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A New Semi Passive RFID Communication System for Indoor Localization

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ABSTRACT: *A standard UHF RFID system for accurate indoor localization of object is presented . The system is of a passive tags of known locations as reference points, RFID reader, and a new semi-passive tags as STs. The STs detect and decode backscatter signals from RFID tags that are in their proximity and can communicate with the reader using backscatter modulation. Object tagged with a ST, can be accurately located from the information acquired by the reader from the ST. The performance of the localization system was studied.. Results show that the tagged object can be localized with high accuracy.The cost and power consumption of ST can be reduced by using the microcontroller instead of FPGA.*

Keywords-,*Backscatter modulation, localization ,sens-a-tag,*

I. INTRODUCTION

Radio or radio frequency (RF) waves are electromagnetic waves with wavelengths between 0.1 cm and 1,000 km.. RFID is a popular information exchange technology based on radio waves communication.[7]. No line-of-sight required, long life span and very low cost for RFID system .In recent years it has helped to increase the business productivity. In a real indoor environment, fading, absorbing, reflection, and interference are major issues affecting the RF waves' strength, direction, and distribution[4]. This make the variation of the RF signal propagation not easily modeled. Since the theoretical model is not applicable, numerous positioning algorithms have been developed[6].Distance-based methods rely on range measurements that can be Received Signal Strength (RSS), Time-Of-Arrival (TOA), or Time-Difference-of-Arrival (TDOA) . With such measurements at (at least three) different reference points and upon converting them to estimated distances, one can employ simple trilateration for localization. In , the authors propose indoor positioning system based on Kalman filtering , where they use the measurements of the backscattered RSS signal propagated from nearby RFID tags. In mobile robot localization is based on TOA of radio frequency signals, where the measured distances are used to compute the coordinates by extended KF[4]. Positioning can be improved by reducing the uncertainties in the measurements by using ultrasonic measurements. It is worth pointing out that a new localization method based on phase difference between two or more receiving antennas may provide a better accuracy and robustness than RSS-based methods.

Proximity-based methods exploits binary information about a target being within small ranges of reference tags by associating the location of the target with that of the closest reference tag, or as a function of the locations of all the reference tags that were detected by the target.. Then, various approaches on geographical calculations, such as triangulation, trilateration, and multilateration, are applied to estimate the final position[5,6]. Both the k Nearest-Neighbor (kNN) approach by using centroid of certain neighbors and the proximity approach by using intersection of several coverage areas avoid the distance estimation step in range-based localization approaches. However, they heavily rely on the density of reference tags or reader/antenna distribution to improve positioning accuracy It was found that, for a given distance, the RSS can vary considerably. This is of poor performance of RSS based methods[4].

II. ABOUT THE NOVEL SEMIPASSIVE RFID SYSYTEM

A semi-passive RFID system for accurate indoor localization is presented .The system is composed of a standard UHF RFID readerThe architecture of the proposed sens-a-tag (ST) based system is shown. The new RFID system is composed of a personal computer (host) that runs the localization algorithms, an RFID reader, multiple passive tags placed at known locations as shown, and STs attached to objects that we desire to locate.

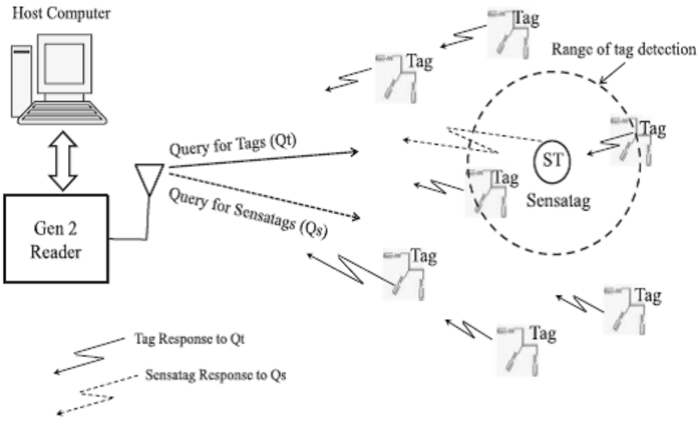

Fig.1 Architecture of the RFID system using sensatag(ST)

The area around ST where it detects backscatter from tags is shown in by a dotted circle in figure . The strength of the tag backscatter and the sensitivity of the ST lead to the maximum range of detection of the ST depends upon.. Prior to operation the locations of all the tags are recorded into the system. In the figure, two of the tags are in the range of the ST. This is more robust localisation than conventional techniques because it relies on backscatter detection in the close proximity of the tag rather than on measuring the RSS of the backscatter signal at longer distances the wireless fading channel makes it worse The back scatter of these two tags will be detected by the ST. This temporary detection is stored as binary information on the ST. Subsequently, the STs talk to the reader like normal tags and convey the detection information to the reader. It was found that, for a given distance, the RSS can vary considerably. This is of poor performance of RSS based methods[4].

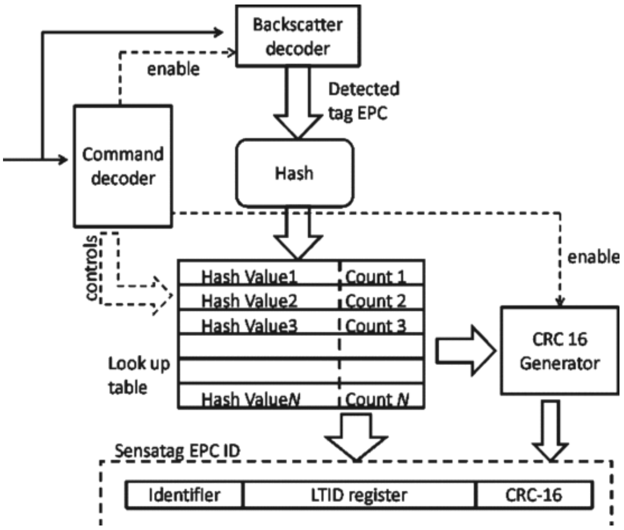

Fig. 2. ST EPC ID generation.

A special Gen 2 based locator protocol is needed by ST based system that allows them to function in with standard readers and tags. As per this protocol, localization takes place through a two-stage query process, which is illustrated in Table I. The host machine controls the reader to send out two distinct query signals, first a query Q_t for tags, followed by query Q_s for STs.. The ST operates in one of two states, listen or respond[2].

I) Listen State

A query of type Q_t drives the ST into the listen state. During this query, the ST does not respond and instead listens for backscatter from tags in its vicinity. If it receives any such backscatter, it decodes this signal, extracts the tag's ID and stores it temporarily. Decodes the tag IDs that it senses and stores a hash value corresponding to each sensed tag ID, along with a count indicating the number of times that it sensed that ID.

II) Respond State

The following query Q_s drives the ST into the respond state. In this state, the ST responds to the reader query as if it were a standard tag, and conveys to the reader the information about which tags were detected in its vicinity during Upon receiving a Query Q_s, all the IDs' hash values that the ST detected, along with the respective counts are packed into a register known as the Located Tags ID (LTID) register. The register is prepended with a ST identifier and appended with a CRC-16. Together they form the ST EPC ID that is backscattered in response to a Q_s query.

III. HARDWARE IMPLEMENTATION

In the current version, the digital section is implemented on a Xilinx Spartan 3AN FPGA chip. This device has an internal configuration memory resulting in significant space saving on the digital section of the board. The current implementation of the ST used in our experiments is shown[2].

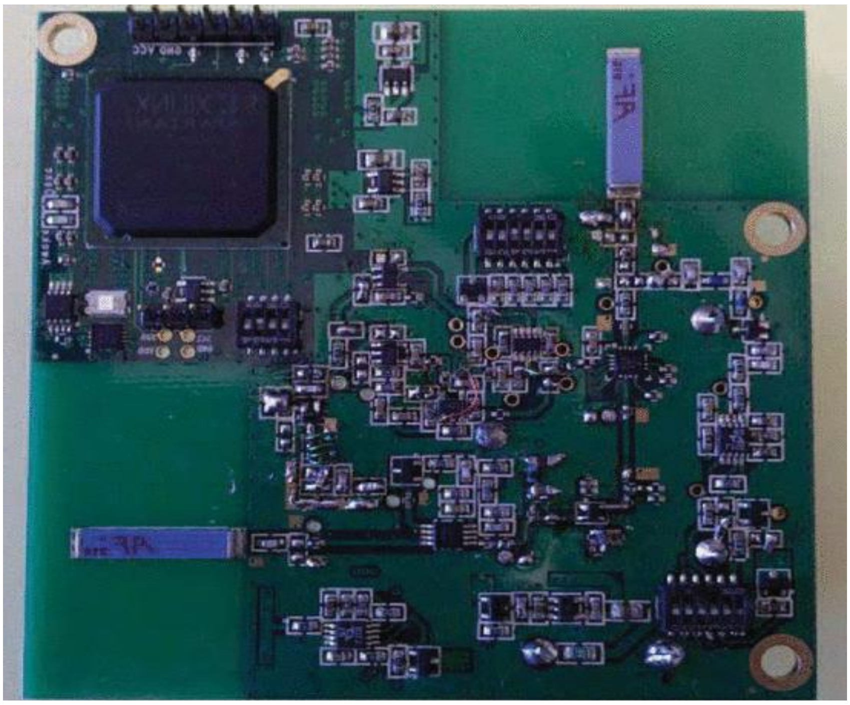

Fig.3 ST board (with dimensions 8.9×8.9 cm) used in the experiments.

IV. TAG LOCALIZATION METHODS

In the system presented in this paper, passive RFID tags are deployed at pre-defined locations within the environment where localization is to be performed. A ST is attached to the object of interest. Using the "Select" functionality the reader is programmed to send alternating queries for the tags and STs. The ST attached to the object operates using the locator protocol and conveys binary information about responding tags to the reader[1].

As a result of the queries, the host receives a list of STs and their associated tags at predefined instant time. The system accuracy depends on the density of the reference tags deployed at known locations. In this paper the aim is to achieve satisfactory localization accuracy without any calibration once the fixed tags are deployed (even in environments with dynamical changes). Three simple localization methods to work well in such circumstances. They are i) association, ii) centroid iii) weighted centroid.

Let there be M reference (passive) tags placed at positions,x_i (i=1,2,…..M) and one ST at unknown position . A reference tag can be detected by a ST with the probability p_i. This probability depends on various factors, but primarily on the distance between the reference tag and the ST, orientation, and the power of the reader. This probability is easily estimated by counting the number of detections of a tag by a ST in a fixed number of reader queries[1].

I) Association Localization

With association we simply associate the ST with the nearest passive tag. The proximity is measured by comparing the p_i $s$of each reference tag. The main drawback of association is that when more passive tags are detected by the ST, the p_i s may not correctly reflect the distance from the ST. For example, if the ST is close to tag A, and the power is sufficiently large so that both tag A and tag B are detected the same number of times, the association of the tag becomes random and as a result, the position error is larger.

II)Centroid Localization

The target calculates its position at the center of the positions of the tags that are in the vicinity or are read.In that case, the position of the ST can be computed by:

$$l = \sum_i x_i \;/n \qquad (1)$$

where the summation is over the locations of the tags that have been detected, and n is the total number of detected tags by the STs. Therefore, the estimated position will be the centroid of the positions of the detected passive tag[1,6]. This approach does not take into account the number of detections.

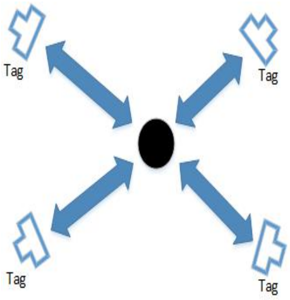

Fig. 4 .Centroid localization

III) Weighted Centroid Localization

To increase the accuracy of the localization, "weights" are introduced[6]. Depending on the system, weights can be a representation of distance from each tag. In our case, number of reads by the ST has been used for weight factors. Since it is expected that the closer tags will be detected more times than more distant ones, the weights are proportional to probabilities of detection of the tags. So, the estimated position is obtained by

$$l = \sum_i p_i \, x_i \qquad (2)$$

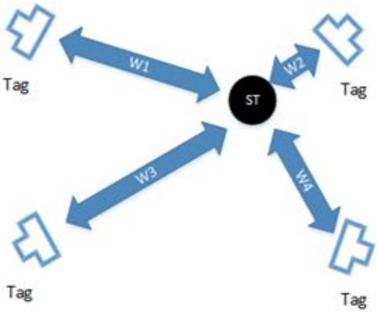

Fig. 5. Weighted centroid localization

IV) Comparison of localization methods

The association method had the worst performance. The method based on the weighted centroid(WC) method outperformed the one that used the centroid. For both methods, with the increase of reader power, the performance improved. The best performance of all the methods was by the WC .To compare performance of the methods discussed we used the cumulative distribution function (CDF) of the location error of the three methods. In probability theory and statistics, the CDF or distribution function, defines probability that a real-valued random variable X with a given probability distribution having a value less than or equal to x. The CDFs of the errors reveal that the WC method performance is better than the other two methods .The probability of the error is less than 38 cm is about 0.94 for the WC , 0.80 for the centroid, and 0.43 for the association-method.

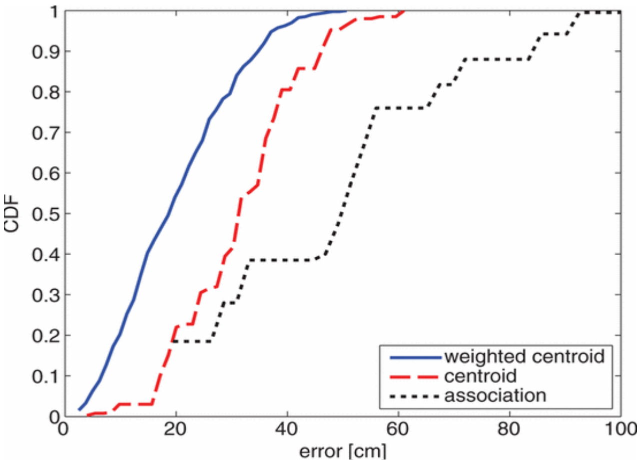

Fig. 6 CDF of position error for three different algorithms.

V. APPLICATIONS AND FUTURE SCOPE

The system can be used for locating items , in warehouses. , retail stores and offices for tagging a large number of low-to-medium cost items such as library .Useful for inventory using mobile readers .In future work, we have to further reduce the cost and power consumption of the ST by replacing the FPGA with a low power microcontroller. Another suggestion is expanding the capabilities of the ST by adding energy harvesting techniques to increase the battery life time. The current implementation of the ST is not optimized to work near human body.It can have potential for various IoT applications.

VI. CONCLUSION

A standard UHF RFID system for accurate indoor localization of object sis presented . The system is composed of a passive tags of known locations as reference points, RFID reader, and a new semi-passive tags as STs. The STs can detect and decode backscatter signals from RFID tags that are in their proximity and can communicate with the reader using backscatter modulation. Object tagged with a ST, can be accurately located from the information acquired by the reader from the ST.The performance of the localization system was studied.. Results show that the tagged object can be localized with high accuracy.The cost and power dconsumption of ST can be reduced by using the microcontroller instead of FPGA.

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