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Performance Evaluation of DV-HOP and Amorphous Algorithms based on Localization Schemes in Wireless Sensor Networks

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Abstract

In the field of high-risk observation, the nodes in Wireless Sensor Network (WSN) are distributed randomly. The result from sensing becomes meaningless if it is not known from where the originating node is. Therefore, a sensor node positioning scheme, known as the localization scheme, is required. The localization scheme consists of distance estimation and position computing. Thus, this research used connectivity as distance estimation within range free algorithm DV-Hop and Amorphous, and then trilateral algorithm for computing the position. Besides that, distance estimation using the connectivity between nodes is not needed for the additional hardware ranging as required by a range-based localization scheme. In this research compared the localization algorithm based on range free localization, which are DV-Hop algorithm and Amorphous algorithm. The simulation result shows that the amorphous algorithm have achieved 13.60% and 24.538% lower than dv-hop algorithm for each parameter error localization and energy consumption. On node density variations, dv-hop algorithm gained a localization error that is 26.95% lower than amorphous algorithm, but for energy consumption parameter, amorphous gained 14.227% lower than dv-hop algorithm. In the communication range variation scenario, dv-hop algorithm gained a localization error that is50.282% lower than amorphous. However, for energy consumption parameter, amorphous algorithm gained 12.35%. lower than dv-hop algorithm.

***Keywords**: WSN, DV-HOP algorithm, amorphous algorithm, localization error, trilateral, energy consumption*

1. Introduction

In this research, we discussed about the Wireless Sensor Network Localization, with focus on performance analysis using DV-Hop and Amorphous algorithm. The DV-hop algorithm [1] is the basic scheme and consists of three stages. First, the use of directional classic distance by changing the protocol so all distances of nodes in the network to the anchor can be obtained, and in this case the distance will be represented within a hop. Each node in the table consists of {Xi, Yi, hi} and changes the update table in accordance their neighbor nodes. The second stage, each anchor node determines the distance to the other anchor node. Meanwhile, the amorphous algorithm is generally like DV-Hop algorithm that is used to calculate the distance between two nodes but the difference is that amorphous algorithm calculates the hop distances between the anchor nodes and unknown nodes. For computing the position, the author used Trilateral algorithm to determine the position of the sensor node. The main reason for using range free method in the application is because the range free method requires little energy consumption, is low cost, and is suitable to be applied to a wide area as well as in the field of high-risk observation.

The nodes are static and the effect of range communication and the number of anchor nodes, the influence of the number of unknown nodes and a range communication to the parameters of performance such as error position, energy consumption, and time position were tested. The hypothesis was that the parameters of DV-hop algorithm performance is better than Amorphous algorithm.

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2. Related Works

There are numbers of sensor nodes deployed an observation area. Some have position information (because it has a GPS or placed manually) while other nodes' positions have to be determined by using localization techniques. The position that is determined is relatively between nodes or other objects that are involved around it. Today, many localization schemes depend on a few anchor deployed in sensor networks.

Anchor is a sensor node that knows its own position (via GPS or other manual configuration) and act as a reference for other nodes whose position is unknown because their position can spread. Here, the authors want to provide an additional reference. There are some algorithms that can estimate range free distance. Those algorithms are dv-hop algorithm and amorphous algorithm. A trilateral algorithm is used to estimate its position. However, do not forget the critical issue in WSN which is the lifetime of the sensor that is limited by power [2]. Therefore, the author added performance parameters of energy consumption that is used to determine the better performing algorithm from dv hop and amorphous which can then be used as a reference for further research, especially into consideration the algorithm that want to be improved [3-4].

3. Methodology

In this chapter, the analysis of simulation results using simulator NS2.34 will be discussed. The analysis is aimed to find out the performance of the DV-Hop algorithm and Amorphous algorithm. In this research, there were several scenarios:

a. Variation of anchor node scheme. The number of anchor nodes will be varied 5% to 25% with an increment of 5% for all nodes.
b. Variation of node density scheme. Number of nodes will be varied from 100 nodes to 500 nodes with an increment of 100 nodes.
c. Variation of range communication scheme. A value of range communication will be varied from 200 meters to 400 meters with an increment of 50 meters.

3.1. Amorphous algorithm

In amorphous algorithm, to calculate hop distance successfully, the anchor nodes have to find out three distances with applying maximum likelihood estimation to determine its position or go through three sided measurements [5-6]:

a. Calculated the minimum hop from the Unknown Node to the Beacon Node. With the flooding method, messages from beacon nodes can be sent to the unknown nodes.

$$S_{(i,k)} = \frac{\sum_{j\in \text{nbrs}(i)} h_{(j,k)} + h_{(i,k)}}{|\text{nbrs}\,(i)| + 1} - 0.5, \quad (1)$$

Based on [5-6], eqn. (1) describes the calculation of the minimum hop from the node i to k. $(i,)$ represents the minimum hop between the unknown node i and beacon node k; meanwhile $h(j,k)$ describes the hop of unknown node j to the beacon node k; $h(i,k)$ represents the calculating hop value of unknown node i to the beacon node k; moreover nbrs(i) describes the number neighbor nodes around the unknown node i.

b. Calculated the distance between the Unknown Node to the Beacon Node.

$$\text{HopSize} = r\left(1 + e^{-n_{\text{local}}} - \int_{-1}^{1} e^{-(n_{\text{local}}/\pi)(\text{arcos}t - t\sqrt{1-t^2})} dt\right) \quad (2)$$

where r represents the wireless range of the node and n local describes the network average connectivity.

c. Use the trilateral algorithm to estimate the position. Trilateral algorithm calculates node position using the line intersection of three anchor circles.

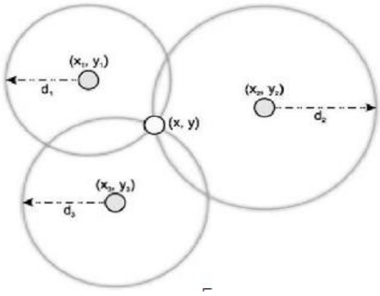


Figure 1. Model of Estimate Position Using Trilateral Algorithm [7]

To estimate a position using trilateration, unknown nodes have to know the position and distance of the three anchor nodes. The distance can be calculated using the following formula:

$$\begin{aligned}(x-x_1)^2+(y-y_1)^2&=d_1^2\\(x-x_2)^2+(y-y_2)^2&=d_2^2\\(x-x_3)^2+(y-y_3)^2&=d_3^2\end{aligned} \quad (3)$$

Where (x, y) is the position of the nodes that will be counted, (xi, yi) is reference node position to the i node, and (di) is the distance from the anchor node to the unknown node. From the formula, there are three quadratic equations with two unknown, which in theory can be resolved into an equation. equation 4 can be linearized by subtracting the last equation from the first equation n-1, and can be formulated in linear multiplication system, which is AX=b, where:

$$2\begin{bmatrix}(x_1-x_N) & (y_1-y_{N2})\\ \vdots & \vdots\\ (x_{N-1}-x_N) & (y_{N-1}-y_N)\end{bmatrix}\begin{bmatrix}x\\y\end{bmatrix}=\begin{bmatrix}x_1^2-x_N^2+y_1^2-y_N^2+d_N^2-d_1^2\\ \vdots\\ x_{N-1}^2-x_N^2+y_{N-1}^2-y_N^2+d_N^2-d_{N-1}^2\end{bmatrix} \quad (4)$$

$$\mathbf{x}=\begin{pmatrix}\mathbf{x}\\\mathbf{y}\end{pmatrix}$$

3.2. DV-Hop Algorithm

DV-hop algorithm can estimate the average distance for every hop, which is then used to correct the entire network [8]. The average hop-size for each anchor node can be calculated with the following formula:

$$HopSize_i=\sum_{j=1,j\neq i}^{m}\sqrt{(x_i-x_j)^2+(y_i-y_j)^2}\Big/\sum_{j=1,j\neq i}^{m}h_{ij}\,. \quad (5)$$

Where m represents as anchor node; hij represent as the number of hop between i and j. (xi, yi) (xj, yj) are the coordinates of the anchor i and anchor j. Then, each anchor node notify the value of hop size in the network. When an unknown node receives the information of hop size, the estimated distance between unknown nodes and anchor nodes can be calculated as follows:

$$d_{ij}=HopSize_j\times h_{ij}\,. \quad (6)$$

Figure 2 shows that the position of unknown nodes can be identified by the computational position algorithm, which is one is trilateral algorithm. The following is a representation of the DV-hop algorithm.

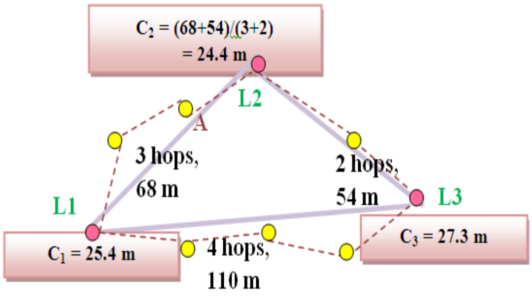


Figure 2 Basic of DV-Hop Method Using Three Node Reference [1]

Table 1. Parameter of Simulation

Channel Type	WirelessChannel
Propagation Type	freespace
Interface Type	WirelessPhy
Queue Type	Queue/Droptail/PriQueue
Link Layer Type	LL
Antenna	OmniAntena
Queue Length	50
Network area	1000mx1000m
Number of nodes	300
Communication range (m)	300
Number of Anchor Nodes	60
Simulation time	3 second
TransmitPower	0.0744 watt
Receive Power	0.0648 watt
Idle Power	0.0000052 watt
Initial Energy	13770 joules

4. Result and Discussion

4.1. Analyze the effect of anchor node variation towards localization error and total energy consumption

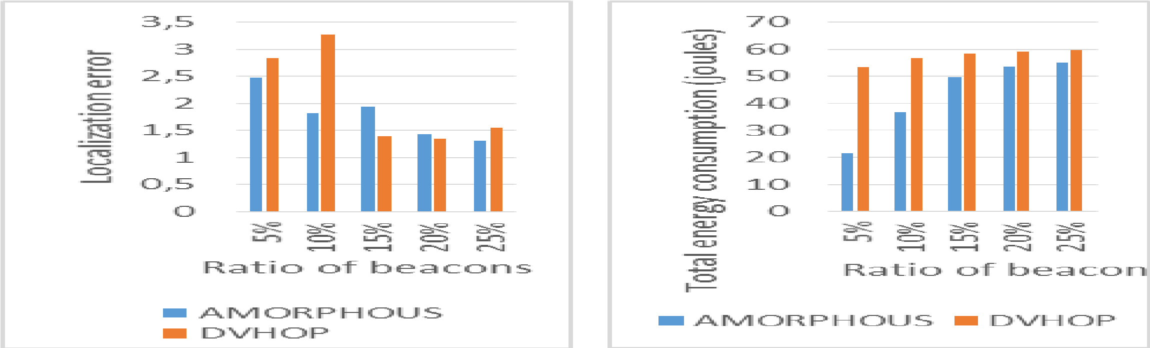
As already described in previous chapters, the localization error is a comparison between error position nodes (meter) with communication ranges (meters). The error position of a node is position error of the estimated node to the real position of node in meters. The total energy consumption is the total energy consumption of the entire node in seconds [9-10]. Table 2 shows that the localization error due to the effect of anchor variation mostly gets lower for Amorphous Algorithm except for the ratio of beacons 15%, it got higher than the previous data. However, the results for location error in DVHOP, the values gets fluctuates. Table 3 shows that the total energy consumption due to the effect of anchor node variation for both algorithm gets higher in each number of nodes value with increment 100 nodes.

Table 2. The Effect of Anchor Node Variation Towards Location Error

Ratio of Beacons	AMORPHOUS (Joules)	DVHOP (Joules)
5%	2,468	2,836
10%	1,82	3,274
15%	1,943	1,393
20%	1,436	1,34
25%	1,307	1,544

Table 3. The Effect of Anchor Node Variation Towards Total Energy Consumption

Number of nodes	AMORPHOUS (Joules)	DVHOP (Joules)
100	3,608	13,334
200	24,346	37,292
300	53,761	59,182
400	57,46	60,847
500	59,012	61,98



(a) Localization Error (b) Energy Consumption

Figure 3. The Effect of Anchor Node Variation towards Localization Error and Energy Consumption

Figure 3 shows that the number of anchor nodes with an increment of 5%, where the number of nodes is 300 and the range of communication is 300m, the localization error got lower but the energy consumption is gets higher. The localization error got lower because the more anchor nodes there are in network, the larger the coverage of network, resulting more hop counts to go through. As more hop counts go through, the localization error gets lower. If the localization error gets lower, it means a better position accuracy of nodes. The energy consumption got higher because there were more anchor nodes in network, resulting in more computation position that needs energy. Besides that, anchor nodes consume more energy than unknown nodes because anchors have GPS.

For the localization error, the Amorphous algorithm have 13.60% less errors than DV-Hop algorithm because the DV-Hop algorithm is based on hop count when estimating position. Less anchor nodes will make the coverage in a network smaller, causing hop counts to get lower. Less hop counts cause the accuracy to worsen. However, the value of the two algorithms equally experienced fluctuations because of other factors. Those factors are node density, random signaling, and deployment of node. For Energy Consumption, the Amorphous algorithm use 24.538% less energy than DV-Hop algorithm because the DV-Hop algorithm is always updating its table in accordance to their neighbor.

4.2. Analyze the effect of node density variation towards Localization error and total energy consumption

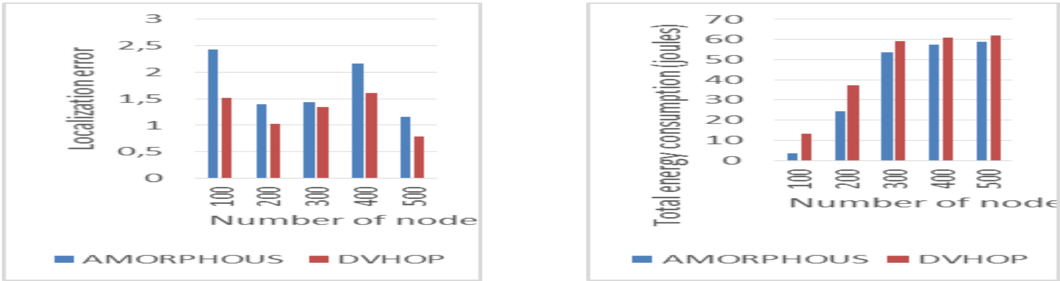
Table 4 shows that the Localization Error due to the effect of node density variation for both algorithm gets higher in each proportion of beacons value with increment 5%. Table 5 shows that the total energy consumption due to the effect of node density variation for both algorithm gets fluctuate in each number of nodes value with increment 100 nodes.

Table 2. The Effect of Node Density Variation Towards Localization Error

Proportion of beacons	AMORPHOUS (Joules)	DVHOP (Joules)
5%	21,645	53,368
10%	36,849	56,803
15%	49,715	58,393
20%	53,761	59,182
25%	55,028	59,814

Table 5. The Effect of Node Density Variation to Energy Consumption

Number of nodes	AMORPHOUS (Joules)	DVHOP (Joules)
100	2,427	1,513
200	1,399	1,026
300	1,436	1,34
400	2,171	1,614
500	1,165	0,788



(a) Localization Error (b) Energy Consumption

Figure 4. The Effect of Node Density Variation towards Localization Error and Energy Consumption

Figure 4 shows that as the number of nodes increment by100, where the composition of anchor nodes is 20% of nodes and the range of communication is 300m, the localization error is gets lower but the energy consumption gets higher. The localization error became lower because there were more unknown nodes in network which results in more hop count and neighbor nodes. More hop counts and neighbor nodes cause the localization error to get lower. If the localization error is low it means better accuracy of node positions. The energy consumption gets higher because there were more nodes in network which means more energy is required to estimate the position of nodes.

For the localization error, the DV-Hop algorithm has 26.95% less errors than the amorphous algorithm because the DV-Hop algorithm is based on hop count when estimating positions. More nodes in the network will create a larger hop count causing the computation to be more accurate. However, the value of the two algorithms equally experienced fluctuations because of other factors including node density, random signaling, and deployment of node. For the Energy Consumption, the Amorphous algorithm uses 14.227% less energy than the DV-Hop algorithm because the DV-Hop algorithm is always updating its table in accordance to their neighbor and the computation of the DV-Hop algorithm is more complex than the Amorphous algorithm, which uses more energy.

4.3. Analyze the effect of range communication variation towards localization error and total energy consumption

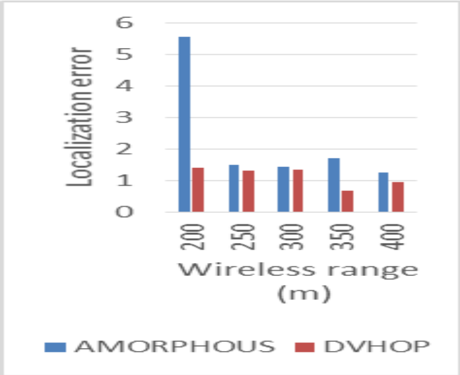
Table 6 shows that the localization error due to the effect of range communication variation mostly gets lower for Amorphous except for the wireless range 350, it gets higher than the previous data. However, the results for location error in DVHOP, the values gets fluctuate. Table 7 shows that the total energy consumption due to the effect of range communication variations for both algorithm gets higher in each number of wireless range value with increment 50 nodes.

Table 6. Analysis The Effect of Range Communication Variation to Localization Error

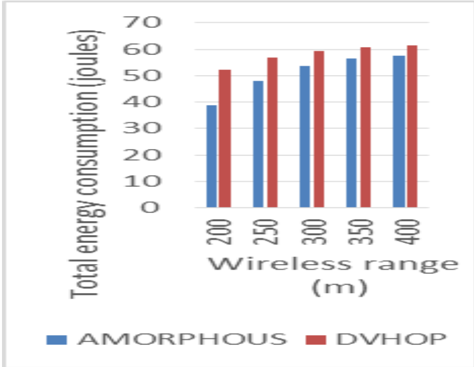
Wireless range	AMORPHOUS (Joules)	DVHOP (Joules)
200	5,578	1,421
250	1,515	1,312
300	1,436	1,34
350	1,713	0,694
400	1,265	0,954

Table 7. Analysis The Effect of Range Communication Variation towards Energy Consumption

Wireless range	AMORPHOUS (Joules)	DVHOP (Joules)
200	38,723	52,151
250	47,956	56,985
300	53,761	59,182
350	56,473	60,638
400	57,485	61,301



(a) Localization Error



(b) Energy Consumption

Figure 5. The Effect of Range Communication Variation towards Localization Error and Energy Consumption

Figure 5 shows that as the communication range increment by 50m, where the number of nodes is 300 and the composition of anchor nodes is 20% of all nodes, the localization error is decreases but the energy consumption increases. The localization error decreases as the there is an increase in node communication range, resulting a larger network coverage and more hop count to go through. More hop count going through means a lower localization error. If the localization error low, it means a better accuracy of node position. The energy consumption also increases because the increase in node communication range uses more power.

For the localization error, the DV-Hop algorithm has 50.282% less errors than the amorphous algorithm because the DV-Hop algorithm is based on hop counts when estimating positions. A higher node communication range will increase hop count, increasing the accuracy of the computing. However, the value of the two algorithms equally experienced fluctuations because of other factors such as node density, random signaling, and deployment of node. For the Energy Consumption, the Amorphous algorithm uses 12.35% less energy than the DV-Hop algorithm because the DV-Hop algorithm is always updating its table in accordance to their neighbors and the computation of the DV-Hop algorithm is also more complex than the Amorphous algorithm, which requires more energy.

5. Conclusion

This research which was conducted to analyze the performance of DV-Hop algorithm and Amorphous algorithm towards localization schemes with error localization parameters and energy consumption resulted the effect of increasing the number of anchor nodes: the number of nodes and the number of communication range for the Amorphous algorithm and the DV-Hop algorithm show that value of localization error gets lower. If the localization error is low, it means a better accuracy of node positions. However, value of energy consumption gets higher. In the localization error parameter: For the scheme of increasing the number of anchor nodes, the Amorphous algorithm have 13.60% less errors than the DV-Hop. When increasing the number of nodes, the DV-Hop algorithm has 26.95% less errors than the amorphous algorithm. For the increase of communication range scheme, the DV-Hop algorithm has 50.282% less errors than the amorphous algorithm because of the DV-Hop algorithm itself. In the energy consumption parameter: For the scheme of increasing the number of anchor nodes: the Amorphous algorithm uses 24.538% less energy than the DV-Hop algorithm. When increasing of nodes, the Amorphous algorithm uses 14.227% less energy than the DV-Hop algorithm. For the increase of communication range scheme, the Amorphous algorithm uses 12.35% less energy than the DV-Hop algorithm.

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