A TECHNOLOGICAL INNOVATION APPLIED TO THE SIMULATION OF RFID ENVIRONMENTS AS USED IN THE LOGISTICS AND SUPPLY CHAINS

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This paper presents the results of experimental research for the development of an innovative product designated the RFID-Env - Software for the Simulation of RFID Environments. This apparatus is designed for use by professionals in computeer systems and plant engineering who are engaged in research and development of Radio Frequency Identification systems as applied to the management and operation of logistic supply chains. The RFID-Env makes it possible to simulate on computer screens a complete RFID environment by processing user data on the technical and physical characteristics of real or virtual RFID environments. Information outputted can include descriptions of the performance to be expected from a given configuration and detailed reports as to whether that particular configuration will succeed in reading all the RFID tags flowing through a defined system. In arriving at these results the RFID-Env considers the anti-collision communication protocols utilized by the tags, the quantity of tags to be read in a given period of time, the temperature at the location, the distance between the tags and the reader antennas, and the velocity of exposure of the tags to the readers. The software required for these results is built into the RFID-Env and includes a library of communication protocols (ACPL - Anti-Collision Protocol Library) covering the four RFID ISO standards most frequently used (ISO 18000-6) in the market.

Palavras-chaves: Logistics, Supply Chains, Simulation, RFID, Technological Innovation

1. Introduction

The major challenge for industry in logistic chains is the need to constantly optimize the processes so as to produce the goods or services as quickly and efficiently as possible, at the right place and precisely as desired by the clients (ROSA, 2006). Nowadays, the variety of products offered in the market place adds to the complexity of managing the flow of information along the productive supply chain and obliges manufacturers to introduce new technologies to facilitate the logistical operations. (NGAI et al, 2005).The technology of Radio Frequency Identification (RFID) is attracting attention and interest from industrial and commercial enterprises because the system has the potential of simplifying the process and improving the efficiency of automatic product identification (PRADO, PEREIRA and POLITANO, 2006).

Brock (2006) states that the principal component of the RFID technology is the intelligent tag, which is affixed to the product. The information electronically written on the tag is read by electromagnetic radiation and passed to a radio transmitter where a radio frequency carrier transmits the data wirelessly to a distant receiver (reader or interrogator) capable of interpreting and registering the information. (YGAL et al, 2006).

Prado, Pereira and Politano (2006) consider that the RFID system is made up basically of three elements which are: (i) the tags; (ii) the electromagnetic and data readers; and (iii) a series of computer programs. Prado (2005) agrees with this and adds that the operation of the RFID system depends on an electronic tag that is affixed to each product and has a unique digital identity. This identity is known as the product code or EPC - *Electronic Product Code.* When the tag is interrogated by the external electronic reader, the data recorded in the tag's memory is recovered and transmitted. This memory consists of an integrated circuit or microchip and has capacity to store a great deal of information such as, amongst others, (i) the electronic code of that particular product; (ii) the product reference number;(iii) the respective production data; (iv) delivery date; (v) validity period; and (vi) information on the supplier. (ATKINSON, 2004).

The RFID technology can be utilized in many different ways and the field of application is growing exponentially (BROCK, 2006). Among the improvements that the system can provide in logistical operations, Prado, Pereira and Politano (2006) emphasize: (i) greater availably of products; (ii) better profit margins due to cost reductions; (iii) improved worker operational efficiency; (iv) reduction in inventory losses; (v) reduction in stock levels; (vi) reduction of the cost of technical assistance; (vii) better industrial or commercial layouts of the installations.

Ygal et al (2006) agree and state that if conventional business processes are compared with those of the RFID technology, it will be seen that the impact of the new technology, principally at the strategic level, include: (i) the development of new business models; (ii) the integration of activities; and (iii) re-engineering and automation of the older processes thus facilitating B2B commerce.

However, in spite of the many promising applications of the RFID technology in the supply chain, various technological difficulties prevent the large-scale use of this system (PRADO, PEREIRA and POLITANO, 2006). The technology has functional problems that have been widely discussed by the software developers and production engineers and which have required constant research to develop technological improvements. These problems are (i) ´´collisions`` caused by simultaneous communication of the readouts of two or more tags; (ii) electromagnetic interference; (iii) insufficient range of the radio frequency (RF) carriers; (iv) difficulties in finding the ideal positioning; and (v) the number of antennas required for the electronic readers. (MYUNG and LEE, 2006; HASSAN and CHATTERJEE, 2006; CHENG and JIN, 2007).

Considering these problems, this article presents the results of experimental research conducted to obtain data for the development of an innovative product: **The RFID-Env, Software for Simulation of RFID environments**. This product is designed for use by developers of computer system applications and research and development (R&D) engineers working on RFID problems and makes it possible to simulate a complete RFID environment away from the factory floor.

The remainder of the article is organized in the following manner: (i) Section 2 presents the methodology and the procedures used in the research; (ii) Section 3 describes the proposed system and an experimental simulated application; (iii) Section 4 demonstrates the results obtained by describing the physical parameters considered in the system and the kind of environments that can be simulated, such as ´´conveyor mode`` or ´´portal mode``; and finally, (iv) Section 5 lists the conclusions of our study.

2. Methodology

Software development is classified as research and development (R&D) and involves the realization of scientific and technological advances in a systematic manner (OCDE 2007). Our research was of an experimental character and resulted in the construction of a prototype. A prototype is defined by OCDE (2007) as an original model that includes all the technical characteristics and functions of the new product.

2.1 Methodological Procedures

The development of the RFID-Env was based on high-level abstract models and can represent all the parameters so that the developer could configure the tests in whatever way best suited the environment to be simulated. The software includes a library of communication protocols (ACPL – Anti-Collision Protocol Library) that covers the four main ISO standards for the area (ISO 18000-6), which are: (i) ALOHA LST; (ii); ALOHA FST; (iii) Btree and (iv) Random Slotted (Q Algorithm). In addition, the protocol library has the Calculated Q proposal, which is an improved edition of Random Slotted, the most recent version of the ISO standards. The software was written in the Java programming language and the developer can readily extend coverage by using new communication protocols. Proper operation of the RFID-Env was confirmed by operation under various test condition with the different protocols proposed by the ISO.

Due to a combination of the tag size, the reading capacity at distances around five meters (m) and control of the reading area by adjusting the antenna direction and the interrogator configuration, a major part of the efforts to use RFID in the control of supply chains and consumer goods, is directed at the UHF passive tags (ISO 18000-6) (HASSAN and CHATTERJEE, 2006; CURTIN and RIGGINS, 2007; BORRIELO, 2005 and WEINSTEIN, 2005). For this reason our development was concentrated on the physical characteristics and anti-collision algorithms used in these tags.

In the simulated environment developed we considered the anti-collision communication protocol impressed on the tags, the quantity of tags to be read in a specified time period, the ambient temperature, the distance between the tags and the reader antennas, and the speed at which the tags passed by the readers. To use the RFID-Env, the operator merely enters the physical and technical characteristics of the RFID environment, and the simulator generates reports predicting whether, for that particular configuration, all the tags will be read correctly.

3. The Proposed System

3.1 Description

When the RFID-Env software is simulating the reading of the ISO 18000-6 standard types A, B and C tags, and the respective anti-collision communication protocols, it respects the manner in which these devices work – there are processes involving the interrogator operation and others related to the tags functioning. Some few processes were implemented specifically for the simulation. For example, the process that generates the unique code identifier denominated UID (Unique Identifier) on each tag. In a typical real-life system, the tags already have a UID value at the moment that the protocols are executed, while in the RFID-Env, a random number generator produces an initial simulated UID numbers and allocates to each tag the corresponding simulated UID value. This can vary between 16 bits (in the ISO 18000-6 C) and 64 bits (in the ISO 18000-6 B) (ISO/IEC 18000-6, 2006a and ISSO/IEC 18000-6, 2006b).

During the process of identifying the tags, the protocol may use only a portion of the data contained in the memory on the tag. In the ISO 18000-6 A, a Sub Identifier (SUID) of 40 bit is transmitted. However, in the ISO 18000-6 B, the whole UID of 64 bits is sent, and in the ISO 18000-6 C a randomic value of 16 bits exclusively for the anti-collision process, called RNI6, is sent out.

The work environment of the RFID-Env is divided into three windows: Simulator, Single Mode and Portal Mode. On the initial screen (see Figure 1), the user specifies which anti-collision protocol wishes to test, the number of tags in the environment, and depending on the protocol selected, provides some specific parameters such as the starting sizes of the frames in ALOHA type protocols utilized by the ISO 18000-6 A and C standards. The user may also select the total number of executions (so as the facilitate the generation of statistic averages of the results) and the format of the printout (which is generated in ASCII file).

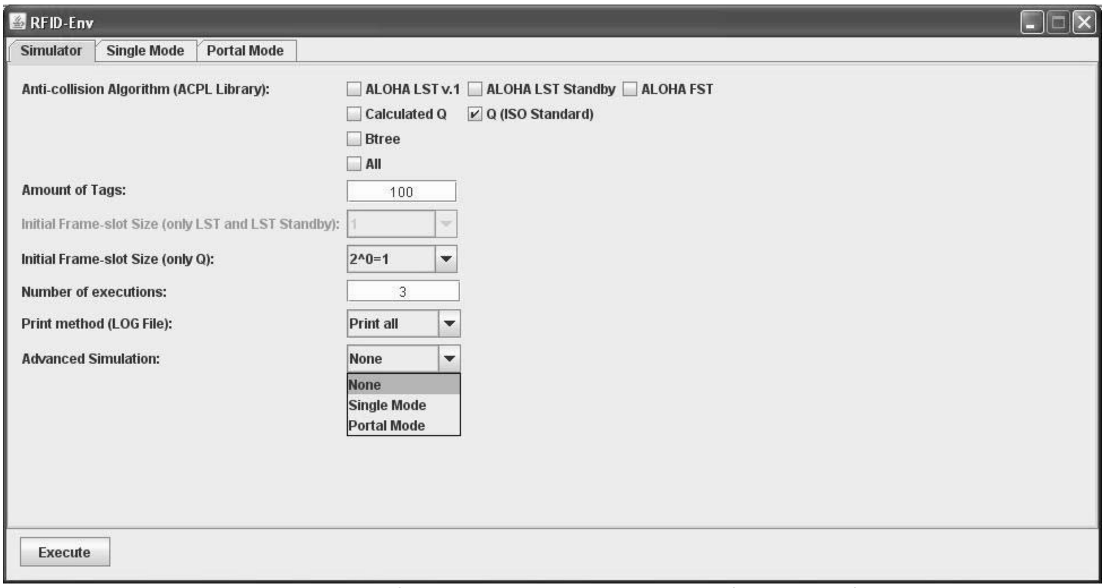

Figure 1 – Initial window of the RFID-Env and selection of the type of environment.

On the initial screen there is an (optional) selection box denominated Advanced Selection where the user can select the system operational mode to be simulated: Single Mode or Portal Mode. If the user only wants to test the algorithms functioning, without interference with the physical environment, this option may be ignored together with the respective tabs. But for tests where the constructive characteristics of the tags (for example, whether the tag base material is plastic or wood) and where environmental variations such as the quantity of the readers and antennas, the speed of the passage of the tags in front of the antennas, .temperature or other variables are to be considered, the user must in this case select either the Single or Portal Mode.

Figure2 shows the Portal Mode screen habilitated after selection of Advanced Simulation by the user and the option corresponding to this mode.

Figure 2 - Portal Mode screen of the RFID-Env.

As soon as the user inputs the number of tags present in the environment, the UID generation process is executed and for each tag of the virtual environment, a unique code is attributed. The environment generated in the RAM memory and the five principle stages for the simulation process are demonstrated in Figure 3.

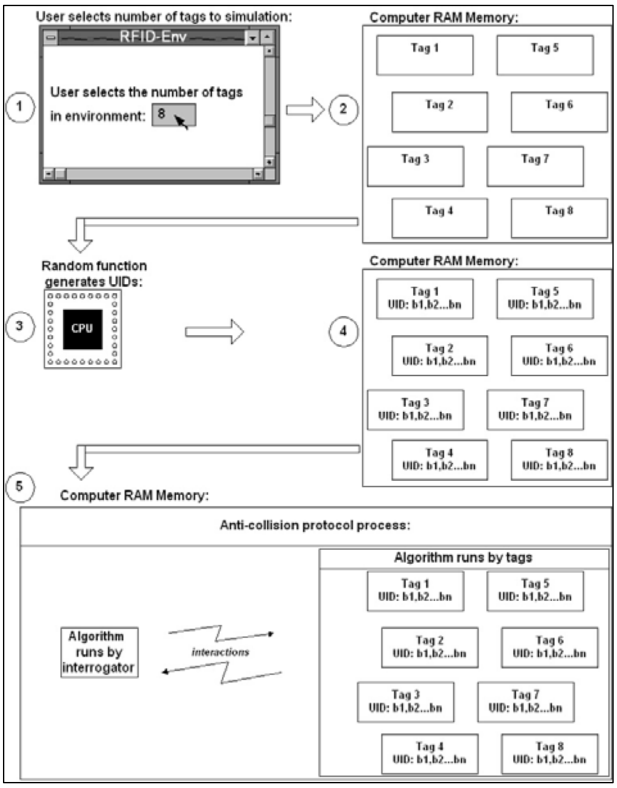

Figure 3 – Simulation environment and the initial stages of RFID-Env operation.

When execution starts the user is requested to input the number of simulation tags to be simulated (See Stage 1 in Figure 3). With this information the software creates a slot in memory where the values will be stored for each tag (Stage 2). When this is complete the process of generation of the UID for the tags commences (Stages 3 and 4). At Stage 5 the process that runs the specific algorithm of the anti-collision protocol to be simulated is initiated and begins to interact with the tags while at the same time the interrogator process starts up.

3.2 Experimental Operation

Having obtained the inputs on the type and quantity of the RFID tags, the system realizes a simple simulation of reading the tags, that is, of the anti-collision protocols. As an example, we will demonstrate the report of a simulation of reading 10 tags using the ISO 18000-6 B (Btree Anti-Collision Protocol) standard. The algorithm utilized by the Btree has a determinant difference in relation to the ALOHA-based protocols – it does not include the concept of the communication frame size (*round size)* (ISO/IEC 18000-6, 2006a).

In the other three ISO protocols the dimensions for the initial *round sizes* are required, but the Btree approach eliminates this necessity. This algorithm has an advantage in that while the algorithms utilized by the ISO 18000-6 A LST and FST standards return very poor performances when reading more than 256 tags, (because this is the maximum *round* size) the Btree does not suffer from this limitation (ISO/IEC 18000-6, 2006a; ISO/IEC 18000-6, 2006b and SHIH et al, 2006). On the other hand, the Btree utilizes a concept where the first iterations of the algorithm, that is, the first communications between the tags and the reader, tend to generate many collisions, as can be seen in the RFID-Env utilization example presented below.

When the number of tags to be simulated is provided, the RFID-Env executes the algorithms and generates the outputs and totals for the final simulation results at the end of the report. (See Figure 4).

```
-----------------|BTREE|----------------
--Iteration #1, Tags that replied:
E0E069FEC02185EC20 | E0B4909015F4627A76
E08C1013BF9FCB2BAE | E059592730460AF424
E0BB6B2EA85B402E70 | E0D49AC0DD20AEE2E7
E041E50008FC2F6965 | E096E4892AAEA7DCF9
E03783A6E0D9449A7D | E0A77048EDBEF83434
--Iteration #2, Tags that replied:
E059592730460AF424 | E0BB6B2EA85B402E70
E0D49AC0DD20AEE2E7 | E041E50008FC2F6965
E096E4892AAEA7DCF9 | E03783A6E0D9449A7D
E0A77048EDBEF83434
--Iteration #3, Tags that replied:
E041E50008FC2F6965 | E03783A6E0D9449A7D
E0A77048EDBEF83434
--Iteration #4, Tags that replied:
E0A77048EDBEF83434
--Iteration #5, Tags that replied:
E041E50008FC2F6965 | E03783A6E0D9449A7D
                    ...
--Iteration #11, Tags that replied:
No tag replied
                    ...
--Iteration #27, Tags that replied:
E08C1013BF9FCB2BAE
---------- Performance Report ---------
Tags: 10
Iterations: 27
Iterations with tag collision: 13
Iterations with no tag reply: 4
```

Figure 4 – Report of execution of the Btree protocol, with 13 collisions, 4 empty slots and a total of 27 slots utilized for communication of 10 RFID tags.

When the number of simulation tags is given, RFID-Env executes the simulation generating a report with iterations and performance summary.

Figure 4 shows that during the first iteration, all 10 tags try to transmit their information, generating many signal collision. After the first frustrated transmission, all tags randomly select zero or one value. Tags that generated one increment their slot counter and they will only retransmit when their slot counter reaches zero. Tags that generated zero do not need to increment their slot counter and keep having the opportunity to retransmit on the next iteration.

If more than one tag randomly select zero (which happens in the second iteration of the Figure 4), again these tags randomly select a new zero or one value, while the ones that already had one in their slot counter (the other three tags in the environment) increment once again this value. These steps are repeated, until only one tag has randomly selected zero and all the others had randomly selected one, which happened in the Iteration #4. This characteristic of many collisions on the first Btree iterations is proper of this protocol.

The final report of Figure 4 shows that the algorithm execution needs 27 iterations for 10 tags reading, considering that 13 slots had tags collision and 4 slots without any tag transmission.

4.Results

4.1 Physical parameters consider by the RFID-Env system

This section presents the physical parameters considered by the RFID-Env, the way they are analyzed and the influence of these parameters on the final results of the simulations.

4.4.1 Maximum reach for reading, velocity and total exposition time

The maximum distance for proper reading varies, on the tag side, because of the following principal factors: (i) tag speed; (ii) the material on which the tag antenna is mounted; and (iii) the presence of spurious magnetic and physical interference in the environment. On average, the UHF tags can operate at distances of 5 meters between the tag and the interrogator antenna, but the average can vary between 3.65 and 10.66 meters depending on the frequency of operation and the tag material (CHENG and JIN, 2007; FRIEDRICH, 2007 and INTERMEC, 2007).
The RFID-Env system considers these values in the following manner: given the average read reach distance of the tags of the system to be simulated and the speed of movement of the ticketed product, it is possible to calculate the total time each tag is exposed to the interrogator. From the values of reading speeds found in the references in ISO/IEC 18000-6 (2006a), ISO/IEC 18000-6 (2006b), Friedrich (2007) and ATMEL (2007) and the quantity of bits to be read from ach tag, the following formula can be solved:

$$\textit{total exposition time} >= [\ \textit{time to read}\ \ (y \text{ bits} * \ n \text{ tags})] \qquad (1)$$

Where:
total exposition time: total exposition time of the group of tags to the reach the interrogator reading distance
y bits: amount of bits of each tag
n tags: amount of tags to be read

In order to calculate the total time that each tag is exposed to the interrogator, it is first necessary to determine the maximum reading reach to the right and to the left of the interrogator antenna. Considering the situation of an environment based on a conveyer belt moving from left to right and with an antenna pointed directly at the tags, it can be seen that a point exists (T1 on Figure 5) where the tags enter the leading edge of the interrogator reading range. Point T2 is the exact front center of the interrogator and is half the distance traveled by the tag within its reading area. As a corollary, one can say that a point T3 also exists to the right of T2, where the tag moves out of the reading range of the interrogator. It is the sum of these two distances that provides the total exposure in meters (m) of the group of tags to the reader. Dividing this value by the velocity per second (m/s) of the tag movements, one can obtain the total time of exposure. This is the time *x* cited in formula (1) in which the interrogator should succeed in reading all the bits of all the tags on each of the moving packages.

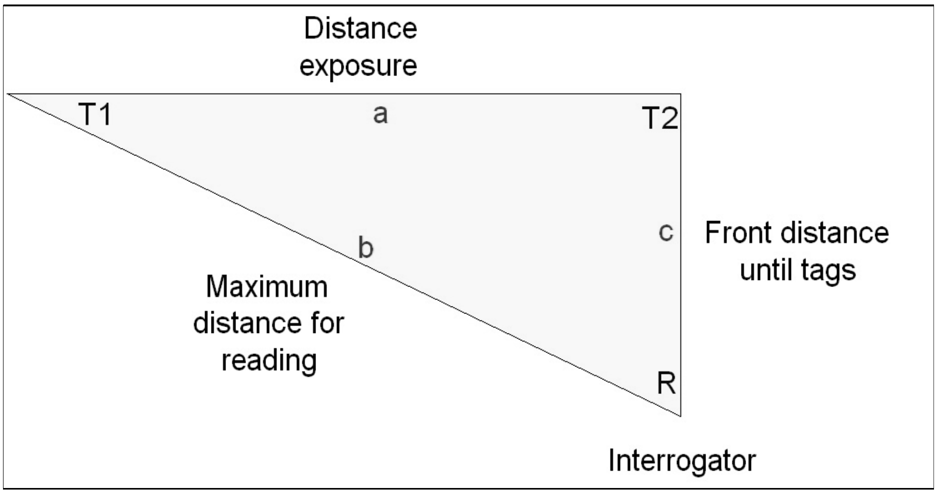

Figure 5 – Calculation of the time and distance of exposition

RFID-Env users need to supply somewhat simpler information about the environment especially since this is generally known in advance. Figure 6 shows the input screen in the Single Mode, where the following information is required: (i) Temperature; (ii) tag material; (iii) maximum reading reach; (iv) speed of tag reading;(v) speed of movement of the tags; and (vi) frontal distance between the interrogator antenna and the tags, that is the distance (c) or the minor cathetus of the rectangular triangle shown in Figure 5.

It should be noticed that the calculation of the total time necessary for reading a group of tags is realized after the simulation of the complete reading of the group of tags with the anti-collision protocol selected on the initial RFID-Env screen. Given the total number of slots necessary for reading the group of tags the simulator will calculate:

$$t\_total = total\_number\_of\_slots \;\; X \; each\_slot\_reading\_time \qquad (2)$$

Where:
t_total: total necessary reading time of the group of tags
total_number_of_slots: number of slots generated in the simulation

each_slot_reading_time: amount of bits to be read in each tag divided by reading speed value of the tags

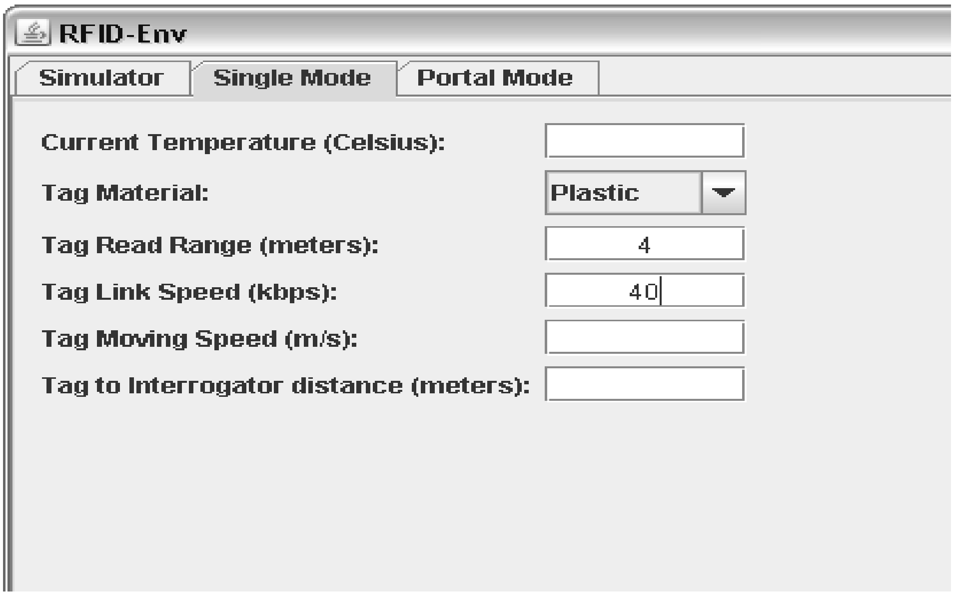

Figure 6 – Data for the analysis of the environment in Single Mode

With the information obtained in the interface of the Single Mode, the RFID-Env can calculate the distance of the cathetus (a), in view of the fact that the maximum tag reading distance is the length of the hypotenuse (b) . The frontal distance between the interrogator antenna and the tags refers to the cathetus distance (c). This configuration of the environment represents a geometric situation in the form of a rectangular triangle whose measurements may be calculated using the theory of Pythagoras. In Figure 5, the formula used by the RFID-ENV for calculating the cathetus length (a) is the following:

$$a^2 = b^2+c^2 \quad (3)$$

The interface of Figure 6 shows the type of material selected (plastic) and the maximum distance of 4 meters typical for this material (INTERMEC, 2007). Depending on the material selected by the user, the value of the reading distance of that material is shown in the Tag Read Range box. But as this value may vary from one manufacturer to another and for other physical reasons, this distance is merely suggested by the RFID-Env and the user can alter it to his/her convenience in the appropriate field to line-up with the technical information provided by his/her tag supplier. This applies also to the speed of reading the tags – the RFID-Env suggests a speed of 40 Kbs but the manufacturers figures may be different.

Given this information, the RFID-Env can predict situations where it is physically impossible to read a stated number of tags. An example is given in the report generated by the RFID-Env and shown on Figure 7 – here the information supplied by the user were: (i) maximum reading distance (hypotenuse) of 4 meters;(ii) Reading speed 40 kbs; (iii) tag movement of 5 m/sec; (iv) frontal movement (cathetus c) of 2 meters. This data referred to a group of 1000 tags (for example, a box containing 1000 products moving on a conveyer belt) using the ISO 18000-6 protocol. With this configuration, the RFID-Env could state that it was possible that the system would not work.

```
-------------------|ISO 18000-6 C Protocol |-----------
-- Performance Report –
Tags: 1000
Slots needed for all tags to reply: 2822
Slots with tag collision: 727
Empty Slots (with no tag reply): 1095
Total required time to read all tags: 2.82 seconds (worst case)
Calculated Total Exposition Time: 1.38 seconds
------------------------------------------------------
With this configuration the group of tags could not be fully read.
------------------------------------------------------
```

Figure 7 – RFID-Env Red Alert – Reading impossible for physical reasons.

Some solutions for the problem detected by the Simulator and described in Figure 7 could be (i) Change the communication protocol to reduce the number of slots necessary; (ii) reduce the number of tags to be read ´´simultaneously`` (i.e the number of tags on one package); (iii) slow down the transport speed; (iv) alter the distance between the tags and the reader; or finally (v) a combination of some or all of the above.

4.1.2 Temperature

The environmental temperature has a profound effect on the time that the registers can maintain storage of the ´´0´´ and ´´1`` logic values (ATNEL, 2007). Basically, the registers can increase the storage time when the temperature falls below 25^{o} but when the mercury rises above that level, the registers start to lose storage capacity by more than 8 s. In addition, operation may cease altogether at some temperatures and the RFID-Env is designed to consider this factor. Thus, if the user specifies a value outside the temperature limits supported by typical circuits, an Alert Signal generated by the RFID-Env informs the user of that fact.

As development improvement work continues on the RFID-Env, the instrument will be enabled to take into consideration the time that the register values can be maintained at different temperatures. This information may be related with the read speed of each tag and the length of time the value is exposed to the electronic reader, the number of tags present in the environment, and physical interferences which result in the tags being without power for brief periods of time. Because of these relationships, the environmental temperature may strongly influence the simulation results

4.2 RFID-Env: environment type configuration

Taking into consideration some of the typical environments in which RFID systems are installed, the RFID-Env user can simulate the reading of a group of tags in three ways: (i) by ignoring possible variations in the environment (Simulator Mode); (ii) conveyer belt mode with an antenna (Single Mode); and (iii) Portal mode for pallets (Portal Mode).

The process of simulation starts in the principal window as shown in Figure 1. If the user only wants to simulate the operation of a one or more anti-collision protocols without considering the physical variations of the environment, only this interface needs to be used. While still in the principal window, it is possible to visualize the selection field for the type of environment: (i) None (simulation without environmental variables); (ii) Single Mode; or (iii) Portal Mode. The respective tabs are activated or not in accordance with the mode selected.

If a user desires to test a conveyer belt environment, he/she should select the Single Mode. This will cause the respective window to be activated and information specific to that kind of

environment to be requested such as: (i) temperature in degrees Celsius;(ii) type of material in which the RFID chip and the tag antenna are mounted; (iii) read speed in Kbs of the tag in use in the environment; (iv) speed of movement of the products on the conveyer belt in meters per second; and (v) the frontal distance in meters between the antenna and the conveyer belt. As soon as the type of tag material is selected, the corresponding value in meters will appear in the box provided for the typical value of read reach (between the antenna and the tag) for that type of material. For example, when the user selects glass, the number 2 will appear in the box, the number 4 for plastic and so on. These values, which are typical for various manufacturers, were obtained from references by Cheng and Jin (2007), Friedrich (2007) and INTERMEC (2007). In any case, these are values suggested by the RFID-Env system as a reference guide for the user, and he/she can easily alter them to reflect the real values obtained from the manufacturer's technical specifications for the tags actually being used.

4.2.1 Portal Mode – quantity of antennas *versus* measurements of portal and pallets

As shown in Figure 2, the RFID-Env Portal mode is designed to simulate environments with portals in the form of tunnels through which pallets and other transporter packages can pass. In addition to the information required for the Single Mode (distances, temperature, and read speed) the Portal Mode needs the dimensions of the Portal and of the pallets carrying the ticketed products. The user should input also the number of interrogators and antennas in the portal. Usually, each interrogator is limited to four antennas.

In relation to the antennas located in the portal, the user may select the position of each antenna (up to a limit of eight antennas simultaneously if the option of two interrogators was chosen). The simulator should be provided with the approximate direction of the antennas in relation to the total of tags to be read, assuming that all the ticketed packages are uniformly distributed over the transporter, that is, if the user selects an antenna in each face of the Portal, (left, right and upper) the simulator will consider that n tags are distributed facing these three direction equally, which would mean $n/3$.

From the measurements of the portal and the pallet, the Simulator can determine the lateral and superior distances between the pallet and the interrogator antennas selected as active by the user. In the present version of the RFID-Env the Portal Mode operates in the same way as the Single Mode, but with the difference that in the Portal Mode the number of tags to be measured are divided by the number of active antennas. This division is performed by the simulator in accordance with number of directional antennas located in each part of the Portal as described in the previous paragraph. The lateral antennas work in exactly the same way as in the Single Mode, but the upper antennas, although they too work in the form of a ´´rectangular triangle`` view this geometric form from a different angle to that of the lateral antennas. The advantages of a greater number of antennas in the portal are evident: an increase in the range of action in various directions and a reduction in the total number of tags captured by each antenna. For the situation demonstrated in Figure 7, (where the simulator found that it is impossible to read the tags in that environment), one can make a simple calculation, where, for instance, the 1000 tags are now divided between, let us say, eight antennas. This would reduce drastically the number of simultaneous readings required from the system.

As the development of the RFID-Env continues, the parameters of analysis of the Portal Mode will be amplified, for example, by a more detailed consideration of the focus and positioning of the antennas, and of the antenna type itself. Antennas are available with characteristics designed to operate over greater distances but only in a straight line while others are better at reading wider angles. Greater attention will also be given to the physical characteristics of the ticketed products and the interference these materials cause by scattering the RF signal. It is known that the products in the center of the pallet present the greatest reading difficulties because of the interference re-transmitted from the surrounding products.

5. Conclusions

This paper describes the results of experimental research undertaken to develop an innovative product – the RFID-Env, Software for Simulating RFID Environments. The product is intended for use by developers in the computer sciences, and by engineers doing research and development (R&D) for the solution of RFID problems, and makes it possible to simulate a complete range of virtual RFID environments so that research and development can proceed in a non-factory atmosphere.

The functionality and the applications of the Software RFID-Env were demonstrated showing how the product permits simulation of the operation of four RFID protocols standardized by ISO 18000-6, the types A LST and FST, the type B, and the type C.

The experimental application demonstrated that this new product can help potential users of RFID systems to select the protocol which will best attend the characteristics of the system they intend to implement.

Considering the physical characteristics of an environment proposed for implementation of the RFID technology, such as the speed of the tags in relation to the interrogators, the distances, the number of antennas in the location and the number of tags to be read simultaneously, the RFID-Env can avoid waste of money by determining if the particular standard or environmental configuration under consideration will in fact attend the necessities of the particular situation.

This work will be continued to introduce more consideration of the physical environment, such as the interferences produced by the ticketed products themselves by scattering the RF signals, and the models, positioning and focusing of the antennas. The present RFID-Env version does not permit adjustment of the antenna direction.

Another improvement to be implemented is the possibility for the software user to indicate the size in bits of the information on the tags (UID or SUID) in his/her system, so that the simulator knows the exact quantity of bits to be read, and can thus indicate which protocol would be best to cater for the necessities of any particular RFID project.

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