A Survey on Localization Methods in Wireless Sensor Networks

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Abstract: Localization is a way to determine the location of sensor nodes. Localization is an essential process in Wireless Sensor Networks (WSNs). This process is necessary to report the origin of events, routing and to answerquestions on the network coverage,assist group querying of sensors, etc. The information of exact physical location of the sensor nodes is useful for various applications like target tracking, intrusion detection, environmental monitoring and so on.This document is about the principles and algorithms that are used in determining the location of sensor nodes.

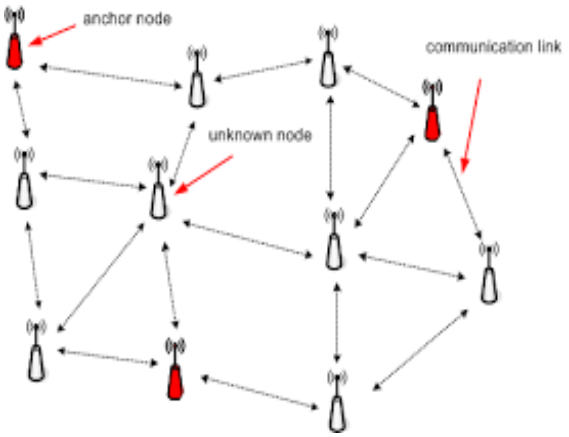
Keywords:beacon nodes,anchor nodes,2D Localization,3D Localization

I. INTRODUCTION

In the real world, Wirelesssensor Networks (WSN) possesseswide application such as vehicle tracking,Traffic control, forest fire detection etc[1].But in all these applications locating sensor node is essential.This process is termed as localization.Localization is the process of locating the sensor nodes[2].It can be done by sensor node itself by using GPS.But it possess serious disadvantage.GPS is hugely affected by trees and buildings as it requires Line-of-sight between receiver and the transmitter.So it provides low accuracy because of less reception of signals.In order to avoid this 2D and 3D localization algorithms were proposed.These algorithms provide accurate determination of location of nodes in WSN's.

II. LOCALIZATION PROCESS

A Localization algorithm localizes sensor node based on input data.If there is any anchor node available then most commonly used input is the location of anchors. Other inputs include information of connectivity for range free techniques like distance or angle between nodes for range based techniques.



Generally localization of sensor nodes can be made in 2D or 3D.

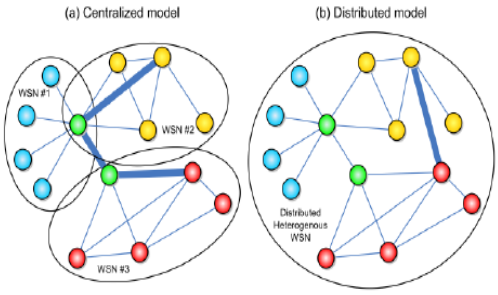
III. 2D LOCALIZATION METHODS

In 2D localization the location of nodes are described in (x, y) co-ordinates. The 2D localization methods are classified as follows

- Centralized Vs Distributed
- Anchor free Vs Anchor based
- Range free localization
- Range based localization
- Hybrid localization

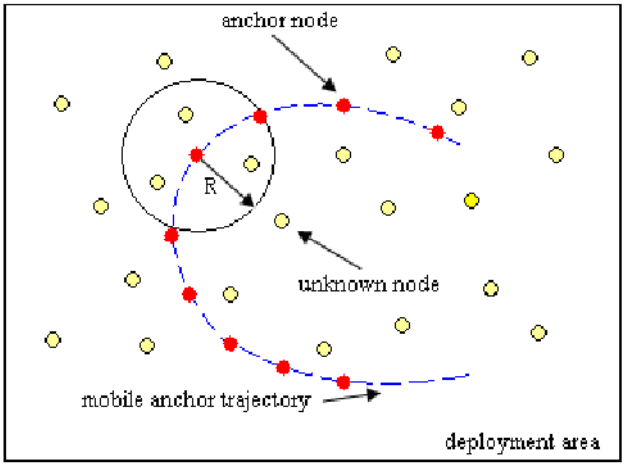
a. Centralized Vs Distributed:[3]

In centralized algorithm it is responsible for the central unit to compute the distance of other node.In distributed algorithm each node gathers information from its nearby nodes and compute its location locally.It introduces overhead in computation overheads.



b. Anchor Free Vs Anchor Based:[4]

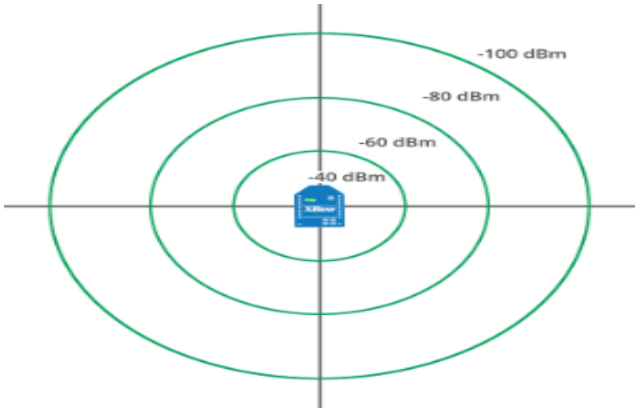
Some nodes use GPS in determining its location.These nodes are referred as anchor nodes whereas node that does not use GPS are called non anchor nodes.Here non anchor node determines its position from the location of anchor nodes.



c. Range Based Localization: [5,6]

It uses Received Signal Strength Indication(RSSI),Time Of Arrival (TOA).Angle Of Arrival.

RSSI It is used to calculate the distance between 2 nodes based on the power present in the signal received by the node.

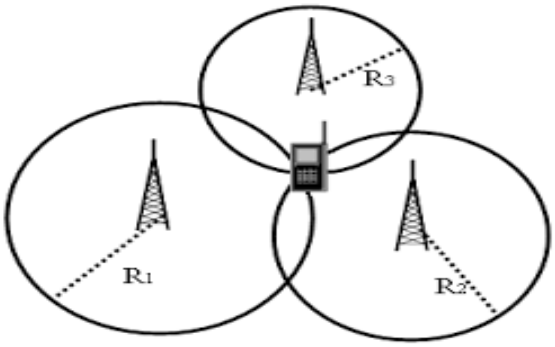


TOA Here distance is calculated using formula,

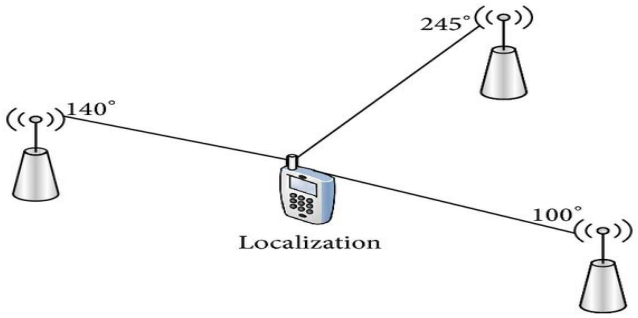
distance=speed*Time

where Time is the time taken by transmitted signal to reach the receiver.

speed is speed of signal at which it is transmitted.Speed is usually the speed of light.



AOA: Distance is calculated from the angle.The estimation of AOA's is done using directive antennas



d. Range Free Localization :[7,8]

It include methods such as centroid technique, gradient,APS.

- **Centroid technique:**
  Here each non anchor determines its position by measuring centre point where it receives anchor message from all the sources.Centroid techniques depend on a high density of messages so that every node can hear several messages.This algorithm is used to accurately determine the location of sensor nodes.
- **Gradient:**
  If error occurs due to an obstacle then the error occurred is called gradient.
- **APS**:
  Here at least 4 beacon nodes are used.The distance of unknown nodes is determined from these beacon nodes.

e. Hybrid Localization Algorithm:

It uses APS and multidimensional scaling.Multi-Dimensional scaling is used to depict data relevant to distance as geometric structure

Issues in 2D Localization :[9]

- In real world with 2D plane accurate position of a node can't be determined.In order to increase the accuracy 3D Localization algorithms were introduced
- 2D localization algorithms possess security issues.Though some 2D Localization is accurate they are subject to attacks.Hence it is necessaryto consider security and privacy issues of sensor nodes.

IV. 3D LOCALIZATION ALGORITHM :

3D Localization methods are given as follows:

- 3D distance vector routing
- Novel Centroid
- 3D ADAL
- 3D Accurate positioning system
- space distance intersection

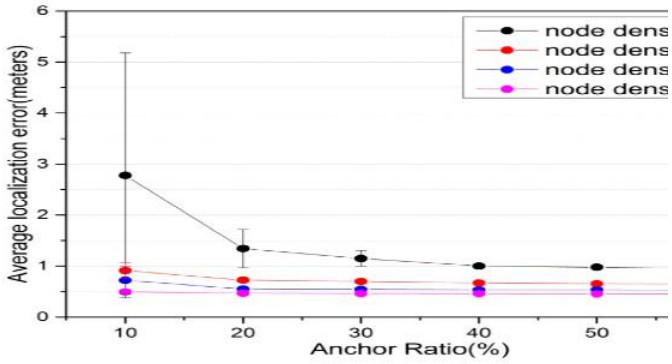
a. 3D Distance vector routing :[10]

Computing minimum hop count between unknown nodes and beacon nodes:

In this method mobile agent is used for localization.Here beacon nodes send mobile agent.The mobile agent records the beacon co-ordinates and minimum hop count between unknown node and beacon nodes.It selectsthose nodes with minimum hop count and discards all the others.

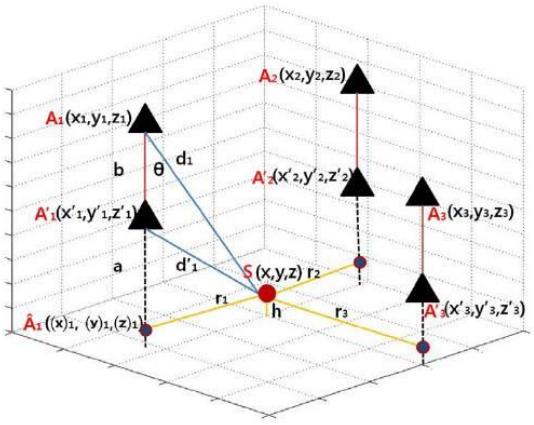
Calculate the per-hop average distance and measurement error:

In this method, the average per hop distance of beacon nodes is calculated and thereby the measurement error of beacon nodes can be done. Then this value is broadcasted to this entire network. All the nodes saves the average per-hop distance that it receives and forwards it to the other neighbor of nodes using this average per hop distance between the beacon node is determined.



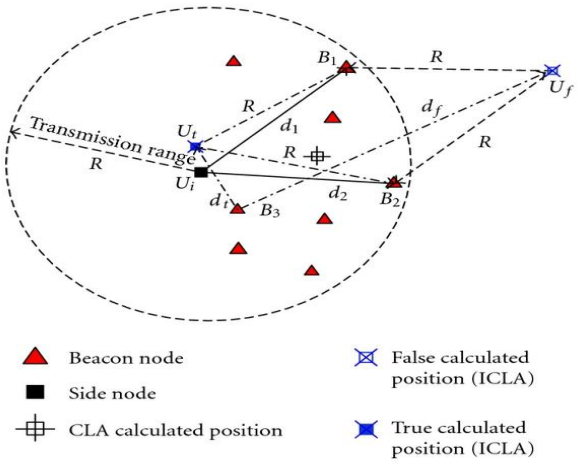
Calculating the average per hop distance of unknown node :

If distance vector routing algorithm is extended to the 3D space the unknown node will save only the first received average hop count of the beacon nodes so that information of most recent beacon nodes are used



b. Novel Centroid algorithm:[11]

Here, all the anchors send their position information to all the unknown nodes within their transmission range.The unknown node receives beacon signals from various anchors.It selects for anchor nodes in sequence to form tetrahedron. Then using the co-ordinates of tetrahedron barycenter(center of mass when unequal masses are placed at the vertices) is calculated.Then average barycenter is calculated.This is used as the final estimated position of unknown node.



c. 3D ADAL (Three dimensional Azimuthally defined Area Localization)

This algorithm makes use of mobile beacon.This algorithm uses two types of antenna

1. Omni directional antenna-used by unknown nodes.

2. Rotational and Tilting directional antenna-used by mobile beacon nodes.

The mobile beacon is in flight in the entire network and broadcast the beacon messages to the sensor nodes during localization.Co-ordinates will be considered to detect the position of sensor nodes.XY co-ordinates is used to detect the position while z-plane is used to detect the altitude.

This algorithm consists of following phases:

- **Initialization phase :**

  In this phase important parameters such as antenna are established.
- **Latitude and Longitude preliminary determination phase:**

  This is used to estimate the local position in the xy plane
- **Altitude determination phase :**

  This performs the calculation of altitudes of each sensor nodes. After determining the xy position it uses information of tilt in the data packet to determine its altitude.

d. **3D Accurate Positioning System:**[12]

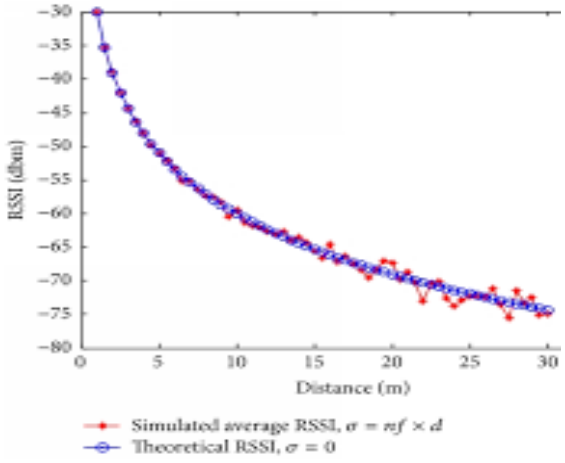
This algorithm makes use of parameters

- **Parameter matching :**

For providing maximum accuracy,any two nodes need rematching before positioning.

- **RSSI Ranging :**

It converts RSSI value to the distance between unknown and the beacon node



Role switching between beacon and the unknown node:

For 3D communication unknown node needs to communicateat least with 4 adjacent beacon nodes.If any one of the four beacon nodes is not present then unknown nodes that know its co-ordinate position can act as a beacon node for a short time. It also improves energy efficiency to reduce power consumption

e. **Space Distance Intersection:**[12]

This method provides two strategies

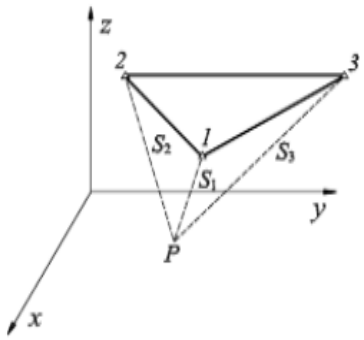
- **Beacon placement strategy :**

Here mobile beacon is used.Mobile Beacons knows their Location by GPS.It moves around the sensing area and broadcast localization beacons periodically.Each beacon contains the location of mobile beacons.The advantage of the such beacon placement mechanism is that it can provide rapid and effective localization signal coverage.

- **3D position derivation :**

Phase 1: Each sensor node measures set of distances to the mobile beacon which are necessary for the localization.Mobile beacon node submits UWB(ULTRA WIDE BAND)signals to the sensor nodes and these nodes measure distance using Time Of Arrival(TOA)

Phase 2: Each sensor nodes derive 3D position for itself for a certain algorithm based on node beacondistance measurement.



f. **Merits Of 3D Localization** :

2D localization uses fixed altitude whereas 3D localization algorithm makes use of real world measurements and hence it is highly accurate

V. COMPARISON TABLE OF 2D LOCALIZATION ALGORITHM IN WIRELESS SENSOR NETWORK

S.No	2D LOCALAIZATION ALGORITHMS	MERITS	DEMERITS
1	**RANGE BASED LOCALIZATION**	Accurate	Needs synchronization between sender and the receiver for some method such as TOA
2	**RANGE FREE LOCALIZATION**	Easy to implement and applicable to large networks	The position error is increased
3	**ANCHOR BASED**	High Accuracy	Needs Additional Hardware and hence high cost
4	**HYBRID LOCALIZATION**	Errors in particular positions are independent	High complexity and need more number of computations to determine the position of nodes.

VI. CONCLUSION

WSN have great deal of application. Through this paper, we have classified Localization techniques in WSN into 2D Localization and 3D Localization and Various algorithm regarding 2D and 3D Localization were discussed. Then a comparative study on various 2D algorithms was made. Localization algorithm must be scalable to very large network sizes without dramatically increasing energy consumptions and computational requirements. Methods suggested in this paper helps in selecting method according to requirement of application and it reduces deployment cost.

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