

# Object Localization for Determining Customer's Behavior: Auto-ID Based Approach

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## ABSTRACT

The paper discusses the possibilities of radio frequency identification technology for identification objects in defined space and thus determine customer's behavior. This paper aims to analyze current methods of detecting movement and behavior of customer in the store area and to achieve the greatest automation possible with more accurate, faster processes of increased quality. The proposed system will collect a large amount of operational data, one of the objectives will also be to transform this data into information and extract the greatest possible amount of knowledge.

The experiments described in this paper demonstrate feasibility and possibility of solution enabling tracking of objects in a given area.

## CCS CONCEPTS

• **Human-centered computing** → **Visualization** → **Visualization techniques** → **Heat maps**;  
• **Hardware** → **Communication hardware, interfaces and storage**

## KEYWORDS

Auto-ID; RFID technology; customer's behavior; localization;

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## 1 INTRODUCTION

Retail chains and manufacturing enterprises driven by global world trend are facing the question of how to exploit the potential of this technology and thus not remain far behind their competition. Compared to traditional methods of identification, RFID brings a number of benefits such as identification without direct visibility, great reading range, and ability to read multiple objects at once and others which will be mentioned in the following chapters. It is not surprising that it seems appropriate to apply this technology also on tracking movement of customers in the store area. Basic precondition for implementation of solution is positioning the RFID tags on the movable object associated with customer. Shopping cart appears to be a suitable object. For the above mentioned reasons, the work aims primarily at utilization in the Makro retail chain because there is will and determination for future implementation from their side. All technical background and procedures mentioned in this work are easily transferable to any business environment and beyond it.

## 2 POSSIBILITIES OF SHOPPING CARTS POSITION IDENTIFICATION IN THE STORE AREA

Many researches carried out by the companies dealing with marketing research obtains information about movement either from a moderated conversation with customer or through a questionnaire. Another possibility is that the employees of these companies set out to do research directly among customers and monitor their behavior while moving directly in the store area.

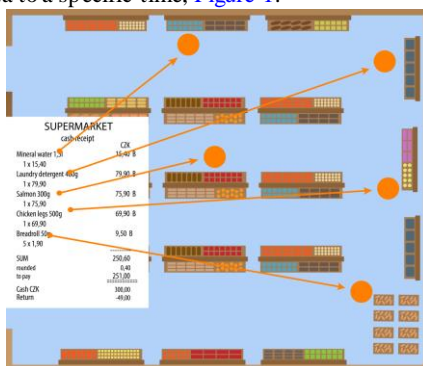
Tracking the location and routes of customers is currently implemented with a number of errors caused by the observer or data distorted by the fact that the respondent is aware his behavior is monitored and therefore does not behave naturally. Additionally, while maintaining reasonable costs we can gather information only on a small sample of customers. The following chapters describe the system which would enable identification of location of all customers simultaneously, automatically and in real time.

Typical sequence of customer activities in the Makro retail chain:

1. Equipping himself with shoppingcart outside the store
2. Entering the store
3. Proving his identity at the counter
4. Shopping
5. Arriving to the cash desk
6. Identifying himself with customer card
7. Making payment
8. Leaving the store and returning the shoppingcart

## 2.1 Monitoring shopping habits through customer's account

The first method has virtually nothing in common with RFID but it can be mentioned as an example of a functional model solving the problem at the most elementary level. When paying at the cash desk the Makro card is submitted and the information on purchased items is retrieved. With the data obtained this way it is enough to compare the electronic map of the store divided into specific zones according to the sold goods to the account of particular customer. According to the goods that customer bought we can compile a map of the places which customer must have visited. At the same time, with the knowledge of the customer's entry time and the exact time of payment at the cash desk we can set this data to a specific time, [Figure 1](#).



**Figure 1: Localization of goods purchases using bill**

This solution has the disadvantage that we do not know where the customer only lingered and wavered over buying. Also we cannot find out where exactly the customer walked and thus we cannot optimize deployment of products around the store. The main advantage of such solution is the fact that it is cheap and fast, almost immediately implementable and it allows to use the information already registered in the Makro stores more effectively. Recently, almost every business has the so-called action zone at the most visible spot where it offers a small amount of goods which is then simultaneously offered at two or three points of sale in the store. The aforementioned method of locating customer movement would not be able to determine at which of these points the goods was purchased.

## 2.2 Alternative methods

Interesting new method of detecting the number and presence of customers in certain places is based on the assumption that every customer has a cell phone. Based on the number of users connected to the station of mobile operator in the shopping centre it is possible to quite accurately estimate the number of customers at given moment. This method is, however, better suited for determining the number of customers in the whole shopping centre and not their current location or route during shopping.

Another option is to use a camcorder for capturing movement of customers and subsequent analysis of the captured video record. This method, however, collides with protection of privacy and very high costs and also with the fact that it is difficult to scan all the space in the store at once and to assess the position and movement of each customer in real time. When capturing a customer with more cameras at the same time, it is also needed to thin him out not to be counted more than once. Another obstacle is the identification of a specific customer in every shot so that his shopping route could be generated. The identification of a specific customer is not easy because the customer is recorded from a different angle and distance in every shot.

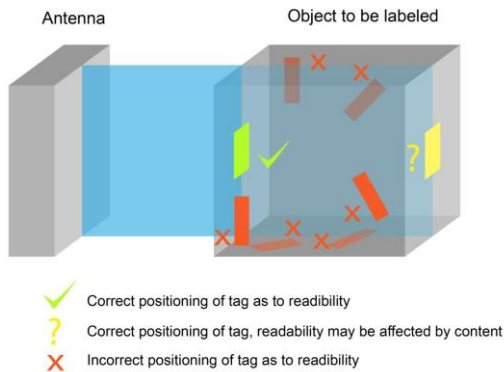
## 2.3 Solution based on RFID technology

The basic idea lies in equipping the cart with the UHF RFID tag. Solution such as using a borrowed localization RFID card upon entry to the store would demotivate shoppers and discourage them from buying because of impression their behavior is monitored. In addition, we can assume unnatural behavior of the customer who is fully aware of being watched.

Subject suitable for monitoring thus could be a shopping cart as it is assumed that buyers in the Makro retail chain usually buy in bulk and shopping cart accompanies the customer throughout all shopping.

Since the carts in the Makro are made of metal, we need to consider choosing the appropriate tag for metal. Another parameter that should be borne in mind is the appropriate position and rotation angle of the tag. The tag will carry the EPC code which can be uniquely identified during the whole shopping time.

For proper placement of the RFID tag on the shopping cart we need to respect mutual orientation of the tag towards the reader antenna, [Figure 2](#).



**Figure 2: Suitability of tag location on the object towards the reader antenna**

Since the shopping cart is gradually filled with goods, it could happen that nature of purchased goods will make reading of the tag impossible in case the cart approaches the rack with the tag on the farther side. Therefore, it is advisable to put two tags on the opposite sides of one cart, Figure 3. The need to place two passive tags on one cart was verified during the testing described in the following chapters.



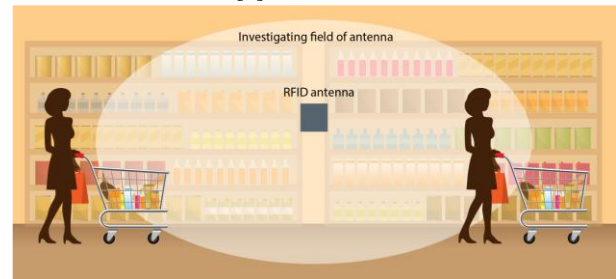
**Figure 3: Suitable locations for the tag**

As to the actual placement, there are three suitable locations for the application of RFID tag. The first one is on the side of the cart ribbing. This position is advantageous because it ensures good reading conditions on both sides. However, this place is overstrained in the so-called "stacking" of carts into a row and the tag could be damaged. There is thus another suitable place by the side of the cart handle. Again, it is desirable to place the tag on both sides. The third place or rather places depend on the selected type of tag, for example a tag in the shape of a tape could be wrapped around the cart construction virtually anywhere.

If the solution were applied also in other retail chains, the RFID tags could be placed on the shopping baskets as well. For example, in the Interspar chain there have been shopping baskets equipped with so-called EAS tags used for several months. These tags do not contain identifier, they are able to provide only one-bit information when they occur in the reading field of the exit gate

behind the cash desk and they only serve to prevent carrying the carts out of the store.

Positioning the antenna in the specific rack seems like a suitable solution. Antennas have different radiating angle so it is necessary to choose an antenna able to cover the particular area in front of the rack where shopping carts will be passing. It should be placed in a height suitable in relation to the tag location and turned in such way so that its reading field would only cover the area we want to monitor [1].



**Figure 4: Principle of one antenna in the shopping center environment**

Evaluation of the cart presence then takes place in a following way. When the cart gets into the reading field of particular antenna, a record in the information system is made about this presence and the same thing happens when the cart leaves the field, Figure 4.

Antennas that monitor the area in front of the racks and detect presence of tags on the carts are connected with the reader. In Figure 5 we can see an example of a reader with four antennas connected monitoring the space in front of four racks. In case the rack uses both sides to display goods, it is possible to place two antennas on both sides of the rack.



**Figure 5: Principle of multiple antennas in the shopping center environment**

### 3 EXPERIMENTAL RESULTS OF SOLUTION

In order to apply the proposed solution, it was necessary to design the individual elements of hardware infrastructure. When choosing the RFID tag, attention was focused on the UHF frequencies because of readability of several meters. Another important parameter was shielding against interference associated with proximity of metals, as most shopping carts in the Czech Republic are made of metal. The UHF band is generally not suitable for applications in metal and liquid environment. Another important parameter was the size and ability to fit on the ribbing of shoppingcart.

### 3.1 Testing of reading angle of RFID antenna

To ensure uniform conditions for testing three types of antennas, they were placed on a stand so that the center of the antenna was at a height of 1 meter above the floor level, Figure 6. Each antenna was gradually connected to the Impinj R420 reader, one by one. Reading device enables setting the power up to 33 dBm (corresponding to 2W) which would probably cause the reading distance to surpass the dimensions of the laboratory while measuring the angle. For this reason, the Impinj Multireader software was used to set the power for antennas to 15 dBm which limited reading distance for the selected tag to easily measurable tens of centimeters.

The angles were drawn ranging from  $-60^\circ$  to  $60^\circ$  (beam angle  $120^\circ$ ) with increments of  $5^\circ$  on the laboratory floor, Figure 8. Due to the lower range of all antennas mentioned in the spreadsheet it was not necessary to measure higher values. According to the manufacturer, the Barco FlexiRay antenna has different beam angle in vertical and horizontal axis, thus I performed the measurements with it in both planes.

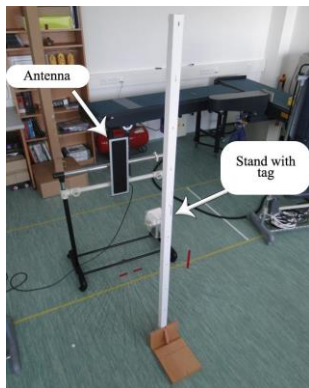


Figure 6: Configuration of measuring

The measurement was carried out by gradually placing the stand with the tag near the antenna and searching for the greatest distance at which the tag will be able to reply. Results of the measured values are neatly listed in the table below (see Table 1). The following graphs show maximum reading distances of the tag in individual angles in millimeters depicted in grey color. The beam angle stated by the manufacturer of antenna is represented by dark blue color.

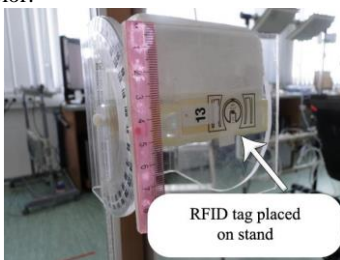


Figure 7: Positioning of tag on the stand

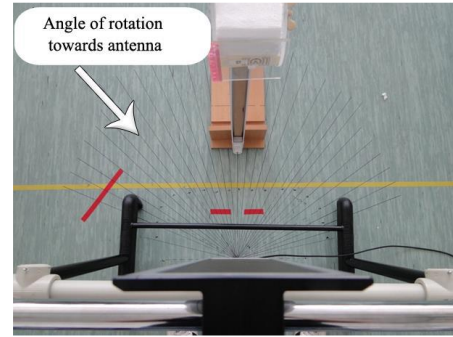


Figure 8: Beam angle with increments of  $5^\circ$

Table 1: Results of measuring reading angles of the antennas  
Measured distance between the tag and antenna [mm]

Beam angle	Metra Blansko	Alien	Barco horizontally	Barco vertically
$-60^\circ$	150	70	82	127
$-55^\circ$	185	91	95	148
$-50^\circ$	210	105	105	160
$-45^\circ$	230	113	110	205
$-40^\circ$	290	142	140	250
$-35^\circ$	335	185	160	265
$-30^\circ$	380	195	163	330
$-25^\circ$	396	230	185	335
$-20^\circ$	395	270	199	335
$-15^\circ$	385	295	219	340
$-10^\circ$	392	310	225	325
$-5^\circ$	385	315	239	322
$0^\circ$	390	318	240	310
$5^\circ$	380	325	235	330
$10^\circ$	375	300	245	305
$15^\circ$	378	285	245	312
$20^\circ$	350	273	233	310
$25^\circ$	305	230	215	295
$30^\circ$	267	205	200	285
$35^\circ$	210	185	160	270
$40^\circ$	185	178	152	225
$45^\circ$	163	146	149	155
$50^\circ$	150	120	140	130
$55^\circ$	145	92	125	124
$60^\circ$	121	86	108	115

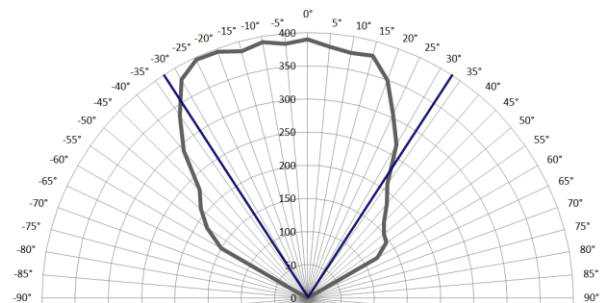


Figure 9: Graphic illustration of results Metra Blansko

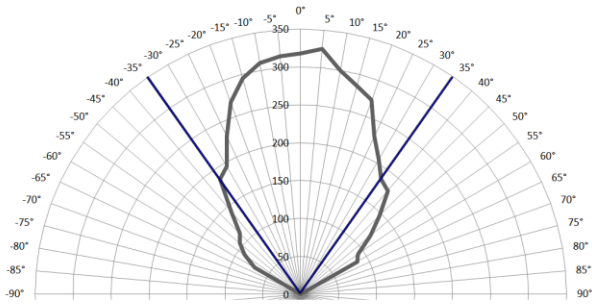


Figure 10: Graphic illustration of results Alien

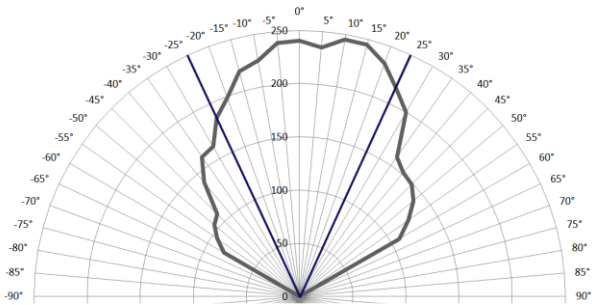


Figure 11: Graphic illustration of results Barco in horizontal position

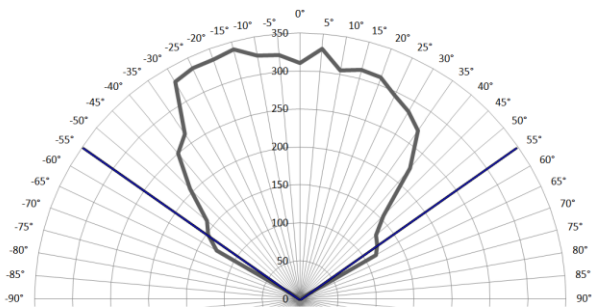


Figure 12: Graphic illustration of results Barco in vertical position

Based on the graphic illustration of the measured data it can be stated that the measured beam angles of antennas correspond with the angles provided by the manufacturer. Minor deviations are mainly caused by reduced power radiating from the antenna. When fully operational, the laboratory results would be closer to the reported values but even at these small distances we can observe correlation between the provided and measured beam angle. Some measurements managed to read the tag even beyond the limit stated by the manufacturer, however the reading distance was significantly reduced in such cases. More accurate measurements could be achieved in a shielded and anechoic chamber. In summary it can be stated that the measured reading angle of all antennas is sufficient for covering the area in front of the store rack.

### 3.2 Test of passive tag positioning

This test was designed to determine the difference in readability of the passive tag located on the front part of the cart ribbing (A) and the tag located on the side of the cart ribbing (B) from outside view.

Two tags were placed on the cart. One on the front ribbing and the other on the side ribbing. During testing, the cart was passing by in front of the antenna with average walking speed (5 km/h). While passing by, the tags were in a distance of 1 meter from the antenna. Using test software, it was recorded how many times the tag was read when passing through the reading field of the antenna, Figure 13.

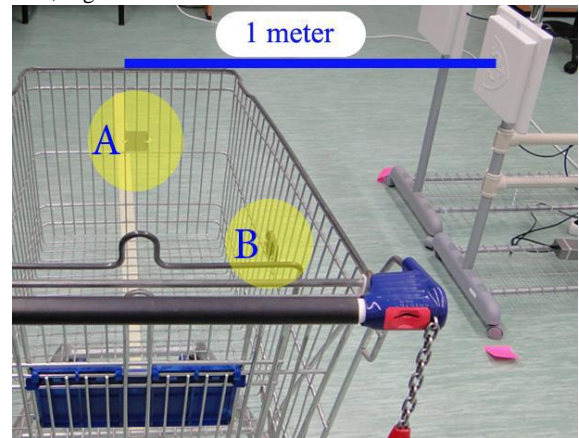


Figure 13: Scheme of basic tests

For simple comparison of measurement results I present the arithmetic mean of the thirty cart passages (see Figure 14).

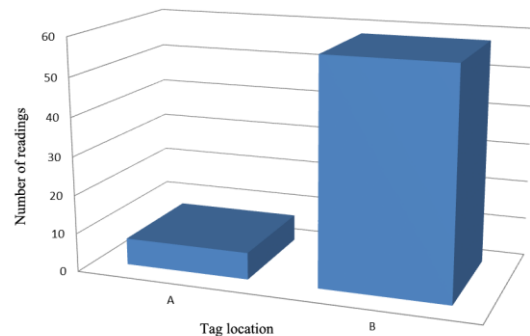


Figure 14: Results of test of tag positioning

Average number of the tag readings in position A was 7 readings during passage, while the tag in position B had 57 readings. According to the test result it can be preliminarily concluded that the difference between the location of the tag in position A and B really exists.

If the number of readings on the front side of the cart was constantly 7, it would be sufficient for the purposes of labeling.

however, the reading of tag in this position completely failed a few times during the test. With regard to the test results it is clear that when using the passive tags the tag must be placed on the side of the cart.

The next test was focused on positioning various tags for metals on the side of the cart and measured the number of their readings. This test was designed to determine the difference in readability of various types of passive tags placed on the side ribbing, Figure 15.

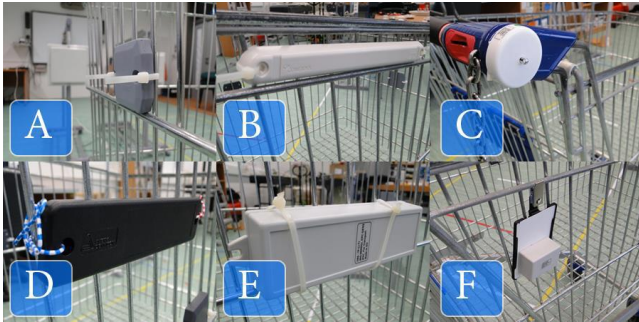


Figure 15: Examples of used tags

Test verified that whichever of these tags for metal was selected, the tag was always read when passing by in a distance of 1 meter from the reading antenna. The smallest number of readings from the overall number of 180 readings was 51 readings and that is more than sufficient for capturing a simple passage by the rack. The number of readings for passages are shown in the following chart, Figure 16.

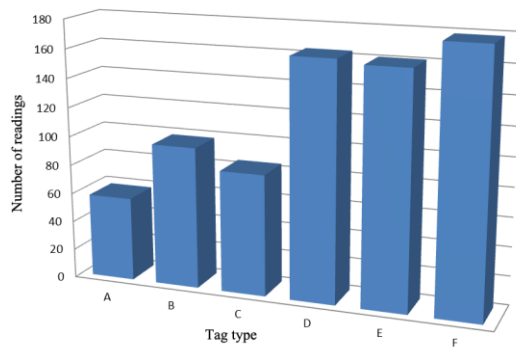


Figure 16: Results of passive tags readability

This test thus proved that there are differences between the tags in terms of reading number which will serve as one of the parameters for selection of a particular tag suitable for shopping cart.

### 3.3 Measuring of reading area

In this test, the goal was to visualize the investigative field of the antenna with respect to the required signal strength enabling communication with tag on the cart. One of the parameters of the report on the presence of the tag is the signal strength with which

the tag was read. The purpose of this measurement is to determine whether this parameter can help to refine localization of the cart.

It was drawn a grid with a step of 0.25 m in the vertical axis and 0.15 meters in the horizontal axis on the floor in front of the antenna. The cart was gradually positioning in the centers of these coordinates, Figure 17. In every position the minimum signal strength enabling communication was measured.

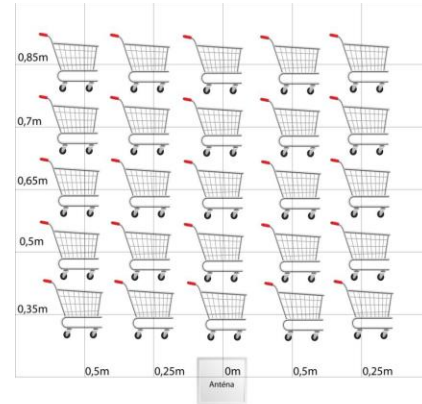


Figure 17: Scheme of reading area measurement test

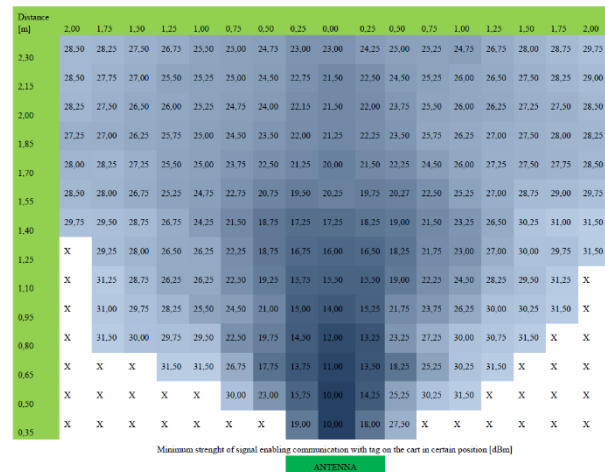


Figure 18: Minimum strength of signal enabling communication with tag

When analyzing the results of the measurements the distinct differences were noticed in signal strength between particular positions of the cart with tag. The minimum signal strength was needed right in front of the antenna, as close as possible to the tag.

If we ignored signal strength, we would be only able to find that the cart is somewhere in the reading area of the reader. However, if we processed also the signal strength from the reading device and watched consecutive time stamps of reports on the presence of tag, we could estimate even the direction of movement of the cart or determine its position in the reading field of the antenna more precisely, Figure 19.

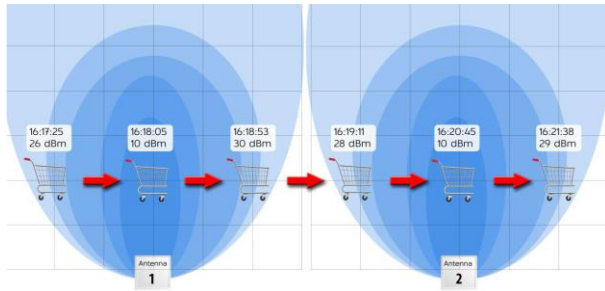


Figure 19: Determining of shopping cart movement using strength of signal of tag reading

#### 4 RESULTS OF TESTS PERFORMED IN RETAIL STORE

After successful laboratory tests the next logical step was to verify the functionality of the proposed technology in an actual store. Thanks to the cooperation with the IPSOS company engaged in marketing research, there was an opportunity to verify how the RFID technology could enrich conducting of marketing research.

For testing, two types of tags were chosen. For carts and baskets it was Confidex Survivor and for participants in the marketing research it was the RFID tag (tag labeled H86-IP-ABS). A unique EPC was uploaded on all tags and they have been marked with a sticker bearing the EPC to make it clear which tag is which even without the RFID reader.

The last necessary step in the preparation was the installation of the RFID infrastructure itself. According to the plan, it was necessary to deploy the antennas and readers, interconnect them with cables and place the power cables so that they would not bother shoppers. All readers were connected to the router through LAN cable and the router was connected to the notebook.

The main purpose of this test was to verify the laboratory results of the applicability of RFID tag in an actual store on the real shopping carts.

Questions to be answered

1. Is the tag on the cart readable?
2. What is the readability of the tag in different distances from the antenna?

An empty shopping cart with the tag attached to the side was placed as close as possible to the rack with reading antenna. In the first phase, the antenna was in a distance of 0.3 m from the tag on the cart. I conducted thirty measurements during which I collected number of tag readings in 5-second intervals. Since the corridor had a width of 3 meters and a width of the cart was 0.7 meters, I carried out the following measurements in the limiting case of the cart pressed to the opposite side of the corridor or more precisely, the tag on the cart was in a distance of 2.3 meters from the reading antenna. Apart from these limiting cases when the cart was the least and most distanced from the antenna in the same plane, I also carried out further measurements in the distances of 1 and 2 meters, Figure 20.

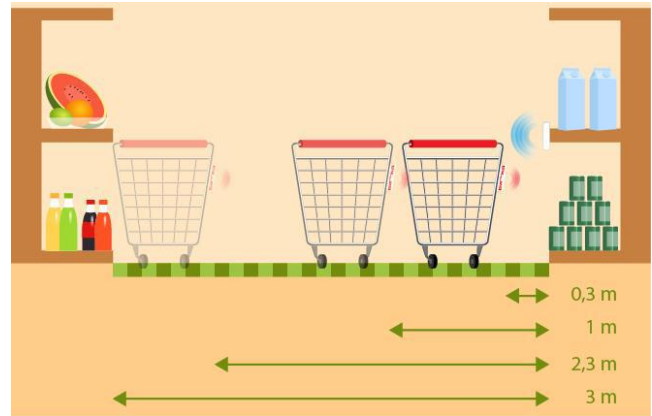


Figure 20: Scheme of readability test in real environment

Table 2: Measured data from readability test in real environment

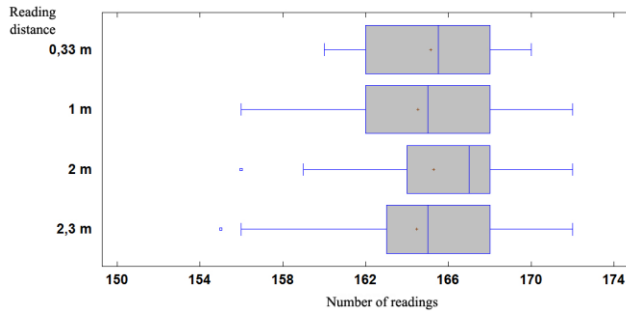
#	0.3 m	1 m	2.3 m	3 m
1	164	158	156	166
2	161	156	167	160
3	163	162	168	166
4	169	158	167	164
5	163	160	167	156
6	161	158	167	154
7	169	153	169	170
8	170	159	168	172
9	165	159	170	168
10	164	159	166	166
11	160	155	149	170
12	166	156	165	170
13	162	160	167	168
14	168	159	168	165
15	161	161	169	164
16	168	158	164	168
17	169	161	159	170
18	166	162	160	165
19	168	156	156	170
20	165	160	168	167
21	164	159	166	166
22	160	155	149	170
23	166	156	165	170
24	162	160	167	168
25	168	159	168	165
26	161	161	169	164
27	168	158	164	168
28	169	161	159	170
29	166	162	160	165
30	168	156	156	170

#### 4.1 Analysis and evaluation of data

To be able to answer the given questions, an analysis of the measured data was performed in the statistical program Statgraphics.

**Table 3: Basic statistical data on readability test in real environment**

	#	Mean	Standard Deviation	Coefficient of Variation	Min.	Max.	Range
0,33 m	30	165.133	3.15937	1.91322%	160.0	170.0	10.0
1 m	30	164.533	3.98041	2.41921%	156.0	172.0	16.0
2 m	30	165.3	4.26817	2.58207%	156.0	172.0	16.0
2.3 m	30	164.467	4.01491	2.44117%	155.0	172.0	17.0
Total	120	164.858	3.84641	2.33316%	155.0	172.0	17.0



**Figure 21: Box and Whisker Plot**

**Table 4: Analysis of variance for readability test in real environment**

	Sum of squares	Degrees of freedom	Mean square	F-value	P-value
Between groups	15.8917	3	5.29722	0.35	0.7876
Within groups	1744.7	116	15.0405		
Total	1760.59	119			

**Table 5: Mean and Homogeneous group**

	Number	Mean	Homogeneous groups
A	30	135.667	X
B	30	135.933	X
C	30	136.333	X
D	30	136.5	X

When applied on the shopping cart used in the retail chains and in conditions of an actual store the tag is readable. Measurements proved that in the 5-second intervals, the average number of tag readings in all measured distances was 136 readings at the maximum power of the reader. This number of readings is more than sufficient to capture the occurrence of tag in the reading field of the antenna. Analysis of variance also showed that when using this tag there are no significant differences in the number of readings among all measured distances in a given time period.

**4.2 Test of interference caused by content of cart**

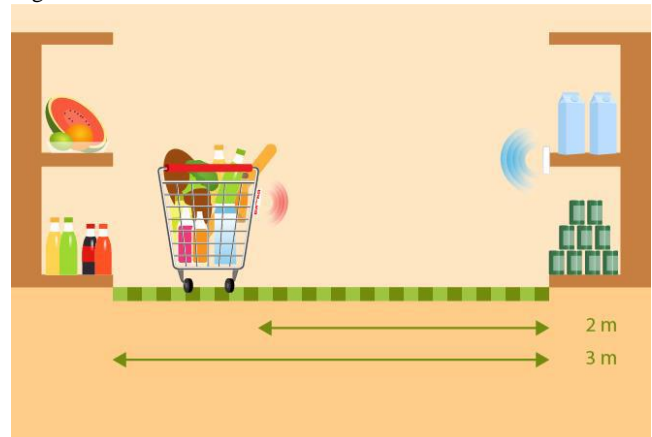
The main purpose of this test was to verify whether the content of the shopping cart affects reading abilities of the tag. Using the UHF RFID tags is generally problematic in metal and liquid environment. To test the interference I therefore chose two limiting cases when I filled the shopping cart with water bottled in

plastic material and then with alcohol packaged in metal and glass.

Questions to be answered:

1. Will the cart filled with water bottled in plastic affect reading abilities of the tag compared to an empty cart?
2. Will the cart filled with alcohol bottled in metal and glass affect reading abilities of the tag compared to an empty cart?

Since the previous test showed that there is no difference between particular distances in the entire width of the corridor, it could be chosen any of the measured distances between the tag and the reading antenna to examine the influence of cart content on reading abilities of the tag. The distance of 2 meters was chosen and same as in the previous cases, the number of readings during 5-second intervals were collected. At first, a shopping cart was put in this distance filled with water bottled in plastic and then with beer packaged in metal and glass. For both options thirty measurements were conducted and compared with previous measurements of an empty cart also in a distance of 2 meters, Figure 22.



**Figure 22: Scheme of testing of interference caused by content of cart**

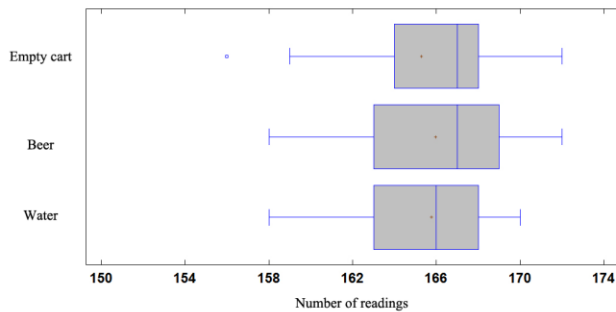
**Table 6: Measured data**

#	water	beer
1	168	162
2	170	167
3	166	163
4	168	168
5	170	170
6	165	162
7	166	163
8	162	171
9	163	164
10	170	162
11	168	169
12	170	172
13	166	167

14	171	172
15	168	169
16	170	168
17	171	165
18	168	169
19	171	168
20	165	169
21	170	162
22	168	169
23	170	172
24	166	167
25	171	172
26	168	169
27	170	168
28	171	165
29	168	169
30	171	168

**Table 7: Basic statistical data on interference caused by content of cart**

	#	Mean	Standard Deviation	Coefficient of Variation	Min.	Max.	Range
Empty	30	165.3	4.26817	2.58207%	156.0	172.0	16.0
Water	30	165.767	3.42086	2.06366%	158.0	170.0	12.0
Beer	30	165.967	3.52805	2.12576%	158.0	172.0	14.0
Total	90	165.678	3.72609	2.249%	156.0	172.0	16.0



**Figure 23: Box and Whisker Plot**

**Table 8: Analysis of variance for readability test in real environment**

	Sum of squares	Degrees of freedom	Mean square	F-value	P-value
Between groups	7.02222	2	3.51111	0.25	0.7804
Within groups	1228.63	87	14.1222		
Total	1235.66	89			

**Table 9: Mean and Homogeneous group**

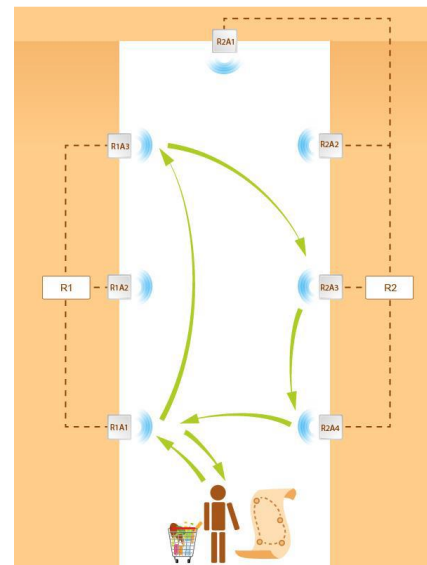
	Number	Mean	Homogeneous groups
Empty	30	165.3	X
Water	30	165.767	X
Beer	30	165.967	X

Based on the variance analysis it can be stated that among the compared sets of measured data, there is no statistically significant difference at 95% confidence level. All the compared files belong to a homogeneous group. Thus, it means that whether the shopping cart is empty, filled with water or alcohol bottled in plastic, metal or glass, it makes no difference to the reading abilities of the tag.

### 4.3 Test of data collection using three customers moving in the store area

The main purpose of this test was to verify whether it is possible to track movement of particular RFID tag in front of particular racks in an actual store. All previous tests involved only the measurement of one tag in front of the antenna. In this test, three unique tags were moving in the store area while the data was collected on reading from the reading devices.

Two readers and seven antennas were deployed in the store area. Customers were given maps of their paths and also time indications of how long they should stay by specific racks. The data was recorded on tag readings with the LLRP commander application and then exported it to csv file. Then the data was exported to the Microsoft Excel software where the data was filtered and it could be compared the time stamps and location of read tags.



**Figure 24: Scheme of testing movement of three customers**

The data analysis using the Microsoft Excel software was conducted where the data was exported from csv file and filtered out according the EPC of specific customers. From the resulting data, the measured position was selected using the reader ID and antenna ID. Then, the timestamps of the first and the last record of the particular tag was subtracted. In the following tables, I present the location of customer according the walking path scenario and the measured location in the data, at the same time I compare the planned time of stay with the measured time.

**Table 10: Comparison of planned and measured data – customer 1**

Real location	Measured location	Location comparison	Planned time of stay	Measured time of stay
R1A1	R1A1	Concurrence	1 minute	55 seconds
R1A3	R1A3	Concurrence	50 seconds	45 seconds
R2A3	R2A3	Concurrence	1 minute	55 seconds
R2A4	R2A4	Concurrence	1 minute	50 seconds
R2A1	R2A1	Concurrence	50 seconds	42 seconds

**Table 11: Comparison of planned and measured data – customer 2**

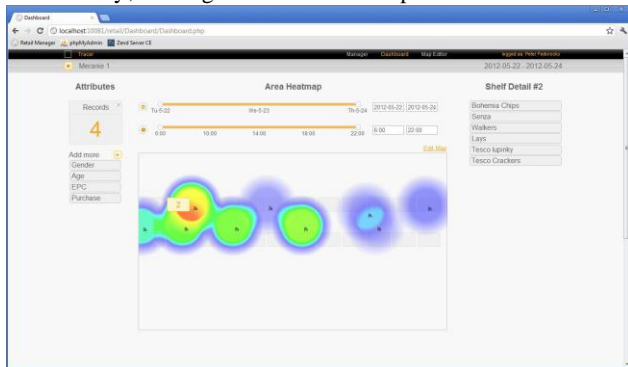
Real location	Measured location	Location comparison	Planned time of stay	Measured time of stay
R1A2	R1A2	Concurrence	1 minute	1 minute
R2A2	R2A2	Concurrence	1 minute	55 seconds
R1A3	R1A3	Concurrence	50 seconds	40 seconds
R2A1	R2A1	Concurrence	1 minute	1 minute
R2A4	R2A4	Concurrence	1 minute	55 seconds

**Table 12: Comparison of planned and measured data – customer 3**

Real location	Measured location	Location comparison	Planned time of stay	Measured time of stay
R2A2	R2A2	Concurrence	1 minute	55 seconds
R1A3	R1A3	Concurrence	1 minute	1 minute
R1A1	R1A1	Concurrence	50 seconds	40 seconds
R2A2	R2A2	Concurrence	40 seconds	30 seconds

Data analysis showed that it is possible to track the paths of individual customers in the measured data and the measured paths coincide with the real ones. Minor differences in planned stays of customers by the rack and the measured ones can be explained by the time the customers needed to reach particular locations.

Analysis of movement of three customers in the captured data set is neatly feasible only with the Microsoft Excel software, however, for a more comprehensive view on a larger number of simultaneously moving people it will be necessary to use more sophisticated software. The next steps of the data analysis will involve the utilization of datamining using the SAS software. Alternatively, the Cognos software in cooperation with the IBM.



**Figure 25: Demonstration of application tracking movement of customers**

## 5 CONCLUSION

The main objective of the paper was to design and demonstrate the applicability of RFID technology in object location identification in a specified area.

In this paper, the methods for labeling and tracking shopping cart were described and evaluated. The initial series of measurements were performed and using the results of these tests, the applicability of RFID on the shopping cart was verified. We worked out the analysis of the retrieved data on the presence of cart near particular rack and the procedure for the data evaluation including subsequent visualization design was suggested.

Experiments on the use of RFID technology to identify the location of objects in a given area have shown that such application is possible and feasible. In a subsequent stage, we want to focus on the possibilities of application of active tags and wireless infrastructure solutions. We also want to focus our efforts on the possibilities of data mining and visualization of outputs using more sophisticated software tools.

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