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Localization in Wireless Sensor Networks

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***Abstract*—Localization has become one of the mandatory services in wireless sensor networks (WSNs) while dealing with critical operations such as coverage, deployment, routing, target tracking and rescue operations. Since the necessity of WSN has increased drastically to provide best solution with accurate results of sensor nodes, it mainly depends on the WSN node localization. This paper provides an overview of different approach of node localization discovery in wireless sensor networks. A survey on various aspects or techniques of localization like localization error, parameters of localization, accuracy, bit error probability, energy consumption has been studied. Various overviews of the schemes proposed by different authors for the improvement of localization in wireless sensor networks are also highlighted.**

***Index Terms*—DV-Hop, Error Correction, MATLAB, Sensor Nodes, Localization, Wireless Sensor Networks (WSN)**

I. INTRODUCTION

INTRODUCTION TO WSN

A **wireless sensor network (WSN)** is basically a distributed sensor network to monitor the physical or environmental conditions, which includes the parameters such as sound, temperature, pressure, etc. and accordingly pass their data to a main location through the network. The more modern networks are bi-directional, which enables control of sensor activities. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; now days these networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and many more.

The WSN is a web of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors i.e. refer to as a network of nodes. Each sensor network node has consists of several parts such as a radio transceiver indulged with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit used for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. The size of the sensor node might vary from that of a shoebox to the size of a grain of dust, although the functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes varies according to its size and its complexity i.e. ranging from a few to hundreds of dollars, of the individual sensor node. Factors like size and cost constraints on sensor nodes result in corresponding constraints on resources such as communication bandwidth, memory, energy and computational speed. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network configuration. The propagation technique between the hops of the network can be flooding or routing. [1][2]

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II. CHALLENGES OF WIRELESS SENSOR NETWORK

In spite of the diverse applications, sensor networks pose a number of unique technical challenges due to the following factors:

1. **Ad hoc deployment**: Various sensor nodes are deployed in regions which have no infrastructure at all. A typical way of deployment of node in a forest would be tossing the sensor nodes from an aero-plane. In such a situation, it is up to the nodes to identify its distribution and connectivity.

2. **Unattended operation**: In most cases, once deployment takes place, sensor networks have no human intervention. Hence the nodes themselves are responsible for its reconfiguration in case of any changes takes place.

3. **Untethered:** There is only a finite source of energy present, which must be optimally used for processing and communication i.e. the sensor nodes are not connected to any energy source. An interesting fact is that communication dominates processing in energy consumption. Thus, in order to make efficient use of energy, communication should be minimized as much as possible.

4. **Dynamic changes**: It is necessary that a sensor network system be adaptable to changing connectivity (for e.g., due to addition of more nodes, failure of nodes etc.) and also in changing environmental conditions.

Thus, unlike traditional networks, where the focus is mainly on maximizing channel throughput or minimizing node deployment, the major consideration needed in a sensor network is to extend the system lifetime and its robustness [4].

III. LOCALIZATION

Localization means to find location of nodes in a network. With the support of some infrastructure, a node can discover its position in the network by extracting information received

from the infrastructure; also, by making a node to send signals at intervals, the infrastructure can calculate the location of the nodes. Localization is the method of finding the position of nodes as data and information are unusable if the nodes have no idea of their geographical positions. GPS (global positioning system) is the simplex method for localization of nodes, but it becomes very expensive if many nodes exist in a given network. Unlocalized nodes approximate their positions from anchor nodes beacon messages, which requires much power. Many algorithms have been proposed to reduce this communication cost. If one node estimates its wrong location, then this error propagates to overall network and further nodes; consequently, wrong information of anchor nodes location is propagated. To determine the position of nodes is mainly depending on distance between anchor node (with known location) and unlocalized node (with unknown location). Sensor nodes are employed in industrial, environmental, military, and civil applications.

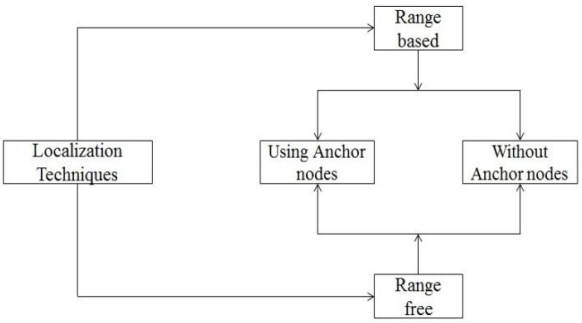

Fig.1: Categorizing Localization Techniques

IV. CONCEPT AND PROPERTIES OF LOCALIZATION

Localization of a sensor node is implemented with the help of neighboring nodes. Several localization techniques are discussed in the paper Fig.1 illustrates the various techniques or methods used to identify the location of nodes.

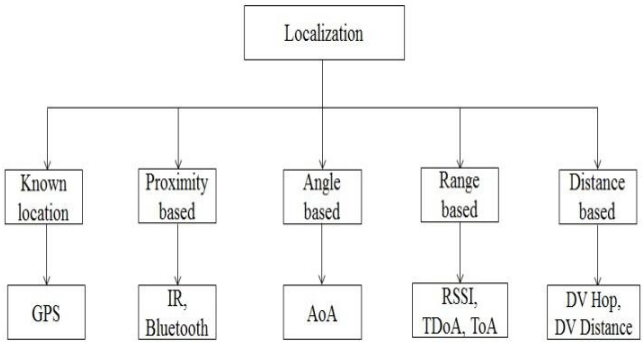

Fig.2: Overview of Localization

The localization can be categorized as known location based localization, proximity based localization, angle based localization, range & distance based localization. In fig.2 the range and distance based localization are categorized individually, though both are same. For range based localization, special hardware is required to find out the range; however it is not required for distance based localization.

1. Known location based localization: In this kind of localization the senor nodes recognize their location in prior. This is done either by manually configuring or utilizing a GPS [8 - 12] device. Manual configuration of the sensor node is done with the help of GPS. The GPS devices are more effective when there are no referral nodes available to get localized. It has a good accuracy with a standard deviation of 4 to 10 meters.

2. Proximity based localization: In this kind of localization the WSN is divided into several clusters. Each cluster has a cluster head that has a GPS device. By use of Infrared (IR), Bluetooth, et al. the nodes find out the nearness or proximity location.

3. Angle based localization: Angle based localization utilizes the received signals angle or Angle of Arrival [14 - 16] to identify the distance. This method necessitate special antenna's that are expensive. Because of this reason AOA is mostly used in Base Station's (BS).D. Range based localization this localization is implemented based on the range. The range is calculated using the Received Signal Strength (RSS) or Time of Arrival (ToA) and Time Difference of Arrival (TDoA) [13, 20]. In RSSI based localization the receiver sends the signal strength regarding the sender, and sender calculates the distance based on the signal strength. ToA and TDoA utilize timing to calculate the range. Time synchronization is an important factor when using ToA and TDoA.

4. Distance based localization: Distance based localization method uses hop distance with each node to localize the node. It uses DV-hop propagation approach or DV-distance propagation method for localization.

V. PARAMETERS FOR LOCALIZATION

For the different ways of approximating location information, we have to name parameters to distinguish the similarities and differences amongst different approaches. In this section we present the most typical parameters to classify different techniques.

1. Accuracy: Accuracy is very essential in the localization of wireless sensor network. Higher accuracy is typically required in military installations, just as sensor network

deployed for intrusion detection. However, for commercial networks which may use localization to convey advertisements from neighboring shops, the required accuracy may not be lower.

2. Cost: Cost is a very challenging affair in the localization of wireless sensor network. There are very few algorithms which give low price but those algorithms don't give the high rate of accuracy.

3. Power: Power is essential for computation purpose. Power play a major role in wireless sensor network as each sensor device has limited power. Power supplied by battery.

4. Static Nodes: All static sensor nodes are analogous in nature. This means that, all the nodes have identical sensing ability, estimating ability, and the ability to communicate .We also suppose that, the initial battery powers of the nodes are identical at deployment.

5. Mobile Nodes: It is supposed that a few number of GPS enabled mobile nodes are part of the sensor network. These nodes are homogeneous in nature. But, are presumed to have more battery power as compared to the static nodes and do not drain out completely during the localization procedure. The communication range of mobile sensor nodes are assumed not to change drastically during the whole localization algorithm runtime and also not to change significantly within the reception of four beacon messages by a particular static node.

VI. LITERATURE SURVEY

Time Period of Research Work:

From (2003 - 2015), the author has proposed various research papers which can be briefly explained below:

Zou, Yi, and KrishnenduChakrabarty (2003):[5] Authors proposed that, Wireless sensor node localization is one of the most crucial techniques on wireless sensor network. We propose an improved wireless sensor network DV-Hop localization algorithm, for reducing localization cost and improving localization accuracy. The mobile beacon node is introduced into DV-Hop which allows a moving beacon node to move on the pre-arranged way, simultaneously broadcast its position information to form multiple virtual beacons. The results by simulation experiment, shows our method can reduce the localization cost and the complexity of network while improving the node localization accuracy and its efficiency.

Chatterjee (2010):[6] Authors proposed that, Sensor node localization is the basis for the entire wireless sensor networks. Because of restricted energy of the sensor nodes, costs of communication, the location error and computation should be considered in localization algorithms. In the isotropic dense network, DV-Hop can achieve position more precisely, but in the random distribution network, the node location error is high. DV-Hop localization algorithm is a typical positioning algorithm that has nothing to do with distance. This paper summed up the main causes of error based on the analysis on the process of the DV-Hop algorithm, pointing at the impact to the location error which is brought by the anchor nodes of different quantity and different position, a novel localization algorithm called NDV- Hop Bon (New DV-Hop based on optimal nodes) was put forward, and it was simulated on Matlab.

C.Wang,J.ChenandY.Sun (2010):[7] Authors proposed that, In Wireless Sensor Networks (WSNs) a multitude of location-dependent applications have been recently proposed, which is very intriguing for researchers to discover and design more cost-effective and accurate localization algorithms. For anisotropic networks, the Euclidean distance between a pair of nodes may not correlate closely by the hop count between them because the corresponding shortest path may have to curve around intermediate holes, thus resulting in poor distance estimation. And without the help of a large number of uniformly deployed seed nodes, these schemes fail in anisotropic WSNs. To address this issue and improve the accuracy of localization, we propose the (RHCP) Removing Heavily Curved Path scheme in this paper. RHCP takes advantage of selecting the path and recalculate the location of each unknown node. Through simulation, results revealed that RHCP performs much better than original DV-Hop networks with different shape of holes. In addition, by calculating iterations of RHCP, the results get improved for different anchor node densities.

X. Bao, F. Bao, S. Zhang, L. Liu (2010):[8] Authors proposed that, Localization is an indispensable part in wireless sensor networks. In consideration of its importance, extensive research has been carried out in recent years. On account of the process that DV-Hop algorithm deals in anisotropic sensor networks density, there can be a big localization error in local area, where the information transfer has excess hop counts between the two nodes. A measure is proposed, that can eliminate the distorted hops by setting its threshold value; to solve the problem relating the

distance accumulated error, we proposed an RSSI based calculation method i.e. hop count, that can accurately reflect the distance between adjacent nodes, and therefore the location error can be minimized for the original DV- Hop algorithm. The simulation shows that the localization accuracy of the improved algorithm is far better than the original algorithm.

Hu Yu, Li Xuemei (2012):[9] Authors proposed that, wireless sensor networks self-positioning classical algorithm DV-Hop (distance vector-hop) algorithm, then analyse its shortcomings. Finally, a new improved algorithm is imposed and the Matlab simulation verified the situation after the positioning accuracy. After the analysis of experimental data, it was declared that the improved algorithm errors are smaller than the original algorithm, and hence more precise positioning.

Zhenxing Luo and Paul S. Min and Shu-Jun Liu (2013-I):[10] This paper describes a novel energy-based target localization method in wireless sensor networks with selected sensors. In this technique, sensors use Turbo Product Code (TPC) to transmit decisions to the fusion center. TPC can reduce bit error probability if a communication channel error occurs. Moreover, in this method, thresholds for the energy-based target localization are created using a heuristic method. This design method to find thresholds is suitable for uniformly distributed sensors and normally distributed targets. Moreover, to save sensor energy, a sensor selection method is also presented. Simulation results displayed that if sensors used TPC instead of Hamming code to transmit decisions to the fusion center, localization performance could be enhanced. Furthermore, the sensor selection method used can substantially minimize energy consumption for our target localization method. At the same time, this target localization method with selected sensors also gives satisfactory localization performance.

Biljana Risteska Stojkoska (2014):[11] In the recent years, there has been a vast advancement in wireless sensor computing technology. Today, wireless sensor network (WSN) has become a key technology for unlike types of smart environment. Nodes localization in WSN has arisen as a very demanding problem in the research community. Most of the applications for WSN are not useful without a priory known nodes positions. Appending GPS receivers to each node is an expensive solution and inapplicable for indoor environments. In this paper, we executed and evaluated an algorithm based on multidimensional scaling (MDS) technique for three dimensional (3D) nodes localization in Wireless Sensor Networks using improved heuristic method for distance calculation. Implementing extensive simulations we investigated our approach concerning various network parameters. We compared the results from the simulations with different approaches for 3D WSN localization and showed that our approach outperforms other techniques in terms of accuracy.

Xu Chun-Xia and Chen Ji-Yu (2015):[12] To solve the incorrect node localization in WSN, this paper first analyzes the problems in current DV-HOP algorithm, takes the received signal RSS as a referral standard through the weighted centroid algorithm, effectively reduces the localization errors and adopts the enhanced two dimensional hyperbola algorithm in the distance estimation to make the estimated distance more precise. The simulation results show that presented algorithm has been significantly improved compared to the algorithms in literature & enhanced the localization accuracy to a certain extent.

VII. TABLE

SR NO.	NAME	YEAR	TECHNIQUE	MERITS
1.	Zou, Yi, and Krishnendu Chakrabarty	2003	Mobile Beacon node is introduced into DV-HOP	Reduce the localization cost. Reduced the complexity of the network. Improved node localization Accuracy Efficiency Increased
2.	Chatterjee	2010	NDV-Hop Bon i.e. New DV-Hop Based on Optimal nodes	Reduced the location error in the random distributed network
3.	C.Wang,J.ChenandY.Sun	2010	RHCP (Removing Heavily Curved Path Scheme)	Selecting the path & recalculate the location of each unknown node. Better Performance

		June		with different shape of holes. Improved results for different Anchor node densities.
4.	X. Bao, F. Bao, S. Zhang, L. Liu	2010 sept	Improved DV-HOP Algorithm (RSSI based calculation method i.e. Hop Count)	Accurately reflect the distance between adjacent nodes. Location Error minimized. Accuracy Improved.
5.	Hu Yu, Li Xuemei	2012	Improved DV-HOP Localization Algorithm	Positioning Accuracy, Errors Reduced, MATLAB Simulation
6.	Zhenxing Luo and Paul S. Min and Shu-Jun Liu	2013	A novel energy-based target localization method	Reduce bit error probability, localization performance could be improved, reduce energy consumption for our target localization Method provides satisfactory localization performance.
7.	Biljana Risteska Stojkoska	2014	algorithm based on multidimensional scaling (MDS) technique	This approach outperforms other techniques in terms of accuracy
8.	Xu Chun-Xia and Chen Ji-Yu	2015	Improved DV-HOP Localization Algorithm	Enhanced localization accuracy to a certain extent

VIII. Conclusion

We have analyzed the various traditional and latest techniques that have been either proposed or implemented for localization techniques in WSN. Selection of the best technique for a particular application is always a challenging task owing to varying parameters of localization, localization error, accuracy, bit error probability, energy consumption etc. Hence a good judgment is required to select a suitable method depending on the project in hand. This paper can prove handy for aiding in proper selection of technique to be used as per the specifications of problem in hand.

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