Survey on Localization Techniques of RFID for IOT

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ABSTRACT
Over the last couple of years Radio Frequency Identification or as often called RFIDs are used to identify unique items using radio waves. RFID is like barcode reader but the reading is done remotely in case of RFID . RFID does not require line of sight for identification. Now a days RFID has a wide application in different fields such as Internet of things(IOT), real-time systems, medical monitoring, Animal tracking, inventory management, etc. In several cases their is a requirement of the localization of the objects, and for this purpose some good localization techniques are required. There are several algorithms which have been proposed for the RFID localization; as distance estimation, scene analysis and proximity. The first technique i.e., distance estimation includes SpotON, SAW ID-tags, Location Position Measurement (LPM), RSP. The second technique i.e., scene analysis includes Landmarc, VIRE, Simplex, Kalman filtering and Scout. This paper summaries and compare the above said techniques and also give a approach that will be fruitful in enhanced efficiency and increase in network system for internet of things.

Keywords
RFID, RFID Localization, IoT.

1. INTRODUCTION
RFID i.e. Radio-frequency identification is a wireless communication or identification technology which uses Radio Frequency electromagnetic fields to automatically identify or track tags attached to an object. RFID tags(chips) itself can be as small as half a millimeter square –roughly the size of a tiny seed also some tags are so thin enough to be embedded in a paper. This technology plays a key role in pervasive networks and services. Indeed, data can be stored and remotely retrieved on RFID tags enabling real-time identification of devices and users. However, the usage of RFID could be hugely optimized if identification information was linked to location.

RFID networks consists of three different entities, i.e., RFID tags, readers, and servers as shown in fig 1.The tags use radio frequency to communicate with the readers. The method of powering the tags are different as an active tag embeds an internal battery which continuously powers it and its RF communication circuitry. Readers can thus transmit very low-level signals, and the tag can reply with high-level signals. An active tags can also have additional functionalities such as memory, and a sensor, or a cryptography module. Whereas, a passive tags have no internal power supply. Generally, it backscatters the carrier signal received from a reader. Passive tags have a smaller size and are cheaper than active tags, but have very limited functionalities. The last type of RFID tags is semi-passive tags. These tags communicate with the readers like passive tags but they embed an internal battery that constantly powers their internal circuitry.

RFID readers consists of two interfaces. The first one is a RF interface that can communicate with the tags in their read range in order to retrieve tags' identities. The second one is a communication interface, for communicating with the servers. Finally, one or several servers constitutes the third part of an RFID system. They collect tags' identities sent by the reader and perform calculation such as applying a localization method. They also make the major part of the middleware system and can be interconnected between each others.

RFID systems can be classified in two main categories in accordance with their usage: monitoring and authorizing[3] . The first class includes RFID systems where tags are attached in an inseparable way to the items they identify. The second class includes RFID systems where RFID tags are not permanently attached to entities.

Radio propagation in indoor environment is subject to numerous problems such as severe multipath, rare line-of-sight (LOS) path, reflection, diffraction and absorption. Since signal cannot be measured very precisely several localization algorithms have been proposed.

RFID is shaping up to be an important building block for the Internet of Things (IoT). The Internet of Things (IoT) is basically the network of physical objects—devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity—that enables these objects to collect and exchange data.

The concept of IOT originally was proposed by professor Ashton of MIT Auto-ID in the research of RFID in 1999. At that time the research primarily focus on RFID, to gain the object information by browsing the Internet address or database entry to achieve recognition for objects. After that, the scope of IOT has been expanded to many areas such as environment surveillance, health care, smart home, logistics, and forest-fire prevention and so on. In 2005 ITU give an Internet reports named "The Internet of Things" [18]. In this reports some technologies for IOT as well as opportunity, challenges are pointed out. In 2009 the European community drafts out a report named "Internet of things - An action plan for Europe" [19], in which Europe insisted on that by adopting a proactive approach they can play a leading role and people can reap the benefits from it.

IoT will increase the ubiquity of the Internet by integrating every object for interaction via embedded systems, which leads to a highly distributed network of devices communicating with human beings as well as other devices. Thanks to rapid advances in underlying technologies such as RFIDs', through which IoT is opening tremendous opportunities for a large number of novel applications that promise to improve the quality of our lives.

The Internet of Things requires a few necessary components to enable communication between devices and objects. Objects need to be augmented with an Auto-ID technology, typically an RFID Tags, so that the object is uniquely identifiable. Also, an RFID tag allows the object to wirelessly communicate certain types of information, which leads us to another requirement – the ability to monitor data.

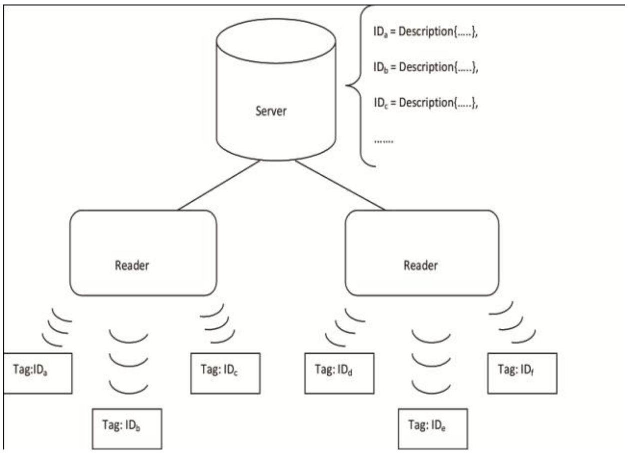

Fig. 1 : Architecture of RFID System

2. LOCALIZATION SCHEMES FOR INDOOR WIRELESS NETWORKS

Radio propagation in indoor environment is subject to numerous problems such as severe multipath, rare line-of-sight (LOS) path, absorption, diffraction, and reflection . In the indoor environment, the external factors deeply affects range value; even in the same location of a node. Since signal cannot be measured very precisely, several indoor localization algorithms have been proposed in the literature. They can be classified in three families: distance estimation, scene analysis, and proximity.

2.1. Distance Estimation

This family of algorithms uses properties of triangles to estimate the target's location. The triangulation approach, as shown in Fig. 2, consists in measuring the angle of incidence (or Angle Of Arrival - AOA) of at least two reference points. The estimated position corresponds to the intersection of the lines defined by the angles. We can also say that triangulation is a process to determine the location of a radio transmitter by measuring the DOA of the received signal from two or three known reference points. On the contrary, the lateration approach, illustrated in Fig. 3, estimates the position of the target by evaluating its distances from at least three reference points. The range measurements techniques use Received Signal Strength (RSS), Time Of Arrival (TOA), Time Difference Of Arrival (TDOA), or Received Signal Phase (RSP).

2.1.1. RSS:

The attenuation of emitted signal strength is function of the distance between the emitter and the receiver. The target can thus be localized with at least three reference points and the corresponding signal path losses due to propagation. Several empirical and theoretical models have been proposed to translate the difference between the transmitted and the received signal strength into distance estimation. The RSS based systems usually need on-site adaptation in order to reduce the severe effects of multipath fading and shadowing in indoor environments.

RSS-based trilateration/multilateration technology can also be used to locate the position of an RFID reader. Using multiple reference tags which are placed at known positions, a mobile reader can localize itself based on the RSS measurements corresponding to two or more tags (DB08)[20].

2.1.2. TOA:

The distance between a reference point and the target is also proportional to the propagation time of signal. TOA-based systems need at least three different measuring units to perform a lateration for 2-D positioning. However, they also require that all transmitters and receivers are precisely synchronized and that the transmitting signals include timestamps in order to accurately evaluate the traveled distances. If more than three reference points are available, the least-squares algorithm or one of its variants can be used in order to minimize the localization error.

For active RFID tags, measurement of one-way TOA requires that the reader and the tag have precisely synchronized clocks. In many active RFID systems, however, achieving precise synchronization between a reader and a tag is impractical. Rather, it is often feasible to synchronously process the data received at multiple readers or reader antennas, and thus the TDOA related to different tag-reader antenna paths can be estimated.

2.1.3. TDOA:

The principle of TDOA lies on the idea of determining the relative location of a targeted transmitter by using the difference in time at which the signal emitted by a target arrives at multiple measuring units. Three fixed receivers give two TDOAs and thus provide an intersection point that is the estimated location of the target. This method requires a precise time reference between the measuring units. Like TOA, TDOA has other drawbacks. In indoor environments, a LOS channel is rarely available. Moreover, radio propagation often suffers from multipath effects thus affecting the time of flight of the signals.

For a conventional narrowband RFID system, immediate application of time-based techniques (e.g., TOA and TDOA) for the localization of RFID tags is often difficult because of the poor time resolution limited by the frequency bandwidth. In addition, time-based techniques may experience additional challenges in the presence of multipath[20].

2.1.4. RSP:

The RSP method, also called Phase Of Arrival (POA), uses the delay, expressed as a fraction of the signal's wavelength, to estimate distance. It requires transmitters placed at particular locations and assumes that they emit pure sinusoidal signals. The localization can be performed using phase measurements and the same algorithm than TOA or phase difference measurements and the same algorithm than TDOA. The disadvantage of the RSP method when applied in indoor environments is that it strongly needs a LOS signal path to limit localization errors.

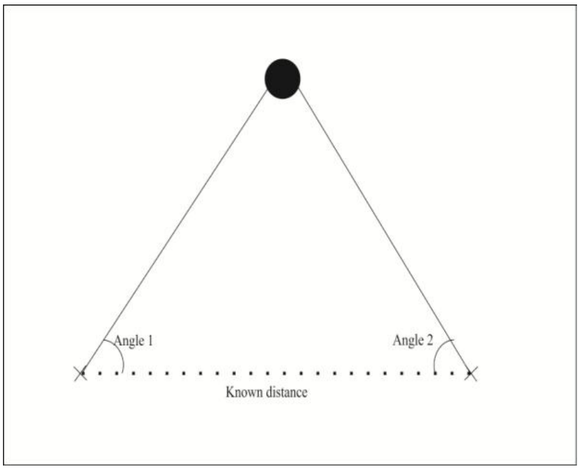

Fig. 2 : Triangulation: the estimated location is calculated with the angles formed by two reference points and the target node[17].

2.2. Scene analysis

Scenes analysis approaches are composed of two distinctive steps. First, information concerning the environment (fingerprints) is collected. Then, the target's location is estimated by matching online measurements with the appropriate set of fingerprints. Generally, RSS-based fingerprinting is used. The two main fingerprinting-based techniques are: k-nearest neighbor (kNN) also known as radio map, and probabilistic methods.

kNN - The kNN method consists in a first time in measuring RSS at known locations in order to build a database of RSS that is called a radio map. Then, during the online phase, RSS measurements linked to the target are performed to search for the *k* closest matches in the signal space previously-built. Root mean square errors principle is finally applied on the selected neighbors to find out an estimated location for the target.

Probabilistic Approach - The problem stated in probabilistic approaches is to find the location of a target assuming that there are *n* possible locations and one observed signal strength vector during the online phase according to posteriori probability and Bayes formula. Thus, the location with the highest probability is chosen. Generally, probabilistic methods involve different stages such as calibration, active learning, error estimation, and tracking with history.

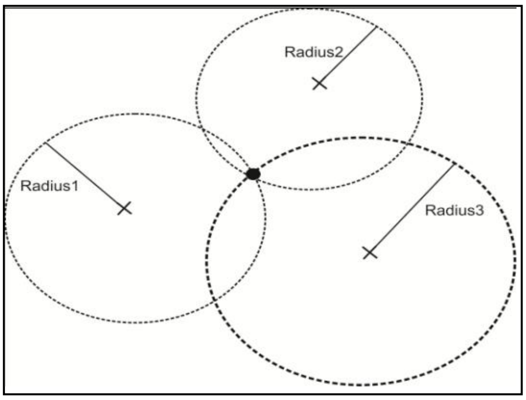

Fig. 3 : Trilateration: the estimated location corresponds to the intersection point of three circles[17].

2.3. Proximity

The last type of localization techniques in indoor environments is based on proximity. This approach relies on dense deployment of antennae. When the target enters in the radio range of a single antenna, its location is assumed to be the same that this receiver. When more than one antenna detect the target, the target is assumed to be collocated with the one that receives the strongest signal. This approach is very basic and easy to implement. However, the accuracy is on the order of the size of the cells.

3. LOCALIZATION TECHNIQUES FOR RFID

It is worth noting that a very challenging problem in RFID localizing lies in the effect of complicated wave propagation due to the presence of various obstacles and reflectors in the environment. Walls, human bodies, furniture and supplies that contain metallic and liquid materials, such as partitions, cabinets, bookshelves, water containers, may cause obstruction and reflections of electromagnetic waves. When a signal transmitted/backscattered from an RFID tag arrives at an RFID reader over a multiplicity of paths, it extends the delay profile and results in fluctuation in the RSS as well as the received signal phase (Rap02, ZYL09)[24],[25]. Similar effects can be observed for downlink propagation from a reader to a tag. Multipath propagation alters both signal strengths and phase. As such, RFID positioning techniques based on RSS and/or signal phase may become inaccurate. The localization performance of the TOF- and TDOA-based techniques may also be compromised due to multipath. For many systems we hope to get location information to provide more intelligent services. For example, a mobile advertising business which needs to know the position of people for pushing services (discount shopping news), to find a nearest coffee shop according to current position, to track somebody in the stadium. Some systems have high precision positioning requirements, because the location accuracy directly impacts the performance of entire application system. For example, cargo tracking in large warehouse, wharf cargo scheduling, cargo location on crane tower.

Several RFID localization methods have been proposed. They utilize the indoor localization principles and are adapted to the characteristics of the RFID technology. Due to the very limited capabilities of tags and contrary to ad-hoc and sensor networks, the localization is always centralized. With passive tags or sparse reader deployment, the proximity approach is privileged. On the contrary, when tags have more energy and thus larger read range or when readers are densely deployed, more elaborated techniques can be applied to localize tags. RFID localization schemes can be classified into three families: lateration with distance estimation, scene analysis with the deployment of extra reference tags, and constraint-based approach.

3.1. Distance Estimation

As previously discussed that this family of algorithms uses properties of triangles to estimate the target's location.

3.1.1. SpotON [5]:

SoptON is based on RSS measurements from adjustable long range active RFID tags. The approach is simple: multiple readers collect signal strength measurements in order to approximate distance through a function defined with empirical data. Classic laterations are then performed to localize tags.

SpotON (HVB01, HWB00)[22],[23] uses RSS to localize long-range active RFID tags in a three-dimensional (3-D) space. Multiple receivers collect RSS measurements and use the trilateration/multilateration method to estimate the tag locations. The Local Position Measurement (LPM) method (SPF04)[27] localizes outdoor active tags based on TDOA measurements using at least four 20 synchronized reader antennas with known positions. Positioning accuracy can be improved by increasing the number of reader antennas through the minimization of the weighted mean square error. A Patient Management and Tracking System (PMTS) using the RSS-based trilateration technique is developed in (KKK08)[21]. It is reported that the average accuracy is less than 1 m in an open-space test.

3.1.2. SAW ID-tags [6]:

Surface Acoustic Wave Identification (SAW ID) tags are completely passive. They utilize pulse compression techniques and a large number of coding possibilities. Each tag is interrogated with the time inverse of its impulse response. Then, it retransmits the correlated signal. This retransmitted signal shows an autocorrelation peak. The response with the highest amplitude identifies the searched tag.

Passive SAW (Surface Acoustic Wave) ID-tags use TOA measurements to localize a tag (BY03)[26]. SAW is an electromechanical device constructed of a piezoelectric crystal or ceramic to convert an RF signal to mechanical wave, which has a much smaller wavelength than that of the RF signal and thus is convenient to implement or measure the delay with a miniaturized size. Localization of a SAW tag is achieved by analyzing the round-trip TOF observed at three separated reader antennas through trilateration. Each tag has a fixed code described as its unique impulse response. Thus, a reader interrogates a tag by transmitting the time inverse of the tag-specific impulse response, and the tag then retransmits the correlated signal with a high peak to be easily detected at the reader[20].

3.1.3. LPM [7]:

The Local Position Measurement (LPM) system uses active tags. Since it is based on the TDOA technique, readers are synchronized with the help of reference tags (RT) at well-known and fixed positions that operate continuously. After having received an activation command, the selected measurement tag (MT) responds at time t_{MT} . The weighted mean squares method is then utilized to estimate the locations of the tags with at least three different readers.

3.1.4. RSP [8]:

The authors propose to apply the RSP technique, which they called Direction Of Arrival (DOA), to the localization of passive RFID tags. Their approach consists in placing two readers at specific locations in order to calculate the phase difference and thus the direction of a moving tag. When several observations are available, the estimation can be improved by using the least-square fitting technique.

3.2. Scene analysis

Following are some of the techniques which can be used for the scene analysis

3.2.1. Landmarc [9]:

This system is based on the kNN technique. Reference tags which are fixed tags with known positions are deployed regularly on the covered area. Readers have eight different power levels.

3.2.2. VIRE [10]:

VIRE uses the principle of Landmarc [9], that is 2D regular grid of reference tags. Nevertheless, this method introduces the concept of proximity map. The whole sensing area is divided into regions where the center of each region corresponds to a reference tag. Every reader maintains its own proximity map.

3.2.3. Simplex [11]:

This method is also based on the deployment of reference tags. It requires that the *n* readers have *K* transmission power levels. For the localization of a tag, the readers start with the lowest power level and gradually increase the transmission power until they receive the response from the tag.

3.2.4. Kalman filtering [12]:

This approach also utilizes reference tags. The first step consists in calculating with RSS measurements from two readers the distance D_i between each reference tag and the target tag. The location of the tag is obtained by solving with the minimum mean squared error algorithm the system of non-linear equations:

$$(x_i \text{ ¡ } x_e)2 + (y_i \text{ ¡ } y_e)2 = D2$$

The second step consists in building a probabilistic map of the error measurement for the readers' detection area. The first step is applied for each reference tag in order to calculate their corresponding error probability distribution function with the help of their estimated location and their real location. The Kalman filter is then used iteratively on this online map to reduce the effect of RSS error measurement and thus to improve the accuracy of the localization.

3.2.5. Scout [13]:

Scout belongs to the family of probabilistic localization techniques. This method also utilizes reference tags and several readers. Active tags are localized following three steps. First, the propagation parameters are calibrated using on-site reference tags. Secondly, the distance between the targeted tag and the readers is estimated with a probabilistic RSS model. Finally, the location of the tag is determined by applying Bayesian inference. Iteratively, predicted beliefs are calculated and then corrected with observations until obtaining a good model resulting in an estimated area.

3.3. Constraint-based approach

3.3.1. 3-D Constraints [14]:

This approach is only based on connectivity information. They are used to define inclusive constraints, that is if a reader can detect a tag that means that the distance between them is inferior to the read range, and exclusive constraints, the complementary with readers that cannot detect the tag. The space is discretized into points in order to delimit the detection area of the readers. The mean of the set of points that respect the maximum of constraints corresponds to the estimated location of the tag.

4. COMPARISION BETWEEN INDOOR WIRELESS NETWORKS AND RFID

Table 1. : Comparision Table(Iwn And Rfid)

PROPERTIES/ FEATURES	INDOOR WIRELESS NETWORKS	RFID
DISTANCE	it works well because distance are less in case of indoor networks.	the performance decreases as the distance increase.
ENERGY EFFICIENCY	energy constrains are their in case of indoor networks.	there is no energy contain in case of passive RFID.
AREA	works in a small range of geographical area.	may be used for large geographical area.
NETWORK LIFE TIME	it will give prolonged network life time.	it will give average network life time.

5. CONCLUSION AND FUTURE SCOPE

This paper, discuss the different indoor localization techniques and its principles also it discuss the RFID localization techniques, issues, types of error, different types of approaches and comparative analysis of each approach. It categorises the methodologies into distance estimation, fingerprinting and proximity. It explained the need of localization of RFID for IOT. Finally, this paper explores the drawbacks found in currently employed Approaches and suggested several solutions in the hope of generating interest in this field of study.

In future this paper will try to bring multiple indoor localization technologies under the same roof and directly compare their accuracy and overhead requirements for IOT.

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