

# Experimental Study of the Antenna Influence in RTLS Based-On RFID

Gonzalo Crespo; Jorge Teniente; Iñigo Ederra and Ramon Gonzalo

Antenna Group, Public University of Navarra  
Campus Arrosadía s/n, 31006, Pamplona, Spain  
gonzalo.crespo@unavarra.es & ramon@unavarra.es

**Abstract**—Nowadays Real-time localization systems (RTLS) are growing up very quickly but there are some remaining issues which need to be analyzed. This paper presents an experimental study that shows how different kind of antennas can help to reach a more accurate localization. Among all different wireless technologies, active radio-frequency identification (RFID) has been chosen due to its development and simplicity. The study has been divided into two different parts. Firstly RF tests are made to assure received signal strength indicator (RSSI) levels are the expected. Secondly measurements with different antennas have been performed. The antennas used in this study are: an Omni-directional monopole standard antenna, a Patch antenna and a 2 Patch Array antenna both in a FR4 substrate.

**Keywords**-RFID, RSS, RTLS

## I. INTRODUCTION

One of the most interesting applications in wireless communications is the tracking of goods and people indoor. Based on the idea of global positioning systems, RTLS uses conventional wireless sensor networks in order to locate people in close environments.

Among the most widely used wireless technologies today, there are 5 used commonly in RTLS, these are: Zigbee, Bluetooth, UWB, Wi-Fi and RFID. In this study RFID has been selected for the identification of objects and people because it is a very cheap and simple technology and it is easy to deploy (1) (2).

To set up a RTLS it is needed to choose a localization technique. There are several possibilities; most commons are received signal strength (RSS), angle of arrival (AOA), time of arrival (TOA), and time difference of arrival (TDOA). RSS localization technique has been chosen in this study due to its simplicity (3) (4) (5).

The accuracy in the localization can be improved not only with the localization technique but also modifying the RF chain of the system. Usually RTLS have Omni-directional antennas in both sides (reader and tag) however accuracy of the system can be enhanced by means of improving the antenna performances, i.e., the radiation pattern and the gain (4) (6).

## II. SYSTEM CONFIGURATION

### A. RFID active system

A commercial active RFID system has been acquired to perform this study. The system consists of 2 readers (SYRD 245-1N) and 3 tags (SYTAG 245-TM-BA1) both from Sirys.

Devices work in 2,45GHz ISM frequency band. Two main parameters are obtained from the readers: the TagID (each tag has an exclusive identification number) and the RSSI (8-bit field which informs about its localization).

Data from both readers were acquired in real-time with a self-application running over Matlab through a RS-232 cable. Once the app is running, it reads every 500 milliseconds the buffer where it is stored at a moment the pair (TagID-RSSI). To store the RSSI information we initialize three vectors, one for each tag. The RSSI value stored in the buffer is copied into the last position of the corresponding vector, so vector increases with each sample. Info is also display into a real time graphic, so we now in real time where tags are.



Figure 1. Reader and tag used in the study.

### B. Antennas

The antennas implemented in this study are three: a commercial Omni-directional antenna and two FR4 antennas (patch antenna and two patch array antenna). Design and optimization were made with EM simulator HFSS v.13.0. As well prototyping of these antennas were made at the Public University of Navarra with Protolaser 200.

- Omni-directional monopole antenna. Commercial antenna provided with the reader. The measured gain of this antenna is 0,87 dB @ 2,45GHz.

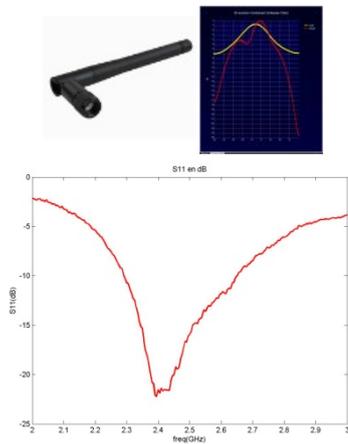


Figure 2. Omni-directional antenna, radiation pattern and S11 measurement.

- FR4 patch antenna. Designed at the Public University of Navarra. This antenna presents a measured gain of 3,06dB @ 2,45GHz.

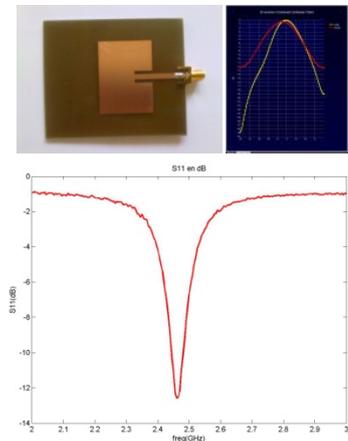


Figure 3. Patch antenna, radiation pattern and S11 measurement.

- FR4 2 patch array antenna. Designed at the Public University of Navarra with a gain of 4,44 dB @ 2,45GHz.

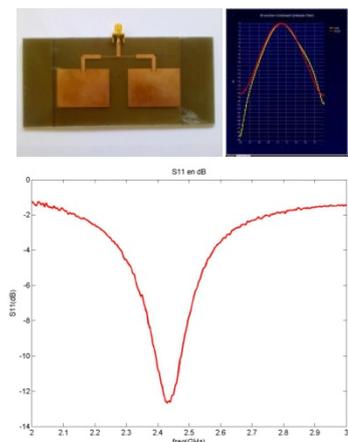


Figure 4. Array 2 patch antenna, radiation pattern S11 measurement.

Measurements have been done with a VNA Agilent PNA E8361C and RFXpert from EMScan (7) (8).

### III. EXPERIMENTAL STUDY

This study was divided into two part and all the measurements were carrying on Electronics and Communications R&D Centre at the Public University of Navarra. First part took place into an Office (5x11 meters), while second part was held in the Exhibition Hall (13x13 meters) and the main Hall of the Centre.

#### A. First Part

In first part the goal was to check if RSSI levels keep the same value regardless of the reader and the tag used. Two different analyses were performed in this part. In both measurements readers were located together while tags were placed in different places for each test.

In first analysis readers were stacked to the wall with an elevation of 2 meters while tags were placed onto the tables, 1 meter height. In second readers and tags were placed onto the tables, 1 meter height.

- Test 1

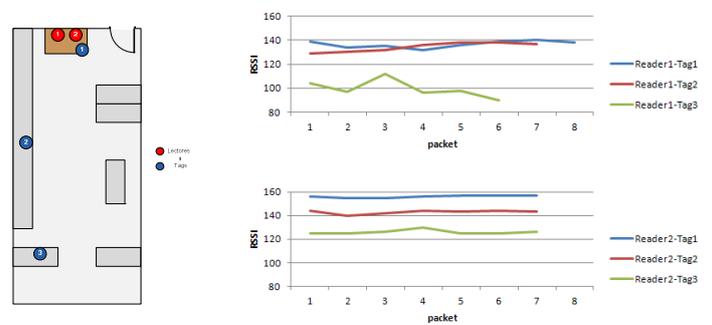


Figure 5. Set up and results obtained in test 1.

In Fig. 5 set up and results obtained in test 1 are represented. It is clear that the results are not identical. These differences could be produced by several effects (differences in the radiation pattern of the antennas or variations in the emitted power levels).

- Test2

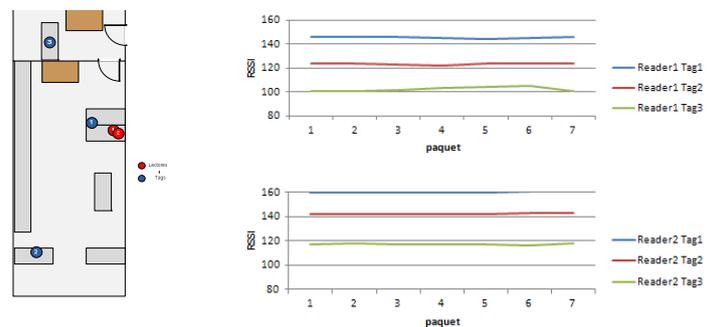


Figure 6. Set up and results obtained in test 2.

In the same way in test 2 levels (Fig. 6) are different again. There is a difference around 20 dB between reader 1 and 2, while readers are located in the same point. Anyway you can see in both that tag1 presents the higher level, while tag3 presents the lowest, despite being tag2 found further. This is due to the attenuation caused by the wall.

Regardless of the cause, these variations can induce high errors when locating the tags. In addition variability of the signal is higher in indoor locations than in free-space, that is a problem add-on RTLS.

**B. Second Part**

Second part of the study seeks to understand how the use of antennas with different radiation pattern can improve RTLS. Antennas presented above were used in this part.

The RSSI analysis as function of the antenna was done by means of walking through the Exhibition Hall and performing specific stops of 20" with intervals of 10". Three tags were allocated within the pocket of a trouser and the person carrying on them moved by investing 10" to reach from one point to the next one and then stopping 20" in each of the fixed points.

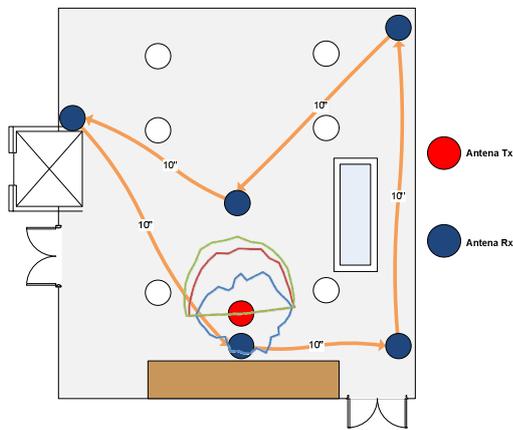


Figure 7. Random-walk 1. Tag's tour through the Exhibition Hall. Tx Antenna in the middle.

In Fig. 7 can be seen the radiation pattern of the antennas and their position in the scenario Blue: Omni-directional antenna, Red: Patch antenna and Green: Array antenna).

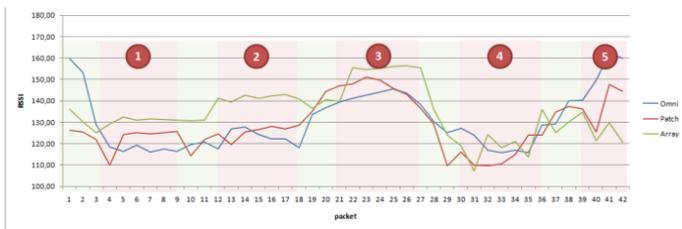


Figure 8. RSSI level obtained with tags moving across the exhibition Hall in random-walk 1.

Fig. 8 shows the measured results in each defined measurement point. In both Patch antenna and Array antenna the maximum was obtained in position 3. On the other hand, the Omni-directional antenna RSSI level corresponded all the times directly with the distance between tags and reader.

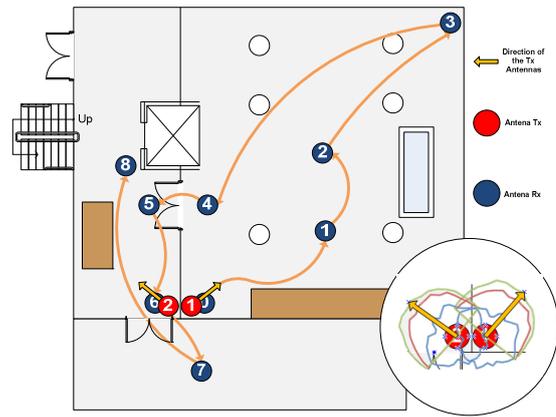


Figure 9. Random walk 2. Tag's tour through the Exhibition Hall and the Entrance of the building. Readers placed into a corner of the room.

Secondly a random-walk through the Exhibition Hall and the entrance of the building was done (Fig. 9). In this test two readers were placed in the same corner (stacked to the wall 2 meters high) but in two different rooms and with different orientation, 90° turn one to each other, so each directive antenna radiate with the maximum intensity to the center of each room. In this test we try to discern how obstacles and orientation can affect to the RSSI, and if we are able to improve the localization of the tag placing directive antennas instead of Omni-directional antennas.



Figure 10. RSS level measured with Omni-directional antenna with tags moving across the Exhibition Hall and the entrance in random-walk 2.



Figure 11. RSS level measured with Patch antenna with tags moving across the Exhibition Hall and the entrance in random-walk 2.



Figure 12. RSS level measured with Array antenna with tags moving across the Exhibition Hall and the entrance in random-walk 2.

It is easy to appreciate difference in levels between reader 1 (P1) and reader 2 (P2) is fewer when using an Omni-directional antenna (Fig. 10) than in the other two cases (Fig. 11 and Fig. 12). This is the expected result because the Omni-directional antenna radiates equal in all directions while Patch and Array antennas radiate in one direction.

In Omni-directional antenna case, RSSI level difference between reader 1 and 2 is mainly due to the attenuation generate by walls (built of concrete and glass). The effect of the attenuation can be seen clearly in the frontier between points 4 and 5, in this time tags leave the Exhibition Hall (where reader 1 is placed) and enter in the building's Hall (where reader 2 is placed). Therefore RSSI levels from point 0 to 4 are higher in reader 1, while from stops 5 to 8 the reader number 2 receives higher levels of RSSI, with the exception of some marginal samples. Difference between curves shows the effects of attenuation. Attenuation of the elements is an important factor for a good design of a sensor network and it must be taken into account for the good implementation of location algorithms.

With Patch (Fig. 11) and Array (Fig.12) antennas we can appreciate how difference in RSSI levels between readers 1 and 2 is higher than with Omni-directional antenna, so it is easier to discern whether tag is in one room or in another.

It is also possible to see, looking for the maximum RSSI levels in each stop, how Array antenna receives more powerful signal than Patch antenna or Omni-directional antenna, when tags locating in the radiating direction of the antenna. This effect is due to the gain of the antennas, Array antenna has a higher gain so reception is better, in the other hand Omni-directional antenna has the lower gain so RSSI levels are lower too.

To make a localization sensor network based on wireless technology (RFID, Zigbee, Wifi...), using directional antennas could be interesting if we want to have a room level accuracy with a low sensors density. Locating directional antennas in a corner of the room, allows having a comprehensive overview of the room but a "blind" overview of the contiguous rooms as can be seen clearly in the frontier between stops 4 and 5 in Fig. 11 and Fig. 12.

#### IV. CONCLUSION

Directives antennas produced a significant drop in RSSI when separate the direction of maximum gain of the antenna. This feature can be interesting to cover specific areas of a room or a floor of a building to improve the RTLS algorithms used nowadays. When tag is moving RSSI fluctuates rapidly in a wide range of values so it is needed to perform an averaging or a filter with the neighboring samples. RSS based-on localization techniques can be used to implement more robust RTLS.

#### REFERENCES

- [1] Finkenzeller, K. "RFID Handbook," 2010, John Wiley & sons.
- [2] Sanpechuda, T. and Kovavisaruch,L "A review of RFID localization: Applications and techniques," 2008, 5th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, ECTI-CON 2008.
- [3] Patwari N., Ash J. N. and Kyperountas S. "Locating the Nodes: Cooperative localization in wireless sensor network," 2005, IEEE Signal Processing Magazine.
- [4] Mao G., Fidan B. & Anderson B. "Wireless Sensor Network Localization Techniques," 2007, Computer Networks: The International Journal of Computer and Telecommunications Networking.
- [5] Pahlavan K., Li X. and Mäkelä J. P "Indoor Geolocation Science and Technology," 2002, IEEE Communications Magazine.
- [6] C., Ash J. N. and Potter L. "Sensor Network Localization via Received Signal Strength Measurements with Directional Antennas," 2004, Proceedings of the 2004 Allerton Conference on Communication, Control, and Computing, 2004.
- [7] Agilent Technologies. <http://www.home.agilent.com>
- [8] RFXpert. <http://www.emscan.com/rfxpert/index.cfmz>