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A Survey on Localization

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Abstract—

For the best WSN scenario, the localization of nodes should be accurate. In this paper WSN and its components are explained and the whole localization concept is explained in detail. The three localization schemes RSSI, PSO and BBO are also explained theoretically.

Keywords: WSN, Sensors, Localization, Beacon node, Anchor node

I. INTRODUCTION

A WSN is a collection of thousands of sensor nodes that are spatially distributed to monitor environmental or physical conditions such as temperature, sound, pressure etc. and pass their data through networks that is being collected by a small number of data collection devices to a main location. Provide a bridge between real physical and virtual world.

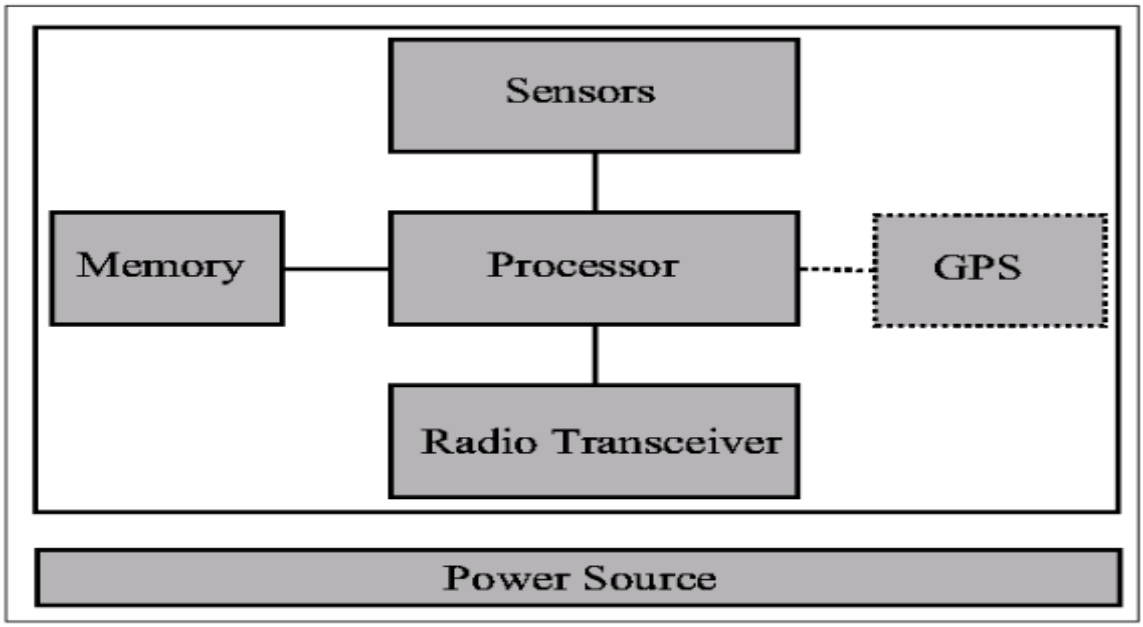


Fig.1 Components of WSN

A. Explanation of Components

1) *Sensor*: A sensor is a device that senses the nearby signals i.e input quantity by functionally generating electrical or optical signal as its output. Sensors consists of one or more microchips used to monitor an asset (or many assets) condition or health. Sensor nodes have specially designed microcontrollers built in them which control monitoring.

2) *GPS*: The Global Positioning System is a space-based satellite navigation system that works in all weather conditions and provides location and time information, anywhere on the Earth where there is an unobstructed line of sight to four or more GPS satellites. GPS services are useful to military, civil and commercial users around the world. United States government has maintained the GPS system which is freely accessible to anyone with a GPS receiver.

3) *Radio Transceiver*: A radio transceiver generates the radio waves and both sends and receives radio signals through antenna. The receiver and the transmitter should be used within the same device and same set of wires should be used. A user can perform a wide range of functions in a radio transceiver for both the receiver and broadcaster of signals on radio frequencies.

4) *Power Source*: Battery is used in WSN as an energy resource.

5) *Memory*: Different sizes of memory are available according to the size of WSN. To accomplish the WSN scenario all work must be stored in some space called memory. Having the process loaded into memory means you can get work done more quickly with less time spent waiting for the other devices to perform tasks.

6) *Processor*: A processor is a piece of hardware that controls the main functions of the WSN.

B. Application areas of WSN

WSN is being used in many application areas: Area monitoring as used in military, healthcare monitoring, air pollution monitoring, forest fire detection, landslide detection, water quality monitoring, natural disaster prevention, industrial monitoring, data logging, water monitoring, structural health monitoring.

When WSN's are deployed in hostile environments, many attacks happen e.g. Attacks on nodes (compromise, replication, impersonation, Sybil attack, wormhole attack) and attack on information (forgery, alternation, interference, replay, flooding and selective forwarding). As secure localization is an important aspect in WSN so, it is considered in two ways: SNA and SIV.

SNA: SNA is needed when an attacker attacks on nodes and it pretends to be an unknown node or anchor node (GPS attached) to disturb the localization process.

SIV: if the attacker attacks on information to be passed between nodes and it forges, modify localization information making the estimated positions incorrect. Therefore, the correctness of localization information can be detected by SIV.

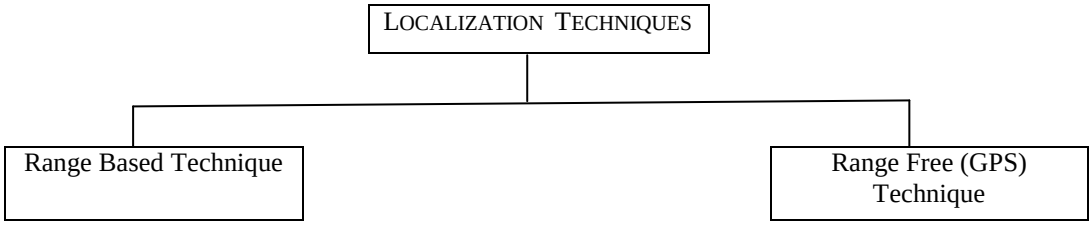
II. APPROACH TO LOCALIZATION

Localization means to determine location of nodes in a network. With the support of some model, a node can determine its location in the network by making a node to send signals periodically; the model can calculate the location of nodes. Basically there are two categories of sensor nodes: unknown node and anchor node. Unknown node is the node whose location is not known and can be located with the help of location coordinates of anchor node, whereas anchor node is the node whose location is known ad mostly GPS is attached with it.

Localization of nodes in WSN is most important to deploy the WSN scenario. Because without correct location of nodes no proper WSN scenario will be made and no results or no experiments can be carried out. As GPS is too expensive to be used with every node to be deployed in the WSN, so we use different localization methods to know the positions of unknown nodes with the help of anchor nodes which have GPS attached with them.

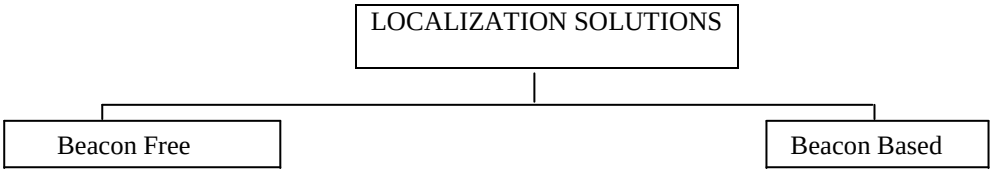
There are few parameters for the localization of nodes i.e higher accuracy of the nodes is required, the cost of nodes should be low, the power is necessary for computation purpose, all static nodes should be homogenous in nature and mobile nodes should have GPS attached to them.

A. Localization Techniques



1) Range based localization scheme rely on availability of ranging or angle information at the nodes. Sensor nodes are equipped with extra hardware capable of measuring distance or angle by mean of techniques such as TOA, TDOA, AOA or RSSI.

2) Range free techniques do not rely on range or angle information to calculate node position. In order to gather information about their position nodes are assisted by special network devices called beacons capable of providing accurate information about their own positions. Nodes with unknown position collect beacon information and estimate their coordinates by calculating the centroid of beacons and calculate node position by counting the number of hops from beacons.

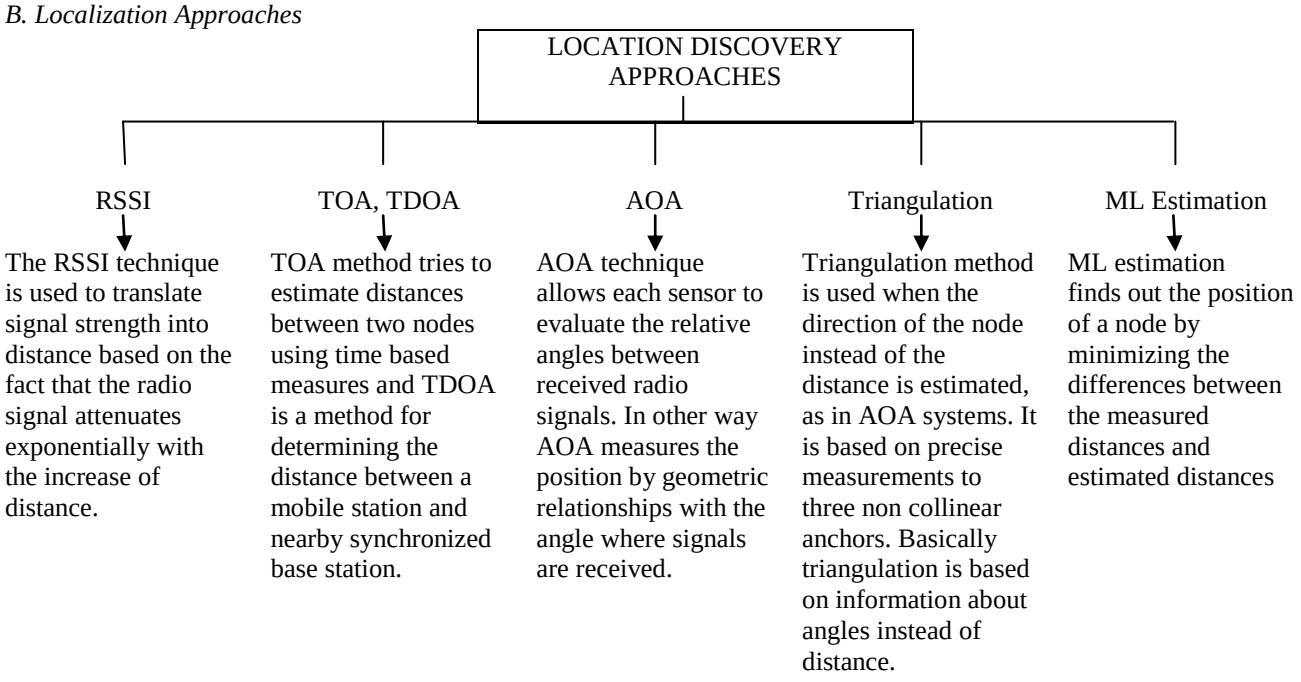


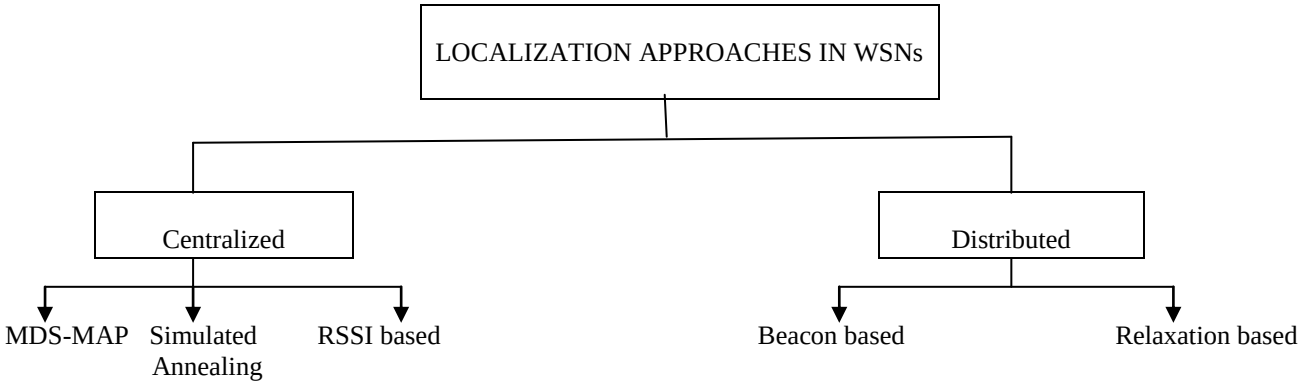
B. Localization solutions

1) Beacon Free solutions: Doherty proposes an algorithm in which the network is modeled as a system of equations representing proximity constraints between nodes and a central location (the beacon). The system is then solved by mean of optimization technique. A GPS free and infrastructure free solution is used to determine the final coordinate system.

2) Beacon Based solutions: Beacon are aware of their positions through GPS or via manual set up. Unknown nodes (sensor) that needs localization use ranging or proximity information from beacons in order to estimate their location by mean of a localization scheme

B. Localization Approaches





1) Centralized Localization: If an algorithm collects and executes the localization related data from one station only then it is called centralized. In centralized model the problem is that if computing server fails due to some problem then entire processing goes down. Scalability is another problem when we consider the centralized model for computation of our data. The three techniques of centralized localization are explained below:
(i) MDS-MAP: This scheme has an advantage that it does not need anchor or beacon nodes to start with. It builds a relative map of the nodes even without anchor nodes and next with three or more anchor nodes; the relative map is transformed into absolute coordinates. This method works well in situations with low ratios of anchor nodes. A drawback of MDS-MAP is that it requires global information of the network and centralized computation.
(ii) Localize node based on Simulated Annealing: This advantage of this algorithm is that it does not create error in localization. The proposed method is based on neighborhood information of nodes and it works well in a sensor network with medium to high node density. It is possible that a node is flipped if the node density is low and it still maintains the correct neighborhood. The proposed algorithm fails to identify the flipped node if this situation occurs.
(iii) RSSI based centralized localization technique: This scheme is practical, self organizing that allows addressing any outdoor environments .This scheme requires extensive generation and need to forward much information to the central unit consuming much power, which is the drawback of this technique.

2) Distributed Localization: If each node collects partial data and executes the algorithm then localization algorithm is distributed. The following are the techniques used under distributed localization:
*(i) Beacon-based distributed algorithms***:** Categorized into three parts:
*Diffusion***:** The most likely position of the node is at the centroid of its neighboring known nodes in diffusion. APIT requires a high ratio of beacons to nodes and longer range beacons to get a good position estimate. For low beacon this scheme will not give accurate results for low beacon density.
Bounding box: Bounding box forms a bounding region for each node and then tries to refine their positions. The collaborative multilateration enables sensor nodes to accurately estimate their locations by using known beacon locations

that are several hops away and distance measurements to neighboring nodes. At the same time it increases the computational cost also.
Gradient: In the presence of an obstacle if the error in hop count distances matrices occurs it is called gradient.
(ii) Relaxation-based distributed algorithms: The limitation of this approach is that the algorithm is susceptible to local minima.
*Coordinate system stitching based distributed algorithms***:** The advantage of this approach is that no global resources or communications are needed. The disadvantage is that convergence may take some time and that node with high mobility may be hard to cover.
*Hybrid localization algorithms***:** The limitation of this scheme is that it does not perform well when there are only few anchors. SHARP gives poor performance for anisotropic network.
*Interferometric ranging based localization***:** Larger set of measurement is required in this scheme which limits their solution to smaller network.

III. LOCALIZATION CONCEPT

Before applying any optimal localization algorithm we should be clear with the localization concept. In the sensing field, a single mobile anchor node moves randomly in all directions broadcasting beacon messages providing its current coordinate location. When the perpendicular bisector of a chord of a circle passes through the centre of the circle, the locations of the individual sensor nodes can be determined. Once three beacon points have been constructed the sensor nodes determines its location by calculating the intersection point of the two perpendicular bisectors of the chords. Accuracy of the localization result depends on the length of the chords. Length of each chord should exceed a certain threshold in order to minimize the localization error [3].
The circle shown in the figure is the area of WSN, the lines are the chords formed, the small circle at the centre of the circle is sensor node and the three small circles that are shown on the boundary of circle are beacon nodes.

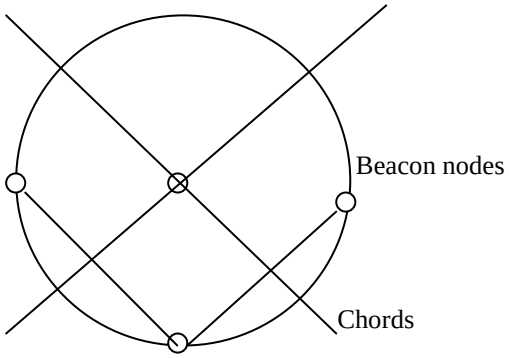


Fig.2 Localization Concept

A. Obstacle Resistant Path
The link between the anchor node and the sensor node is by radio connectivity which can be obstructed if an obstacle appears in the sensing field. Enhanced beacon point selection mechanism handles the obstacle problem. The path of the anchor node can be blocked by the obstacle. Thus, sensor nodes may not receive enough beacon points for estimating their positions. If the beacon (anchor) node which is moving along the proposed path finds an obstacle, the beacon node detour around the obstacle towards right –hand direction. After detouring, the beacon node returns to the original proposed path.
Once the anchor node contacts with the obstacle within a beacon distance, the anchor ode broadcasts the beacon messages with a detour flag to notify sensor nodes of detouring around the obstacle. If the anchor moves away from the obstacle, the anchor node starts broadcasting the normal beacon messages again [3].

IV. LOCALIZATION TECHNIQUES

A. RSSI Localization Technique
Measurement of the received signal strength indicator (RSSI) parameter is used for distance determination between sensor nodes. The measurement of the received signal strength (RSS) offers a possibility to determine distance with minimal effort. The strength of the RSSI signal can be known by the power level being received by the antenna. The higher the RSSI level is the stronger the signal. In small wireless devices RSSI do not use hardware devices and exhibits favorable properties with respect to power consumption, size and cost. RSSI can be used internally in a wireless networking card to determine when the amount of radio energy in the channel is below a certain threshold at which point the network card is clear to send (CTS). A packet of information can be sent.
One possibility to acquire a distance is me assuring the received signal strength of the incoming radio signal. In RSSI the configured transmission power at the transmitting device (Pt) directly affects the receiving power at the receiving device

(Pr). According to Friis' free space transmission equation, the detected signal strength decreases quadratically (n is usually two) with the distance to the sender.

B. Particle Swarm Optimization

Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by Dr. Eberhart (electrical engineer) and Dr. Kennedy (social psychologist) in 1995, inspired by social behavior of bird flocking based or fish schooling on the movement of intelligence of swarms. A number of agents which constitute a swarm move around in the search space looking for the best solution.

Each particle follows its coordinates in the solution space which are associated with the best solution that has achieved so far by that particle. This value is called, pbest. Another best value i.e. gbest is tracked by the PSO, which is obtained so far by any particle in the neighborhood of that particle. Accelerating each particle toward its pbest and the gbest locations is the basic concept of PSO, with a random weighted acceleration at each time step as shown in Fig.3

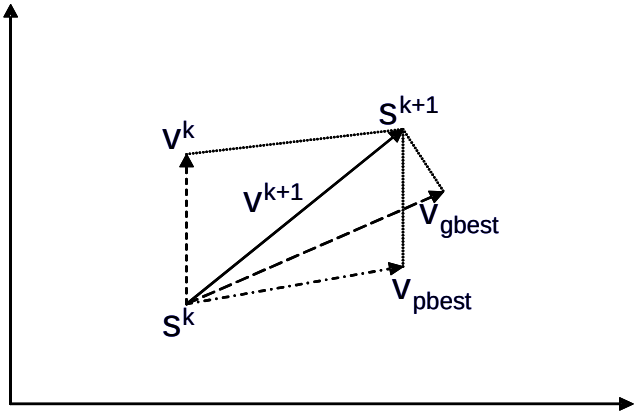


Fig.3 Concept of modification of a searching point by PSO

s^k: current searching point
s^{k+1}: modified searching point
v^k: current velocity
v^{k+1}: modified velocity
v_{pbest} : velocity based on pbest
v_{gbest} : velocity based on gbest

Algorithm for PSO:

1) Initialize positions and velocity vectors of the particles randomly.
2) For each particle's position (p) evaluate fitness.
3) If fitness (p) better than fitness (pbest) then pbest = p.
4) Set best of pbest as gbest.
5) Update particles velocity and velocity.
6) Loop until all particles exhaust and you get max iter
7) Stop running the loop when you get gbest, optimal solution.

C. Biogeography based Optimization

BBO is a population based global optimization technique developed on the basis of the science of biogeography, i.e., study of the distribution of animals and plants among different habitats over time and space [1]. The techniques like Ant Colony Optimization, Particle Swarm Optimization, Genetic Algorithm and Simulated Annealing etc gives results not as good as BBO technique.

In BBO one node passes the data to another node i.e. the beacon messages and they pass through the sensing field so that the sensor nodes can find out their location. In this we consider HSI (High Habitat Suitability Index) value. Islands that are friendly to life are said to have high HSI. Factors such as rainfall, diversity of vegetation, diversity of topographic features, land area and temperature are responsible for high HIS value.

The various migration variants of BBO are:

1) Immigration refusal: Immigration is the arrival of new species into a habitat while emigration is the act of leaving one's native region. In BBO, if a habitat has a high emigration rate, the probability of emigrating to other habitats is high and probability of immigration from other habitat is low.

2) Blended Migration: this operator is a generalization of the standard BBO migration operator and inspired by blended crossover in GA's [1].

3) Enhanced Biogeography based Optimization: Standard BBO migration operator creates the duplicate solution which decreases the diversity of algorithm. To prevent diversity decrease in population, duplicate habitats are replaced with randomly generated habitats.

Algorithm for BBO:

1) N Target nodes, M Anchor nodes are randomly distributed in 2-D sensor field.
2) Anchor nodes compute their location awareness and transmit their coordinates.
3) Mean of co-ordinates of anchors is evaluated.
4) Randomly deploy some nodes around mean.
5) Evaluate actual distances, objective functions.
6) Optimization algorithms search to get best solution.
7) Average localization error is evaluated.

IV. CoN CLUSION

The various localization techniques which are explained in this paper are different from each other in their behavior and methods. The algorithms of PSO and BBO technique are also presented in this paper. Many more techniques of localization are being used now days including techniques of artificial intelligence also to locate the position of nodes accurately in WSN. Although these techniques vary from each other but users use different techniques according to their own convenience.

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