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A Comparative Study of Localization Techniques for Ad-Hoc Sensor Network

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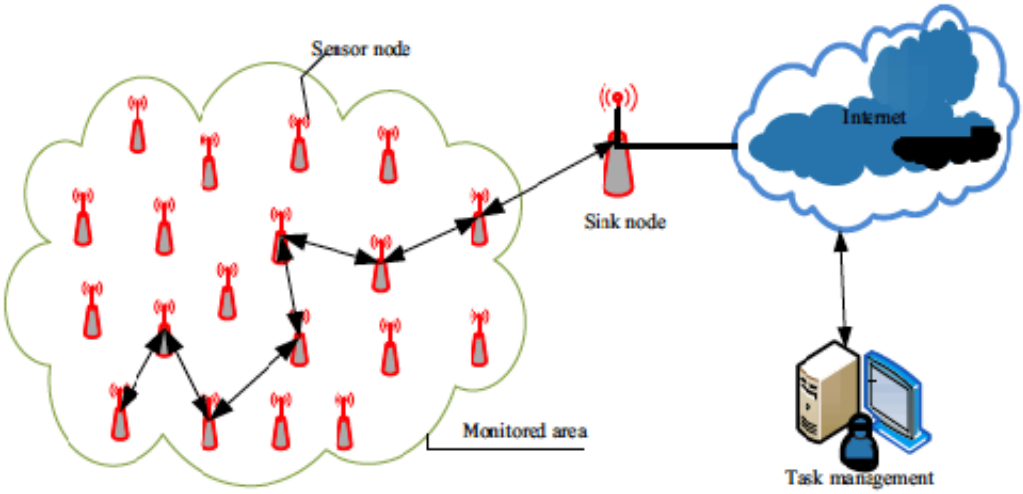
Abstract: - Wireless sensor networks consist of sensor nodes that are required to move around to complete their job assignments like collecting data or sampling the environment. Through fully, the location of sensor nodes is important information for core operation. So, Localization is most fundamental problems in WSN. The exact and accurate location of targeted sensors is highly desirable to achieve because it has very strong impact on overall performance of network and its operation. The locations of the sensor nodes are too critical for both of the network operations and mainly for application level assignments. Majority of the existing localization techniques required certain anchor nodes to be used to provide the location references for other sensor nodes. So the new localization technique should obtaining locations as well as spatial relations of nodes in WSNs without requiring specialized hardware, anchor nodes and/or employing only a limited number of beacons that is aware of their own locations.

Keyword: - WSN, Anchor Node, Localization.

I. Introduction

The WSNs play a vital role in modern technological era, as it becomes the archetype of pervasive technology. A WSN is a large scale adaptive network consisting of densely distributed light, small, cheap sensor nodes that are equipped with low-power transceivers and have limited data processing capabilities. It consist of a variety of sensors either of similar or diverse types, interconnected by communication network especially wireless channels. While designing the sensor networks our fundamental objective should be reliability, accuracy, flexibility, cost, effectiveness and ease of deployment [1]. Deployed Sensors perform routing function to create single or multi-hop wireless networking to route data from one to other sensor nodes. The self-organization, rapid deployment and fault-tolerance, characteristics of the WSN make them promising for a number of industrial, military and day to day applications. Baoli Zhang et al. [6] has meaningfully visualise the architectural model of WSN i.e. specified given below.



In most of the applications of WSN, the core function is to detect and report events which can be meaningfully assimilated and responded to iff the accurate location of the event is known. The locations of sensors are much needed, when identifying the location of the node where the collected information comes from. To determine the coordinates of the sensors is one of challenging problems and is referred to as the localization and it become very challenging in concern of completely heterogeneous ad-hoc sensor network [2].

There are many localization proposal are available for the location estimation of the sensor nodes, where the coordinates are not known in a network termed as sink or target nodes. By utilising, available prior knowledge about the positions of a few specific sensor nodes the new targeted nodes location can be are easily estimate that nodes termed as anchor node. There are various inter sensor measurements are in nature by which anchor node assist the new node to estimate its location such as Time of Arrival (TOA), Connectivity Distance, Time Difference of Arrival (TDOA) and Angle of Arrival (AOA) etc. localization technique are proposed that is a work in two phase process i.e. ranging estimation and position estimation [3].

Background

Mainly localization technique are classified in three categories; statistical localization method, Anchor node Assisted Localization and predictive localization technique. In this section, the description about the three main localization categories is modelled

Statistical method

These method works with the concept of RSSI (Received signal strength indicator), TOA (Time of arrival), TDBA (time difference between arrivals), Angle of arrival (AOA) etc. These methods works good in very small scale network and where sensor nodes are stationary, but it is very error prone with different environmental condition and also in case of large scale adaptive network. Additionally it is not much accurate for location estimation, due to random mobility patterns [4].

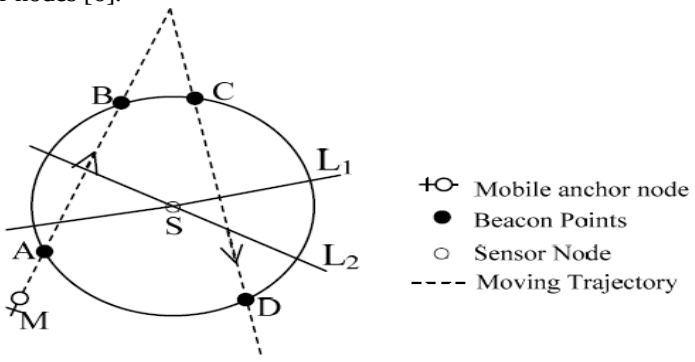
Anchor Node Assisted Localization

A sensor node which is configured with GPS establishment can easily estimate its location so it may be an anchor node. It is a simplest way to estimate location, but it's infeasible in term of cost for GPS addition also for its specialized hardware requirement and energy consumption also.

Anchor node may be static or mobile. Let us consider the scenario where the anchor node is mobile and other nodes are stationary. The mobile anchor node moves around in the network area simultaneously broadcasting the beacon messages. The beacon message includes its location information. Each stationary sensor node r receives the position as a beacon point and calculates its own location by computing the intersection area of its communication coverage. A node can determine whether it is in the transmission radius of an anchor node according to the beacon signal received from the one-hop anchor. The anchor node can adjust its transmission radius by tuning the transmission power. After receiving the beacon messages, a sensor node records them and then searches for the first and last locations of the mobile anchor node when it moves into its communication range. Generally 3 beacon messages from different anchor node are required by a node to estimate its location [5].

Let us see an example of this, the first and last locations of the mobile anchor node are the positions that, it just enters and leaves the reception range of the sensor node respectively, Qiong Wuet al. [14] has meaningfully visualised the model of anchor assisted localization i.e. describe with the help of Fig. 1 centred below.

Point A and C are the positions of the anchor node when stationary node S receives its broadcast messages at the first time. On the other respect, B and D are the positions of the anchor node when stationary node S receives its broadcast messages at the last time. Then we can get the perpendicular bisectors (L1, L2) of the chords AB and CD. The intersection point of L1 and L2 is the centre of the circle, which is the location of the stationary sensor node. After the first round of localization performed, the sensor nodes that are un-localized yet are compute their locations with the help of localized stationary sensor nodes [6].



Predictive Localization Techniques

After too much research on Anchor assisted localization technique & Statistical method of localization technique, now the arena of Predictive Localization is open. There are various predictive techniques on which research is going on or proposed. Such as localization with the help of; artificial neural network concept where Multi Layer Perception (MLP), Radial Basis Function (RBF) Network, SVM (Support vector machine) concepts are used. Localization takes place with the help of popular machine learning algorithms M5 tree Model (M5P) and Sequential Minimal Optimization for Regression (SMOreg). There are techniques that also work on Genetic algorithm concept, random diffusion etc [7, 8 and 9].

The main aim of predictive localization is to develop such a hybrid technique that support random mobility pattern for large scale ad-hoc wireless sensor network without using anchor node assisted localization. That should be distributive, on-demand, comparatively error free, and perform better in term of energy consumption, average localization error and average response time.

II. Related Studies

Today's scenario is slightly different form previous one, the development of technology or application using single concept is now over. Now cohesive and hybrid era is started, where new technologies and application are developed using no. of technological concept or domain. Hybrid technologies perform better in real time scenario that is the main reason for that there requirement is magnetising day to day. The very relevant example is the concept of cooperative communication in MANETs etc. In this section, the target is to focus on the some hybrid localization concept on which many research works is going on.

Anil Kumar et al. [10] have proposed a new algorithm for node localization using application of H-Best Particle Swarm Optimization (HPSO) and Biogeography Based Optimization (BBO) algorithms for distributed optimal localization of randomly deployed sensors. The proposed HPSO algorithm is designed for fast and active mature convergence. Previous PSO models had only fast convergence but less mature in all respect. In General bio geography is a school work assignments for collective learning through the geographical allotment of biological organisms is taken. BBO has a new inclusive arena which works on the biogeography's science and employs the migration operator to share information among the different habitats such as problem solutions. Here, author describe an error model for location estimation of the optimal node's location such in a manner where that the location error is much minimized using the newly proposed BBO and HPSO algorithms. The both algorithms proposed by the author are much able or pre matured to optimizes the locations of the sensors node and perform much better as compared to the available optimization algorithms such as Genetic Algorithms and Simulated Annealing.

Osman Mudthir Elfadil et al. [11] suggested a new algorithm for node localization which based on adjacent node relationship is proposed by the author. Author initiating his work by solving the problem of sparse beacon in sensor network, where range-free localization algorithms is taken in consideration by using adjacent node relationship of the location of the removable beacon. This approach not only saved the cost of anchor node but also distributed the beacon information densely and uniformly across the network, which has overcome the traditional limit in range-free localization techniques. The computation quantity of the algorithm and communication traffic has been much promisingly minimized and it obtain higher location accuracy rate, but has resulted in time delay which is appropriate for application in small scale.

Prince Singh et al. [12] introduces the concept of machine learning algorithms M5 tree Model (M5P) and Sequential Minimal Optimization for Regression (SMOreg) for more accurate node localization in WSN. Here the author compares the performance of MP5 & SMOreg algorithm with Multi-layer Perception (MLP) and Radial Basis Function Network (RBFN) based algorithms and also considered Time of Arrival (TOA) based technique for distance estimation from anchors to sensors. When these models trained with less number of samples SMOreg's performance is better than M5P. M5P algorithms performance can be improved by train it with more number of samples by which it can outperform the SMOreg.

Bing Hu et al. [13] proposed a new hybrid algorithm for node localization. This Hybrid method estimate the position of unknown node, the idea is to repeat the computation of node positions by more than one method to reduce the Distance Measurement Error on one hand and benefit from the advantages of using more than one method on the other hand. This method consists of three phases the first phase computes the position of unknown node using bounding box method, the second phase calculates and corrects error of measuring distances DME mathematically and the third phase refines the node position by re-computing the node position using lateration method and reverses the use of these methods if DME is large. So the problem of distance measurement error was solved by correcting this distance estimation and filtering out this error using the mathematical manner. Thus, the hybrid method combines the advantages of both the lateration and the bounding box methods, which improve the performance of localization system by enhancing the estimation the accuracy of nodes position and makes it less sensitive to distances measurement error (DME).

Qiong Wu et al. [14] suggested a new approach for localizing the node in WSN. Here author propose an improved algorithm named random diffusion distributed localization (RDDL) algorithm. It is adapted to mass density of the large-scale square network with many nodes and many anchor nodes. In RDDL algorithm, it can find and get new local maps by random diffusion, during which a whole global map can be obtained finally by constantly merging the local maps. Thus RDDL algorithm can effectively reduce computation traffic and calculation amount. RDDL algorithm is based on the loose iterative MDS (Multi Dimensional Scaling) algorithm. The results of simulation show that RDDL algorithm is fit for random square network notably connectivity level of the network is high.

III. Comparative Analysis

There are various techniques on which research is going on. The hottest techniques are Hybrid MDS (Multi dimensional scaling) algorithm, Algorithm based on believable factor & node cooperation factor, Algorithm based on Random Diffusion, Virtual anchor node assisted distributed Localization algorithm. There are other predictive techniques on which various researches is being proposed. Such as localization with the help of; artificial neural network concept where Multi Layer Perception (MLP), Radial Basis Function (RBF) Network, SVM (Support vector machine) concepts are

used. Localization takes place with the help of popular machine learning algorithms M5 tree Model (M5P) and Sequential Minimal Optimization for Regression (SMOreg). There are techniques that also work on Genetic algorithm concept.

In this section, here the short concise information on the few recent research concepts is described and their characteristics formulated in terms of various parameters.

Publication	**Technique Used**	**Strength**	**Weakness**
IEEE, 2012	HPSO & BBO based algorithm	Distributive technique, Higher localization rate.	Localization accuracy is low.
IEEE, 2012	Adjacent node relationship based localization technique	Easy to use and comparatively cost beneficial.	Not adequate for large scale network. Localization rate is very slow.
IEEE , 5th ICCICN, 2013	M5P & SMOreg machine learning algorithm and neural network	Useful for very large scale adaptive sensor network. Distributive on-demand technique.	When using un-supervised learning the Localization rate will be desirably low. So extra effort is required to train the network for better performance
IEEE, ICCEEE, 2013	Hybrid method based on DME and Residual error	Lower localization error rate, useful for hybrid WSN.	Centralised technique. Localization accuracy is high but Localization rate is slow.
IEEE, 12th ICTSPCC, 2013	RDDL algorithm based on MDS Concept	Support random mobility pattern. Able to localize both the stationary and mobile ad-hoc node with same constraints.	Required 20% nodes as anchor node for fast localization. So, in-efficient to use with large scale network scenario.

We perform our comparative study on the basis of many research articles yet available for this domain, here we describe the various parameters of five efficient techniques that we found. From our comparative study we observed that, now the eras of adaptive cum hybrid technique are open. We can't estimate the location of a mobile sensor node with the help of statistical technique efficiently. Hybrid approaches provides required flexibility and efficiency together. The two hybrid approach that we discussed in our paper is SMOreg and PSO approach. In near future it's better to work with predictive cum hybrid approaches rather than statistical or GPS assisted techniques for localization of Ad-Hoc sensor Network.

IV. Research Issues & Challenges

Statistical method which works on the characteristics of received beacon message such as RSSI (Received signal strength indicator), TOA (Time of arrival), TDBA (time difference between arrivals), Angle of arrival (AOA) etc. Statistical methods are not much accurate for location estimation, due to random mobility patterns. Now in modern technological era these statistical techniques are infeasible and very error prone. The performance of these techniques may be badly affected by different environmental condition.

Most of the localization technique usually requires high-density anchor nodes which are disposed in order to get sufficient reference information to achieve the localization of target nodes. Otherwise it would be difficult to achieve the precision of application demand in today's scenario. But the problem is the cost of the anchor nodes that is much higher than a normal sensor node, and after the localization is completed those anchor nodes will be transferred to work as normal node.

Therefore the increasing amount of anchor nodes, which increases the cost of disposing the sensor network, and computational and communication load of localization algorithm will be also increased which will cause excessive waste of resources from anchor nodes. The GPS equipped Anchor node facing problem in Indoor scenario. So Anchor oriented localisation is not feasible in today's scenario [15, 16 and 17].

Therefore, a new predictive approach is required to consider from which the location of the mobile sensors accurately measurable. The technique should be distributive and support random mobility pattern with time series evaluation capacity. It should have hardware independent, takes less energy, less average localization error for location estimation and computation, less average response time.

V. Conclusion

For Localization in WSN, Using Anchor node the evaluation of geo position is cost effective due to the hardware implementation. Additionally, statistical methods are not much accurate for location estimation, due to random mobility patterns. Therefore, a new approach is required to find by which the location of sensors accurately measurable. The technique should inherit the range free scheme for geo position estimation, which incorporates the predictive technique

with time series evaluation and mobile pattern discovery. That is hybrid techniques consume polynomial series with time variant manner to find the next position of mobile sensor.

VI. Future Work

The comparative study is intended to find accurate method for location estimation of sensor nodes. The presented background & comparative study as well as research issues & challenges, is exactly guide us about the trend should be carry out when proposing new approaches. In near future we are passionate to work with location estimation, our concern would be to proposed a new predictive cum hybrid approach which works much better than previous in term of accuracy, localization error and with accumulated hybrid parameters. So, our comparative study is much useful for research scholars to work on different other applications such as sensor node localization, mobility aware routing algorithms, Vehicular network's implementation and other low cost location aware service development.

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