4th International Conference on Information and Automation for Sustainability, Dec 2008, pp. 295–300.
[27] B. P. Deosarkar, N. S. Yadav, and R. P. Yadav, "Cluster head selection in clustering algorithms for wireless sensor networks: A survey," in 2008 International Conference on Computing, Communication and Networking, Dec 2008, pp. 1–8.
[28] M. Zhao, Y. Yang, and C. Wang, "Mobile data gathering with load balanced clustering and dual data uploading wireless sensor networks," IEEE Transactions on Mobile Computing, vol. 14, no. 4, pp. 770–785, 2015.
[29] P. Nayak and A. Devulapalli, "A fuzzy logic-based clustering algorithm for WSN to extend the network lifetime, IEEE Sensors Journal, vol. 16, no. 1, pp. 137–144, Jan 2016.
[30] L. Xu, G. O'Hare, and R. Collier, "A balanced energy-efficient multi-hop clustering scheme for wireless sensor network," 7th IFIP Wireless and Mobile Networking Conference (WMNC), 2014.
[31] G. Sirisha, R. B. Babu, and K. R. Rao, "Establishing path quality management in wireless sensor networks through cluster head determination," Indian Journal of Science and Technology, vol. 9, no. 5, 2016.
[32] C. R. Lin and M. Gerla, "Adaptive clustering for mobile wireless networks," IEEE Journal on Selected Areas in Communications, vol. 15, pp. 1265–1275, 1997.
[33] R. Nagpal and D. Coore, "An algorithm for group formation and maximal independent set in an amorphous computer," Cambridge, MA, USA, Tech. Rep., 1998.
[34] W. Heintzelman, A. Chandrakasan, and H. Balakrishnan, "Energy efficient communication protocol for wireless microsensor networks," in System Sciences, 2000. Proceedings of the 33rd Annual Hawaii International Conference on, Jan. 2000, p. 10 pp. vol.2.