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Spider Web Based Path Planning For Mobile Beacon Assisted-Sensor Localization

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ABSTRACT

In wireless sensor network Localisation is described as a crucial service and energy demanding *process* in sensor network. GPS-equipped node where used for localisation process, in order to reduce the cost and increase the life time of the network, the mobile beacon localization is considered to eliminate GPS nodes. A localization error control scheme, namely "Spider Web", based on which the mobile beacon trajectories along a predefined spider web intersection path. The accuracy of the localization of nodes, time consumption of mobile beacon is efficient and localization error ratio is controlled. Based on the results, the spider web algorithm is efficient in localization accuracy and time, energy, consumption of mobile beacon, throughput and packet delivery ratio than Z-power algorithm.

1. Introduction

A Wireless Sensor Network is a sensor network of many sensor node which communicate with each other through a wireless communication link. Each sensor node consists of a processing device, smaller memory, battery and radio transceiver for communication. These sensor node obtain data, e.g. temperature, pressure and humidity, process internally, and transmit the data to a neighbour node or a static beacon node or a mobile beacon, which may be connected to a central computer where major processing is performed. The central computer may be part of a bigger computer network so that the information can be communicated to other computers which are part of the bigger network. The wireless sensor networks has lots of demand and can be used both in industrial and commercial environments. Some of the most commons applications of wireless sensor networks include habitat monitoring, fire detection, object tracking, traffic monitoring and area monitoring. The characteristics of wireless sensor networks are small sized nodes, mobile nodes, a dynamic network type, harsh operating environment and limited energy or power source that these nodes utilize efficiently as these may remain in an area for years without more energy being available.

1.1 Overview of Wireless Sensor Network

In Wireless Sensor Network, the sensor nodes should know their position relative to the sensor network. The data such as temperature, humidity and pressure is significant and to be of value, gathered by sensor nodes must be ascribed to the relative position from where it was collected.

The term localization, has been previously used in robotics monitoring where it is used to refer to determination of location of a mobile robot in some coordinate system.

In sensor networks, the nodes are categorized as:

- Dumb Node (D)

A dumb node is a node which does not know it location and position, and which is capable of finding its location and position from the output of the localization algorithm under investigation. Dumb nodes are also known as free nodes or unknown nodes.

- Settled Node (S)

A settled node is a node which was initially an unknown node but managed to find its position using the localization algorithm.

- Beacon Node (B)

A beacon node is a node that knows its position from the initial point and always knows its position further, without the using of localization algorithm. It has a different mechanism differ from localization algorithm to find its position. For example, the beacon node is installed with a GPS indicator or it may be placed at a position with known coordinates. The beacon nodes are also called anchor, reference or landmark nodes.

2. Spider web algorithm

In spider-web algorithm the structural similarities between the spider-webs and localization segments and to create a spider web-like model for localization to obtain the paths. The spider web is constructed using the spokes and hypotenuses. Spokes begin from the web centre and form the framework of the structure. Hypotenuses are the concentric circles around the web centre. The lines formed by path intersections with same layer are regarded as the hypotenuses. The path segments connecting the adjacent layer intersections can be regarded as the spokes.

In the figure 1, Selection of the source intersection is based on the distance between the source node and the nearest possible adjacent node intersection, as well as the angle formed by the adjacent node intersection.

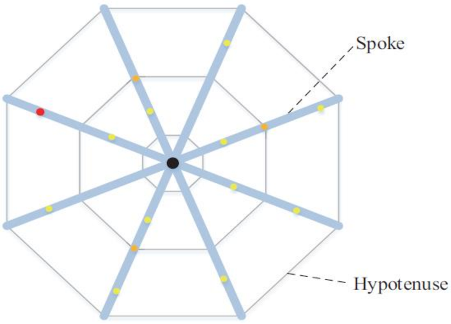

Figure. 1 Spider web model.

Each adjacent node intersection has a grade, and the node with the highest grade is selected as the first node of path intersection. The grade expression is as equation (1)

$$Gr(i)=\lambda(1- d(i)\ L\ )+(1- \lambda)R(i) \qquad (1)$$

Where L is the path length,d(i)is the distance between the intersection node direction parameter expressed by equation (2).

$$R(i) = \begin{cases} 0\ (\ \alpha > \pi/2\ ) \\ 1\ (\ \alpha < \pi/2\ )\ \text{or}\ (\alpha = \pi/2 Di = 1) \end{cases} \qquad (2)$$

Using equation (2), the is angle formed by the mobile beacon, the node as the vertex, the node intersection are the end points. Dir is the mobile beacon movement direction. If the mobile beacon is moving towards intersection i, then Di = 1, otherwise Di = 0, without loss of generality.

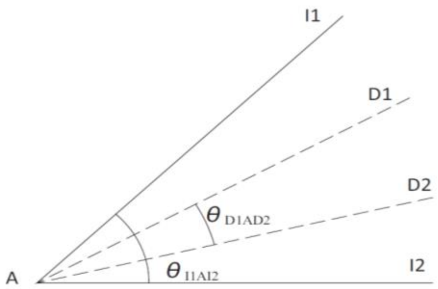

Figure. 2 First-layer intersection.

From the figure 2 assume that I1 and I2 are the two neighbour intersections of A, I1AI2 is the angle between the lines which connect A, I1 and A, I2. D1AD2 is the angle between the lines connecting A with D1, D2, AI1 and AI2 are defined as the spokes. The condition _I1AI2 and_D1AD2 should satisfy equation (3).

$$\theta D1AD2 \leq \theta I1AI2\ min \qquad (3)$$

When D1AD2=0, there is only one destination intersection. Besides, if AI1 and AD1 (AI2 and AD2) coincide, only the intersection I1 (I2) is selected as the first layer intersection. As a result only one first layer intersection is obtained. Otherwise I1AI2 min should be the minimum angle bigger than D1AD2.

The construction of spider web like model, according to which the availablepaths intersections can be found by

Input: number of nodes

Output: beacon path

1: procedure path discovery
2: create the spider web like model w
3: create the path tree t
4: depth-first search t and get paths
5: send request spiders
6: activate(request clock)
7: if receive confirmed spider when request clock is not timeout then
8: calculate intersection of node when receive confirmed spider
9: return the path with the smallest (Tr-Ts)
10: else
11: restart Path Discovery
12: end if
13: end if
14: end procedure

3. Results and Discussion

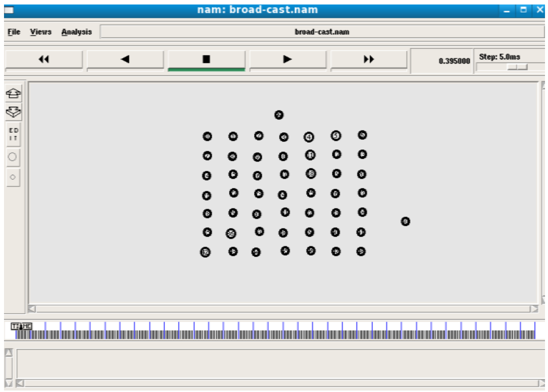

Figure. 3 Node creation.

The figure 3 shows, node creation done by using network simulator number of node set by Tcl language is 50 nodes. Thus total there are 49 static nodes, 1 mobile node and 1 destination node.

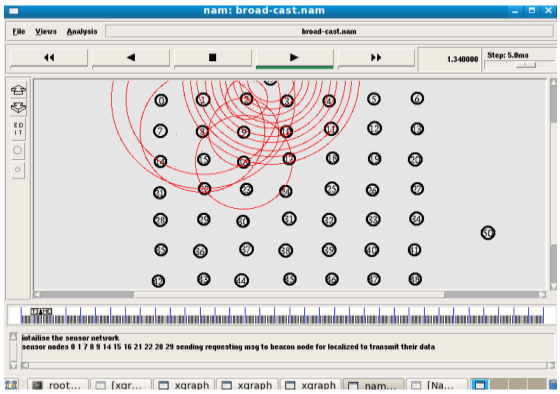

Figure. 4 Beacon message sharing.

The figure 4 shows, network nodes send requesting message packets to beacon node for localization, beacon follows intersection path formed by spider web algorithm. During initialization of the network, sensor nodes send requesting message packets to the mobile beacon, the mobile beacon follows the predefined trajectory using spider web intersection node points. The nodes calculate its position using RSSI algorithm. The mobile beacon traverses the entire region of interest and localize the sensor nodes.

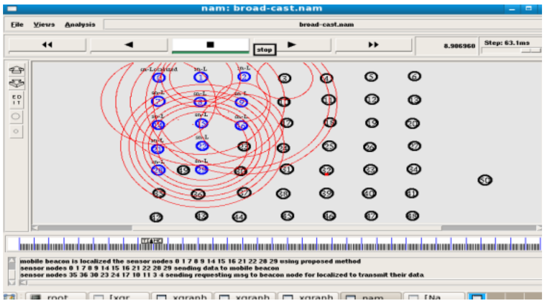

Figure 5. Localized nodes.

The figure 5 shows, localized nodes of network by mobile beacon using spider web algorithm. The nodes are localized through the intersection path to minimize the localisation error. The localized sensor node sends data packets to mobile beacon. The next neighbouring sensor node send requesting packet to the mobile beacon to obtain its current position.

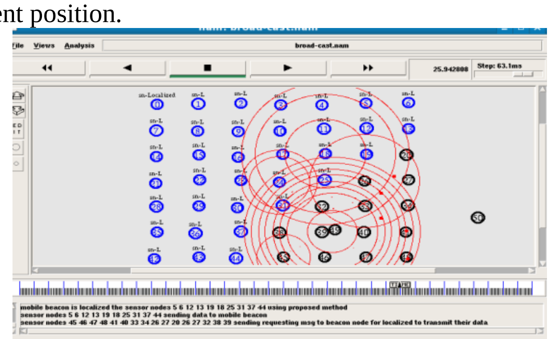
Figure 6. Intersection node identification.

The figure 6 shows, localization done by using intersection nodes identified by web mechanism. The blue colour sensor node denotes the localized nodes though the spider web algorithm, the mobile beacon node traverse the entire region of interest and localize the sensor nodes. The current position of the sensor nodes are synced with the destination node for the future data transmission. Therefore using the location coordinates the sensor node transmit the data along with its location to destination, the central processor process the data and manipulate the resultant output.

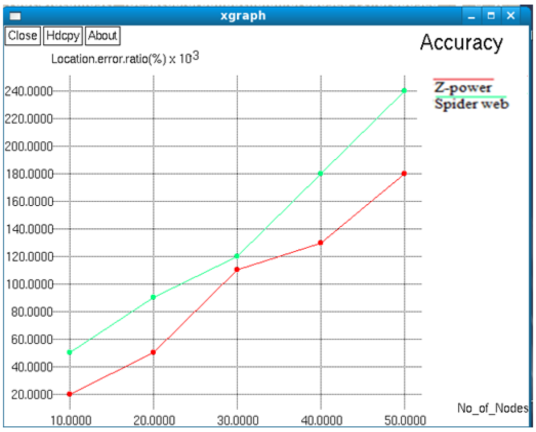

Figure. 7 Accuracy.

The figure 7 shows, localization accuracy for Z-power algorithm and Spider web algorithm. The graph shows accuracy increases when number of node increases, when compared to the Z-power algorithm. The result shows 38% increase in accuracy than Z- power algorithm.

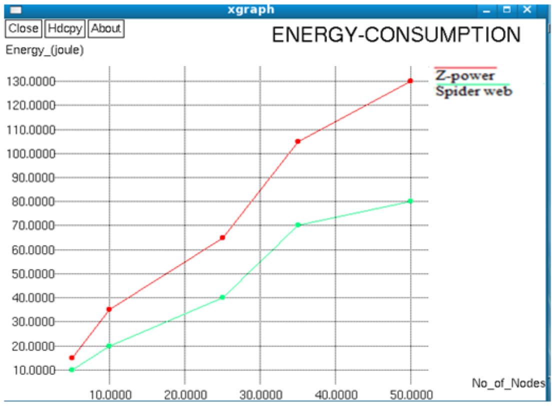

Figure. 8 Energy Consumption.

The figure 8 shows, energy consumption analysis for Z-power algorithm and Spider web algorithm. The graph shows that energy consumption is reduces by intersection based path planning. In spider web algorithm energy consumption is less compared to the Z-power algorithm. The result shows 26% decrease in energy consumption than Z- power algorithm.

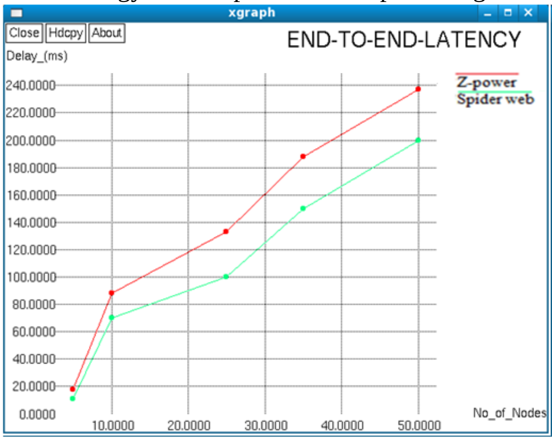

Figure. 9 End to End Latency analysis.

The figure 9 shows, delay analysis for Z-power algorithm and Spider web algorithm. The graph shows, delay overhead is reduces by intersection based path planning. In spider web algorithm end to end latency is less compared to the Z-power algorithm. The result shows 32% decrease in latency than Z-power algorithm.

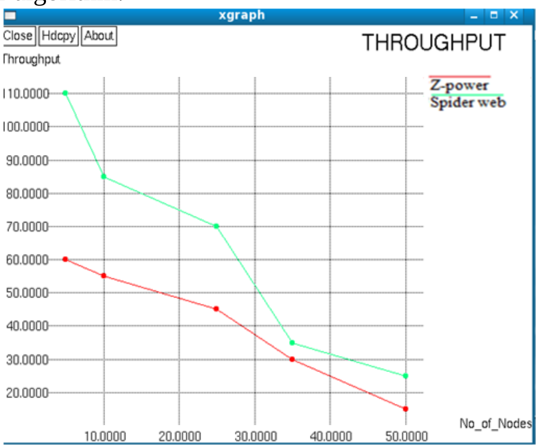

Figure. 10 Throughput.

The figure 10 shows, throughput analysis for Z-power algorithm and Spider web algorithm. The graph shows throughput is improved by intersection based path planning. In spider web algorithm throughput is high compared to the z-power algorithm. The result shows 24% increase in throughput than Z- power algorithm.

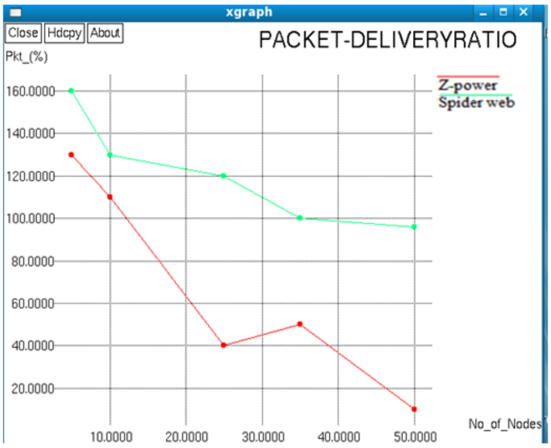

Figure. 11 Packet-Delivery ratio.

The figure 11 shows, packet delivery ratio analysis for Z-power algorithm and Spider web algorithm. The graph shows packet delivery ratio is improved by intersection based path planning. In spider web algorithm packet delivery ratio is high compared to the Z-power algorithm. The result shows 52% increase in packet delivery ratio than Z-power algorithm.

4. Conclusion

To fulfil the real-time constraints, the new path planning, a novel spider web like mechanism for localization. A spider web model to restrict the searching area. Simulation results show that spider web scheme performs better than Z-power in terms of average transmission delay, packet delivery ratio, accuracy, energy consumption and throughput. The results prove that spider mechanism can ensure real-time requirements of in the presence of network congestion.

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