A NOVEL RANGE FREE LOCALIZATION METHOD FOR MOBILE SENSOR NETWORKS

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ABSTRACT

This Range free localization methods are commonly used in mobile sensor networks as they have many advantages over other methods. They are of low cost. They don't need more complex hardwares. But this type of localization also have some bad effects like more power consumption at nodes, which reduces network life time. And as a result communication cost is very large. For solving these problems, in this paper, the localization is done using beacon signals, anchor nodes, sensor nodes and Received Signal Strength(RSS). By using these parameters, a novel low cost localization method is introduced. This reduces the communication cost and network lifetime is improved. Theoretical analysis and simulations are done. Coding is done in NS2. The simulation and calculations shows that this method has more accuracy than previous methods.

Key Words: Mobile Sensor Networks, Anchor nodes, Beacon signals, Received Signal Strength.

1. INTRODUCTION

Today, mobile sensor networks are used for different applications, as technologies are becoming more and more smarter. Some of the areas where these mobile sensor networks are used are hazardous areas, remote areas or when large number of sensor nodes have to be deployed. Sensor node localization is a highly desirable capability for wireless sensor network applications. Localization issue is very important, when the position of nodes are unknown. It is inevitable to find the most apt method to find the location of the nodes. So an efficient localization algorithm can then use all important parameters to find the position. The aim of this paper is an effective localization algorithm for mobile sensor nodes. The algorithm should be applicable to all nodes. Also should use almost all data from the network and calculate the location. Since the algorithm should be run in individual nodes, the method must be relatively simple and the resources must be limited. The performance of localization algorithms will depend on critical sensor parameters like radio range, density of nodes, anchor to node ratio. And it should be noted that the solution gives adequate performance over a range of reasonable parameter values and also in worst environmental conditions.

Localization is a process of estimating coordinates of mobile sensor nodes in a network based on various parameters and with the aid of a number of anchor nodes whose locations are already known by using GPS. An anchor node broadcasts beacon signals with limited information in it, so that transmission is easy and faster. These anchor nodes are required for localization in a global coordinate system. The location information of an anchor node can be acquired by using localization systems such as Global Positioning System (GPS) receiver[1].

There are a lot of reasons for the importance of this localization. For example, sensor location information can be used for tagging sensory data, which is important for environmental monitoring and military surveillance applications. The operation of a sensor network relies on sensor location information for uncovering and healing coverage holes in the network. Sensor location information

ISSN 2229-5518

can also be used to perform efficient spatial querying or tasking, e.g., scoping the query or task propagation to sensor nodes in specific locations or geographic regions without the need to flood the whole network, significantly reducing the network overhead and minimize consumption of energy and resources in the network.[4],[5],[6] Recently, many sensor localization techniques have been developed for wireless sensor network applications [2],[3]. In this paper, we focus on beacon signal and Received Signal Strength (RSS) -based sensor localization approaches.

2. PROPOSED ALGORITHM

The localization methods are divided into range methods, that would compute an estimation of the distances between two motes, and range-free methods, that would not compute distances.

2.1 Range based methods

The range methods exploits information about the distance to neighbouring nodes. Although the distances cannot be measured directly they can, at least theoretically, be derived from measures of the time-of-flight for a packet between nodes, or from the signal attenuation. The simplest range method is to require knowledge about the distances to three nodes with known positions (called anchors or beacons), and then use triangulation. However, more advanced methods exist, that require less severe assumptions.

2.2 Range free methods

Regarding localization, it uses fusion of RF received signal strength information and acoustic time of flight. There is an interesting definition of a distributed algorithm for random WSN. The minimal density of known nodes is presented. The main objective of their algorithm is to broadcast a request (*"Do you hear me ?"*) and compute the estimated localization by the interpretation of the answer of all the known nodes. The influence of noise can be important, shows (flip and flex ambiguities).To minimize it, Robust Quadrilaterals and Clusters are defined and analyzed. But the computation complexity increases as it is extended to large-scale WSN, which is a big inconvenient. Localization schemes that exploit the additional information that can be obtained when some nodes are mobile. Three schemes are possible: static nodes - moving seeds, moving nodes - static seeds, or both moving. By knowing the original emitted power and comparing it to the received signal power, one can estimate the attenuation g and deduce the distance via, for example, a free space path-loss model:

$$g=d^\alpha$$

In this scheme the exponent α is around 2 in an open-space environment, but its value increases if the environment is more complex (walls, etc.) or less suitable for radio waves (metallic devices...). Another issue is that there is no unique path from the transmitter to the receiver. Any reverberations of the signal will influence the received strength, so it has to be measured at the appropriate moment. Some consider the first peak, whereas others prefer an average of the first periods. Contrary to the first ones, those methods never compute the distances to the neighbours. They use hearing and connectivity information to identify the nodes and beacons in their radio range, and then estimate their position. Do you hear me? This idea of only using the information of the immediate neighbours fits perfectly the distributed approach of the localization problem. In those type of schemes, every node only uses direct communications to refine his position estimates, and when it succeeds to achieve a given accuracy, it broadcasts the result. The big advantage is that it saves a lot of traffic, but an overload of the radio channels can occur. This has to be carefully studied, and the rules for priority clearly established. Another drawback is the fact that those techniques usually require a great amount of nodes.

This work starts by analyzing a range-free localization algorithm for mobile sensor networks. In this algorithm, mobile sensor networks have normal mobile nodes, anchor nodes and sensor nodes. Anchor nodes are assumed to be mobile whereas the sensor nodes are stationary. Each anchor node broadcasts beacon signals to its neighbouring nodes and they are received by the one hop distanced nodes. And the mobile nodes which receives this beacon signal has different Received Signal Strength because of variation in distances. The location of nodes can be approximately found using a detailed analysis on the beacon signals. A possible region of a's location is a region which covers a's location. Clearly, a smaller possible region implies higher localization accuracy. A beacon is called a current beacon if it is delivered in the current time slot, and a historical beacon otherwise (i.e., prior to the current time slot). Associated with each current beacon, there is a one-hop-anchor-constrained region, which is the communication range of the anchor node when it sent out the beacon. Similiarly there is a anchor constrained region associated with historical beacon, which is a circle centered at the anchor node that sent out the beacon. If the historical beacon was delivered t time slots ago, then the circle has a radius of r + V_{max} * t, where r is the communication radius of an anchor node and V_{max} is the maximum moving distance of a normal node during a time slot.

2.3 Block diagram

The figure 2.1 shown below is the detailed block diagram for localization of mobile sensor networks. This algorithm has mainly three steps:
1. Sample generating

2. Sample filtering

3. Location estimation

In the first step, ie, sample generating a vast number of samples are generated. It is by use of intersection method. In second step, ie, sample filtering , a certain number of samples are filtered out which is not our desired location points for sure. In the third step, centroid of all the samples got in previous steps are found and thus the desired location is estimated.

In practical scenarios, the number of nodes is very much large. So the nodes are further classified into anchor nodes and mobile nodes. And also there are some sensor nodes. Anchor nodes is the representation of the base stations itself. These nodes continuously sends signals to the surrounding nodes. Moving nodes are the mobile phones or other devices used by us. These nodes receives the signals sent by the anchor nodes and re-transmit it back. This is received by the sensor nodes. The first, step is the deployment of mobile sensor nodes. That is, the mobile sensor nodes are aligned in the created network.

The control of the normal nodes and sensor nodes are done by anchor nodes. So it must be placed with considerable importance. It should be placed in the network such that no node's signal is gone without receiving by any anchor nodes. Only then the location can be identified. The next step is the broadcasting of beacon signals by anchor nodes. This is received by nodes around it. The node which is near gets signal with high received signal strength. And the node which is far away gets the signal with low strength. This RSS is the main parameter used to find the location of the node.

In the next step, the intersection region are detected. If a mobile node gets signal from two or more than two anchor nodes, it will become complex. In that case, the intersection region is found by simple mathematical calculations. The points which lie in this region is taken as sample points, one of which is the desired point. Thus the sample points are got. This process is called sample generating.

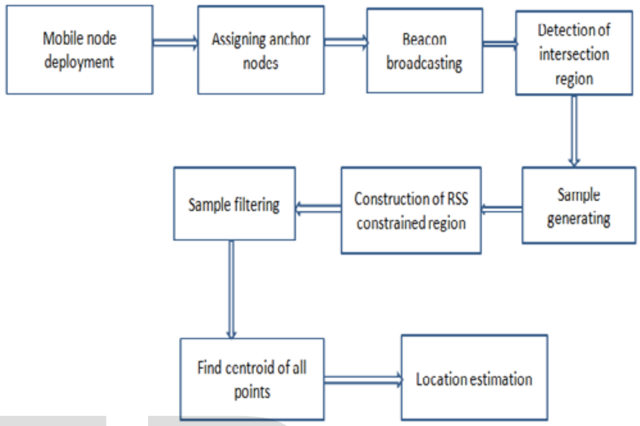

Fig 2.1 : Block diagram of localization algorithm

Construction of RSS constrained region is the next process. By analyzing the nature of beacon received, the RSS constrained region is constructed. By doing this, some more closest points are got. Remaining are filtered in the sample filtering process. Next, the centroid of all the points got in the sample filtering step is found. This gives the location of the desired node. The main concept is as follows: Sensor nodes are placed to receive beacon signals. Anchor nodes continuously sends signals to the environment. This signals are received by moving nodes. And sends back to the sensor nodes. By analyzing the RSS (received signal strength) of this signal the location of the node is calculated.

3. SIMULATION AND RESULTS

There are three types of nodes: anchor nodes, mobile nodes and sensor nodes. Fig. 3.1 shows how these different types of nodes are aligned in a mobile sensor network.

ISSN 2229-5518

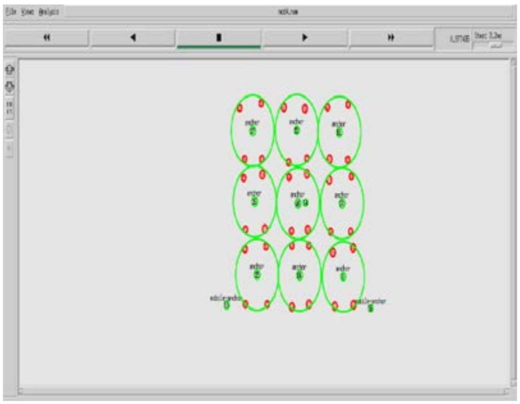

Figure 3.1 deployment of mobile nodes

Anchor nodes are the base stations itself. It is represented in the simulation as the node placed in the centre of the coverage area shown as circle in the figure. Also there are four sensor nodes in each circular coverage area for better localization. Mobile nodes are the mobile phones or other handheld devices which transmit and recieve data. These mobile nodes move in the mobile sensor network.

Next step is the assigning of anchor nodes. It is also shown in fig. 3.1. Anchor nodes are placed in such a way that no beacon signal is lost without reaching near mobile nodes. Beacon signals are transmitted from the anchor nodes continuously. This signals are recieved by the mobile nodes nearby the anchor nodes. But the recieved signal strength is different depending upon the distance from the anchor nodes. The red color node shown in the figure is the anchor node. It is placed in the network in uniform manner according to the traffic.

After assigning anchor nodes, beacon signals is broadcasted by anchor nodes. These signals are received by sensor nodes which helps in locating mobile sensor nodes. It is shown in fig 3.2. The recieved signal have different recieved signal strength. By analyzing the recieved signal strength it is easy to determine the nodes' position.

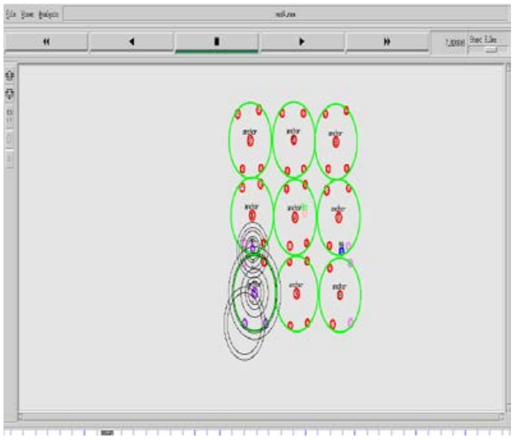

Figure 3.2 broadcasting beacon signals

The next step is the representation of mobility of nodes in the mobile network. The mobility of node in the mobile sensor network is unpredictable. So it is very difficult to locate the position of the node. So beacon signals are used to locate the position of the node.

When nodes are moving in the network, it receives beacon signals sent by anchor nodes. Each node gets signals with different strength. This strength is a key parameter in determining the location of mobile nodes. The mobility of nodes is shown in fig 3.3 (a) and (b).

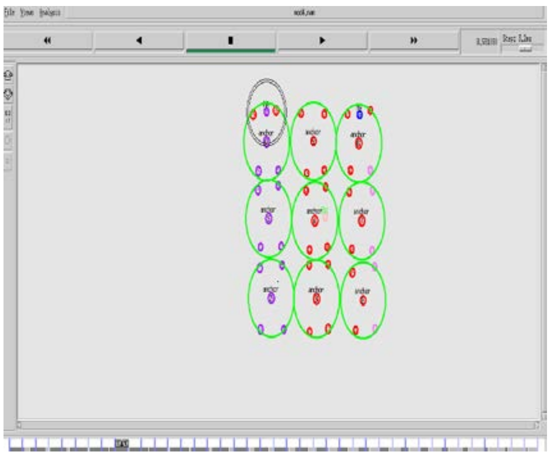

Figure 3.3 (a) mobility of nodes

ISSN 2229-5518

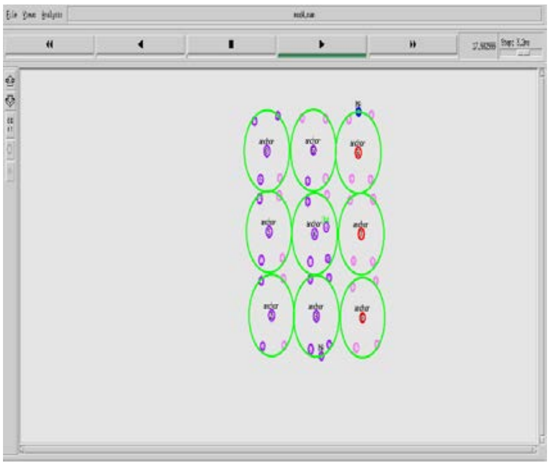

Figure 3.3(b) mobility of nodes

But lots of nodes recieves the signal sent from the mobile nodes and the nodes that are far away from the anchor node will recieve feable signal. So such signals are neglected to obtain accurate results.

4.PERFORMANCE ANALYSIS

Localization using mobile beacons has many advantages over those that use static beacons. The use of mobile beacons pushes the hardware complexity and power consumption requirement on the mobile beacon, which is less resource constrained and has access to the required power for repetitive message transmission to sensor nodes to be localized. In addition, the use of mobile beacons can significantly reduce the cost of sensor deployment. A mobile beacon transmitting at different locations can be considered equivalent of multiple static beacon deployment. Mobile beacons can move and easily avoid environmental obstructions. Using mobile beacons can also avoid the problem of interference and collision of beacon signals due to uncoordinated beacon transmissions of static beacons.

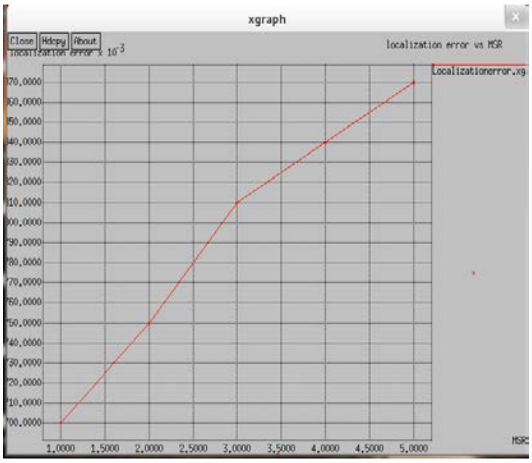

Figure 4.1 localization error Vs MSR

Figure 4.1 shows the changes in localization error with MSR.

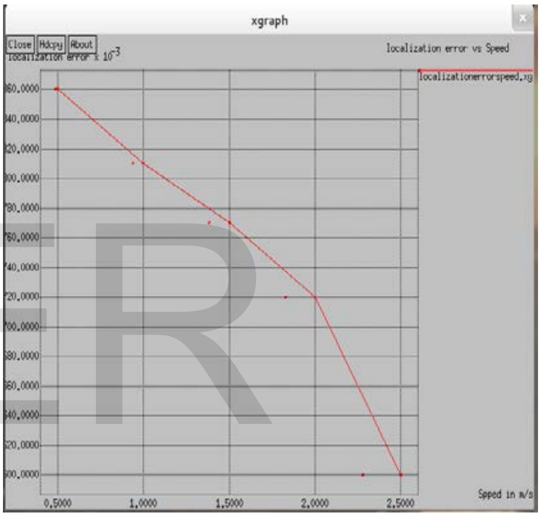

Figure 4.2 localization error Vs Speed

Figure 4.2 shows the changes in localization error with Speed of the node mobility.

5.CONCLUSION

As wireless sensor networks became a key technology and are used in more and more industrial and environmental problems, defining an effective localization algorithm became an important task. An optimum algorithm could not be defined yet, and thus the choice of the suitable one has to be founded on the specificities of the situations, taking into account the size of the network, as well as the deployment methods and the expected results. Due to the important amount of scenarios where localization processes comes into play, it has been and will continue being an important research field. This work implemented the Localization algorithm which gave better results than the previous methods. It gave more accurate location of mobile nodes. Because the parameter taken into account is the received signal strength (RSS). In the simulation results, the deployment of nodes are done, then the mobility of the nodes in the wireless sensor network and the RSS is analyzed to get the better localization results. This work is further extending to get a highly secure localization and data discovery protocol.

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