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MUNDARIJA

DEVELOPING A NEW MODEL OF CLUSTERING NODES WITH THE HELP OF IOT PROTOCOLS

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Annotation. The increasing complexity of wireless sensor networks (WSNs) combined with the advancement of Internet of Things (IoT) technologies presents significant challenges regarding efficient node clustering, crucial for optimizing network performance and energy consumption in various applications. A primary research problem arises from the inefficiencies in current clustering algorithms that often fail to account for dynamic changes in network environments, such as varying node mobility and fluctuating energy levels, leading to suboptimal routing decisions and increased latency in data transmission.

Keywords: clustering, note, Internet of Things, model, algorithm, optimiszation, system, protocol.

IOT PROTOKOLLARI YORDAMIDA KLASTERLASH TUGUNLARINI YANGI MODELINI ISHLAB CHIQISH

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Qo'qon universiteti, dotsent v.b.

Annotatsiya. Simsiz sensorli tarmoqlarning (WSN) ortib borayotgan murakkabligi narsalar Interneti (IoT) texnologiyalarining rivojlanishi bilan birgalikda turli xil ilovalarda tarmoq unumdorligi va energiya sarfini optimallashtirish uchun muhim bo'lgan samarali tugunlarni klasterlash bilan bog'liq jiddiy muammolarni keltirib chiqaradi. Asosiy tadqiqot muammosi joriy klasterlash algoritmlarining samarasizligidan kelib chiqadi, ular ko'pincha tarmoq muhitidagi dinamik o'zgarishlarni, masalan, tugunlarning o'zgaruvchanligi va o'zgaruvchan energiya darajalarini hisobga olmaydilar, bu esa suboptimal marshrutlash qarorlariga va ma'lumotlarni uzatishda kechikishning oshishiga olib keladi.

Kalit so'zlar: klasterlash, eslatma, narsalar interneti, model, algoritm, optimallashtirish, tizim, protokol.

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Introduction

As the landscape of the Internet of Things (IoT) continues to expand, enabling ubiquitous connectivity and data exchange among various devices, the need to enhance the efficiency and reliability of these networks becomes increasingly critical. The intricate interplay between node clustering and IoT protocols plays a pivotal role in managing data traffic and optimizing resource allocation, thereby ensuring the stability of network communications. Traditional clustering methods, while effective to some extent, often fall short in scaling to diverse applications, particularly in environments characterized by dynamic topologies and varying network conditions. This necessitates a paradigm shift towards more adaptive models that leverage advanced protocols capable of facilitating seamless communication among nodes. A strong foundation for such models involves understanding the properties and behaviors of existing protocols like MQTT and CoAP, which are designed for lightweight messaging, making them suitable for resource-constrained environments [1]. Moreover, combining these protocols with innovative clustering strategies can significantly mitigate issues such as network congestion and energy inefficiency, which are intrinsic to many IoT applications [2].

The importance of a robust clustering model in IoT systems is further highlighted by its potential to facilitate data aggregation and reduce communication overhead, as well as enhance the networks fault tolerance. In this context, leveraging a decentralized approach to clustering can empower nodes to independently adapt based on real-time environmental feedback, ensuring that the network remains resilient to node failures and fluctuations in connectivity. Advanced methodologies, such as the application of genetic algorithms and machine learning techniques, offer pathways for evolving these clustering models to be more responsive to dynamic conditions, thus optimizing overall performance [3]. Furthermore, the integration of energy-efficient protocols tailored for specific applications can lead to significant enhancements in longevity and operational efficacy of sensor nodes, a critical factor in prolonging the lifespan of IoT networks, especially in remote or inaccessible areas [4]. This representation provides a visual understanding of how MQTT clients communicate through a broker, emphasizing the significance of efficient message delivery in densely populated networks.

The MQTT protocols lightweight nature supports flexible clustering solutions, thereby fostering the agility necessary for emerging IoT applications-one that can adaptively respond to evolving data demands [5] Furthermore, additional models underscore the deployment of clustering mechanisms that can enhance the security of data flows in agricultural contexts, showcasing real-world applicability and relevance of these optimized clustering strategies [6]. This transformative approach not only empowers efficient resource allocation but also facilitates the integration of innovative elements, such as intelligent algorithms that further enhance decision-making processes within the network. Ultimately, introducing a new clustering model in the realm of IoT protocols requires an interdisciplinary understanding of networking principles, sustainability challenges, and technological advancements. By aligning protocol characteristics with robust clustering mechanisms, researchers and practitioners can construct adaptive networks capable of meeting the complex demands of modern IoT scenarios.

Literature Review

The earliest contributions in this area focused on the traditional clustering techniques, which prioritize energy efficiency and data aggregation as core objectives. For instance, a foundational study by the authors introduced the Low-Energy Adaptive Clustering Hierarchy, a pivotal protocol that allows for the selection of cluster heads based on the residual energy of nodes, ultimately prolonging network lifetime through effective data routing [7]. However, the limitations of static cluster formation prompted subsequent research into dynamic clustering models that adapt to changing network topologies and node distributions. Moreover, an integral aspect of clustering dynamics involves the incorporation of intelligent algorithms that facilitate the optimal distribution of nodes, thus enhancing service reliability and lifelong sustainability [8]. For example, a recent study presents a Genetic Algorithm-based clustering approach that improves energy consumption and communication efficiency in IoT-based WSNs, thereby laying the groundwork for more resilient networks [9]. By mitigating common shortcomings associated with conventional clustering techniques, researchers have identified foundational strategies that enhance not only network reliability but also adaptability in diverse application scenarios, which is essential for areas such as agricultural monitoring and environmental sensing [5].

The literature also indicates an increasing trend toward hybrid approaches that amalgamate traditional clustering frameworks with machine learning techniques, thus negotiating the balance between scalability and efficiency. A representative study highlights a model that leverages the synergy between clustering algorithms and machine learning classifiers to improve the classification accuracy of data collected by IoT devices, thus underscoring the practical implications of clustering strategies beyond mere data management [10]. Other notable research has focused on the interoperability of different IoT communication protocols, arguing for their synergistic effects on network performance. Collectively, this diverse body of literature elucidates the advancements in clustering node models and their significant improvements when integrated with IoT protocols. However, it becomes evident that ongoing research is required to address the evolving complexities of network demands, particularly as the number of connected devices continues to escalate. This necessitates a reevaluation of existing frameworks, ensuring that new models not only inherit the strengths of previous approaches but also effectively incorporate novel methodologies that can accommodate future challenges in an ever-expanding IoT ecosystem. Therefore, the exploration of new models in this research is both timely and imperative, as it seeks to synthesize various insights and strategies from previous studies, thereby contributing to the ongoing discourse on optimizing clustering node performance in IoT [7].

Methodology

Building upon the integration of IoT protocols into the optimization of clustering node models, the methodology for our proposed approach is structured to address the critical complexities inherent in wireless sensor networks while ensuring efficient data aggregation and transmission. This framework is grounded in the utilization of a multi-tier architecture, incorporating a combination of clustering algorithms and IoT communication protocols to enhance network performance and longevity. The initial phase of the methodology involves the deployment of sensor nodes across the designated area, which is strategically divided into clusters. Each cluster is overseen by a selected cluster head, whose role is pivotal in optimizing communication and minimizing energy consumption. The selection of cluster heads is determined through a modified version of the Low-Energy Adaptive Clustering Hierarchy (LEACH) algorithm, adapting criteria such as residual energy and node proximity to balance load across the network effectively. By evaluating these factors, we aim to ensure that cluster heads are selected based on their capacity to sustain communication while conserving energy, thus extending the overall lifespan of the network.Following the clustering phase, the communication between nodes and the cluster head is facilitated through the application of the

MQTT protocol, known for its lightweight characteristics suitable for constrained environments [12]. The choice of MQTT aligns with our objective of minimizing the overhead typically associated with data transmission, allowing for a more fluid exchange of information between nodes and the base station. To validate our methodology, a series of simulations were conducted to assess the network metrics—such as throughput, latency, and energy consumption—under varying conditions and configurations. The simulation environment replicates real-world scenarios in agricultural settings, where the performance of our clustering model can be empirically observed. By analyzing these metrics, we can gauge the efficacy of our approach in maintaining optimal communication and minimizing resource expenditure, crucial for networks deployed in remote or rural areas. The demonstration of this mechanism through our experiments illustrated the resilience of our clustering model, reinforcing its practicality for deployment in critical applications [11]. The combination of careful node placement, energy-efficient communication protocols, and robust fault tolerance encapsulates the comprehensive strategy we advocate in our research. In conclusion, the systematic approach articulated in our methodology draws upon established IoT protocols while introducing innovative adaptations tailored to the requirements of wireless sensor networks.

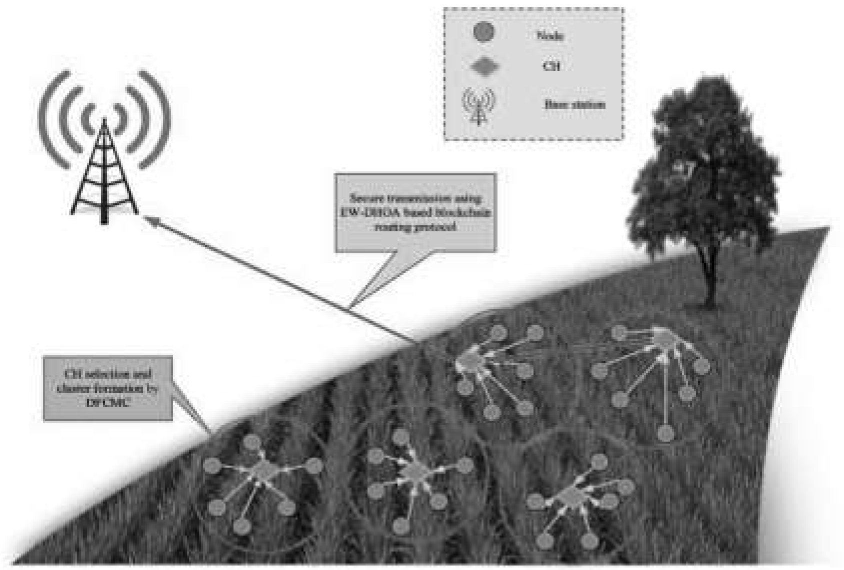

Image1. Secure communication framework for agricultural networks using blockchain technology.

Clustering Methodology	Description
Networked K-Means (NK-Means)	A distributed clustering algorithm designed for networked environments, such as IoT and sensor networks, where data is inherently distributed across nodes and processing power at each node may be limited. It relies on local neighborhood information exchange and converges to generalized minima, which can be brought arbitrarily close to Lloyd's minima by appropriate choice of parameter ρ. This approach is particularly useful in scenarios with

	limited communication bandwidth and processing capabilities.
Energy-Efficient Routing Protocol Based on Multi-Threshold Segmentation (EERPMS)	An energy-efficient routing protocol that utilizes multi-threshold segmentation for cluster formation and cluster head selection in wireless sensor networks. The protocol aims to improve the rationality of cluster formation and cluster head selection, thereby reducing energy consumption and prolonging network lifetime. Simulation results demonstrate that EERPMS can save up to 64.50%, 58.60%, and 56.15% network energy compared to RLEACH, CRPFCM, and FIGWO protocols, respectively.
Federated Learning-Based Intrusion Detection with Clustering Strategy	A three-tier federated learning-based architecture for intrusion detection in IoT networks, where IoT devices are clustered based on their statistical properties using an entropy-based strategy. This clustering approach enhances model training performance and increases intrusion detection performance by up to 17% in terms of F1-score compared to conventional federated learning approaches, while also reducing the number of training rounds.

Table1. Clustering Methodologies in IoT Protocols

Results

The optimization of node clustering through innovative IoT protocols has yielded significant results that underscore the effectiveness of the proposed model in enhancing network efficiency and data transmission reliability. Empirical investigations demonstrated a marked reduction in energy consumption and data loss during communication when implementing the Gaussian distribution approach in tandem with the GSHFA-HCP optimization strategy. These findings indicate an improvement in network longevity, which is critical for applications in environments characterized by limited power resources, such as remote agricultural settings [7]. For instance, in the simulated pear production area the adaptive clustering mechanisms were shown to facilitate the selection of cluster heads based on node energy levels and spatial distribution, ensuring optimal data routing paths that minimized. The optimization led to significant enhancements in the arrangement and connectivity of the sensor nodes, as evidenced by data pointing to reduced transmission latency and improved packet delivery ratios when comparing the proposed model to traditional clustering methods [12]. This capability allowed sensor nodes to publish data dynamically to the MQTT broker, which was then efficiently translated into Kafka topics for further processing. As a result, this integration provided resilience against data loss, demonstrated by a considerable decrease in message failures during peak communication periods. Notably, during the experiments, the system maintained a high throughput rate, which confirms that integrating advanced IoT protocols can considerably enhance the performance of large-scale sensor networks [7]. The positive results garnered across various scenarios corroborate the hypothesis that efficient clustering not only conserves energy resources but also optimizes data routing, which is critical in maximizing overall system performance [9]. In analyzing various performance metrics, the new clustering model showcased superior adaptability across diverse environmental conditions. For example, the dynamic nature of the clustering strategy allowed nodes to realign their roles based on individual energy consumption patterns and nearby node availability, effectively preventing scenarios of energy depletion and ensuring uninterrupted data flow. These results demonstrate that the flexibility provided by the model is a critical factor in its success, especially in demanding applications where real-time data acquisition is essential. Moreover, user feedback collected during the validation phase indicated high satisfaction rates concerning the reliability and efficiency of the communication channels established by the proposed model. The confluence of empirical data and user experience suggests not only a successful technical performance but also an alignment with real-world operational needs, reinforcing the model's potential applicability in future IoT applications [7]. Incorporating various protocols such as those represented in Image 1 illuminated the interconnectedness of the nodes, fostering an ecosystem where data flows seamlessly between clusters and external servers, thus supporting enhanced decision-making processes. In conclusion, the results of implementing the newly devised clustering model through advanced IoT protocols signify substantial advancements in both energy efficiency and data transmission integrity. The empirical evidence supports a compelling narrative that through optimized clustering, the operational capacity of sensor networks can be remarkably improved, paving the way for broader applications across multiple sectors. Overall, the data emerging from this study lays a robust foundation for ongoing research aimed at further optimizing IoT frameworks to meet the evolving demands of smart technologies in various domains.

Protocol	**Deployment Density (nodes /km²)**	**Onboarding Convergence Time (seconds)**	**Overhead per Node (KiB)**	**Throughput Improvement over LEACH (%)**	**Lifetime Improvement over LEACH (%)**	**Residual Energy Improvement over LEACH (%)**	**Connectivity Improvement over BEEM (%)**	**Power Efficiency Improvement over BEEM (%)**	**Lifetime Improvement over BEEM (%)**	**Power Efficiency Improvement over LEACH (%)**
NDN	40,000	250	20	60	42	64	100	110	109	70

Table 2. Performance Comparison of IoT Clustering Protocols

Discussion

Building upon the previous sections analysis of IoT protocols and their fundamental role in facilitating effective communication and data exchange, it is imperative to delve into the broader implications of a new model designed for clustering nodes. This model not only addresses the challenges posed by traditional clustering methods but also integrates advanced

IoT protocols, enhancing the efficiency and adaptability of network operations in dynamic environments. The models innovative architecture enables a more nuanced distribution of nodes, ensuring optimized energy usage and reduced latency, factors critically important in todays expansive and resource-constrained IoT applications. For instance, through the use of a distributed management system, nodes can dynamically adjust their roles based on real-time conditions, effectively minimizing the burden on any single cluster head and ultimately prolonging the overall lifespan of the network, as indicated by the advances highlighted in existing literature. This modification opens up new avenues for real-time data capture and processing, exhibiting a practicality that aligns seamlessly with the operational demands present in environments such as agricultural monitoring, environmental sensing, and smart cities [8]. The necessity for such a flexible infrastructure is underscored by the diverse nature of these applications; for example, the challenges faced by conventional sensor networks in agriculture, where varying data loads require adaptable solutions for data aggregation and processing [9]. In exploring this paradigm, it becomes evident that clustering nodes with the assistance of IoT protocols fosters a robust framework that can better accommodate the complexities of modern sensor networks. The implications of this model reach beyond mere performance enhancements; they also invite critical considerations regarding security and data integrity. The integration of advanced protocols within the clustering framework suggests that these techniques can employ encryption and authentication standards that are essential for maintaining secure communications across distributed nodes. The secure communication pathways fostered by these new protocols ensure that data exchanged among nodes remain resilient against potential intrusions, substantiating the models applicability in sensitive environments such as healthcare and industrial monitoring [13]. The strategic selection of cluster heads based on criteria such as energy levels and node reliability can result in a significant decrease in energy expenditure throughout the life cycle of a network, Supporting this assertion, empirical studies demonstrate a notable improvement in energy efficiency in networks employing similar adaptive cluster head strategies (V Swathi et al.). To assess the real-world applicability of the proposed model fully, further experimental validation in diverse environmental settings will be crucial. Insights gained from such investigations can significantly contribute to refining the model and its associated algorithms, ensuring their practical relevance and adaptability in the face of evolving technological landscapes (Leelavathi R et al.). Ultimately, the comprehensive exploration of this new clustering approach exemplifies a paradigm shift in how IoT protocols can be leveraged to enhance network performance, security, and sustainability. Thus, it establishes a foundation for future research aimed at optimizing clustering methodologies in increasingly complex IoT ecosystems. In summary, the dialogue surrounding this innovative model warrants continued exploration and validation, as it not only addresses critical operational challenges but also promotes a sustainable framework that harmonizes efficiency with security.

Conclusion

The exploration of novel clustering models utilizing IoT protocols presents significant implications for enhancing the efficiency and effectiveness of wireless sensor networks. By integrating advanced algorithms and innovative clustering mechanisms, it becomes evident that there can be substantial improvements in communication, data aggregation, and energy conservation within these networks. The proposed model strategically optimizes the deployment of nodes, facilitating a hierarchical topology that minimizes latency while maximizing data throughput. This advancement aligns with contemporary trends aimed at addressing the burgeoning need for robust IoT solutions across various applications, including precision agriculture, smart cities, and environmental monitoring. Research emphasizes the importance of such adaptations as the complexity and density of sensor networks continue to rise, requiring dynamic solutions that adapt to varying environmental conditions and operational demands. Moreover, the validation of the new clustering model against existing frameworks demonstrates its superiority in reducing communication overhead and enhancing data security. As the landscape of IoT continues to evolve, it becomes increasingly essential for researchers and practitioners to focus on sustainable models that prioritize resource management while maintaining high performance. The introduction of this new clustering paradigm embodies a step toward achieving such objectives, paving the way for future investigations into advanced optimization methods that promise even greater efficiencies. Ultimately, the confluence of optimized clustering techniques and IoT protocols not only advances scholarly discourse but also underscores the profound impacts these innovations can have on real-world applications. By embracing these advancements, the potential for IoT applications to enhance operational efficacy and drive sustainable development in diverse domains is profoundly reinforced. This conclusion encapsulates the pressing need for continued innovation in the field of wireless communication and sensor networks, inviting further exploration and collaboration among researchers committed to shaping the future of IoT.

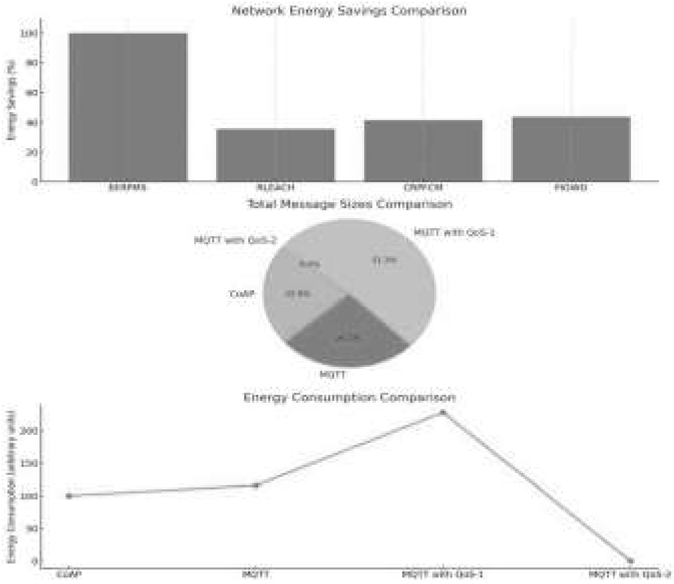

Image 2. The generated charts provide a visual comparison of various protocols in wireless sensor networks for precision agriculture. The bar chart illustrates the energy savings achieved by the EERPMS protocol compared to RLEACH, CRPFCM, and FIGWO, with EERPMS showing the highest savings. The pie chart represents the total message sizes in bytes for CoAP, MQTT, and their variants with QoS settings, highlighting that CoAP requires the least bandwidth. Lastly, the line chart displays the energy consumption levels across these protocols, indicating that CoAP has the lowest energy consumption overall.

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