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Scan and Z-Curve Trajectory for Mobile Anchor in Localization of Wireless Sensor Network

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Abstract*: In the recent decades, Wireless Sensor Networks has become an inevitable and dependable research area in the field of communication. Sensor Networks is an apt application for the complicated and instant communication fields like the surveillance in the military services, monitoring of medical analysis and research, detecting forest fire break outs, and detection of acoustics. For an effective application of sensor networks, the research issue shall be laid on the path planning. By path planning it is meant the path through which the mobile beacon should travel without any interruption by enhancing the accuracy in localization process. Of late Global Positioning System (GPS) has become a reliable means for its precision in sensor localization. However, GPS does not provide cost-efficiency or energy-efficiency. As a result, single GPS could be positioned along the travel path. To optimize this constraint, in this paper, an attempt is made to derive the performances of two path planning techniques namely Z-curve and SCAN. It is known that in sensor localizing and for broadcasting of data, the mobile beacon is determined to travel in both directions, viz forward and backward. Comparison is made between the Z-curve trajectory positioned with mobile beacon and SCAN trajectory affixed with mobile beacon having a path planning scheme. The comparison results showed that Z-curve method yielded better performance in terms of high precision and short duration for localization. Further, Z-curve produced only minimum localization error.

Keywords* : *Localization, Beacon node, SCAN, Z-Curve, Trajectory etc.

I. INTRODUCTION

This Recent research studies in wireless communication technology face a challenging task of developing a compact, efficient and less power sensor node. Such a node is planned to sense the physical environment for sensing and send transmit them to the base station [1]. Generally, wireless sensor networks are equipped with remote sensor nodes, based on the physical environment. These nodes monitor and sense particular geographical region, especially suited for harmful, hazardous and far off locations.

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A mote contains a micro-controller, memory, power source, a transceiver and ADC. The physical structure of this mote is illustrated in Fig.1. The micro-controller processes the sensed data while the memory cabin stores the information for future reference. The memory cabin passes the information to the base station on the fixed time. Power source is derived from a battery while a transceiver receives and transmits the data signals from other and neighboring nodes. ADC converts the signals from analog channel to digital channels. Finally, there would be minimum one sensor gadget.

A sensor node is formed out of combining the mote and the sensor gadget [7]. The sensor receives the power for sensing operations from the built-in battery. Since there is a possibility to prolong the life of the battery, network can be created even in a hazardous or harmful environment. The ease of Sensors facilitates easiness by which they are dispensable and suitable for networks of large sizes.

In WSN, the position of anchor nodes is determined by GPS. These anchor nodes duly send and receive the data or information from sensor nodes, and pass to or get back from the base station. Thus, the role of anchor nodes in the sensing process in wireless sensor networks is very vital.

Anchor nodes gather and compile the sensed data from attentive field to transfer them to sensor nodes. The position of a sensor node is determined after specifying the destination area of data. This distinguishing of the sensor nodes is called the localization. However, anchor nodes know there are assigned positions [11]. As the anchor nodes are tied with a GPS in each of them, the cost factor is a major constraint. WSNs are designed with large number of sensor nodes and anchor nodes. Hence, providing a GPS for each of the nodes will lead to huge invest of money. So, for cost-efficient method of localization involving sensor nodes is the object of this study [2]. Further, more power will be consumed in the network when GPSs are installed at large number.

Localization is done by applying range free technique or range based technique. The choice of these algorithms depends upon the distance factor of the sensor networks. By the first technique range the distance between nodes is measured, by making use of messages from beacon and count of hop. Yet, in practice, neither of these methods yields proper accuracy as a result of low cost and complex architecture. Thus, in this research paper, range free scheme using dual mobile anchor nodes is proposed for localization. On the other hand, in range based scheme, distance between the nodes is measured by adding hardware.

This, however, provides appreciable accuracy. There are four procedures of extension procedures namely arrival time, difference in time of arrival, arrival angle, strength of received signal [10].

The proposed technique has been trialed in agricultural environment so as to monitor the sampling of seeds at an unspecified distance. SCAN [9] is an approach in which anchor node navigates the remotely optimized path in an attentive area. This mobile anchor node is capable of reaching the close regions of static sensor nodes and gather data or information to be sent to the base station. The anchor mobile beacon nodes send message packets to other nodes through a beacon message. This beacon message exhibits the position of e anchor node.

Due to this beacon messages, every other nodes in the network identify their individual position. This is further based on a geometric concept that positions the sensor nodes at bisected right angle of two chords, in crossed circle. Hence, communication from and to the base station in the network is perfectly carried out by the sensor nodes.

II. RELATED WORK

ZhongwenGuo et al [13] discussed the mobile enabled localization by proposing the Perpendicular Intersection (PI) method. In this method, the restraint on geometrical position of the vertical intersection determines localization. Meanwhile, the distance between the anchor node and the sensor node is measured from the computed RSS values. The mobile anchor nodes transmit or broadcast messages from beacon, while sensor nodes act as a medium to pass these messages to the base station. It is on this path that the major RSS spot is measured, when the perpendicular lines stretched out at the meeting point of the ridges. The central point is the location of sensor node. Similarly, the paths through which mobile beacons travel form Virtual Triangle (VT).

Chang.C.T et al [3] discussed the localization technique based on a guiding mechanism, which acts upon the range free scheme of mobile anchor node. An area to which the sensor node is deployed within the communication range is called estimative region. As a result, there are four possible localization stages viz, promising region, weighing phase, phase construction, beacon locations and in the initial stage of the process, the promising region is identified based on the estimative region and range of communication from the sensor node. Then, the region is fragmented and divided into various grids, followed by weighing of each grid. The third stage involves selecting the promising grids when the mobile beacons send beacon to these locations. The final stage is creating the shortest possible path to pass all the travel path through the grids of promising region. The authors came out with enhanced accuracy in localization. Yet, they have not discussed the concept of mobile anchor node in detail.

Ssu.K.F et al [12] analyzed localization of sensor nodes and the range free scheme. They made use of the geometric aspect of right angle bisection of ridge chords. The mobile anchor, while in its travel around the observant environment, transmits beacon messages in addition to the location of the nodes. The two chords are derived out of three diverse beacon messages from communication circumference. From two chords, perpendicular lines are drawn at cross-centre of the circle. This is marked as the location of the sensor.

Koutsonikolas. D et al [9] discussed methods such as SCAN, DOUBLE SCAN and HILBERT. In SCAN algorithm, the mobile nodes move either vertical horizontal. Hence, the distance between the two segments forms the resolution of path. In DOUBLESCAN scheme, the mobile anchor node takes up its travel along the whole paths of the sensing field. It monitors the Y axis and gathers a fair estimation of the Y coordinates. After this, the anchor mode takes up its movement towards the X axis, and allows the nodes to scratch X coordinates. HILBERT curve creates a linear ordering and divides the space into 4 square cells. Then it amalgamates these four square cells by using 4 line segments, in such a way that each length is equivalent to the side of these four cells.

Chia-Ho Ou et al [4] promoted SCAN route planning for localization. In this process, mobile node traverses more than three times of the sensor node coverage area. This results with creation of more number of beacons in the sensing area, wherein obstacles are overcome by using the detouring technique. As there are few complexities and short distance factors, SCAN provides fairly reasonable movement, compared to other traversal schemes. SCAN scheme has an advantage over others with its identical coverage of the sensing area or region. In the proposed study, this SCAN scheme is exploited for locating the sensor position.

Huang.R et al [8] made a deep analysis on the route planning. The author referred two schemes namely CIRCLES and S-CURVES. In CIRCLES, there are a number of circles under sensing. Unlike SCAN, S-CURVES does scanning of sensing by moving in a ‘S’ style. This ‘S’ curve is formed out of short straight lines. The main discussion of this paper is categories of mobile beacons related to static sensor nodes. The discussion focused the scope of wider application with regard to localization. Concrete examples of this scheme are surveillance of military applications and fire detection at distance spot. In such spots, the sensor nodes are air dropped from an airplane. The action of soldiers at far off are attached with transmitters, which take up the role of mobile beacons. There are two major issues related to localization, namely proposing an effective localization scheme or method, and devising optimum mobile beacons. The proposed study takes up this issue and discusses in the following pages.

The discussion presented in [15], analyzed the localizing of static nodes on RSSI of mobile beacon and on Bayesian inference. The principles of statistical processing received data from mobile beacon are worked out without dictating any constraints on geometrical elements. However, this paper lacks the efficient power consumption, due to its complex computation.

Ssu et al. [12] came out with a localization method for static nodes based on four mobile beacon points. This method, in fact, either resists or overcomes the obstacles in the path, yet with irregular radio frequencies. This mechanism loses its superiority due to enlarged beacon overhead and more time consumption.

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As an improved process for accuracy in localization with Ssu's scheme, Lee et al. [16] came out with a geometric constraint-oriented localization method. In this method, a single mobile beacon is positioned to move around the entire network region. Due to this extended area of monitoring, there is an occurrence of error in localization. Yet another mobile beacon oriented localization scheme was proposed in [17]. In this scheme, the computation of node positions is carried out by using the geometric element of perpendicular intersection. As an extension to this scheme, a new mobile beacon was suggested resist any obstacles in the path. However, this extended pattern proved its demerit in cost factor by way of including rotating arm and wheels.

Ou et al. [18] discussed the localization of static sensor by using mobile beacons and with multi-directional antennas. During the application of range free localization method, the obstacles were encountered. However, this method is ideal when the sensor nodes do not require any additional hardware devices.

In [19-23], Various techniques are introduced for various applications.

III. PROPOSED WORK

3.1 SCAN Trajectory

Figure 1 illustrates the proposed single anchor node which could identify the position of static sensor node in respective network. SCAN route planning technique enables the movement of anchor node.

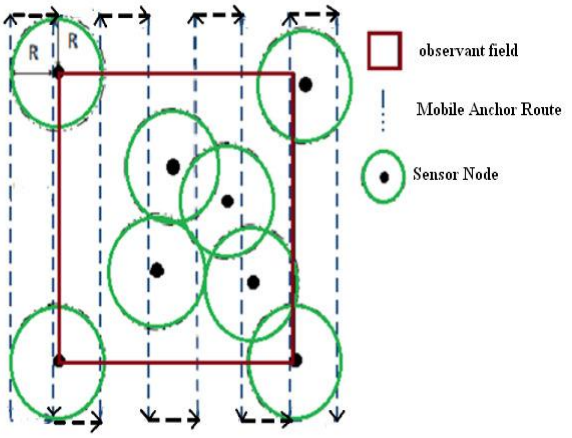

Fig.1. Single Anchor Node Trajectory

3.2 Z-Curve Trajectory

The mobile beacon path planning mechanism called Z-curve presented in [24] is discussed in this section. Figure 2(a) depicts the Z-shape curve attained from trajectories. The vital aspect in devising this Z-curve is that trajectory encounters the collinear beacons constraints. In addition, it paves way for creating a transmission path through which the three consecutive non-collinear beacons pass through. These beacons reduce the duration or time taken for localization. In the case of mobile beacons move on the Z-curve, there is a possibility of unknown sensors being localized in an accurate manner. Meanwhile, the trajectory is retained all through the border of the sensor deployed region, and in some cases in the entire network itself.

In this proposed study, the level of the curve is exploited in the following way: The basic curve is found to exist at level (1), where l=1. For extracting this, a 2-D field is divided into 4 sub-squares. In the meanwhile, the mobile beacon forms the connection of centers of the cells for deriving Z-curve.

The mapping of level (l-1) with level (l) is done by replacing each vertex of the four basic curves, C1;C2;C3;C4 with that of level (l-1), as depicted [19] in Figure 2(a). For this, the level could be rotated in apt manner and made to reflect for getting fit to the new curve. Similar mappings for level (2) and level(3) are illustrated in Figure 2(b) and 2(c) respectively.

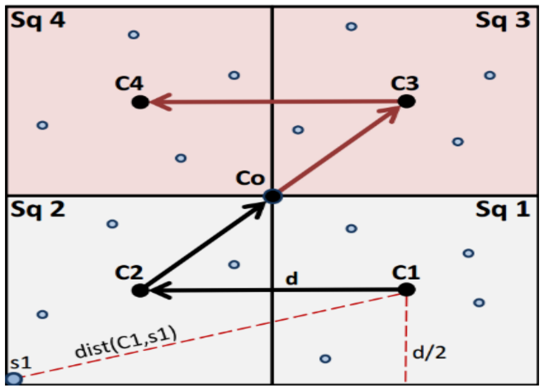

Fig.2(a) Level (1) [19]

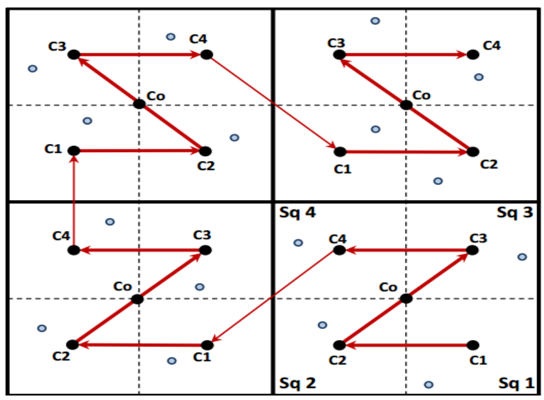

Fig.2(b) Level (2) [19]

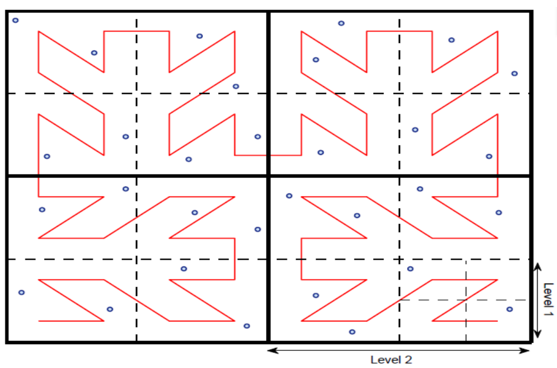

Fig.2(c) Level (3) [19]

Geometric inference scheme, by way of using right angles bisector of the chord [12] is employed in localization. In this scheme, an anchor node travels in distinctive path and broadcasts beacon packets containing position information.

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Sensor receives beacon message at the initial movement itself. Sensor node positions the first heard beacon packet based on the first beacon packet sent by anchor node. The anchor node continues to fix the second beacon point which happens to be the last position of anchor node. This is the occasion when anchor node leaves the range of communication for sensor node.

In the same way, anchor node forms three beacon points in circle of communication range. Two chords are drawn with these three beacon points to form a geometric conjecture, as shown in Fig.3. The vertical lines crossing the circle at centre are marked by two chords. From this circle centre, location of sensor node is derived.

In this proposed work, the position of all static sensors is identified by deriving this geometric inference of both anchor nodes.

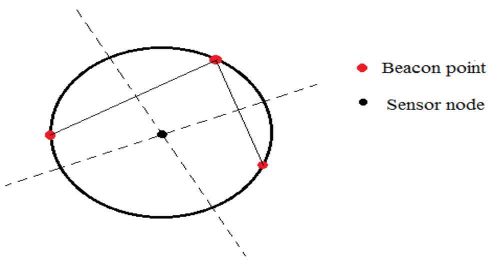

Fig.3. Geometric Conjecture [4]

IV. SIMULATION RESULTS

This section displays the examined result of proposed localization method. To start with, fifty static sensor nodes were deployed in two sensing fields of 100*100 dimensions. The anchor nodes are set to travel on SCAN method for localization of all static sensor nodes of sensing field. Similarly, the anchor nodes were set to travel on Z curve method in other sensing field. The comparison results listed in Table 1 clearly show Z curve technique is able to localize all the nodes in shorter duration than SCAN method.

Localization Time(min)	No. of nodes localized using SCAN Trajectory	No. of nodes localized using Z-curve Trajectory
1	4	5
4.5	5	7
5.5	7	11
9.5	15	19
10.5	17	22
12.5	19	25
15	28	33
18.5	30	35
20.5	35	42
21.5	45	50
22.5	47	
25.5	50	

Table 1: Comparison for SCAN and Z-Curve Trajectory

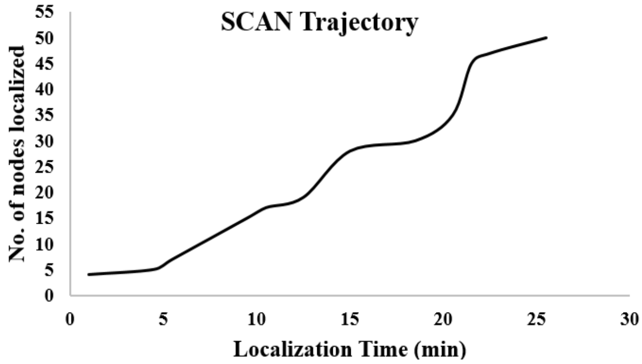

Fig.4(a) SCAN Trajectory

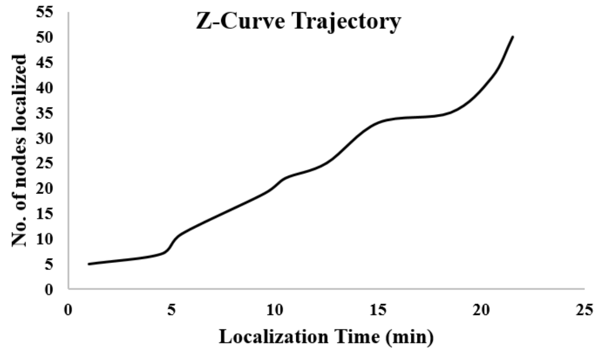

Fig.4(b) Z-Curve Trajectory

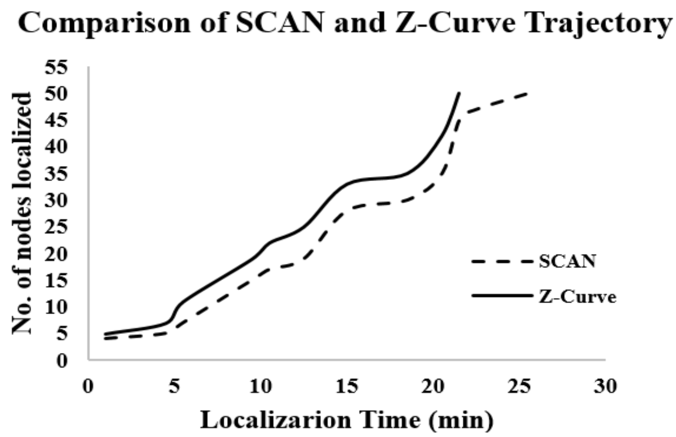

Fig.4(c) Comparison of SCAN and Z-Curve Trajectory

V. CONCLUSION

Before In the proposed research paper, trajectories of SCAN and Z-Curve method were compared. The proposed work proves the efficient localization of static sensor nodes under the application of geometric inference, which is termed as right angle bisector of two chords. The optimization of anchor nodes' movement in sensing was achieved by employing both the SCAN trajectory and Z-curve trajectory schemes. The study demonstrated that the proposed work of localizing all the static nodes on utilizing the beacon nodes. The study illustrates that three beacon points are sufficient in localizing the static sensors. The obstacles on the planned trajectory path during the localization of sensor nodes were located by using virtual beacon points. The comparison results show and prove Z-curve is efficient,

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\by enabling the maximum zero-fault tolerance under shortest duration possible. The proposed study is ideal and suitable for environments of continuous sensing. In addition, the proposed method facilitates data transfer in an effective manner at minimum intervals.

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