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Cluster Routing for Real Time Location Awareness QoS Specific Spatial Distribution for Improved QoS in Wireless Sensor Networks (WSNs)

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Abstract – Wireless Sensor Networks (WSNs) have been used in various applications because of their salient characteristics. However, like any other network, they have their deficiencies. The sensor nodes of WSN have been fabricated with the radio device capable of transmitting or receiving the radio signals within a specific range. This restricts the sensor's direct communication with the faraway node. Regarding data transmission, the source and destination would be located in different geographies. Still, to perform data transmission, they are involved in cooperative transmission. Similarly, the traffic-based approaches select the route based on the traffic with the least traffic route. This introduces a longer hop count and increases the latency, which in turn affects the throughput performance. Finally, a QoS Specific Spatial Distribution Clustering Routing (QSSDCR) approach is presented. The method clusters the nodes according to their distribution factor of any window and identifies the list of routes in each cluster. The clustering of nodes is performed according to the value of the CTS (Cluster Transmission Support) measure, where the value of CTS is measured according to different factors like throughput, traffic, and energy. Similarly, the forwarding route is selected according to the Localized Coordinate Route Measure (LCRM) to perform data transmission. The proposed method improves the performance in data transmission and improves the QoS in WSN.

Index Terms – CTS (Cluster Transmission Support), Cluster Head Selection, Data Transmission, Localized Coordinate Route Measure (LCRM), QoS Specific Spatial Distribution Clustering Routing (QSSDCR), Wireless Sensor Networks (WSNs).

1. INTRODUCTION

Wireless Sensor Networks (WSNs) have been used on several occasions by different organizations to enable different service accesses provided. However, the service access executed by any user is transmitted in the form of data packets to the service point. The physical characteristics of any sensor node restrict direct access or direct communication with the service point. So, they participate in cooperative transmission to complete the service access. Such data packets have been transmitted through the route selected. The routing in WSN has several methods. In general, the basic hop count approaches are used in a few articles that perform route selection according to the hop count or number of sensor nodes present in the route being identified. In this, select a least hop counted route, but the presence of higher traffic in any of the intermediate nodes in the route selected would introduce latency, and sometimes, even the packet would be dropped [1]. This affects the throughput performance of the network. Similarly, the selection of a transmission route according to the traffic would lead to the selection of a longer route with a higher hop count, which increases the latency and affects the throughput performance.

The energy of sensor nodes plays a vital role in deciding the quality of service of the network as well as its lifetime. So, based on the energy of nodes, there are many approaches

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available. The wireless sensor network contains numerous sensor nodes that are geographically distributed. However, performing cooperative transmission leads to energy loss. However, to reduce energy depletion and to maximize the lifetime of the entire network, different routing strategies are used. In this way, spatial clustering is important for improving QoS in WSNs. Such methods select a more energetic route towards QoS development. So, there are several factors to be considered for the QoS development of WSNs. Spatial Based on these data, we propose a spatial distribution clustering routing algorithm for real-time location in terms of improving QoS in WSNs.

1.1. Problem Statement

The sensor nodes are geographically distributed in the network in various locations. Any sensor node can be identified as stated by its location and ID. By identifying such locations of sensor nodes, we proposed an efficient routing algorithm for real-time location-aware QoS-specific spatial distribution cluster routing for improved QoS in WSNs.

The proposed cluster-based routing toward QoS development is organized as follows:

Section 1 discussed the general introduction to WSN and different approaches to routing in WSN.

Section 2 presents a detailed review of the various methods available for the routing of WSNs.

Section 3 deals with the proposed working principle, QoS Specific Spatial Distribution Clustering Routing (QSSDCR).

Section 4 highlights the real-time location QoS-specific spatial distribution cluster routing for improved QoS in WSN.

Section 5 illustrates the experimental setup and results.

Section 6 summarizes the research and points out futuristic studies.

2. RELATED WORK

Lipare, A. et al. (2019) proposed an improved LEACH and EAUCF algorithm. The algorithm was used to enhance energy efficiency and solve the clustering problem in WSN. The drawback of the system is that the route selection is not performed with the cluster head within the transmission range. [2]

Indranil Gupta et al. proposed the use of a pulse extractor; the pattern received may be broken down into individual bits, which can then be cross-referenced with an oscillator to determine the precise wake-up call meant for a specific WSN node. This allows for the design of an efficient wake-up receiver [3]. The drawback of this method is that a network with a biased distribution of nodes cannot be tested. John et al. implemented a fuzzy logic algorithm for clustering and cluster head election based on deterministic, probabilistic, logic, and multi-attribute decision-making strategies that are covered in this work. Current algorithms improve energy efficiency and network lifetime, but they fall short in terms of security and quality of service. [4].

Haider et al. developed a UAV (unmanned aerial vehicle) method. The suggested methods plan extends a WSN's lifespan by a reasonable amount when compared to contemporary techniques. However, the author does not concentrate on the spatial distribution. [5]

W. A. Altakhayneh et al. proposed a Genetic Low Energy Adaptive Clustering (G-LEACH) that is assessed in terms of the number of live nodes, energy usage, cluster heads, and packet delivery to cluster heads. The primary factors to be taken into account in this situation are the nodes' lifespan and the quantity of packets they can send back and forth between nodes. This indicates that the characteristic that should be improved to enable WSNs to function efficiently and for an extended period is the nodes' energy. [6]. The main issue to be considered here is the lifetime of the node, and the data packets of one node can be converted to another node.

Panchal et al. proposed a LEACH data fusion algorithm. This method's cluster heads are randomly selected, and the parameters include the energy of consciousness. But the uniform distribution of clusters is due to problems and excessive energy consumption of the route, which is due to the cluster head information of the two clusters clustered in a wireless sensor network based on the low-energy adaptive clustering (LEACH) data fusion algorithm [7].

Alafeef A et al. proposed a reliable routing approach that is presented towards the improvement of energy utilization. The method uses a neural network in the selection of the route where the selection is performed based on a smart sampling technique. The method improves the reliability in transmission, which predicts the energy of nodes and their neighbours using a back propagation algorithm [8].

Lenka (2017) developed reliable routing methods to provide quality communication on WSN. It first measures the link quality to provide quality communication. The link quality is measured based on the energy of different nodes of the route. Finally, a single route with more quality is selected to conduct routing. [9]

Cao et al. (2017) tried to improve the performance of WSN by utilizing an energy-efficient uneven clustering algorithm with low energy consumption. The LCUCR (location-centric uneven cluster routing) approach conducts inter-cluster communication, which considers energy and distance factors in measuring the fitness of selecting a node as a cluster head and subheads to perform communication through the base station. [10]. similarly, in Bhaskar et al. (2017), an efficient bio-inspired self-healing routing scheme is presented to maximize the lifetime of WSN. To handle the problem of topology change due to energy depletion in sensor nodes, an ant colony-based self-healing routing scheme is presented. It uses swarm intelligence techniques to maximize the lifetime of WSN. [11].

Kamarei et al. Proposed SiMple, a unified algorithm to jointly route single- and multi-path packets in WSNs. Different requirements query driving traffic BS and multiple castings to generate multipath streams, better sensors, and general path multipath data groupings in a single mobile wireless sensor network. However, in multicast or multipath routings, it is not supported [12].

Zhang et al. proposed that the spatial QoS is assigned to each data packet in different ways according to the waiting time. The end-to-end weight should be minimized and distributed to applications in separate data packets but does not provide data integrity and delay differentiated services. [13].

Chen et al. proposed a random routing mechanism. This method finds the wireless communication range that is sending nodes around a specific choice. The drawback of the system is it will not be able to source nodes for another year. [14].

Di Valerio et al. introduced an adaptive routing protocol to optimize the energy consumption of adaptive single-pass and multi-pass. Based on the learning dispersion reinforcement framework, the path length is the ratio of switching joint-guided routing and packet transmission [15]. The drawback of the system is that it does not concentrate on QoS parameters.

The application of genetic algorithms has no limit, and it has been used in routing in WSN by Muruganantham & El-Ocla (2018). The method adapted the working of GA with popular AODV, where the route selection is optimized with the genetic algorithm; it optimizes the link quality of any route identified [16]. The drawback of the system is that it does not support the energy consumption of the spatial distribution.

Wang et al. developed multi-path routing and calculated it to meet different constraints while ensuring that multiple paths are selected among the paths measured by the specified geographic distance [17].

Farhoudi et al. proposed a multi-plane routing (MPR), which integrates into the all-IP architecture, and studied the widely accessible network structure [18]. The drawback of the system is that it does not consider the energy consumption occurring in different data transmissions.

Jain et al. (2019) prescribed the Objective Modular Network Tested (OMNeT) tool, which has been used for the simulation and evaluation of hierarchical routing schemes, always a key to improving the execution of WSN. To do this, the author has considered three different hierarchical routing schemes and analyzed their execution under different conditions. The drawback of the system does not analyze QoS [19].

K. J. Pai et al. proposed the tree search algorithm to support the construction of dual CIST (completely independent spanning tree) low-dimensional networks [20]. The author has considered three routing protocols: location-based, data-centric, and hierarchical routing schemes. The drawback of the system is the method does not analyze the node energy and density at every sensor node to get an optimal path.

W. -K. Yun et al., the authors present a Q-learning-based data-aggregation-aware energy-efficient routing algorithm to maximize the node energy performance. The method analyzes the node energy and density at every sensor node to get an optimal path. The drawback of the system is real-time location spatial distribution is not considered [21].

Shital et al. propose the orthogonal code of light will be used as the code for the signature of water mobile users. Therefore, it backhauls structure, its potential applications, and its design challenge are important basic aspects of the network that have been introduced. The drawback of the system is QoS is not considered for spatial distribution [22]. Following a discussion of the literature review, spatial distribution clustering is crucial for enhancing WSN QoS.

3. PROPOSED METHODOLOGY

We proposed a location awareness QoS-specific spatial distribution in wireless sensor networks. The proposed QOS Specific Spatial Distribution Clustering Routing (QSSDCR) technique enhances data transmission performance in terms of QoS in WSNs by providing location-aware cluster routing, cluster head selection, and data transmission.

3.1. Location Aware Routing in QoS Development

The sensor nodes have certain characteristics in terms of their energy and transmission range. In the case of transmission range, it defines the boundary of any sensor within which the node can communicate with other nodes. In general routing procedures, the protocol identifies a set of routes between any two sensor nodes by transmitting a set of control messages. The control message is broadcast within the network, which introduces higher overhead in the network and introduces energy depletion in many nodes, which affects the lifetime of the entire network. To overcome such a deficiency, the location details of different sensor nodes can be used in routing procedures. The location details of different sensor nodes can be obtained from the topology maintained. From the topology, the location of different sensor nodes is identified, and based on the transmission range; the possible routes between any two sensor nodes are identified. By identifying such routes, the quality of service of WSNs can be improved.

3.2. Spatial Distribution Clustering in QoS Development

The WSNs are several nodes and are spatially distributed. Consider the network N, which has K number of sensor nodes

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that are geographically distributed. As stated by this, when routing is performed, the protocol selects the optimal route according to the energy and distance as the number of hops of any route. Consider a route R, which is present in a specific part of the network with r number of hops. Route R is selected as it has a lower hop count. The data transmission is performed in the selected route R, but what happens in the middle is that one of the hops becomes dead due to the poor energy conditions, and the transmission cannot be completed. To identify an alternate route in the middle, there may be no alternate hop as there is a poor density of nodes. This increases the frequency of retransmission and affects the throughput performance.

To handle this difficulty, the clustering of nodes according to the spatial distribution should be considered. By clustering the nodes like this, when there is a link failure, there will be an alternate route that can be identified to continue the data transmission with less overhead. Spatial distribution clustering is the process of grouping the sensor nodes based on the location of nodes and their distribution in a specific region.

Consider a network N, which is of X/Y size, and the network is split into several integral networks based on the window size s. The window size is considered from minimum to maximum. In each window size, the method generates an integral image and adds it to a set. Now, for each integral image, the method identifies the number of sensor nodes in the integral image and computes the spatial distribution factor. First, the list of sensors present in the network is identified, as shown in equation (1). Now, each sensor may be located in different locations, and it is identified as shown in equation (2).

Sensors in the network Sel= $\sum \text{Sensors} \in \text{NT}$ (1)

Lds = $\sum_{\text{i}=1}^{\text{size(Sel)}} \text{Sel(i)}.\text{location(NT)}$ (2)

The value of Lds represents the location of a specific sensor, which is identified for each sensor shown in equation (3)

Now, the number of time windows is generated as follows:

Compute No of window Nw = $Size(NT)/_{10}$ (3)

As stated by the size of the window, the integral images are generated and added to the set INS. Consider the set INS has k number of integral network images, where each has a set of sensors. According to that, for any Integral Network (IN), various measures are computed as follows:

First, a distribution factor is measured as shown in equation (4)

SDF = $\frac{Size(\sum Sensors \in In)}{size(Sel)}$ (4)

Second, the inclusion factor is measured, which represents the selection of an integral network to the set which is decided by the average distance of all the nodes with the diagonals of the integral network. This represents how dense the nodes or how close the nodes are within the integral network as shown in equation (5)

Inclusion Factor InF = $\frac{\sum Dist((\sum Sensors \in \forall Diagnols(IN)), \sum Sensors \in In)}{size(\sum Sensors \in IN)} \times 1.0$ (5)

Similarly, the emission of any integral network is identified by measuring the exclusion factor as shown in equation (6) the value of the exclusion factor is measured.

ExF = $\frac{\sum Dist((\sum Sensors \in \forall Diagnols(IN)), \sum Sensors \in In)}{size(\sum Sensors \in IN)} \times 0.3$ (6)

Using both of them, the value of selection support is computed as shown in equation (7)

Selection Support Ss = $\frac{InF \times ExF}{SDF}$ (7)

By computing the selection support, the integral network considered can be either selected or emitted from the list. Similarly, for each size of the window and each integral network on the specific window, different selection support values are measured to select a set of integral parts of the network to perform spatial distribution clustering. This supports the detection of different dense regions of the network towards spatial distribution clustering.

Once such a set is identified for the entire integral network, a set of sensors located in the network is identified. Further, for each network and its sensor set, a single sensor is selected based on the Cluster Transmission Support (CTS), which is measured based on the energy.

4. REAL-TIME LOCATION-AWARE QOS SPECIFIC SPATIAL DISTRIBUTION CLUSTER ROUTING

The proposed location-aware QoS-specific spatial distribution cluster routing scheme first generates an integral network of varying window sizes to identify a set of integral networks or regions of the network where the clusters can be formed.

Further, for each integral network, a single cluster head is selected based on the cluster transmission support. According to the cluster head selected, the method performs data transmission in two ways: first, the possibility of localized routing is identified, and if possible, the localized routing is carried out. Otherwise, cluster-based routing is performed. The localized routing is done based on the localized coordinate route measure (LCRM) for different routes. A detailed approach has been presented in this section.

The functional architecture of the proposed QSSDCR routing scheme is shown in Figure 1. Each functional component is discussed in detail in this section.

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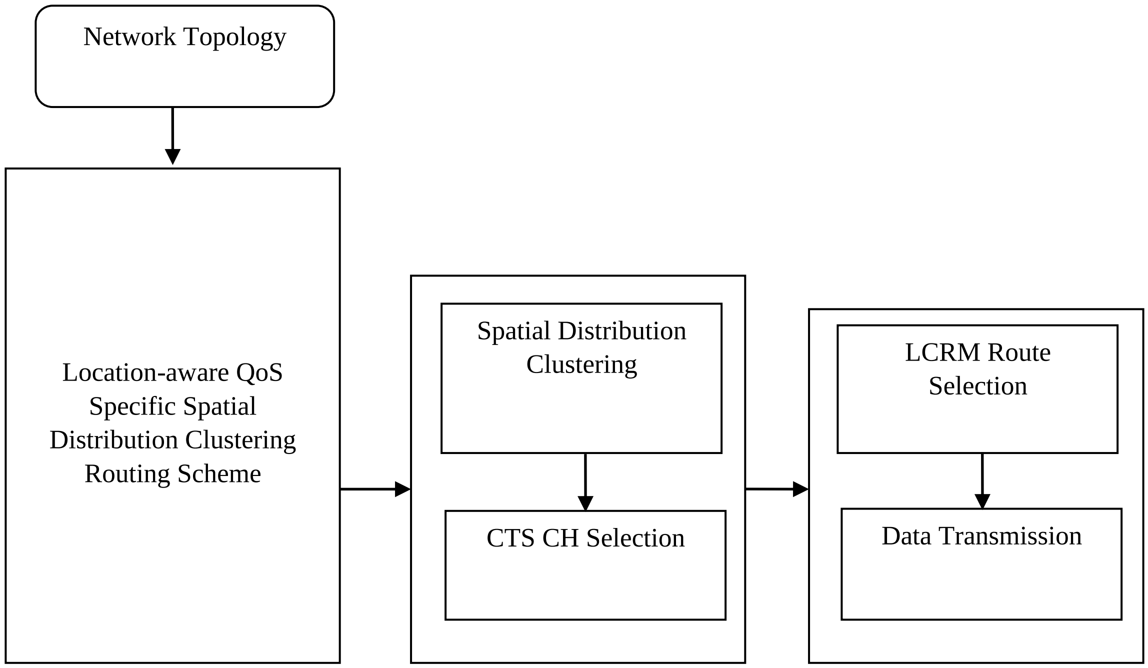

Figure 1 Architecture of Proposed QSSDCR Routing Scheme

4.1. Spatial Distribution Clustering

The spatial clustering is carried out for the topology of the network. With the network topology available, a set of sensors in the network is identified initially. Also, their location features are identified. Further, with varying window sizes, numerous integral networks are generated in equation (8). For the entire integral network, the method computes the spatial distribution factor according to the number of sensors in the integral network shown in equation (9) and the coordinates of the integral part. Similarly, the values of inclusion and exclusion factors are computed to measure a support value. Using all these, the value of selection support is computed to select or drop the integral network. The networks selected are used in generating the cluster, which selects the most energetic node from a set of nodes based on the cluster transmission support value to continue data transmission. The step-by-step is represented as shown in algorithm (1).

Given: Network Topology NT

Obtain: Cluster set Cs

Begin

Step 1: Read the topology NT.

Step2: Find the sensor nodes in the network as Sl using equation (1)

Step3: Fetch the locations of all sensors Lds using equation (2)

Step4: Find the total time window Nw = $^{Size(NT)}/_{10}$ (8)

Step 5: Now for the time window

Generate Integral Network Set INS = Split (NT, size (window)) (9)

Step 6: End

For all integral networks

Step 7: Measure spatial distribution factor SDF using Equation (4)

Step 8: Measure the Inclusion factor using Equation (5)

Step 9: Measure the exclusion factor using Equation (6)

Step 10: Measure selection support using Equation (7)

Step 11: If Ss>Th , then

Add into Cluster Set Cs.

Step 12: End

Step 13: End

Step 14: For each sensor in Sel

Step 15: If S, ∋ $\forall CS$ then

Identify nearby cluster

Otherwise

Deploy random nodes

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Step 16: End

Step 17: End

Step 18: Stop

Algorithm 1 Spatial Distribution Clustering

The spatial distribution clustering algorithm identifies the list of sensors and their location. Further, it generates a set of integral networks and measures spatial distribution factors, inclusion, and exclusion factors to compute selection support. For the value of selection support, the method selects or drops the integral network towards spatial distribution clustering. Such selected networks are used in generating the clusters according to the cluster transmission support for various nodes, and a single one is selected as the cluster head according to the value of CTS. The selected node is used in data transmission and acts as the cluster head.

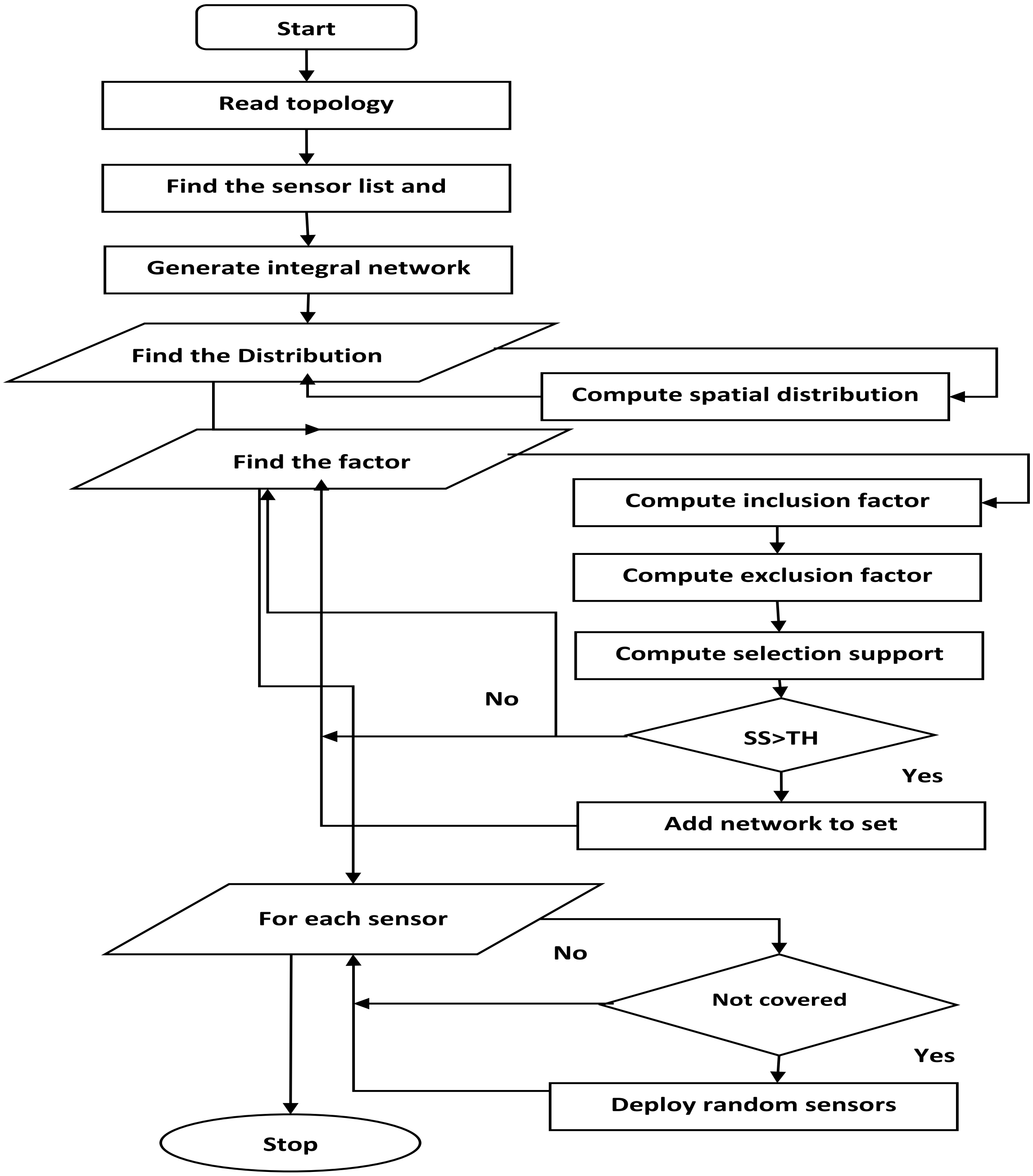

Figure 2 Flow Chart of Spatial Distribution Clustering

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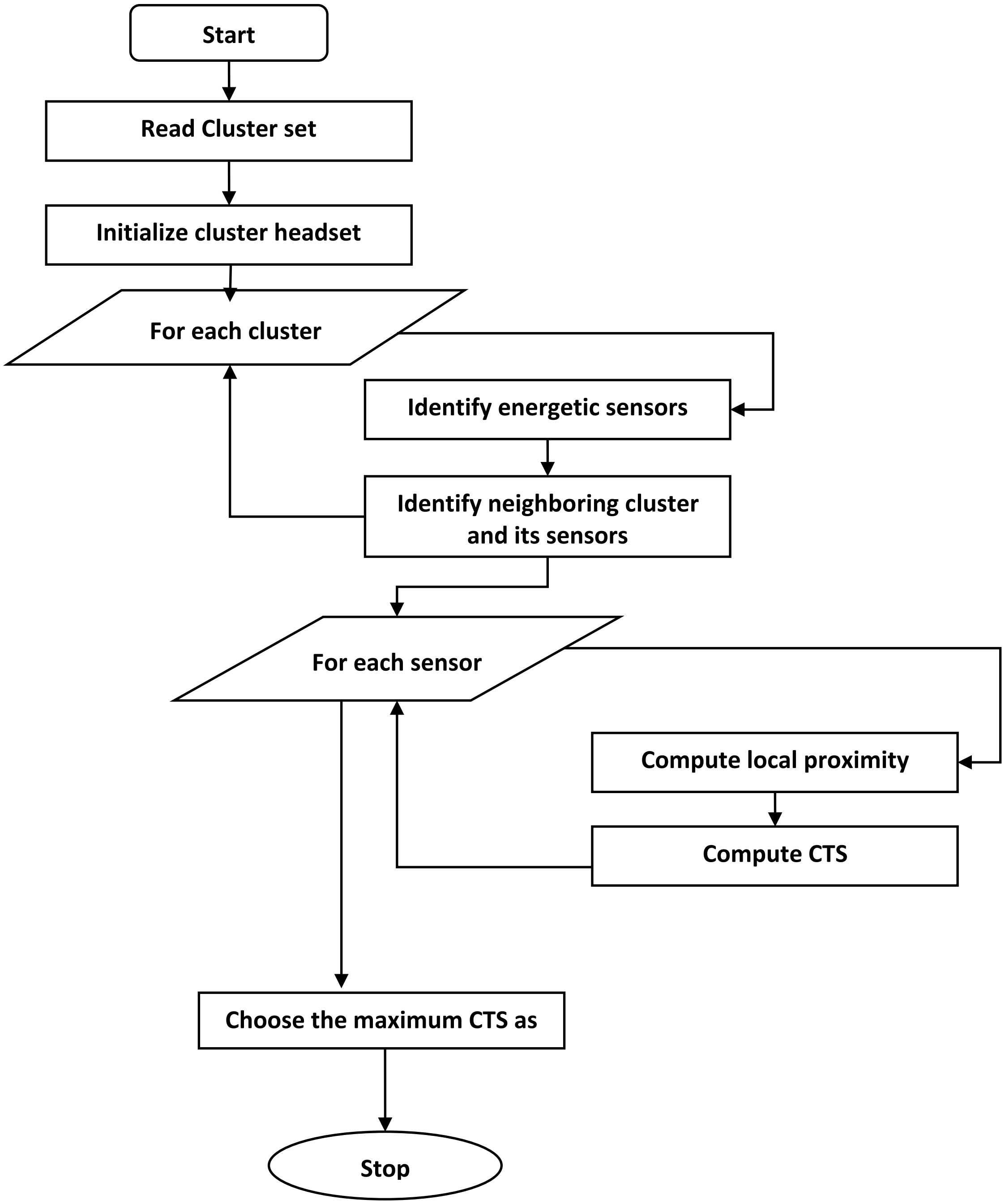

Figure 3 Flow Chart of Cluster Head Selection

The working principle of the spatial distribution clustering approach is shown in Figure 2.

It measures the spatial distribution factor, inclusion factor, and exclusion factor for different integral networks generated for different window sizes. According to the values, selection support is measured, a set of networks is selected, and the nodes of the network are clustered under the cluster head.

4.2. Cluster Head Selection

The routing in WSNs is done in several ways, and by performing cluster-based routing, the execution of WSNs is improved. To obtain such development, the clusters should be formed with a cluster head. In this approach, the cluster head selection is carried out in each integral cluster generated.

First, a set of energetic nodes is identified, and for each of them, the method computes the location proximity value.

The location proximity is measured based on the average distance with the other cluster energetic nodes. By selecting the cluster head based on location proximity, any node in the cluster can reach the cluster head in a minimum hop count, which in turn would reduce the latency values.

Similarly, according to the traffic and throughput expectation, each sensor is measured using the traffic and throughput expectation for the cluster traffic support (CTS). Finally, a sensor with maximum CTS is selected to execute data transmission. The detailed steps involved in CH Selection as shown in algorithm 2.

- Given: CS
- Obtain: CH set CHS.

Begin

Step 1: Read Cluster Set CS.

Step 2: Initialize Cluster Head Set CHS.

Step 3 For each cluster C

Step 4: Identify a set of energetic sensor ES according to the energy threshold as shown in equation (10) and the neighboring clusters are calculated as shown in equation (11).

$$\text{Es} = \sum_{i=1}^{\text{size}(\text{Sensors}\in\text{C})} \text{Sensors.Energy} > Th \qquad (10)$$

Step 5: Find the neighboring clusters $\text{NC} = \sum \text{Clusters} \leftrightarrow \text{C}$. (11)

Step6: After calculating the neighboring clusters, finding all sensors in neighboring clusters is calculated as shown in equation (12).

$$\text{Ns} = \sum_{i=1}^{\text{size(NC)}} \text{Sensors} \in \text{NC(i)}. \qquad (12)$$

Step 7: For each sensor from Es the location proximity and cluster traffic support are calculated as shown in equations (13) and (14)

$$\text{Measure location proximity Lp} = \frac{\sum_{i=1}^{size(Ns)} Dist(Ns(i),s)}{size(Ns)} \qquad (13)$$

$$\text{Measure CTS} = \frac{Energy(s)}{(Size(C)/\mu)} \times \frac{Energy(s)}{Size(C)\times\rho} \times Lp \qquad (14)$$

where µ-minimum energy is required in servicing a sensor under the cluster.

P – Minimum traffic generated by any sensor

Step 8 : End

Step 9: Choose a sensor with maximum CTS as Cluster Head.

Step 10: Stop

Algorithm 2 CH Selection

The working cluster head selection procedure is presented in the pseudo-code, which measures the location proximity for all the nodes of a cluster with its own and other cluster nodes. Also, the cluster transmission support (CTS) is measured for more energetic nodes. Based on these two, a single cluster head is selected for any cluster.

The working principle of the cluster head selection algorithm is shown in Figure 3, where the method first identifies the list of sensors and neighbour cluster sensors. For the sensor identified, the method measures the local proximity and computes the CTS values. According to the value of CTS, a single sensor is selected as a cluster head to support data transmission.

4.3. Data Transmission

The data transmission in the QoS-specific spatial distribution cluster routing scheme is involved in two stages. The priority is performing routing for local coordinates. It is performed by identifying a set of routes to reach its level towards the destination. This would reduce the time complexity of transmitting the data through the cluster head. It is identified by measuring the value of Localized Coordinate Route Measure (LCRM), which is computed, based on the location of the destination node and the routes available to reach the node. If there is a short route to reach the destination, then it is selected and transmitted. Otherwise, regular cluster-based routing is carried out.

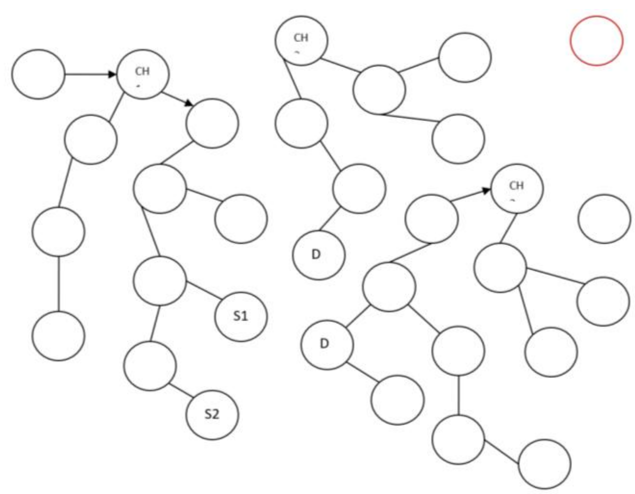

Figure 4 Sample Network Topology

The network topology being considered for cluster-based routing is shown in Figure 4. Consider scenario S1, having the packet be transmitted to D1, where the hop count to reach the destination D1 through the CH1 is 7, while the localized route is about 3.

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This reduces the hop count by 4, and this would support the performance development. Towards this, the proposed approach would select the routing type for the Localized Coordinate Route Measure (LCRM) calculated as shown in equation (15). Interns of the LCRM value the route among the available routes set that is selected when there exists more than one localized route available. The step-by-step is represented as shown in algorithm (3).

Given: Target Node Tn, Network Topology Nt

Obtain: Null

Begin

Step 1: Read T, C.

Step 2: If Dist (S.locaion & Tn.location) <Th then

Identify the routes as Rl to reach Target node Tn.

Step 3: For any R

Step 4: If Hops to CH > size®, then

Measure LCRM = $\frac{\sum Hops \in R}{Dist(S.location, Tn.location)} \times size(Rl)$ (15)

Step 5: End

Step 6: End

Step 7: Choose the route with the maximum LCRM and transmit the data.

Else

Transmit through cluster head

Step 8: End

Step 9: Stop

Algorithm 3 Data Transmission

The working data transmission procedure is presented in the aforesaid pseudo-code, which measures the LCRM values for different routes in the localized environment. If there is a possible route, then it is selected to perform transmission. Otherwise, the data transmission is performed in cluster-based routing.

This chapter has dealt with a detailed implementation of a QoS-specific spatial distribution cluster routing scheme that generates several integral networks according to network topology. For each integral network, the method measures the spatial distribution factor and computes the selection support to group the nodes under different clusters. Further, for each cluster, the method computes the cluster traffic support for throughput, energy, and traffic. The cluster head selection is carried out in terms of the CTS measure computed for different energetic nodes of the network as stated by different constraints. Finally, the data transmission is carried out by measuring localized coordinate route measure (LCRM) for different destinations to conduct data transmission. The proposed method improves the performance of QoS regarding various parameters. The method improves the performance of throughput and reduces the latency and packet drop ratio.

5. RESULTS AND DISCUSSION

This section presents detailed information on the evaluation results achieved by the different methods proposed. The methods are evaluated for their performance in terms of various factors. The evaluation is carried out in Network Simulator NS, and the results obtained are presented in this chapter.

Table 1 shows the details of the simulation being used for the evaluation of proposed approaches of routing in WSN. The performance is measured on the following parameters:

The performance of throughput, packet delivery ratio, average hops, packet delay ratio, and average energy consumption of the networks is used to evaluate the effectiveness of the suggested spatial distribution clustering routing approach.

Table 1 Simulation Parameters

Parameters	Value
Data rate	2 Mbps
Application Type	Constant bit rate (CBR
CBR interval	1.0 (second)
Simulation Time	350 s
Simulator	NS-2
Data Speed	20 m/s
Total energy	500 joule

5.1. Analysis of Throughput Performance

The throughput performance is measured based on the total number of bytes delivered to the destination. It is measured as follows, as shown in equation 16.

Throughput $= {Total\ Packets\ Delivered}/{Total\ Packets\ Sent}$ (16)

Table 2 Performance of Throughput vs Time

Time in Sec	EECR in %	EECMHR in %	REACR in %	QSSDCR in %
10	16	37	49	57
20	48	51	61	68
30	59	63	73	79

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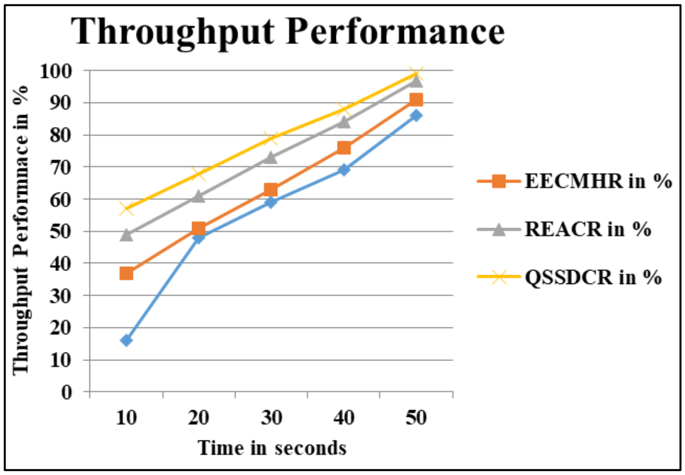
40	69	76	84	88
50	86	91	97	99

The throughput performance generated by different approaches at different timestamps is measured and presented in Table 2. The proposed QSSDCR approach has produced 99% higher results compared to other methods.



The performance of the methods on throughput at different timestamps is measured and compared in Figure 5. The QSSDCR algorithm has achieved higher throughput performance at all the time stamps compared to the EECR, EECMHR, and REACR algorithms.

5.2. Analysis of Average Number of Hops

The average number of hops is calculated by adding up all of the paths between source and destination nodes and dividing by the total number of paths.

Table 3 Performance in Average Hops

Number of Nodes	Average Number of Hops				Gain in Hops
	EECR	EECMHR	REACR	QSSDCR	
100	2.5	2.0	1.5	1.3	0.2
150	3.0	2.7	1.9	1.6	0.3
200	3.5	3.1	2.4	1.9	0.5
250	4.0	3.0	2.7	2.2	0.5
300	5.0	4.1	3.3	2.6	0.7

The average hops being used in data transmission in different timestamps are measured between different methods and presented in Table 3. The proposed QSSDCR scheme has produced better results than EECR, EECMHR, and REACR algorithms and improved the gain.

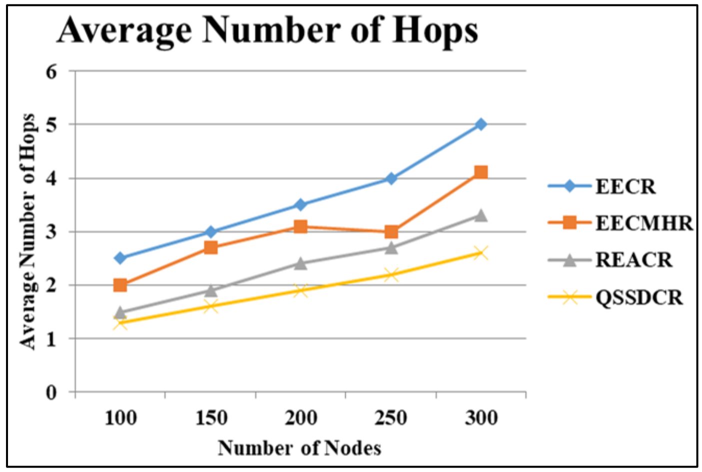


Figure 6 Average Hops vs Number of Nodes

The average number of hops used for data transmission is presented in Figure 6. The QSSDCR algorithms have produced a lower hop value.

5.3. Network Utility Factor (NUF)

The total bandwidth of the network system is split and randomly distributed to all individual WBANs that are connected to the local server. The network utility factor is increased while the number of sensor nodes increases within the WBAN network. Table 4 shows the performance analysis in terms of network utility factor. NUF is inversely proportional to the number of sensor nodes.

Table 4 Performance Analysis in Terms of NUF

Number of Sensor Nodes	NUF
1	125
2	252
3	320
4	420
5	515
6	625
7	752
8	862
9	916
10	985

Higher NUF shows that the performance of the WBAN network is good, and lower NUF shows that the performance of the WBAN network is worse.

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Table 5 Comparisons of NUF for the Proposed Method with Conventional Methods

Number of Sensor Nodes	NUF			
	QSSDCR	EECR	EECMHR	REACR
1	125	75	92	98
2	252	128	122	128
3	320	267	187	278
4	420	315	298	387
5	515	478	318	438
6	625	564	468	526
7	752	614	518	612
8	862	715	629	728
9	916	831	738	810
10	985	892	812	912
Average	577.2	487.9	418.2	491.7

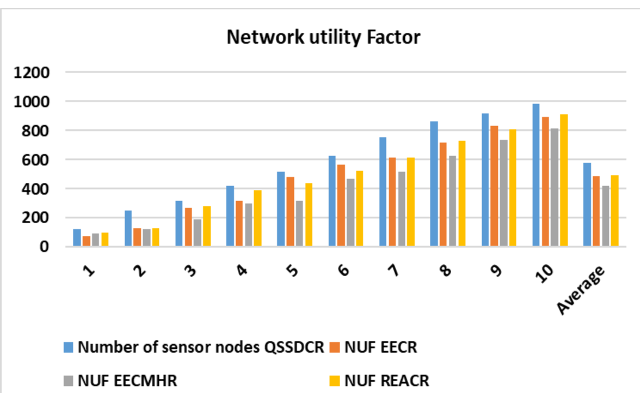

Figure 7 Graphical Illustration of Performance Analysis in Terms of NUF

Table 5 shows the comparisons of NUF for the proposed method with conventional methods. The proposed interference detection methodology stated in this paper achieves 577.2 NUF as an average value. The performance analysis in terms of network utility factor is shown in graphical format as shown in Figure 7.

5.4. Analysis of Energy Consumption

The problem with WSNs is that they have limited onboard energy sources. The two main components that use the most power in a WSN are packet transmission and sensing.

Total energy consumed = ∑(power for active mode *active time)* + ∑*(power for sleep mode* sleep time) (17)

Table 6 Energy Consumption Comparison Result

Number of nodes	EECR in Joules	EECMHR in Joules	REACR in Joules	QSSDCR in Joules
100	26	12	9	7
150	37	23	17	14
200	46	37	26	21
250	57	51	42	29
300	89	64	49	37

The performance of methods in energy consumption (equation (17)) is measured based on the number of transmissions performed on a timestamp and the number of nodes involved with the total energy spent by all the nodes.

According to that, the average energy spent has been measured and compared in Table 6, which denotes the proposed QSSDCR algorithm has produced less energy consumption than other methods, which supports the improvement of network lifetime.

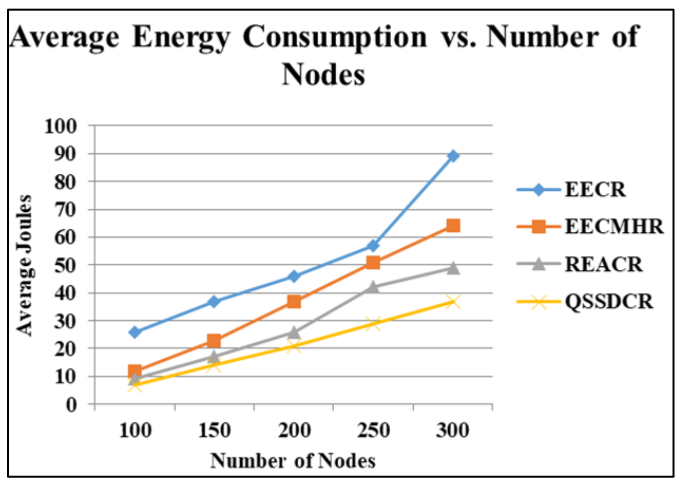

Figure 8 Analysis of Energy Consumption Ratio

The performance of methods in energy consumption is measured and presented in Figure 8, which denotes the proposed QSSDCR algorithm has produced less energy consumption than other approaches.

5.5. Analysis of Packet Delivery Ratio

The percentage of data packets successfully received relative to the total number of packets sent is known as the Packet Delivery Ratio (PDR), and it is a metric used to assess how well data packets are delivered from a sender to a recipient.

Table 7 Performance of Packet Delivery Ratio vs Time

Performance of Packet Delivery Ratio In %				
Time in Sec	EECR in %	EECMHR in %	REACR in %	QSSDCR in %
10	26	32	46	56
20	37	43	59	64
30	46	57	71	76
40	57	71	82	87
50	89	92	96	98

The performance of the packet delivery ratio produced by different methods at different times has been measured and presented in Table 7. The proposed QSSDCR algorithm has produced 98% packet delivery performance compared to other methods.

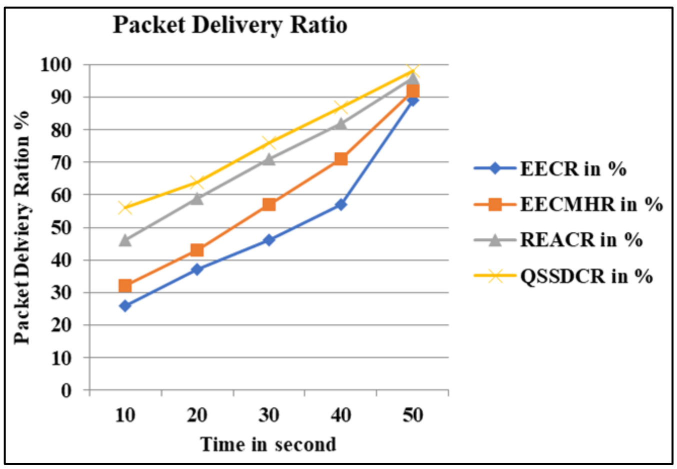

Figure 9 Packet Delivery Ratio vs Time

The performance of PDR is measured, and the QSSDCR algorithm has produced higher performance than the EECR, EECMHR, and REACR algorithms shown in Figure 9.

This chapter presented a detailed study on the evaluation results of different methods proposed. QoS-specific Spatial Distribution Clustering (QSSDCR) approach is proposed, which clusters the sensor nodes by Cluster Transmission Support (CTS) measures. The value of CTS is measured for different factors like throughput, traffic, and energy. Similarly, the forwarding route is selected for localized Coordinate Route Measure (LCRM) to enable data transmission. The proposed method improves the performance in data transmission and improves the QoS in WSN.

Each method has been implemented, and its performance has been measured on various parameters. According to the value obtained, the performance of the proposed approaches is compared.

6. CONCLUSION

Routing in wireless sensor networks is performed in several ways. However, when the source routing is performed, the source node chooses the route to perform routing. This introduces higher energy depletion in all the nodes in the route. Finally, a QoS Specific Spatial Distribution Clustering Routing (QSSDCR) approach is presented, which clusters the sensor nodes by CTS (Cluster Transmission Support) measures. The value of CTS is measured for different factors like throughput, traffic, and energy. Similarly, the forwarding route is selected for Localized Coordinate Route Measure (LCRM) to enable data transmission. Further, the execution of routing in WSNs can be improved by adapting region-centric density approximation algorithms to carry out clustering, and the cluster head selection should be done by computing the density measures on each cluster, which encourages cluster merging and cluster splitting. The proposed QSSDCR to evaluate the performance of throughput is 99%, the performance of packet delivery ratio is 98%, the performance in average hops is 0.7 hops, and the packet delay ratio is 6.2 sec. The proposed method improves the performance in data transmission and improves the QoS in WSNs.

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