

RSSI based Localization Scheme in Wireless Sensor Networks: A Survey

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Abstract— Now a days, Wireless Sensor Networks (WSNs) are most growing research area because of its low cost, infrastructure less, increase capabilities of nodes, real time and accurate. Localization is a major issue in the wireless sensor networks because it has a number of sensor nodes which are deployed at positions and they may not be fixed at their own position. In localization different techniques are used for distance and position estimation. In this paper we will focus on RSSI based localization in WSN which will show how to reduce location errors and improve accuracy by using various models and techniques. After that we will focus on how to make an algorithm scalable and improve the energy efficiency by providing authentication and key management.

Keywords-Wireless Sensor Network, Localization, Range based and Range free Techniques, RSSI.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) is significant current attention research subject in the world wide area [1]. It is a collection of distributed autonomous devices for monitoring physical or environmental conditions through sensors. Sensor nodes play a vital role in physical environment for sensing.

In real world applications, WSN is widely used and provide tremendous facilities in deployed surroundings such as environmental monitoring, health monitoring, site security, home automation, military applications, assisted living, etc.[1][2][3][4] It is composed of huge numbers of sensor nodes and consist a four constituents, that are: transmission element, processing element, power element and sensing element. In hostile environment when WSN is deployed it is vulnerable to threats and risks. Many attacks like sinkhole attack, wormhole attack, Sybil attack, etc. make the estimated positions incorrect [5]. Many secure techniques are used in WSN such as geographical routing, geographic key distribution, location based authentication, etc. In WSNs, there are various network services such as time synchronization, coverage, compression, security, localization and data aggregation; this paper mainly focus on RSSI based localization . WSN has self-configuration and self-optimization capabilities [6] [7]. There are enormous numbers of sensor nodes used for deployment and all nodes are coupled with each other. For long term applications development in WSN many issues have be noticed due to some constraints such as limited computational, energy resources, communications, etc. [8]

In WSN, localization [8] [9] is a critical activity and major issue since it is not aware about position of its sensor node. It is one of the most important network service in WSN because of reporting data geographically meaningful and also it increase network's lifetime. In recent days, it is very demanding approach for target tracking, localization based routing, etc. This survey paper aims to provide various RSSI based localization schemes for wireless sensor networks in an indoor and an outdoor environment.

The paper is organized as follows. Section II describes the background of localization, section III shows the different localization schemes, section IV presents related work and section V describes conclusion and future scope is presented.

II. BACKGROUND OF LOCALIZATION

Localization is an important when it determines the exact location of fixed or movable nodes or devices in wireless environments. Localization is motivated by military applications such as battlefield surveillance. In localization, there are various algorithms and techniques that have been proposed for a localize node [11]. Mainly localization uses two types of nodes namely anchor node or beacon node and target node or unknown node [9] [10]. Beacon node knows its own positions where as name suggests as target node is aware of its position in an environment.

Localization is broadly classified into two main categories: Target based or Source based localization and another is Self-Node localization. In target based localization, single or multiple nodes are used for binary decisions during measurement. And self-node localization is used for distance estimation through geometric principles.

Several key issues [10] [11] [12] in localization are as follows:

- Limited resources.
- Accuracy is important for positioning.
- Node mobility is required for error reduction.
- Cost is high when using hardware components.
- Power is more required when batteries are used.
- Security is necessary for nodes in Personal Networks.
- Complexity of hardware or software devices.
- Range of coverage
- Scalability is required for large system applications.

III. LOCALIZATION SCHEMES

Localization is the process of discovering the position of all sensor nodes within a sensor network. The link between sensed value and the location of the source data is necessarily fundamental and important motivation for localization [13]. Localization scheme is generally categorized into two parts are: Range-based localization scheme and Range-free localization scheme. Figure. 1 shows the localization scheme.

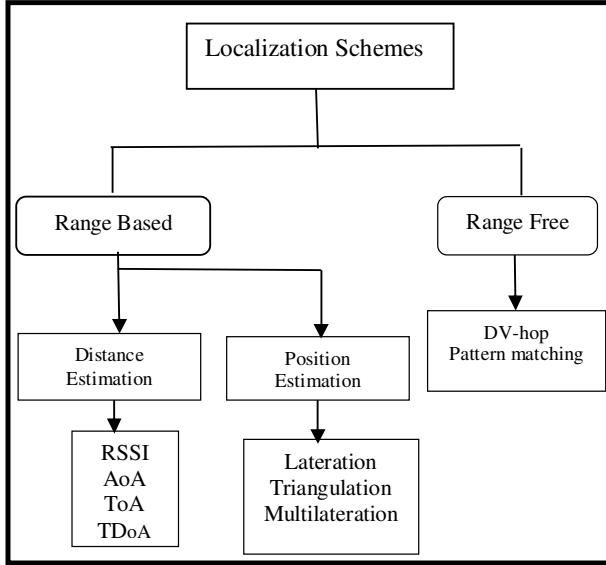


Figure. 1 Localization Scheme

Range-based localization scheme is used to measure the distance or angle between anchor node and unknown node in a fixed area whereas, Range-free localization scheme is used to measure the distance or position between unknown nodes. Range-based localization scheme estimate the distance between the unknown node and the reference node and in range-free localization scheme estimate the location of unknown node without determining the distance. It has no prior knowledge about the node. Range-based scheme is further divided into two distance estimation RSSI, ToA, AoA, TDoA techniques are used. Whereas, in position estimation lateration, triangulation and multilateration techniques are used [2] [14]. For the range-free scheme there is DV-Hop and pattern matching method are used such as fingerprinting [10] [15]. Localization is very important in many real time applications. Various techniques of Range based localization are as follows:

1. Received Signal Strength Indicator (RSSI)

RSSI is a Radio- Frequency term which is mainly used for distance measurement between transmitter and receiver. It is most popular technique for indoor and outdoor environment for improve accuracy. It is most suitable for WSN due to low cost, low power consumption, simple hardware, etc. RSSI achieves high accuracy in short distance.

2. Time of Arrival (ToA)

It is mainly measure the distance between anchor node and target node and also proportional to the

propagation time of signal. It requires high precision timing and synchronization.

3. Time Difference of Arrival (TDoA)

The implementation of technique depends on the measurement of time of arrival (ToA). It measure the transmitter's signal at a number of receiver.

4. Angle of Arrival (AoA)

In this technique each sensor allow to evaluate the relative angles between received radio signals. It required antenna and complex hardware.

RSSI based technique is more suitable estimate position due to its nature and low cost, low power consumption. Other techniques required hardware and also complex. For position estimation multilateration technique is more required than other techniques because it performs the better result than other. Various techniques are used for position estimation are as follows:

i. Lateration

It consist of three non-collinear anchors for precise measurement. In this, position is estimated by non-collinear anchor nodes and location is estimated using calculated values.

ii. Triangulation

Technique is based on information about angles rather than distances. It is also called as angulation. It is used for position computation.

iii. Multilateration

The multilateration technique is used more than three anchor nodes. It is a simple range based technique based on geometry principles. It provides better performance than other techniques and widely used for indoor environment.

Table 1 shows the different distance measurement techniques.

Table 1 Different measurement techniques

Type of measurement		Accuracy	Overhead
Distance	RSSI	Low	Low
	ToA	High	Low
	TDoA	High	Low
	AoA	Low	Low

IV. RELATED WORK

In localization scheme various algorithms and models are used with different techniques are used for distance and position estimation and also improves the localization errors in an indoor and outdoor environment. In this survey paper we will focus on RSSI based localization.

Jiuqiang Xu et al [3] proposed RSSI based distance measurement model using LNSM propagation model. For the improvement of self-adaptability of the model, a new improved log normal shadowing model is proposed with the use of LS method to estimate the coefficients. LNSM-DV can be applied in different environments. For the further positioning research LS needs to collect a large number of sample data to estimate the coefficients in LNSM-DV. It performs the better accuracy and improve self-adaptability.

Ndeye Amy Deieng el at [6] proposed a Two-mode Gaussian Mixture Model for detect and filter outlier patterns. The trilateration and biased-maximum likelihood (B-MLE) method identify any abnormal landmark. GMM method improves the significant localization errors in an indoor environment. It is also potentially tool for performing selection and identify online the operational scenario.

Ndubueze Chuku el at [8] proposed a simple spatial correction mechanism and apply it to select a random subset of a large number, if beacons signals to perform multilateration technique. The scheme applies a clusterization technique to select the location which is in agreement with the maximum number of individual multilateration. The proposed scheme uses multilateration technique by using all beacon signals together for varying number of obstacles and reduce the localization errors in an obstacle network.

Z.Mary Livinsa el at [11] proposed the RSSI based localization algorithm for distance estimation and position estimation for reduce the localization error. In distance estimation, path loss model is used for the received signal strength power and 3 anchor nodes are used for the position estimation with trilateration method to reduce the localization error by using linear equation. Finally, outdoor environment has a better result than the indoor environment. If the anchor node's density will be increase than reduce the localization error.

Attila Buchman el at [15] proposed localization method to achieve a room level accuracy. Path loss model is used for distance measurement and fingerprinting method is used to map room level accurate indoor localization with method filtering in WLAN infrastructure. Actual results are promising so, more testing are required in different indoor environments.

K.Vadivukkarsi el at [16] proposed an approach for reduce an error in localization. When using modified log normal shadowing model with linear curve reduce an error in indoor environment. For position estimation maximum likelihood estimation method is used and it reduce position error using improved RSSI method.

Omotayo G. Adewumi el at [17] proposed, the theoretical and empirical models are used to translate loss into a distance estimate and received signal power is inversely converted into distance. The distance between the two sensors nodes in the same range increase at that time receive signal strength is reduces. The mean estimated distance error is 0.9753 meters for indoor environment and 0.8831 for outdoor environment.

Safa Hamdoun el at [18] proposed RSSI-based indoor localization by using multiple antennas for better performance. In this paper, trilateration as well as mulilateration algorithms are used with different system models for relative comparision of position accuracy. The accuracy of single antenna system is improved than the multiple antennas. Also, multilateration algorithm is better than the trilateration algorithm.

Yiping chen el at [19] proposed the patient position estimation by using a moving object localization algorithm for localization accuracy. By using LNSM model measure the distance between anchor node and patient in the indoor environment. In this, if a large

number of anchor nodes are increases than the accuracy of localization node increase.

Long XIAO el at [20] proposed a new method based on off-the-shelf RFID technology by using low-complexity Gaussian filter and Bayesian interface to improve localization accuracy. In large scale indoor positioning the propagation parameters are changed according to the environment at that time localization errors are reduce and improves the positioning accuracy. The performance of system improves by increasing the value of recursion time, path loss exponent, window size and the low propagation standard deviation. It improves the accuracy of system and cost-effective for indoor environment.

Mengmeng Gai el at [21] proposed a novel approach for indoor localization. Strew vision technology is used for distance measurement in this paper and BIM is used for 3D spatial information for localization in an environment. The objects are roaming in different connected regions and recording their position at different points of time for that reason the proposed scheme is useful in real-world applications. For the future it needs better complete are coverage for sensors while minimizing false positives and it can be achieved by using fault tolerance technique. Also, it needs to increase the accuracy and speed of localization by using better equipment.

LAN Yun el at [22] proposed a new SSKM for reduce the high probability of keys, prevent attacks and reduce the energy consumption. The SSKM uses the different stages for sharing secret keys. Using network key and cluster key generates a new keys form various polynomials by Lagrange interpolation formula. The proposed scheme reduce the energy consumption as well as the proposed scheme enhance the security level.

BAI Si-qi- el at [23] proposed an accurate path loss exponent correcting algorithm for the ignoring the noise in log normal shadowing model. To achieve an accurate position in an environment between an anchor node and the target node through dynamically correcting the value of PLE with maximum likelihood estimation algorithm. Also, an algorithm has good environmental adaptability.

Gaurish M-Edake el at [24] proposed a node authentication and key distribution protocol for reducing communication overhead in node re-authentication method. The proposed protocol contains five stages are respectively neighbor discover, sink-to-sink relationship, neighbor group authentication key, initial node-authentication and node re-authentication. The re-authentication node of a single mobile node achieves 2-3 times more efficiency for computational overhead than initial node authentication.

Bodhibrata Mukhopadhyay el at [25] proposed an evaluation model based on RSSI for an accurate indoor localization. In this, three different techniques are used for calculating the distance between an anchor node and target node using LNSM model. But for the target node's position estimation trilateration method is used with least square method and improve an accuracy in indoor environment node+filter technique achieves a 64.86% less error and mean technique achieve 21.33% less error in location estimation. Table 2 summarizes schemes discussed above.

Table 2 A survey on various RSSI based localization schemes in WSN

AUTHOR, JOURNAL, YEAR, REFERENCE	PAPER DESCRIPTION	CONTEXT IN USE	METHODS	PERFORMANCE	FUTURE SCOPE
Jiuiang Xu SciRes. 2010 [3]	A propagation model is used for improving accuracy and self-adaptability.	LNSM model, Dynamic Variance, Distance Measurement, RSSI	LS method is used with LNSM-DV model.	LNSM-DV reduces an error and shows strong self-adaptability in vary environments as compared to LNSM.	LS needs to collect a larger number of sample data to estimate the coefficients in LNSM-DV for research on the layout of nodes.
Ndeye Amy Dieng IEEE 2013 [6]	A two-motes of Gaussian Mixture Model (GMM) using reduce the effect of outlier measurements.	Positioning, GMM model, Maximum likelihood technique, RSSI, Wireless networks	Trilateration technique is used with GMM-MLE algorithm.	GMM-MLE algorithm achieves a better accuracy and improves localization errors in an indoor environment.	For large scenario, the selection of different methods are required to identify for online operation.
Ndubueze Chuku IEEE 2013 [8]	An RSSI based localization scheme mitigate the shadowing effects through an obstacles.	Localization, moving beacons, obstacles, LNSM model, Multilateration technique.	LNSM model, Multilateration technique with clusterization, Gaussian pdfs.	A self-localization scheme gives a less errors using a peak of Gaussian mixture to localize an unknown sensor node positions in an obstructed environment.	To implement and test an existing scheme in large real life monitoring environments.
Z.Mary Livinsa IEEE 2013 [11]	RSSI based localization algorithm measure better distance estimation in indoor environment.	Distance estimation method, Trilateration method, RSSI	Path-loss model, trilateration, LS method is used.	The outdoor environment has better distance estimation than indoor environment and also achieved minimum localization error by varying the density of anchor nodes.	The effect of varying the anchor node density on localization error with minimum number of anchor nodes enhancing an accuracy of the network.
Attila Buchman IEEE 2013 [15]	A covariance RSSI based method is used to achieve room level accuracy in an indoor environment.	WLAN, Wi-Fi, covariance, fingerprinting method, path-loss model, Trilateration, Min-Max and Maximum likelihood algorithm	Covariance based fingerprinting method is used on WLAN infrastructure.	A covariance method is achieve a room level promising accuracy.	Various types of devices must be required for testing in an indoor environment.
K. Vadivukkarasi ACEEE (IJRTET) 2013 [16]	An approach based on RSSI localization measurement reduce the error in an indoor environment.	Power levels, RSSI, Anchor, Localization, LNSM model, Maximum likelihood estimation	LNSM model, Maximum likelihood estimation technique with linear regression analysis is used.	An improved RSSI method produce better distance estimation and average 36% error reduction for different power levels.	We can also apply different techniques for distance measurement and reduce more power levels.
Omotayo G IEEE 2013 [17]	A real system deployment in an indoor and outdoor environment by empirical measurement to estimate distance by using Crossbow IRIS motes.	Localization, Distance, RSSI, IRIS motes, LNSM model	LNSM model is used for distance estimation.	Path-loss exponent of indoor environment is larger than outdoor environment.	To develop an accurate algorithm to perform localization in indoor and outdoor environment.
Safa Hamdoun IEEE 2013 [18]	Multiple antennas used in RSSI based localization for measuring an accurate position.	Multiple fading, shadowing, RSSI, antennas, indoor localization	Trilateration and Multilateration algorithms with SISO, SIMO, MISO, MIMO systems are used.	MIMO gives better performance than SIMO and MISO using Multilateration than Trilateration.	Use of different models in real platform.
Yiping Chen IEEE 2013 [19]	Localization indoor patient for home health care applications in WSN.	RSSI, localization, ML algorithm, ZigBee	ML algorithm with ZigBee is used.	Accuracy meets more home health care applications.	More nodes or samples are required for higher accuracy.
Long XIAO IEEE 2013 [20]	A new method i.e. low complexity Gaussian Filter improves the Bayesian inference with an accurate and cost-effective objects in an indoor environment.	Gaussian filter, wheel graph, probabilistic localization algorithm, RFID technology, threshold value, path-loss exponent factor	Average Localization Distance Error (ALE) algorithm is used.	The performance improves by high values of recursion time, window size, path-loss exponent and the lower propagation standard deviation.	Other different metrics can improve Bayesian inference.

Mengmeng Gai IEEE 2013 [21]	A novel approach using mobile object i.e. equipped with sensors and cameras by utilizing BIM and 3D stereo image measurement technique.	Building Information Modeling (BIM), Sensor Area Localization (SAL), stereo vision, Distance Measurement Sensor (DMS), 3D images	Stereo Vision technology and BIM are used for 3D stereo image measurement.	The image matching algorithm i.e. ICP algorithm and distance measurement techniques connect different regions and recording their positions at various point of time and it is useful for real applications.	Increase the accuracy and speed of localization by using higher resolution cameras with depth sensors or by devising better mathematical schemes to account for lower quality hardware and better comparison process.
LAN Yun IEEE 2013 [22]	A secret-sharing based key management generates dynamically different keys and protect the network form the compromised nodes and reduce high probability of the common keys.	Secret Sharing Key Management (SSKM), Cluster	SSKM is used with distribution process to share keys.	SSKM mechanism enhance the scalability as well as isolate the compromised node. Also, it reduce the energy consumption and increase the security level.	We can focus on how to enhance security in mobile and scalable WSNs.
Bai Si-qi IEEE 2014 [23]	A dynamically PLE correcting method using the reference node information improves the higher positioning accuracy and good environmental adaptability.	PLE, correcting method, Fixed PLE Method (FPM), PLE correction Method (PCM)	LNSM model and PLE correction algorithm is used.	The positioning accuracy and adaptability of environment is higher than the traditional algorithm.	PLE algorithm can be used for real time positioning.
Gaurish M. Edake IEEE 2014 [24]	Node authentication and key distribution protocol reduces the overhead in re-authentication node.	Authentication, mobile node, localization	Neighbor discovery, Sink to Sink relationship, Neighbor group authentication key, Initial node authentication, Node re-authentication	Node re-authentication achieves 2-3 times more efficiency for computational overhead than initial node authentication.	Increase the energy efficiency of sensor network at starting authentication process.
Bodhibrata Mukhopadhyay IEEE 2014 [25]	Using a set of techniques in an indoor environment for distance estimate with less errors and improve an accuracy of signal strength.	LNSM model, Trilateration method	Mede technique, Mode technique, Mean + Filter technique, Mode + Filter technique	Mean + Filter technique has a 21.33% lower error in location estimation, Mode + Filter technique achieves a 64.86% less error.	RSSI technique can be integrated with RAPIDSnap.

V. CONCLUSION

In WSN, various algorithms, techniques are used for various applications. In this survey paper we examine various RSSI based techniques for indoor and outdoor environment. There are different techniques performs various metrics in terms of low energy efficiency, mitigate shadowing effects, improve accuracy etc. RSSI based location widely used propagation model for distance measurement and different techniques like trilateration, multilateration are used for position estimation. RSSI based localization is mostly suitable for an indoor environment and it improves the accuracy of system and improve self-adaptability. Using security algorithms with RSSI localization we can achieve more energy computation as well as increase security level of system.

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