Wireless Sensor Networks Cluster Head Selection Using Fuzzy Logic

Related Work

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Previous Work

In 2020, HQCA-WSN: High-quality clustering algorithm and optimal cluster head selection using fuzzy logic in wireless sensor networks by Keivan Navi [1]. In this work, it presents the High-Quality Clustering Algorithm (HQCA) for wireless sensor networks (WSNs) to enhance energy efficiency and network lifetime. HQCA uses fuzzy logic to select optimal cluster heads based on criteria like residual energy and node distances, improving inter-cluster distances while reducing clustering errors. The method ensures high reliability, scalability, and performance in large-scale networks. Simulation results show HQCA significantly outperforms existing methods in energy consumption, network lifetime, and metrics like first and last node deaths.

In the same year there is one another work, Fuzzy Clustering Algorithm for Enhancing Reliability and Network Lifetime of Wireless Sensor Networks by Sonam Lata [2]. It presents the LEACH-Fuzzy Clustering (LEACH-FC) protocol, a fuzzy logic-based clustering algorithm that aims to advance the reliability and the lifetime of wireless sensor networks (WSNs). The author proposes LEACH-FC to provide enhanced concerning traditional probabilistic clustering protocols such as LEACH. Probabilistic approaches can deploy inefficient cluster heads (CH) and perhaps, select CHs that are too close or too edge in terms of clustering, which would consume more energy, anyway you mention it. In fuzzy clustering, fuzzy logic optimizes the evaluation of every individual sensor node to establish CH selection and CH selection to determine clusters. For example, fuzzy logic can optimize by factoring residual energy and proximity of nodes when establishing CHs. Other clustering metrics improve energy distribution. Simulation results denote that LEACH-FC outperforms existing methods in network lifetime, reliability, and energy efficiency for large WSNs.

Another work, An Energy-Efficient Mobility-Based Cluster Head Selection for Lifetime Enhancement of Wireless Sensor Networks by Sehar Umbreen [3]. This article presents the Energy-Efficient Mobility-based Cluster Head Selection (EEMCS) algorithm, targeting wireless sensor networks (WSNs), to improve network lifetime and energy efficiency in dynamically changing environments. The EEMCS algorithm is hierarchical in terms of clustering and achieves a goal optimized cluster head (CH) selection based on the degree of node mobility, residual energy, distance to sink, and density of neighbours. With the use of single-hop intra-cluster communication and multi-hop inter-cluster communication, a more energy-efficient means of data-transmission is achieved. MATLAB simulation results show that EEMCS performs better compared to five previous protocols and cluster-based algorithms (e.g., LEACH, CRPD, and MODLEACH) in terms of load balance, network stability, energy efficiency, throughput, and overall improved network lifetime.

In 2021, An Unequally Clustered Multi-hop Routing Protocol Based on Fuzzy Logic for Wireless Sensor Networks by Liu Yang [4]. The article proposes a multi-hop routing protocol for wireless sensor networks (WSNs) that is called Unequally Clustered, Multihop Routing Protocol based on If-Then Rules and Fuzzy Logic. Human-centric fuzzy logic is used to select cluster heads (CH) based on three influences, the residual energy of the cluster nodes, the distance to the base station, and the concentration of neighboring nodes. The smaller proposed clusters located near the base station are in response to the problem of energy holes in WSNs. The use of multi-hop communications for the data from sensor nodes to the base station reduces energy consumption within the network; therefore, increasing network's lifetime. The WSN based simulations, implemented in an artificially simulated environment (MATLAB), demonstrated that the proposed routing protocol outperformed several familiar protocols (LEACH, EAMMH, EAUCF, and TTDFP Tier-1) for energy efficiency, network stability, and afterward network lifetime - especially within large-scale WSN's.

In the same year there is one another work, Cluster Head Selection in Heterogeneous Wireless Sensor Network Using a New Evolutionary Algorithm by Manmohan Singh [5]. This work proposes a Diversity-Driven Multi-

Parent Evolutionary Algorithm with Adaptive Non-Uniform Mutation to carry out optimal cluster head selection in heterogeneous wireless sensor networks (WSNs). It investigates the challenge of limited energy by optimizing the residual energy as well as the distance travelled to maximize lifetime, stability, and throughput for the network.

Another work, Analysis of Cluster Head Selection Methods In WSN by N. Bhagyalakshmi [6]. This study provides an overview of key algorithms for choosing cluster heads (CH) in wireless sensor networks (WSNs), a category of a wireless network that collects data using sensors based on the sensed phenomenon. It discusses the disadvantages of existing algorithms for choosing CH's to give us proposed useful mechanism to improve network lifetime on clustering.

In 2022, Type II Fuzzy Logic Based Cluster Head Selection for Wireless Sensor Network by K. Dhayalini [7]. This work presents Type-II Fuzzy Logic-based Cluster Head (CH) selection with Low Complexity Data Aggregation (T2FLCH-LCDA) method for Wireless Sensor Networks (WSNs). T2FLCH-LCDA applies three input parameters (i.e., residual energy, distance to the base station, and node centrality) used for CH selection and clustering, followed by a Dictionary-Based Encoding (DBE) method for data aggregation. Simulation evaluations have been conducted for three scenarios based on the distance of the base station, and these evaluations demonstrate that T2FLCH-LCDA outperforms state-of-the-art methods in energy efficiency, network lifetime, compression ratio, and power saving, thereby improving WSN performance.

In the same year there is one another work, Fuzzy Logic-Based Cluster Head Selection an Underwater Wireless Sensor Network: A Survey by Hetal Panchal [8]. The work describes an underwater wireless sensor network (UWSN), consisting of underwater sensor nodes, floating buoys, and underwater vehicles, designed to monitor environmental conditions for various applications, such as navigation, exploration, and surveillance. This paper surveys fuzzy logic-based reasoning for selecting cluster heads due to the issues of limited power, limited connectivity, and limited computing capabilities that are common in underwater sensor networks. This survey covers fuzzy logic-related topics, such as clustering methods, routing methods, data aggregation methods, coverage methods and security methods, and highlights the pros and cons of the methods described in the various protocols and includes a discussion of results to enhance the efficiency of UWSNs.

Another work, Cluster head selection using hesitant fuzzy and firefly algorithm in wireless sensor networks by Mojgan Rayenizadeh [9]. The work presents a novel cluster head (CH) selection protocol for wireless sensor networks (WSNs), based on the firefly algorithm and hesitant fuzzy logic to help address energy constraints. The protocol selects the maximum CHs by evaluating three sensor node parameters, and simulation results of three different scenarios show that the proposed CH selection protocol achieves better energy efficiency and extends the network lifetime.

In 2023, A Fuzzy Logic Based Cluster Head Election Technique for Energy Consumption Reduction in Wireless Sensor Networks by Dominic Konditi [10]. The work presents a fuzzy logic-based cluster head (CH) selection model for Wireless Sensor Networks (WSNs) that improves energy efficiency and network lifetime. The fuzzy logic-based cluster selection model considers residual energy, node centrality, and mobility factor inputted into a Mamdani fuzzy inference system for appropriate selection of CHs, minimizing the energy consumption during data transmission. The MATLAB simulation with 100 nodes shows that this model outperforms the HROCF protocol showing a 28.57% improvement in network lifetime, delayed first node death (FND) after 2054 rounds, half nodes dead (HND) at 4103 rounds, last node death (LND) at 4500 rounds, as well as, reduced energy consumption per round.

In the same year there is one another work, Fuzzy Clustering and Routing Protocol with Rules Tuned by Improved Particle Swarm Optimization for Wireless Sensor Networks by Yu Haitao [11]. This work presents NFCRP, a fuzzy clustering and routing protocol for Wireless Sensor Networks (WSNs) utilizing fuzzy logic systems optimized by an evolutionary enhanced Particle Swarm Optimization (PSO) algorithm. The NFCRP protocol chooses cluster heads (CHs) based on node properties such as residual energy, deviation in node degree, and distance to centrality to make cluster organization more effective. The routing in NFCRP is also determined based on residual energy, distance to the base station, and data load to improve routing efficiency for any path taken. When scenarios were simulated in MATLAB, the NFCRP protocol outperformed protocols from state-of-the-art studies, including LEACH, EFUCA, EEFUC, FBCR, and FMSFLA, which improved network lifetime by a factor of 79.59%, reduced deviation from CH by a factor of 25.28-31.42%, increased throughput by a factor of 16.87-71.79%, and reduced energy consumption by a factor of 15.71-53.95%.

Another work, Energy efficient cluster head using modified fuzzy logic with WOA and path selection using Enhanced CSO in IoT-enabled smart agriculture systems by Senthil Kumar C [12]. This work presents an energy-saving method for IoT-enabled smart agriculture using modified fuzzy logic with Whale Optimization Algorithm (WOA) for cluster head selection and Enhanced Crow Swarm Optimization (ECSO) for best path selection. Sensors were clustered using K-means, followed by evaluation of parameters for cluster head selection (energy, distance and trust). The method achieves throughput, packet delivery ratio, delay and energy efficiency metrics comparing to existing approaches proposed, including MATLAB simulations as results.

In 2024, Energy efficient clustering and routing protocol based on quantum particle swarm optimization and fuzzy logic for wireless sensor networks by Xinji Fan [13]. This work proposes QPSOFL, a new clustering and routing protocol for Wireless Sensor Networks based on a modified Quantum Particle Swarm Optimization (QPSO) algorithm and fuzzy logic. QPSOFL intends to maximize energy efficiency and network lifetime. QPSOFL selects cluster heads using Sobol sequences, Lévy flight, and Gaussian perturbation. For routing, QPSOFL executes fuzzy logic to define the optimal forwarding paths using residual energy, energy deviation and distance to the relay. QPSOFL is subsequently evaluated with a series of simulations, and performance improvement is demonstrated over E-FUCA, IHHO-F, F-GWO and FLPSOC, with dramatically enhanced network lifetime, throughput, energy consumption, and scalability.

In the same year there is one another work, Optimization of Fuzzy Logic-Based Clustering for Wireless Sensor Networks by Mohammed Ayad Saad [14]. This work examines how clustering in Wireless Sensor Networks (WSNs) can be optimized with a fuzzy logic-based design. It proposes an energy efficient routing protocol that uses Fuzzy C-Means (FCM) clustering methodology to organize stationary clusters while separately selecting cluster heads that is engaged using fuzzy logic based on communication cost and residual energy. The performance of the proposed algorithm is evaluated based on simulation experiments which demonstrate that the proposed protocol has a longer network lifetime, is more energy efficient, and consolidates transmitted data more effectively in comparison to traditional methods. This work has sufficiently expanded the capabilities of WSNs that are operational in dynamic environments.

Another work, Fuzzy Logic-Based Cluster Head Selection Method for Enhancing Wireless Sensor Network Lifetime by Raghu Vamsi Potukuchi [15]. A fuzzy logic-based cluster head selection method for Wireless Sensor Networks (WSNs) is proposed in the paper to enhance network lifetime. The paper uses Mamdani Inference engine to consider residual energy, node centrality, and distance to the base station to select optimal cluster heads in a heterogeneous network. The simulation results demonstrate that our proposed protocols FL-SEP and FL-SEP-E outperform the original protocols, SEP and SEP-E respectively, in terms of first node death time by 14% and 7% respectively, as well as increased throughput and residual energy.

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