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Reviewing Static Path Planning for Mobile Beacons to Localize Mobile Networks

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***Abstract* - Localization is an essential issue in mobile networks because many applications require the mobile to know their locations with a high degree of precision. Various localization methods based on mobile anchor nodes have been proposed for assisting the mobile nodes to determine their locations. However, none of these methods attempt to optimize the trajectory of the mobile anchor node. Different static path planning algorithms are SCAN, DOUBLE SCAN, HILBERT, CIRCUL, S-CURVE. In SCAN, the mobile anchor node travels along a single dimension while in DOUBLE SCAN, the collinearity problem is resolved by driving the anchor in both the x- and the y-directions. In HILBERT, the mobile anchor node is driven along a curved trajectory such that the sensor nodes can construct non-collinear beacon points and the total path length is reduced, In CIRCLES, the mobile anchor follows a sequence of concentric circular trajectories centered at the center point of the deployment area, while in S-CURVES, the anchor follows an S-shaped curve rather than a simple straight line as in the SCAN method. Accordingly, discussed path planning scheme, ensures that the trajectory of the mobile anchor node minimizes the localization error and guarantees that all of the mobile node can determine their locations.**

***Key Words* - SCAN, DOUBLE SCAN, HILBERT, CIRCUL, S-CURVE, Path planning Algorithm.**

I. INTRODUCTION

What is mobile network? With the increasing use of small portable computers, wireless networks, and satellites, a trend to support computing on the move has emerged—this trend is known as mobile computing or nomadic computing. Also referred to as anytime/anywhere computing, mobile computing has several interesting and important applications for business (such as instant claim processing and e-commerce), telecommunications and personal communications, national defense (tracking troop movements), emergency and disaster management, real-time control systems, remote operation of appliances, and in accessing the Internet. Since a user may not maintain a fixed position in such environments, the mobile and wireless networking support allowing mobile users to communicate with other users (fixed or mobile)

becomes crucial. A possible scenario may involve several different networks that can support or can be modified to support mobile users. When dealing with different wireless networks, a universal mobile device should be able to select the network (LAN, the Internet, PCS, or satellite) that best meets user requirements.

Wireless and mobility are not the same, but they are features which are quite synergistic. It is possible to have wireless computers that do not move, just as it is possible to move wired computers from place to place. Clearly, however, the possibility for wireless data communications creates an irresistible urge to find ways to support mobility and network access at the same time. As a rule, wireless dominates the design space at the lower levels in the context of mobile computing, because at the lower levels the differences between physical media are most visible. At the network layer and above, mobility dominates. These design parameters require variability in essential protocol elements in ways not envisioned by the designers of existing network protocols.

A Mobile Network consists of hundreds or thousands of nodes and a small number of data collection devices. The nodes have the form of low-cost, low-power, small-size devices. The nodes gather the information of interest locally and then forward this information over a wireless medium to a remote data collection device (sink), where it is fused and analyzed in order to determine the global status of the sensed area.

In Mobile Networks, sensed data with location information is valuable. Several schemes, broadly classified into two categories, have been proposed for dealing with the localization. First, the range-based schemes need either node-to-node distances or angles for estimating locations. The range based schemes typically have higher location accuracy but require additional hardware to measure distances or angles. Second, the range-free schemes do not need the distance or angle information for localization. Although these schemes cannot accomplish as high accuracy as the range-based ones, they provide an economic approach. However, the accuracy of current algorithms is mostly environmentally sensitive which leads to low reliability and low success rate about the location results.

Most localization mechanisms use fixed anchors. However, if all of the nodes within the network have the ability to determine their locations, a large number of fixed anchors are required. Thus, several methods have been proposed for reducing the anchor deployment cost by utilizing GPS-enabled mobile anchors, which navigate the sensing field and issue periodic beacon messages advertising their current coordinates. However, the problem of deriving the optimal trajectories of the mobile anchors in the sensing field has attracted relatively little attention. Although several anchor movement strategies have been proposed for mobile networks, they are all based on some specific localization algorithms (e.g. trilateration).

Problems of Localization in Mobile Network:

Determining the physical location of the node after they have been deployed is known as the problem of localization. The problem of localization is very important for many engineering fields and has been researched for many years. In robotics, the exact location, as well as the orientation, of a robot was extensively considered. Many of the outdoor localization systems rely heavily on infrastructure. In 1996, the US Federal Communications Commission (FCC) required that all wireless service providers be able to provide location information to Emergency 911 services. Cellular base stations are now used to determine the position of the users. In 1993, the global positioning system, based on 24 NAVSTAR satellites, was deployed. Since that time, it has become the standard way to do localization whenever a GPS receiver can be used. LORAN operates in a similar way to GPS but uses ground base stations instead of satellites. In the ad hoc domain, fewer localization systems have been proposed and implemented.

II. THE COMPONENTS OF LOCALIZATION SYSTEMS

Localization systems can be divided into three distinct components:

• Distance/angle estimation: This component is responsible for estimating information about the distances and/or angles between two nodes. This information will be used by the other components of the localization system.

• Position computation: This component is responsible for computing a node's position based on available information concerning distances/angles and positions of reference nodes.

• Localization algorithm: This is the main component of a localization system. It determines how the available information will be manipulated in order to allow most or all of the nodes of a WSN to estimate their positions.

Figure 1 depicts this component division. Besides providing a didactic viewpoint, the importance of such a division into components comes, as we will see, from the need to recognize that the final performance of a localization system depends directly on each of these components. Also, each component has its own goal and methods of solution. They can thus be seen as subareas of the localization problem that need to be analyzed and studied separately.

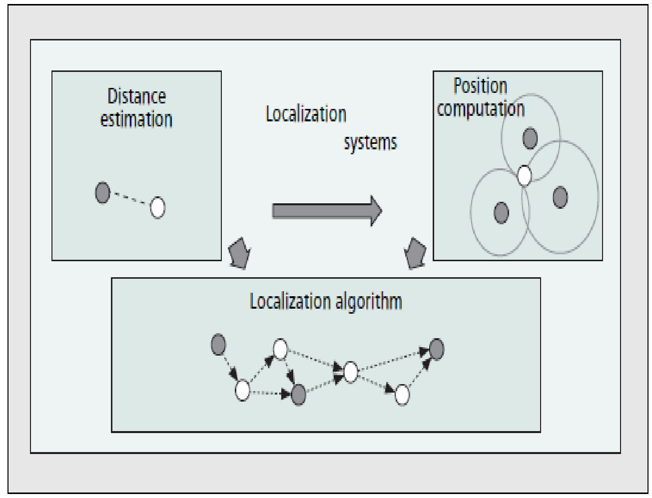

Fig 1: Division of Localization system into three distinct Components

III. STATIC METHOD FOR PATH PLANNING

Although several anchor movement strategies have been proposed for Mobile network, they are all based on some specific localization algorithms, and thus their compatibility with other localization methods is not guaranteed.

Different algorithms are proposed to acquire the position information of unknown nodes in mobile networks with the help of mobile beacon, which becomes available with the rapid development of various related research area such as automation and aviation. The existing path planning methods can be classified into static and dynamic methods. The static methods design the trajectory before localization, and the anchor must follow the give path during localization.

Some static methods are as follows:

Koutsonikolas et al. proposed three path planning schemes for the mobile anchor node in the localization scheme presented by Sichitiu and Ramadurai, namely SCAN, DOUBLE SCAN and HILBERT. In SCAN, the mobile anchor node travels along a single dimension (e.g. the x-axis or y-axis direction), and the distance between two neighboring segments of the node trajectory defines the resolution of the trajectory. SCAN is simple and provides uniform coverage to the entire network. However, the collinearity of the beacons degrades the accuracy of the localization results. In DOUBLE SCAN, the collinearity problem is resolved by driving the anchor in both the x- and the y-directions. However, whilst this strategy improves the localization performance of the sensor nodes, the path length is doubled compared to that of SCAN, and thus the energy overhead increases accordingly. In HILBERT, the mobile anchor node is driven along a curved trajectory such that the sensor nodes can construct non-collinear beacon points and the total path length is reduced. The results presented in showed that through an appropriate setting of the curved trajectory parameters, a significant reduction in the localization error could be obtained compared to the case in which the anchor node simply moved randomly through the sensing field.

Huang and Zaruba presented two further path planning schemes designated as CIRCLES and S-CURVES, respectively, for avoiding the collinearity problem inherent in the localization method. In CIRCLES, the mobile anchor follows a sequence of concentric circular trajectories centered at the center point of the deployment area, while in S-CURVES, the anchor follows an S-shaped curve rather than a simple straight line as in the SCAN method. The results showed that given a trajectory resolution much larger than the radio range, both schemes cope effectively with the collinearity problem and provide a significantly better localization accuracy and coverage than previous solutions.

SCAN

Of the four path types, SCAN is the most straight-forward in which the mobile beacon simply sweeps the deployment area in straight lines from left to right. More formally, SCAN divides the square deployment area into n by n sub-squares and connects their centers using straight lines. The resolution, R, of SCAN is defined as the side length of each sub-square. The drawback of SCAN is that straight lines introduce collinearity, and there are many locations where the beacon broadcasts heard are collinear. The area near the vertical lines cannot be localized because all beacon broadcasts come from the same vertical line and thus are collinear. To reduce collinearity, we would have to reduce the resolution to match the broadcast range, which would substantially increase the path length.

HILBERT

To reduce the collinearity without significantly increasing the path length, HILBERT is proposed, which makes the mobile beacon to take more turns. Same as SCAN, HILBERT divides the 2-dimensional space into n by n sub-squares, but connects the centers of the sub-squares using n line segments. The resolution of HILBERT is defined as the side length of each sub-square. While the path length of HILBERT is nR longer than that of SCAN at the same resolution, it contains shorter line segments, which reduces collinearity.

CIRCLES

Since straight lines invariably introduce collinearity, we would like to reduce the amount of straight lines on the beacon path. Thus, we design CIRCLES which consists of a sequence of concentric circles centered within the deployment area. We define the resolution, R, of CIRCLES as half of the radius of the innermost circle, and we sequentially increase the radius by R at each outer circle. Since CIRCLES does not introduce collinearity, all areas within the circles can be localized. However, since the deployment area is a square, CIRCLES would not cover the four corners effectively without adding larger circles, which would increase the path length. Furthermore, CIRCLES has an inherent scalability issue. When the deployment area increases, CIRCLES would require the beacon path to contain larger circles. As the circles become larger, the amount of non-collinearity reduces, which in turn reduces the localization accuracy.

S-CURVES

S-CURVES is based on SCAN, which progressively scans the deployment area from left to right. However, at each scan, S-CURVES takes an ‘S’ curve instead of going in a straight line. More formally, dividing the deployment square into n by n sub-squares, and let the resolution of S-CURVES be R. Then, each vertical S curve consists of $n - 1$ half squares of radius $R/2$, and there are a total of $2(n - 1)/3 + 1$ S curves from left to right. The S curves are connected with short straight lines like in SCAN.

IV. Problems of above Static Path Planning Algorithm

The simplest path is random paths such as RWP (Random Waypoint) and Gauss-Markov path, whose drawback is that they cannot cover the entire ROI to localize all unknown nodes. To overcome this drawback, three paths are used called as Scan, Double-Scan, and Hilbert.

Scan and Double-Scan are composed of a series of straight lines, and Hilbert is Hilbert spacing-filling curve. They can cover the whole ROI to offer significant benefits compared to a random movement of mobile anchor but the drawback of these methods is path length is doubled and thus energy overhead is increases accordingly.

Circles and S-Curves proposed in aim to avoid the collinearity of virtual anchors, which require the anchor moves along curves instead of straight lines, but they cannot covers entire ROI. CIRCLES can only guarantee that the four corners of the sensing field are covered by expanding the diameter of the concentric circles. As a result, the path length is extended, and the energy consumption is increased. In S-CURVES, the trajectory of the mobile anchor cannot guarantee that each sensor node can construct two valid chords.

V. Path Planning Algorithm for Mobile Anchor-Based Localization in Mobile Networks

The objective of path planning algorithm is to optimize the trajectory of the mobile anchor node. It also guarantees that all of the sensor nodes can determine their locations. It proposes obstacle-resistant trajectory to handle the obstacles in the network field. Also this system proposes an optimal path planning method for the mobile anchors used in the localization scheme. A single mobile anchor is used to enable the mobile nodes to construct two chords of a communication circle of which they form the center point, and the intersection of the perpendicular bisectors of these two chords is then calculated in order to pinpoint the node position. However, the mobile anchor moves randomly through the sensing field (i.e., in accordance with the Random Waypoint model), and thus it is possible that some of the sensor nodes cannot be localized. The path planning scheme proposed is specifically designed to 1. Minimize the localization error of the individual mobile nodes 2. Maximize the number of sensor nodes which can determine their locations. The performance of the proposed scheme is evaluated by conducting a series of simulations using the ns-2 network simulator.

VI. CONCLUSION

Mobile computing opens the door to a fresh examination of practically every area of network protocol engineering. In this paper, we discussed different path planning methods like SCAN, DOUBLE SCAN, HILBERT, CIRCUL, S-CURVE. Path planning scheme for Mobile Anchor-Based Localization in Mobile Networks, ensures that the trajectory of the mobile node minimizes the localization error and guarantees that all of the mobile node can determine their locations. A single mobile anchor is used to enable the mobile nodes to construct two chords of a communication circle of which they form the center point, and the intersection of the perpendicular bisectors of these two chords is then calculated in order to pinpoint the node position.

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