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RF based Indoor Asset Tracking

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Abstract: Real time location system is used to track object in real time. Here real time mean little near to live location of object. GPS is used for location tracking, but is useful at outdoor location and difficult to track at indoor environment. In GPS GPS-module work as receiver which receive signal from satellite, satellites location are known to GPS module after receiving signal GPS-module calculate distance from satellite and determine location. It only useful for outdoor environment. Indoor asset tracking is a unique specialty of many types of RTLS, as Global Positioning Systems (GPS) have difficulty to provide asset localization within buildings. RTLS deployments generally address the problems of determining the location of equipment and products in a warehouse or even tracking employees and files in an office. The most common RTLS uses a Wi-Fi infrastructure to determine the location of tagged assets. These systems employ Received Signal Strength Indication (RSSI) techniques to wirelessly determine asset location. In this report RF Based indoor asset tracking system is describe. In which sub 1 Ghz RF chip is used.

Keywords: Radio Frequency (RF),Location based service (LSB), (Radio Frequency Identification(RFID),Real Time Location System (RTLS),Non-Line of Sight (NLOS), Angle of arrival (AoA), Time of Arrival (ToA),(Time Difference of Arrival (TDoA),Receive signal strenght (RSS)Real Time Localization (RTL),Texas Instrument(TI).

I. INTRODUCTION

RTLS (Real-time locating systems) are used for tracking the location of people or assets in real time [1]. These systems are generally composed of three components—RTLS tags, readers (or location sensors), and a location engine. RTLS tags are attached to objects and radiate signals called beacons. RTLS readers receive beacons from tags and estimate distances between the tags and themselves. Further, they forward these estimated distances to the location engine, and the engine then estimates the coordinates of each tag [1]. In general, these systems communicate through various communication media such as ultrasound, infrared, and RF (radio frequency). RF is the most commonly used medium for these communication tasks because it has a relatively long communication range and there are many solutions for this medium [1] [2] [3]. There are some algorithm by which we can determine the position of asset. The most of common algorithms are listed below [4]:

- Angle of Arrival (AoA)
- Time of Arrival (ToA)
- Time Difference of Arrival (TDoA)
- Received Signal Strength (RSS).

Every algorithm have their own advantages and disadvantages. Indoor RF based tracking system composed by three component which are listed below [7].

A. Reader (Reference node)
B. Tag (Mobile/Asset node)
C. Location Engine

A. Reader

A RFID reader is a device modulating and demodulating RF signals to communicate with supported RFID tags via one or several antennas. Most readers are compatible with either active tags or passive tags of certain operating frequency; only a few are able to work in dual mode. A database for managing all readers and tags, and some complicated control logics, such as noise threshold setting, antennas balance, and active history, may be deployed on the computer connected to the readers. [3]

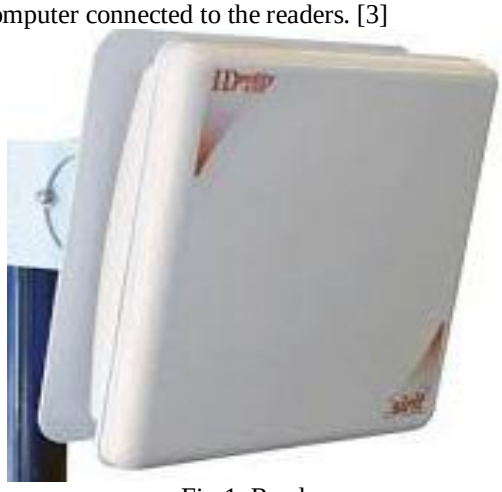

Fig 1. Reader

B. Tags

Usually, an RFID tag has two key components: an integrated circuit for executing commands and storing data; and an antenna coil for receiving and transmitting RF signals. Additional components include batteries and/or special sensors as mentioned above. Based on different power source and working mechanism, RFID tags can be categorized into three major types: passive, semi-passive, and active tags. Both passive tag and semi-passive tag are activated by the querying RF signal from the reader. The passive tag is only powered by the energy transformed from the querying RF waves, which significantly decreases its read range, cost and size. [7]

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Figure. 2 Tag [7]

C. Location Engine

Algorithm for computing the location is implemented on location engine. Location engine collect data from reader and then compute location by implemented algorithm or that data transfer to system where algorithm is implemented it can be window, Linux, or mobile app. In this paper we write about 3 Reference nodes and 4 reference nodes based indoor RTL. For that we uses TI's CC430f6137 Experiment board and CC430f5137 Satellite board with SimpliCiTi protocol. In this paper we write how to actual system can be develop in brief.

II. RELATED WORK

In general, RF-Based localization categorized as two way. 1 Client based scheme and 2 Network based scheme. While mobile node or Asset will determine the location than it knows as client based scheme, whether if location will determine by the reference node to server side than it known as Network based scheme [5]. Also, RF-based location methods are divided into one-way and two-way ranging methods.

In one-way ranging methods, the tags only radiate the signal frequently. RSS is one of the one-way ranging methods. It simply uses the strength of the received signal for estimating location. This method is easy to implement, but the accuracy is low.

The TDOA method uses the time difference between two nodes for estimating location. First, time-synchronized readers receive the tag's beacon message simultaneously. Then, a location engine calculates the position of the tag using hyperbola because the time difference is converted into the difference in distance between each tag and the reader [6].

III. INDOOR ASSET TRACKING SYSTEM

In this section we describe 2 approaches of indoor asset tracking.

A. 3 Reference nodes based indoor RTL

From figure 3 we get idea about what indoor system contain. In this figure 3 master/reference nodes one Tag/asset are used. Tag broadcast message and all master device catch it and measure RSSI value of signal between reference node and Tag then pass this information to pc. In pc one window application is developed where tracked object will locate. In this window application algorithm for tacking is developed. In our case RSSI based algorithm developed.

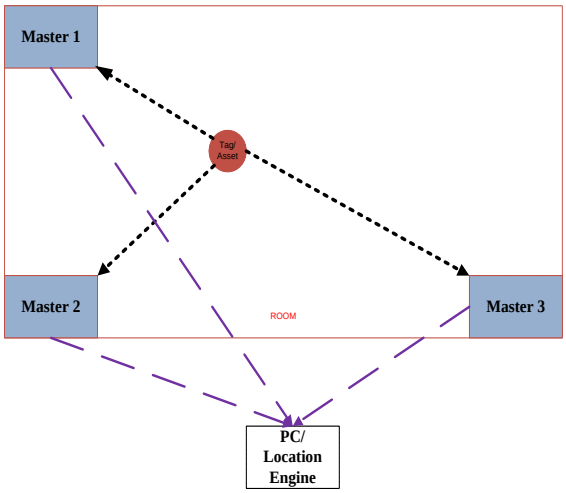

Figure 3. 3-Reference nodes based Indoor RTL

B. 4 Reference nodes based indoor RTL

In this figure 4 master/reference nodes one Tag/asset are used. Tag broadcast message and all master device catch it and measure RSSI value of signal between reference node andTag then pass this information to pc. In pc one window application is developed where tracked object will locate. In this window application algorithm for tacking is developed. In our case RSSI based algorithm developed. By increasing reference nodes accuracy will increase.

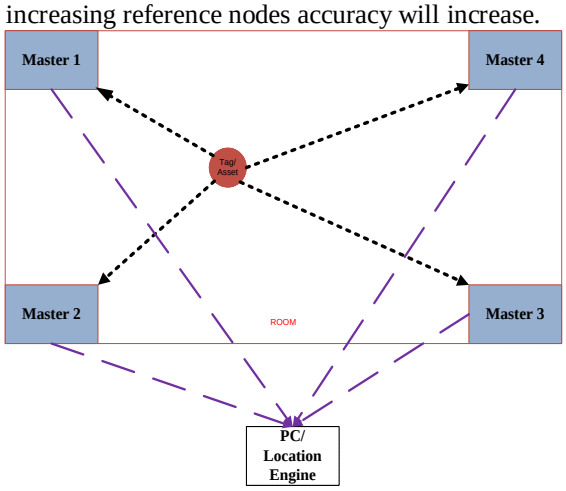

Figure 4. 4-Reference nodes based Indoor RTL

C. Algorithm

In our case we used trilateration estimation algorithm. Trilateration estimation is also used to find an unknown location from several reference locations.

However, the difference between trilateration and triangulation is the information provided into the process of estimation. Instead of measuring the angles among locations, trilateration uses the distances among the locations to estimate the coordinate of the unknown location.

In trilateration, the distances between reference locations and the unknown location can be considered as the radii of many circles with centers at every reference location. Thus, the unknown location is the intersection of all the sphere surfaces [8].

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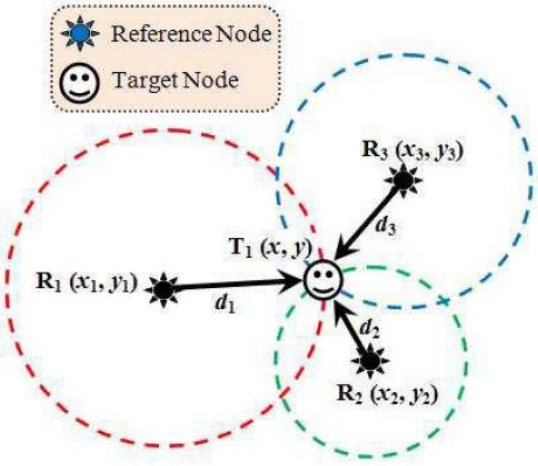

Figure 5. Trilateration Estimation [8]

Before applying trilateration estimation we have to convert RSSI value to distance using following equation.

RSSI = - (10*n*log10(d) + A)
Where

- RSSI is the RSSI value received (dBm)
- n is the path-loss exponent
- d is the distance
- A is the RSSI value at a reference distance

Path Loss Exponent:
The path loss exponent has to be determined experimentally. The path loss variable ranges from around 2 to 4, where 2 is the free-space value (no obstruction, line of sight) and 4 represents a very lossy environment. In following table value of N according to environment are defined.

N	Environment
2.0	Free space
1.6 to 1.8	Inside a building, line of sight [2]
1.8	Grocery store [2]
1.8	Paper/cereal factory building [2]
2.09	A typical 15 m × 7.6 m conference room with table and chairs [3]
2.2	Retail store [2]
2 to 3	Inside a factory, no line of sight [2]
2.8	Indoor residential [4]
2.7 to 4.3	Inside a typical office building, no line of sight [1]

To determine location assume R1(0,0), R2(x_2,0), R3(x_3,y_3).
So,
$X = ((d_1 * d_1) - (d_3 * d_3) + (x_3 * x_3)) / (2 * x_3)$
$Y = ((d_1 * d_1) - (d_2 * d_2) + (x_3 * x_3)) / (2 * y_2)$

IV. CONCLUSION

We conclude that, we have to consider LOS, NLOS condition for indoor tracking. For that we have to develop algorithm to estimate location. Which accuracy depend on number of reference nodes. If we increase reference nodes than accuracy will increase. Because if we increase number of reference nodes than we can calculate location basis on averaging the location from different reference nodes. Assume in room 4 reference node from 4 only 3 node received broadcast message so estimation possible using above method. If 4 reference nodes R_1, R_2, R_3, R_4 received broadcast message than we apply above estimation method to 3 reference nodes (R_1, R_2, R_3) and calculate X,Y than apply above method to (R_1, R_3, R_4) and calculate X,Ythan take average of that values so we can determine more accurate location than 3 reference based indoor location system.

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