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Optimizing Sensor Localization and Cluster Performance in Wireless Sensor Networks through Internet of Thing (IoT) and Boosted Weight Centroid Algorithm

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Abstract

Localization is an extremely important component of applications that make use of wireless sensor networks. It has a substantial impact on academics as well as real-time sensor deployment applications in the aim of lowering the amount of energy that is used while simultaneously locating unknown nodes. The process of obtaining the coordinates along an axis that represent the locations of the sensor nodes is referred to as localization. The accuracy of locating the positions of the nodes varies depending on the environmental conditions, the type of nodes, the type of application, and the type of localization methods used. A standard localization method known as distance vector hop (DV-hop) localization will be able to determine the positions of unknown nodes with typical accuracy with the assistance of beacon nodes based on Internet of things. The DV-hop and improved weighted centroid localization algorithms, in addition to the suggested boosted weight centroid-based localization approach, are both addressed in this article. The suggested boosted weight centroid localization technique is utilized to find nodes in the remote area of the WSN while conserving energy. This is accomplished with the assistance of measurements involving both the nodes and the centroid. The modified weight metric is utilized in the process of carrying out the task of localisation of an unknown node. The performance of BWCLA is evaluated based on a number of different metrics, including accuracy in localization, average localization error, total packets utilized, and energy usage.

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1. Introduction

WSN has numerous uses across a range of industries. The effectiveness of the WSN is plagued by several problems. The behaviour of the sensor nodes in the environment in which they are deployed determines how well sensor networks perform [1]. The sensor nodes' integrity is essential for enhancing the network's performance. WSN clustering methods link different sensor nodes into groups and choose the CH. There has been sufficient research done on clustering in WSN. The design of the routing protocol, in addition to clustering strategies, is crucial to the effectiveness of WSNs [2].

The needs and characteristics of an application will affect the WSN's capacity and performance. Some applications need a longer battery life, while others need information that is very accurate [3]. These performance indicators include longevity, cost-effectiveness, and ease of deployment, as well as coverage, temporal accuracy, response speed, and security [4]. The following are important factors to consider for the design of WSN: Small Node Size, Self-Configuration, Scalability, Multi-hop Communication, Reliability, Fault Tolerance, Adaptability, Security, and Channel Utilization. Lower Power Consumption [5].
In applications involving wireless sensor networks, localization is an important fact. It has a significant impact on academics and real-time sensor deployment applications in the direction of reducing energy usage while locating unidentified nodes [6]. Localization is the process of determining the coordinates of the sensor nodes' position within the axes. Depending on the ambient conditions, the kind of nodes, the kind of application, and the kind of localization methods, the accuracy of placing the nodes' locations varies. With the aid of beacon nodes, a conventional localization technique known as distance vector hop (DV-hop) localization will be able to detect the positions of unknown nodes with normal accuracy. For effective localization, DV-hop has undergone various changes in recent years. Although the approach is applicable to applications in remote sensor management, a model with lower energy consumption is required for localizing the deployment of remote sensors. DV-hop, centroid, weighted centroid, and improved weighted centroid localization algorithms are discussed together with the suggested boosted weight centroid-based localization method [9].

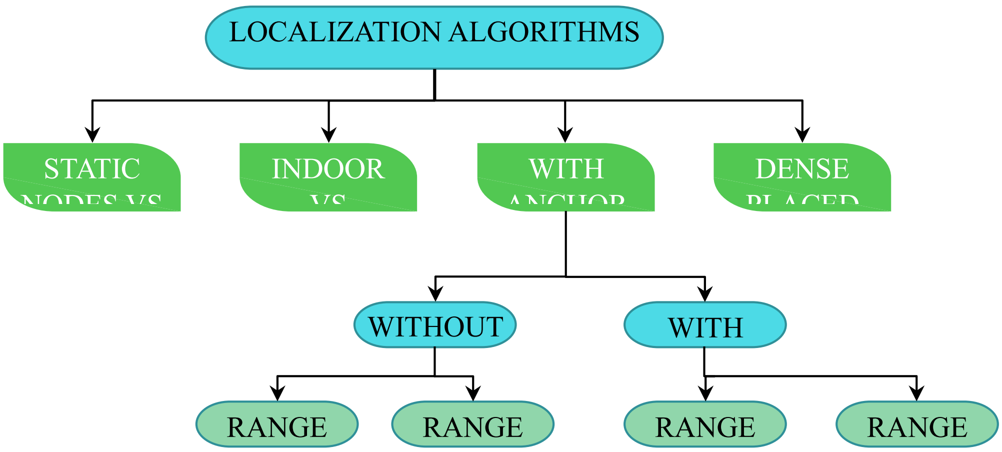

Figure 1: Localization Topographies.

In wireless sensor networks, the conventional DV Hop algorithm is used for the best localization. Based on the required Euclidean distances between the beacon nodes and the unknown nodes, the DV-Hop theory is used [10]. By multiplying the average hop distance over the entire network by the hop metric of beacon motes, the metric determines the distance. The DV Hop localization algorithm uses vectorial routing distance and is a range-free technique. Finding the distance between unknown nodes and beacon nodes is the main criterion [11].

The mean hopping distance between beacon nodes is increased, and further triangulation, multi-late ratio, and trilateration techniques are applied to determine the information about the location of the unknown nodes. The DV hop technique has a chance of making an error since the topology of the network in WSN is randomly configured and the path of the unknown to the beacon is not straight [12].The essential principle of centroid-based localization differs slightly from that of the DV Hop technique. In essence, there are only two processes in CLA. Similar to DV Hop at first, all anchor nodes transmit beacon messages to the other nodes inside the network's threshold area that contain location-related information [13]. DV-hop is more computationally difficult and uses more energy. By utilizing a centroid localization algorithm, such as two phases make up the DV hop process. WCL calculates the minimum hop value of each beacon node using the same methods as the DV hop in the first step. The position of an unknown node must be determined [15-17].

The localization algorithms work in a variety of ways dependent on range metrics. Based on the received signal strength indication, RSSI is one of the best localizations. Signal strength is crucial because the localization of nodes in wireless transmission is considered [19-21]. The received signal strength indicator (RSSI) is produced using a log-normal shadowing model. In the proposed study, localization in WSNs is carried out using the boosted

weight centroid approach [22-25]. When considering WSN, most of the applications are distantly based, and energy plays a significant role in node localization. Most of the problems and solutions are discussed under the section for existing localization algorithms. It is necessary to maintain the trade-off between energy usage and localization accuracy [26].
The subsequent section presents the framework delineating the remaining content of this scholarly document. The exposition of the relevant literature is concisely delineated in the second section, while the third section expounds upon the methodology and the theoretical underpinnings of the employed techniques. Section 4 encompasses the presentation of the simulation results and subsequent analysis. In the concluding segment of this manuscript, denoted as the "key findings" section, we shall proceed to succinctly encapsulate the paramount outcomes.

2. Previous related work

The existing work done on the same field is tabulated below to summarize the research work done on the same field.

Table 1: The existing work done on the same field.

S. No.	Citations	Research work	Findings
1	[7,27]	They studied rumor routing, one of the classic protocols, And the problem due to scalability, resulting in spiral paths.	Rumor routing is an agent-based technique for identifying routing paths. The writers have taken the shortest straight-line distance between any two nodes into account. Utilizing intermediate hops, straight-line routing (SLR) is built to reduce the spiral route problem, improve routing, and save energy.
2	[8, 29]	They proposed the heterogeneous ring topology to address the energy balance issue in the IPv6 protocol for low-power lossy networks.	According to the Routing protocol for low-power network (RPL) communication messages, cluster and cluster acknowledgment is carried out. For routing and cluster management, "Energy-efficient heterogeneous Ring Clustering" (E2HRS) and routing protocol are employed. When compared to RPL, the aforementioned approach performed better in balancing the energy of WSNs.
3	[14, 28]	Proposed a new optimal routing algorithm that finds the ideal path for data transmission in WSN.	The novel ant colony approach, on which this algorithm is based, considers transmission direction, residual energy, and the distance between the source and the destination node. The suggested heuristic technique lowers energy use and lengthens the network's lifetime.
4	[18, 30, 31]	He investigated a technique utilizing rechargeable sensor batteries. For proper battery level, the suggested architecture is built on wirelessly powered sensor nodes.	A mobile robot is used to recharge batteries, and a robot is positioned in such a way as to best access CHs. Using the LAECH-C algorithm, CHs are chosen. The network's lifetime and overhead performance both improved as a result of the results. Mobile robots, however, are not suitable for many real-time applications.

5	[20, 32, 33]	They looked at the sensor's popular low-duty cycle mode for the energy conservation standard. It has two states, active and dormant, and the standard routing algorithm has a very high delay when switching between them. Additionally, measures were taken to enhance traffic flow while taking collision and congestion into account.	The suggested approach determines the best global path with the least end-to-end (E2E) delay while using the least amount of energy by balancing energy conservation and latency. It consumes 30% less energy than other conventional approaches while also reducing the E2E delay.
6	[23]	They suggested that the two primary stages of clustering are the grouping of nodes and assigning tasks to the nodes. Clustering nodes can be done using a Voronoi chain or a spectrum.	A maximum of two hops is permitted to link to the CHs in the Voronoi arrangement, which has the network separated into unequal parts of clusters and a chain-based network structure. Gateway nodes serve as cluster heads through which communication between CHs and the BS occurs. The purpose of multi-hop communication is to connect CHs from their member nodes in a multi-hop fashion.

3. The objective of the work

1) To create a Boosted Weight Centroid Localization algorithm that minimizes energy conservation for the node localization identification process.

4. The Proposed Work

This study updates DV-hop with some new features to improve localization performance. Although the approach can be used in remote sensor management applications, a less power-intensive model is required to properly localize the deployment of remote sensors. We present a boosted weight centroid-based localization method and evaluate it in comparison to DV-hop, centroid, weighted centroid, and enhanced weighted centroid. Figure 1 displays the many ways in which localization can be categorized.

The power needed to run DV-hop and the complexity of its computations are both increased. Like the DV hop approach, WCL's improvement utilizes a centroid localization algorithm with two distinct phases.

Step 1: Beginning with the minimum hop value of all beacon nodes, WCL employs the same methods as DV hop.

Step 2: Second-stage work involves pinpointing where the mystery nodes are.

The inverse of the number of hops is used to calculate the weight factor Wj. Because of the inverse proportionality, the closer node will have a higher value. A beacon node that has fewer hops than a target node is relatively close to that target. Unlike WCL, where information is only provided to selected nodes, DV-hop broadcasts data about nodes.

$$w_j = (\frac{1}{h_u})^{\frac{R}{AS}} \qquad (1)$$

Where,

AS= Average Hop Size

R= Communication Range

h_u: Hope count between nodes

The suggested study employs the boosted weight centroid approach to carry out localization in WSNs. When considering WSN, most applications are remote-based, and energy plays a major role for node localization; thus, most problems and their solutions are discussed in the section for existing localization techniques. It is important to strike a balance between energy use and localisation precision.

1. At the outset, data from all the anchor nodes is broadcast throughout the network to the other nodes within l hops. To find out what value 'l' should take,

$$h_{min} \le l \le h_{max} \qquad (2)$$

Where,

h_{min}: Minimum hop value

h_{max}: Maximum hop value
The amount of energy used is set by the value of l.

2. Each anchor determines its own average hop distance. It uses group casting to send the position data to a smaller subset of the network, limited to no more than 'l' hops away. It will lighten the load on the control packets. Because not all anchors are used for localization in the proposed approach, localization errors are kept to a minimum. Every cluster of anchor nodes broadcasts its data to the established cluster.
3. The BWCLA is used to compute the coordinates of the unknown node (Xun, Yun). Specifically, we derive the updated weighted boost metric by

5. Result and Discussion

In this part, we demonstrate the modelling of the intended BWCLA work. Metrics like localization inaccuracy, energy usage, and total packets consumed are compared between the BWCLA and other localization techniques including DV-hop, Centroid, Weighted centroid, and enhanced weighted centroid. MATLAB is used to carry out the work. Parameters used to simulate the network are shown in Table 2. The network may scale from 40 to 50 to 60 to 70 to 80 nodes. Only ten nodes out of every hundred are designated as beacon nodes. The strength of a node's transmission is measured in terms of the communication radius at which transmissions are possible.

Table 2: Imitation Constraints

Imitation Constraints	**Cost**
Network area	100m*100m
Nodes whole count	40, 50, 60, 70, 80
beacon nodes full count	4, 5, 6, 7, 8
Communiqué radii of the node	20, 25, 30, 35, 40 meters
Data packet extent	512 bits
Topology	Arbitrary

5.1. Localization Error (LE) (%): The localization error quantifies how far off the estimated position of the unknown node in the network is from its true location. How to calculate 'UN' node localization error

$$LE = \sqrt{(Ex - Ax)^2 + (Ey - Ay)^2} \quad (3)$$

Where,
Ex, Ey=Calculated position of unknown node.
Ax, Ay= Actual position of unknown node.

5.2. Average Localization Error (ALE) (%): The ALE of the entire network can be calculated by dividing the total number of unknown nodes by the sum of their localization errors.

$$ALE = \sum_{i=1}^{k} \frac{\sqrt{(Ex-Ax)^2+(Ey-Ay)^2}}{K*R} \quad (4)$$

To what extent the unknown node's position may be determined is defined by the Average Localization error. Comparisons are made between the proposed BWCLA algorithm and the DV-hop, Centroid, Weighted centroid, and enhanced weighted centroid algorithms. The average localization error caused by changing the node's communication radius is shown in Figure 2. In the BWCLA, the rate of ALE might range from 20% to 40%. It has been found that the localization error decreases as the node's communication radius grows.

Table 3: Proposed Work Comparison with the existing work.

Node Count	Average Localization Error (ALE) (%)			Whole data packed consumed count		
	DV- Hop	Improved Weighted Centroid	Proposed method	DV- Hop	Improved Weighted Centroid	Proposed method
20	32	23	18	50000	30000	25000
40	35	24	19	54000	33000	28000
60	38	23	20	64000	35000	30000
80	48	34	22	72000	38000	34000
100	56	38	25	81000	42000	38000

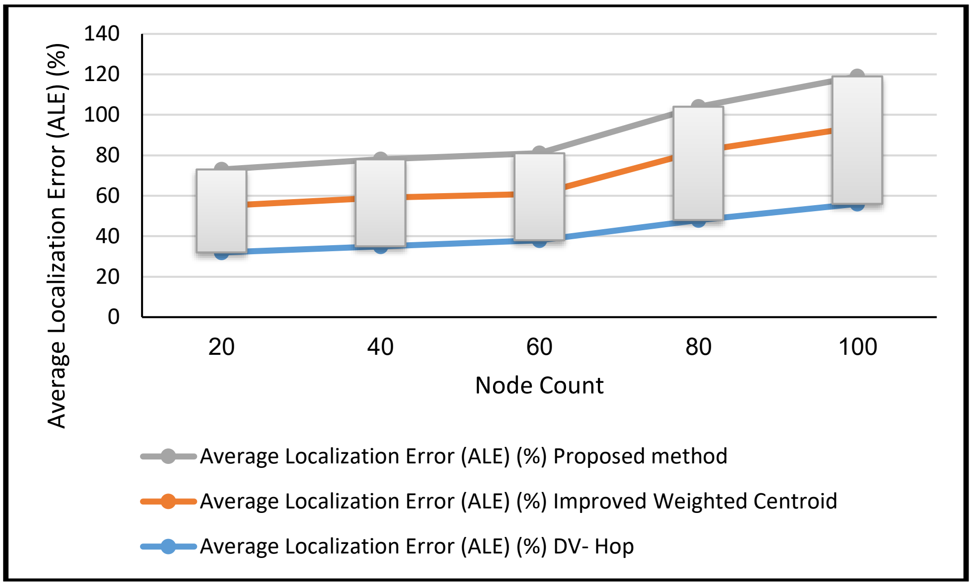

Figure 2. Average Localization Error (ALE) (%) comparison with existing methods.

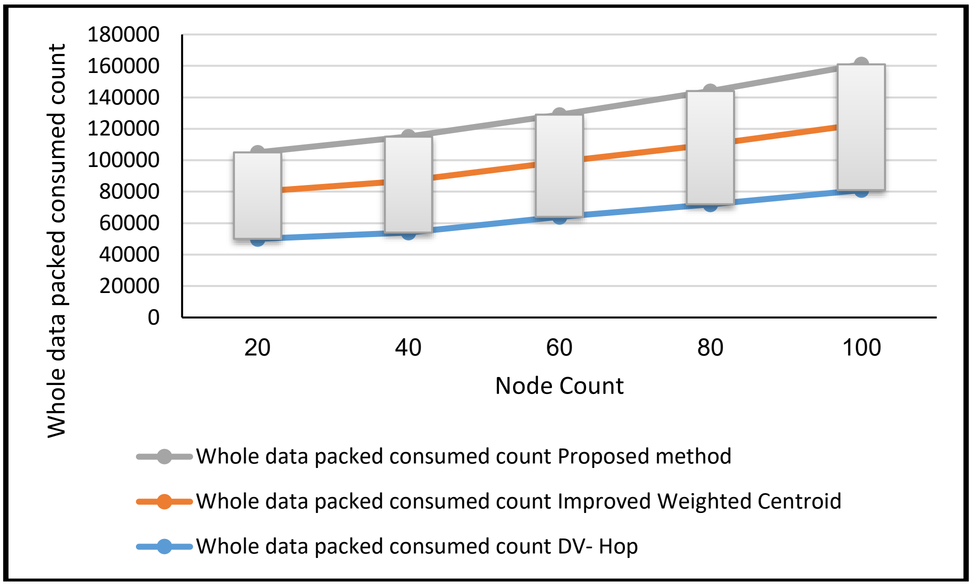

Figure 3: Whole data packed consumed count comparison with existing methods.

Figures 2 and 3 illustrate the performance of the proposed BWCLA method. The core objective of BWCLA is to minimize power consumption during the localization process of unknown sensor nodes within a network. Power consumption for this process is measured in mill watts. The proposed method requires less energy for localization because it involves fewer communication packets. Instead of relying on a central node, BWCLA uses a centroid, which results in a lower number of data packets compared to traditional methods like DV-hop and the improved weighted technique. This reduction in data packets is consistent across various network sizes and node counts.

The advantage of using BWCLA lies in its efficiency. By reducing the number of communication packets, the method not only conserves energy but also potentially extends the operational lifespan of the sensor network. This efficiency makes BWCLA a superior alternative for applications where energy conservation is critical. In summary, the analysis of figures 2 and 3 confirms that BWCLA significantly reduces power consumption during the localization of sensor nodes, thereby offering a more sustainable and efficient approach compared to existing methods.

5. Conclusion

In wireless sensor network applications, localization is a crucial component. It has a profound effect on the way scientists and developers of real-time sensor deployment applications think about how to reduce power consumption while still accurately pinpointing the whereabouts of unknown nodes. Localization refers to the process of pinpointing individual sensor nodes by assigning them coordinates along a set of axes. Environment, node type, application, and localization technique all play a role in how precisely node locations may be determined. In the proposed BWCLA, a novel modified weight-based centroid is computed for the localization. Energy usage is reduced by isolating neighbours within a single hop and limiting control messages to only those individuals. Changing the total number of nodes in a network allows for a wide range of experimental conditions to be explored. In all scenarios, 23% of the nodes are designated as beacon nodes. In order to evaluate the effectiveness of the proposed work, the localization error is computed, and the results show that the BWCLA performs better than the alternatives in every scenario tested.

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