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Optimizing QoS-Based Clustering Using a Multi-Hop with Single Cluster Communication for Efficient Packet Routing

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ABSTRACT: Modern day communication systems have gained a revolutionized growth in long-distance wireless data transmission. High speed packet transfer impacts quality requirements. Critical factors that ruin service quality (Qos) are calculated by the primary factors involving power efficiency, packet delivery ratio, and overall transmission and reception delay. A well-developed routing protocol with unique attributes should be deployed to give improved QoS. The drawback of single path routing in delivering a packet at traffic is challenging since it does not have an alternative path in case of path failure. This problem can be targeted by a properly structured protocol with a multipath mechanism. In this article, Multi-hop with single cluster (SCMC) protocol is designed to increase the overall system efficiency by improving bandwidth, packet delivery ratio (PDR), reducing communication delay, and quality improvement. Adopting a single cluster and several hop protocol achieves power conservation for an additional period and balances the energy level. In multi hopping communications, numerous paths with various members can be produced by a single cluster is an added advantage. The proposed work is tested in NS-2 in comparison with equal cost multipath and protocol SPEED. The outcome of the designed protocol outperforms all other protocols in terms of minimum latency, lower power usage and improved packet delivery ratio.

Keywords: WSN, QoS, Single Cluster, Multi-hop Communication, End - to-End.

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1. INTRODUCTION

All around the geographical area the sensor wireless networks found a pathway of connecting efficiently through distributed approach. The randomly placed sensors all over the network are connected to one another by efficient routing protocols. The merit of WSN is to keep efficient tracking of various physical and climatic factors. They are noise pollution, pressure, temperature variations, and contaminants, all of which are significant contributors in a country's development. These WSNs aren't just for monitoring natural phenomena; they're also for noise detection, congestion analysis in networks, trespasser identification, earthquake monitoring, army trafficking, healthcare monitoring, and smart gadgets. Numerous nodes were connected via sub-nodes to produce a communication way for information sharing. Inside a network covering a large geographical area. Forming a large network on a global scale is not an easy task, as it involves dealing with a variety of challenges such as bandwidth, high failure rates, and limited power, among others. Because there are so many facets to leading the network by conquering difficult difficulties, the system may concentrate on building potential and power-efficient set of rules. To maintain a longer network life, individual sensor node's power must be properly utilized. It is dependent on the type of sensor and the application for which it will be used to track the data properly. These data should be used indefinitely with little energy use to avoid potential issues. In practice, nuclear reactors and data monitoring should be properly aligned with energy consumption as well as network lifetime. As a result, there is a worry that a protocol should be designed that takes into account several crucial characteristics such as application and network density, among others. Most WSN routing techniques have been developed in the past based on the unique qualities of WSN.

Multipath-based, QoS-based, cluster-based, and query-based procedures are used to construct our protocol in this study. Our recommended method is as follows: Multiple pathways are used to transport data from source to destination in the Multi-hop with single cluster (SCMC) protocol. It may be improved further by adding a cluster mechanism, which would improve the overall performance and extended lifetime of the network. The article is structured as follows: The literature survey is discussed in section 2 along with various associated techniques. In section 3, we go over the suggested technique and why multipath propagation routing protocols for cluster and event-based WSNs are required. Our novel multipath routing technique is described in detail in Section 4. The fifth section uses a graphical output to display and compare performance evaluation of our structured work with the earlier protocol. Finally, section 6 summarizes the paper's conclusion.

2. BACKGROUND

In this section, Quos-based routing systems are discussed [1]. Rather than summarizing the related work, we discussed some of the papers that are relevant to our suggested protocol in depth. Sequential Assignment Routing (SAR) protocol [2] was the early routing protocol that enabled QoS on those days. Muhammad et al. (2009) presented a two-tiered architecture which provides potential application of a decentralized network, in a large area wsn, the backbone of the network such as energy requirements is provided by top layer WLAN to the bottom level adaptive clustering hierarch (LEACH) based WSN. In-spite of the impact of the minimum availability of the random nodes the WLAN layer communicates between the control station and the sensor networks.

K.Akkaya and M.Younis structured a queuing model utilizing routing principle for cluster-head QoS[3], this model has the advantage of controlling congestion in both real and non-real time. However, it just considers end-to-end latency, which connects links according to cost functions. It uses the K-least-cost path technique to discover the ideal routing path, which compares each route to the end-to-end restrictions. Those data will be sent from source to destination using the path that satisfies those constraints. The bandwidth ratios are all the same across the network's nodes. As a result, there is no need to use more bandwidth on the network. The main flaw in this routing protocol is that it ignores delay packet transmission and cost evaluation, resulting in network delays.

He.t et al. demonstrated a well-known QoS-based routing system at the time, which was guaranteed to solve real-time overall network delay concerns. It finds the optimum pathways by using the sensor nodes' geographical information and forwarding it. Packets must be delivered at the stipulated time limit to maintain the accuracy and efficiency of the system. Packet delivery ratio must be maintained according to the distance of the network and utilization of sensor nodes, The problem is that it would cause congestion in the network and cause overburdened.

A Multi-path and Multi-Speed Routing Protocol (MMSPEED) is presented by Felemban et al [5] for attaining QoS in wireless sensor networks. It accomplishes multiple QoS according to the timeliness domain, which is supported by different pathways that forward according to the domains' reliability. Nan Jiang et al. (2009) discussed fault tolerance in a network is forwarded by the topology power-law gains the moment of building structured reliable efficient topology for WSN. By stochastic wandering of sensor nodes using power-law evolving model (PLEW) and by continuum theory, the analysis and results show the higher rating of the distribution as per power law.

X. Huang and Y. Fang introduced multi constrained QoS multi-path routing (MCMP) protocols in their article [6], the shortest routes are identified in the overall network to deliver the packet at faster rate to the end nodes. The performance is measured in terms of speed and packet without loss. Linear integer programming handles the problem related to latency due to the optimization process.

According to the ECMP protocol, it deals with limited hops and low energy consumption by implementing a way that meets QoS requirements while using minimal energy. The second one is EQSR, which is a multipath routing protocol that is energy efficient and QoS aware and is used to balance energy usage among multiple nodes in a network.

Following that, [7] will explain a well-known clustering protocol. It's referred to as LEACH, and it's one of the most popular clustering-based routing techniques for wireless sensor networks. The cluster head is chosen from among the sensor nodes that were constructed at random using this approach. Data was transmitted directly between the base station and the cluster heads using protocols. The LEACH solves the energy hole problem, however the cluster heads are too far away from the base stations to avoid delays. HEED8, which selects the cluster head by combining the relationship between residual energy and reference energy in HEED, is another well-known clustering-based routing technique.

Gopalakrishnan et al. discusses congested node detection using Adaptive Neuro Fuzzy Inference System (ANFIS). The malevolent nodes are easily detected using the ANFIS classifier. The overall network performance of the system will be degraded by the increased rate of malicious nodes. This impact of malicious nodes involves efficiency, packet delivery ratio, power consumption, and connection failures.

Ramadhani Sinde et al. (2019) addressed improvement of energy of the node’s and lifetime of the network by using the efficient cluster structure using the LEACH algorithm and a multiplexing technique of Time Division multiplexing (TDMA) scheduling access. Clusters are built-up by the formation of protocol utilizing Enhanced-LEACH that works on the principle of parallel optimization technique similar to Grey wolf and Discrete PSO optimization techniques for identifying cluster head and assist head. The best optimal cluster head is proposed by the fitness estimation of GWO and D-PSO concatenation and possibly manages the size of the cluster which advantages from the LEACH protocol.

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3. PROPOSED SYSTEM ARCHITECTURE

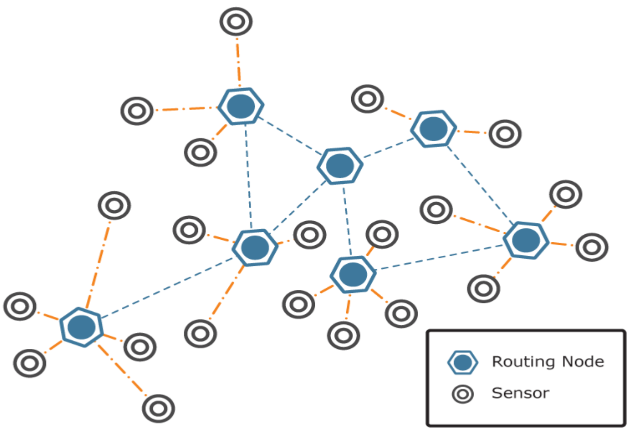

Figure 1: Sensor Node Deployment Dynamic Structure

A sensor network is a collection of multi-functional sensor nodes with a low-cost capacity to work. These are dispersed over a large region within the system via sensor media or closer by way of a network with nodes capable of detecting, transmitting packets, and data processing. According to the applications [1,] they are smaller in size. WSN is a wireless network that uses intermediary nodes to distribute data. For data collection, it usually uses a gateway node or a sink node. It has a large number of sensor nodes that are tightly deployed [2].

Within their range, each sensor node communicates with other nodes. Node deployment is one of the primary challenges in WSN, and a flawless node deployment scheme can reduce complications such as routing, data fusion, and communication, among others. The lifetime of a WSN can be extended by using the least amount of energy possible. We discovered that a homogeneous approach to node placement results in less complexity and better manageability, which translates to a wider spectrum of homogeneity. In most WSN applications, these nodes were distributed at random. Because the complexity of WSN are amplified by incorrect node deployment. Another key issue in WSN is energy consumption, which may be reduced to extend the lifetime of WSN [3].

4. PROPOSED DESIGN GOAL

In this research, a unique Multi-hop with single cluster (SCMC) protocol is developed, with the goal of improving bandwidth, PDR, and end-to-end delay to meet QoS. According to our proposed approach, the cluster head remains the same for all randomly connected nodes. This single dynamic cluster head will perform in accordance with the energy levels of all nodes. The cluster head will be the source node, which will distribute data to the other nodes based on their energy levels. With all individuals within its transmission range, the cluster head maintains a balanced energy level. Once the single cluster head has been discovered, data is dynamically transmitted from all of the other nodes to that cluster head. It achieves excellent energy conservation with increased longevity using the described technique. The finest part is that the energy level of cluster nodes was reevaluated at regular intervals and compared to the remaining nodes in a dynamic cluster. Nodes with higher energy levels were used for communication in order to achieve better performance and successful transmission, as well as to save energy for future usage. The creation of the proposed mechanism is addressed in detail in the section below.

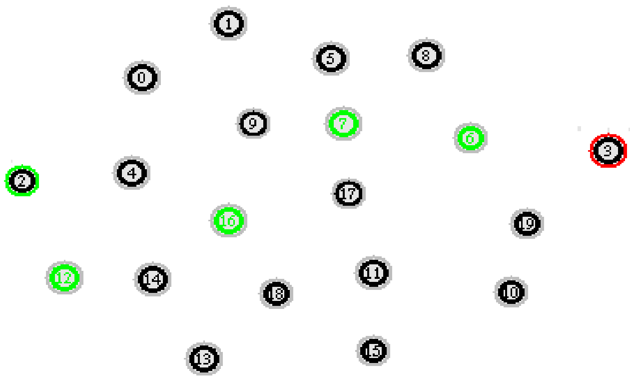

Figure 2: Dynamic multi cluster 12, 16, 7, 6

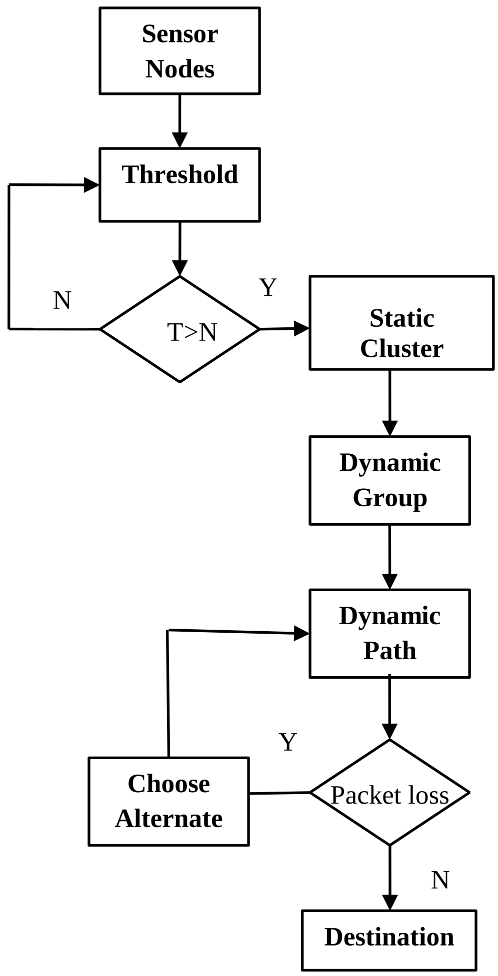

Figure 3: Process flow of the defined network

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Figure 2 shows that a cluster is constructed between 2,12,16,7,6 and 3 using the proposed Multipath Cluster with Dynamic Mode Routing Protocol, with node 2 serving as the source node and node 3 serving as the destination node. The data may be passed from one node to the next in the order shown in the cluster.

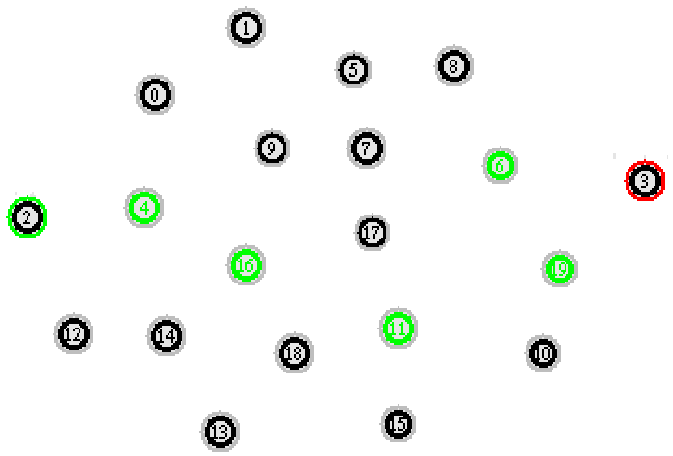

Figure 4: Dynamic selection of multi cluster 4, 16, 11,6,19

Figure 4 shows the identification of an alternate routing path, and if there is failure in the cluster, a dynamic cluster is built automatically in this fashion, for example, between nodes 4,16,11,6, and 19, which all have the same source node 2 and destination node 3. When a cluster timeouts, as seen in Figure 4, a new cluster is dynamically formed.

5. EXPERIMENTAL RESULTS

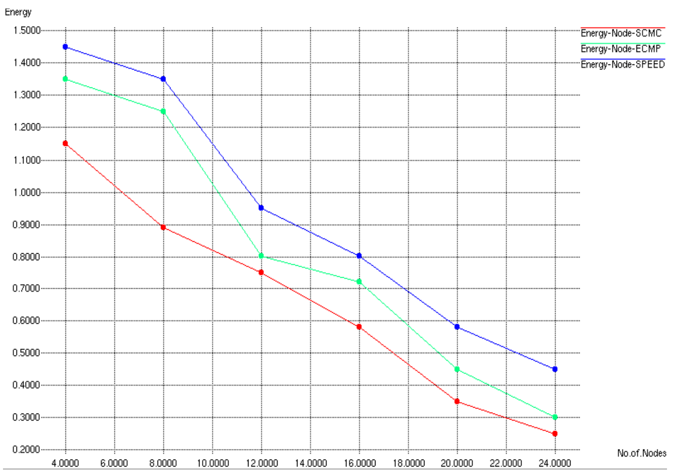

Figure 5: Number of Nodes Vs Energy

Figure 5 depicts the energy usage as a function of the number of nodes used to complete the packet transfer. These 24 nodes are set up to send packets using each protocol until they reach their target. The suggested SCMC protocol outperforms the other two protocols in terms of energy consumption.

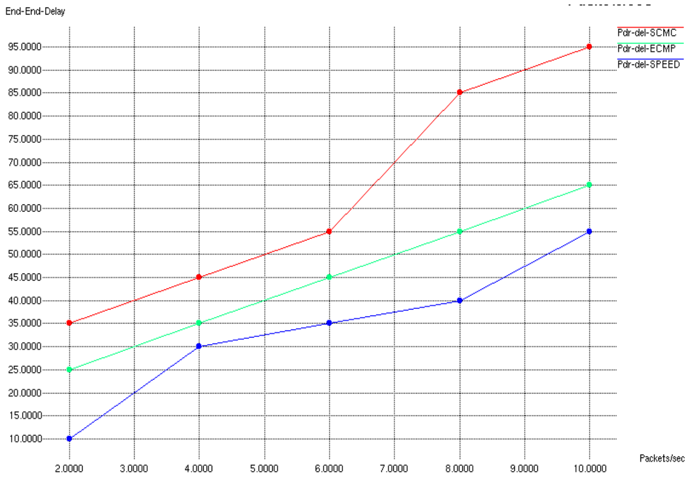

Figure 6: Packets/sec Vs End-to-end delay

Figure 6 shows the end-to-end delay vs the number of packets for the MCDMRP, ECMP, and SPEED protocols, with the dynamic cluster mechanism showing the least amount of delay. The other two protocols, on the other hand, increase the latency as the number of packets grows. In comparison to ECMP and SPEED, the preceding graph clearly shows that the implemented protocol gains improvement compared to earlier.

6. CONCLUSION

In this work, many authors discussed how to achieve QoS in WSN in a real-time setting. Finally, we create a one-of-a-kind protocol that uses the input link as the cluster head (CH) and performs a dynamically hopping at different nodes to reach the destination in the multi-hop communication. Even if a dynamic path was constructed in the event of a path or link failure, communication would still come to a halt. The cluster head will be the source node in this path configuration, and it will distribute data to the other nodes based on their energy levels. By implementing the proposed approach advances to create routes dynamically in a multipath propagation in case of route failure. To demonstrate its effectiveness, the suggested scheme's performance is compared to that of ECMP and SPEED in numerous areas, including overall efficiency, throughput and reduction of latency. The obtained findings were visually expressed in all aspects, demonstrating that our SCMC is unique and outperforms the ECMP and SPEED in terms of overall network performance. As a result, our proposed approach provides the greatest QoS results for wireless sensor networks.

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