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RFID System Applicability Model for Traceability of Luggage at Airports

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Abstract *- One of the critical points in the framework of air transport, is the management of luggage at airports. Every year, a large number of people feel the need to travel for various reasons and that efficient management is a difficult task that needs to keep up with the growth demand in a satisfactorily. One of the problems that has not been solved is exactly the loss, misplacement or mishandling of baggage at airports, given the difficulty of the current management systems to monitor the baggage, which causes unwanted situations to life. Radiofrequency Identification Technology (RFID), integrated with an information system, presents itself as a solution to numerous daily setbacks in various segments, because its main feature is basically to capture information at a distance about some element in movement. By implementing a smart tag (tag) in each baggage, it becomes possible to trace it along the path. In order to solve this problem, the present work aims to develop a prototype software, integrated with RFID, to simulate the control of luggage at airports by means of three scenarios where luggage misplacement may occur.*

Keywords - Information Technology, RFID, Traceability.

I. INTRODUCTION

Traveling is something that is part of the daily lives of people, whether it's for business or simply leisure and choice of an aircraft as a means of transportation for this purpose, has been common. Hence arises a problem quite often, it's the luggage misplacement. One of the biggest fears of travelers is that something goes wrong. Proper planning already prevents more than half of the problems, but it's good to be prepared for unforeseen events, mainly in relation to the belongings.

According to the report from the Ministry of Labor and Employment (MLE), the total passenger movement in Brazilian airports, as graph of the illustration 1, increased 2.56% in August 2017, compared to the same period in 2016, with a rate of monthly medium growth of 2.59% from March of the same year [2].

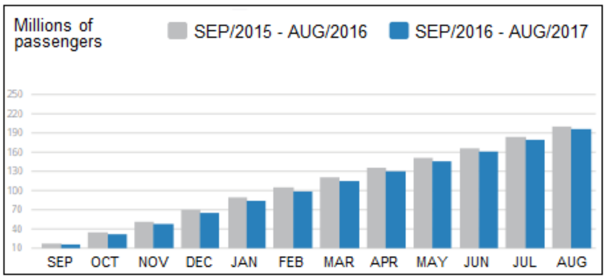

Fig. 1 – Movement of passengers in Brazilian airports in 2017 [2].

Every year, over 3 billion luggages are checked at airports all over the world, an impressive number that will continue to increase drastically in the next two decades [8].

The movement of loads also had a relevant increment, in the comparison between August 2017 and August 2016, being registered a growth of 12.56%, with 96 thousand tons in the month. Year to date through August 2016, the air cargo market obtained a growth of 8.23% in the load tonnage transported in relation to the same period of the previous year, having the domestic and international market grown in similar magnitudes, 7.42% and 8.59%, respectively [6].

Given these expressive numbers and the current demand for this type of transport, the airport infrastructure needs to follow the demands of users, who are often harmed. In Brazil, not especially, there is much to be done in relation to improving the management of baggage and passengers. For now the solution consists in indemnity, that is, compensation for the damage caused by the loss of the

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luggage after the fact accomplished. That depends on each airline.

A new International Air Transport Association (IATA) resolution came into force in June 2018, forcing airports to ensure that their baggage handling systems come into compliance. The resolution is mandatory for IATA members, who represent 85% of global air traffic. Airlines must set up four baggage tracking points (check-in, loading, transfer, arrival) and share these data with everyone involved in the process. With the implementation and fulfillment of Resolution 753, IATA intends to increase customer satisfaction, reduce overheads and curb fraud and robbery [7].

A technology that has been expanding worldwide is the Radio-Frequency Identification (RFID). According to reports from International Air Transport Association (IATA), RFID holds the potential to save industrial aviation, generating savings of 3 billion dollars, over seven years, improving the management and operation of the baggage, as shown in figure 3. The technology has high reading performance and low maintenance cost. Initial implementations show that the bags are tracked at a rate of over 99%, allowing reduction of manual operations and can be deployed for only US$ 0,1 per passenger [8].

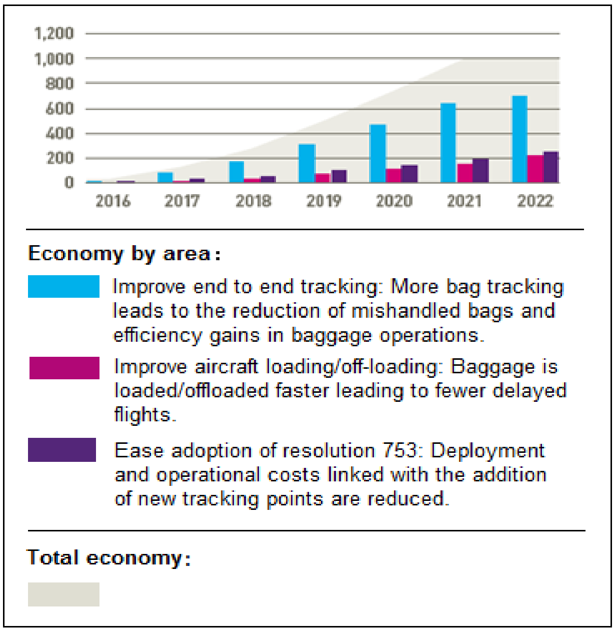

Fig. 2 – Economy, in millions of dollars linked to the adoption of RFID [8].

Some airports around the world already use this technology, such as the international airports McCarran, in Las Vegas, USA, and Hong Kong, in China. The McCarran, in 2005, was the first from the United States to install a system based in RFID for the control of luggage. At check-in, an employee of the airline McCarran inserts a luggage label for the destination. This label (tag) also has a RFID UHF chip, EPC standard (Electronic Product Code) Gen 2, with a unique identification number that relates the luggage to your flight and destination, through the Vanderlande's software known as VIBES. The airport also has installed 130 self check-in kiosks, so that the passengers could print their own RFID tags. The cost in this period was 5 million dollars a year with passive tags, but through a mass adoption, the price of the chips, which cost more than 1 dollar each, could be reduced [5].

Hong Kong International Airport, which began its RFID program in 2004 and answered about 48 million passengers a year, has updated its bar code system by radio frequency identification at a cost of HK $ 50 million $ 6.5 million). The overall reading accuracy of the airport baggage handling system increased from an average of 80% with the bar code to 97% with the RFID tags. Due to this constant technological evolution it remains one of the best airports in the world [10].

With the help of this technology it is possible to control all objects that have electronic tags deployed, from the information contained in each object. Such data can be provided for viewing through an interface with the user, being possible to extract some information in real time and accurately. Currently, there are few companies that use this technology worldwide, mainly due to its deployment cost. However, the trend is that this technology be spread more with the reduction of costs.

In order to solve this problem, this article aims to develop a prototype software, integrated with RFID, to simulate the luggage control at airports by means of three scenarios where there may occur misplacement.

II. THEORETICAL REFERENCE

2.1 SURVEY ON LOST LUGGAGE

In 2015, all over the world, about 10.4 million luggage were lost [8]. The scene is increasingly common in Brazilian airports: boarding an airplane and, upon arrival at the final destination, not get the bag back, or find it violated.

A survey conducted in 2016 by SITA, as shown in picture 3, displays the amount of bustling luggage over 10 years:

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
35.5	46.9	36.9	28.2	32.3	25.3	26.3	21.8	24.3	23.1

Fig. 3 - Movement of luggages, in billion, per year (8].

Another survey conducted by the website Reclame Aqui, through the intelligence tool Knowit, showed an increase of 96% of the number of complaints involving luggage, against airlines, between June and October 2017 [6].

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According to SITA, according to a report carried out in 2015, of all the problems related to luggage, 79% are about misplacements, 15% concerning to thefts and damages and 6% to robberies and losses. And related to misplacements, which represent the most of the problems related to luggages, of 10.4 million misplaced luggage in 2015, the most common causes are represented in the graph of figure 4:

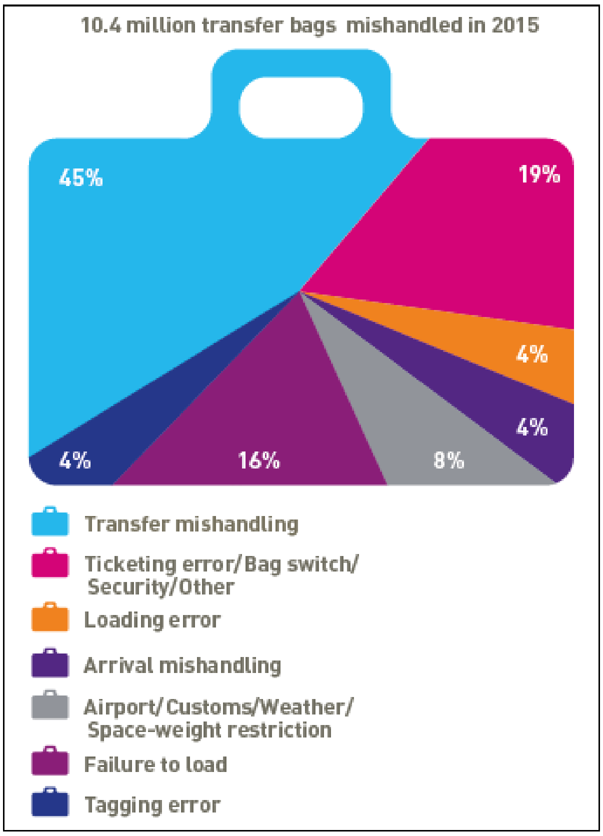

Fig. 4 - Main causes for misplacement of baggage [8].

According to specialists, apart from the lack of policing to prevent thefts, the strong growth of the sector, without infrastructure improvements at airports, has contributed to the increase of luggage misplacements [1].

2.2 PROCEDURE AFTER LOSING A LUGGAGE

When the luggage does not appear it is necessary to seek and airline employee and fill out the Registration of Baggage Irregularity (RIB) or a similar form, such as the Property Irregularity Report. It works as an occurrence bulletin, in which you fill out the necessary data to start searching for your belongings.

When a suitcase does not arrive at its destination, the airline makes a search in the holds of the airplane, in the passenger's terminal and cargo sheds and also send the information about the luggage to computerized networks of tracking. In general, the airlines begin the search for the external characteristics of the suitcase. After some days, it starts a second search phase, for the content of the luggage. In Brazil, the misplacement of a suitcase is characterized if it is not found within a period of thirty days. But this may vary from company to company, mainly among the international ones. After this period, it begins the compensation process to the passenger for the lost luggage.

2.3 RFID SYSTEM

This identification technology uses radio frequency signs to do the communication between a reader and a tag with RFID chip to capture the data that will identify the object that carries the label (tag).

Characteristics	RFID	Bar Code
Mechanical resistance	High	Low
Formats	Several	Tags
Requires eye contact	No	Yes
Lifespan	High	Low
Possibility of Writing	Yes	No
Social Reading	Yes	No
Data Stored	High	Low
Additional Functions	Yes	No
Safety	High	Low
Initial Cost	High	Low
Maintenance Cost	Low	High
Reuse	Yes	No

Fig. 5 - Comparison between RFID and barcode [3].

As it can be seen in the table of figure 5, the advantages of RFID on the bar code are countless. This way, RFID can be seen as the technology substitute of bar code, this technology was developed in the 60's and currently essential for identification of any marketed product. With the expansion of RFID it is necessary to understand how this technology works which is so present in the current technological debates.

As it can be seen in figure 6, the RFID system is composed basically of three components: the antennas, the tags and the reader. Briefly the operation of this system happens in the following way:

1. The reader is connected to the antenna, generating the radio frequency signal;
2. When a tag enters the coverage area of the signal generated by the reader, it happens the reception of energy and activation of the circuits;
3. Tag circuits are energized by the reader, engaging reading tag data of the tag that you/they are sent to the reader;
4. The reader processes the information and stores the identifier of the tag, sending it to a server that will be processed by a computer system.

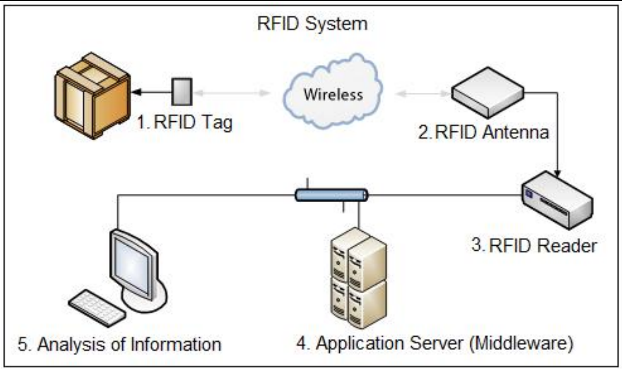

Fig. 6 – RFID System.

2.3.1 ANTENNAS

The antenna is the RFID system element responsible for radio frequency signal propagation. They are radio waves that correspond to electromagnetic oscillations, generated by the reader. It is the simplest component and it has the lowest cost of the entire system.

There is a wide variety of commercially available antennas and since they are passive elements, which only depend on the frequency of operation, several models can be used in a RFID system.

2.3.2 TAG

The tag, also known as smart tag or transponder, the element of identification of the RFID system, being composed of three basic components: antenna, integrated circuit and encapsulation. The composition between the antenna and the Integrated Circuit (IC) or RFID system, receives the name of inlay and after being encapsulated becomes a RFID tag. The construction and use of the tag is also tied to the definition of the system as a whole. The tags can be passive, in which they obtain energy through magnetic field generated by readers or they can be active, when they have a battery that supplies the energy to perform processing and signal modulation. The active ones have battery, a component that increases its cost, while passive tags have no battery which reduces.

2.3.3 READERS

Readers are interface elements between the tags and the systems. Technically, they are responsible for converting radio waves reflected from the RFID tag in digital information to be processed by computers. As all the other system components, readers have several characteristics that, according to the desired application, should be evaluated so that the chosen equipments add the features that more assist the needs of the project. A RFID reader can be sorted according to its mobility by the following types: fixed and mobiles. Mobile readers are those which are connected to a Personal Digital Assistant (PDA), a pocket computer, data collectors or notebooks and they are used for applications where it is necessary to go until the identified item and perform the reading of the tag. Fixed readers are those which have direct interface to computers or even network interfaces and connect directly with local computer network. These readers have optimized performance and provide the greatest reading distances [4].

2.4 EPC

The EPC (electronic product code) consists of a sequency of numbers and letters, encompassed in a header and three sets of data partitions. By separating the data into partitions, readers can search for items with code of a particular manufacturer or product. This becomes it possible, for instance, to find more quickly products which might be approaching its expiration date or that need to be collected. That way the RFID, with the use of this standardized system of codes, helps to reduce human mistakes, due to its ability to record all objects at once [5].

III. MATERIALS AND METHODS

It was accomplished a simulation, through a software emulator, to solve problems related to misplaced luggages at airports. The proposed scenarios were mapped according to potential situations for occurrence of misplacement, having the necessary equipments: readers, antennas and tags.

The software used as development environment was Delphi 7. The emulator used for simulation of the scenarios was RIFIDI. The database management system was *Firebird 2.5*. The integration between the development environment and the emulator occurred through *sockets*, using the TELNET protocol. The communication between the integrated system and the RFID reader, as shown in figure 7, was accomplished through USB, serial and Ethernet.

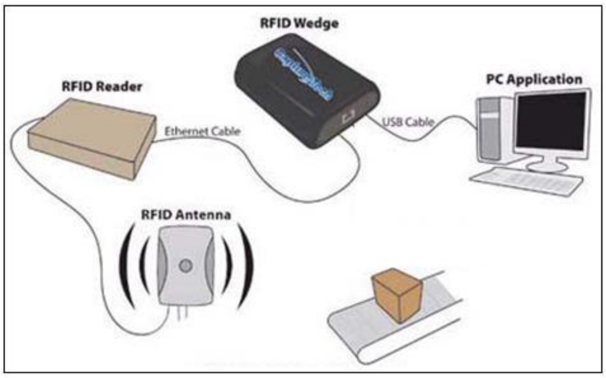

Fig. 7- Communication equipment

3.1 RIFIDI EMULATOR

Rifidi emulator was used to create a test environment in order to simulate real-world events required for the study. With the aid of the emulator we created the *tags*,

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simulated the reader performance and established the necessary connections. It was not possible to simulate all possible physical interference problems. The basic operation of the emulator, as shown in figure 8, offers multiple readers and antennas disabled by default. This way, to simulate a specific tag in the field of the view of the antenna, you must select one of the tags created and drag it to the main module of the emulator. Once this is done, the antenna sensor, green and red field, begin to oscillate showing that a tag has entered the view field of the antenna. Thus, the information can be handled by the virtual reader and transferred to the software [9].

Fig. 8 - RIFIDI Emulator

IV. RESULTS AND DISCUSSIONS

The scenarios refer to typical situations in which may happen intentional or unintentional misplacement of luggage. The developed *software* will simulate the baggage control in three scenarios: dispatched baggage to the airplane (in the luggage compartment); the airplane exit (exit of the luggage compartment); exit of the airport (arrivals). The equipments used for the scenarios are: RFID antenna panel, fixed RFID reader, passive tag and monitor with sound.

We will use antennas of type panel, which are more suitable for projects that require greater coverage area for identification. The polarization used will be linear, by the fact of having more quality in the propagation of the signal and information capture.

4.1 SCENARIO 1

The front door of the baggage from the airplane, an antenna and a RFID reader are installed to read the placed tag in the luggage, as shown in figure 9. So, the operator has only to verify if the luggage is in the correct destination through the system panel. If the luggage is in the incorrect destination, the system will emit an error beep, so the luggage will return to the airport, as the flow of figure 10. All checks will be performed based on the flight information stored in the database.

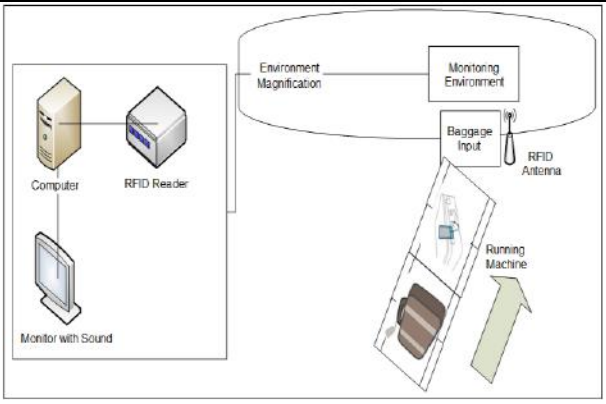

Fig. 9- Architecture of equipment in the airplane compartment.

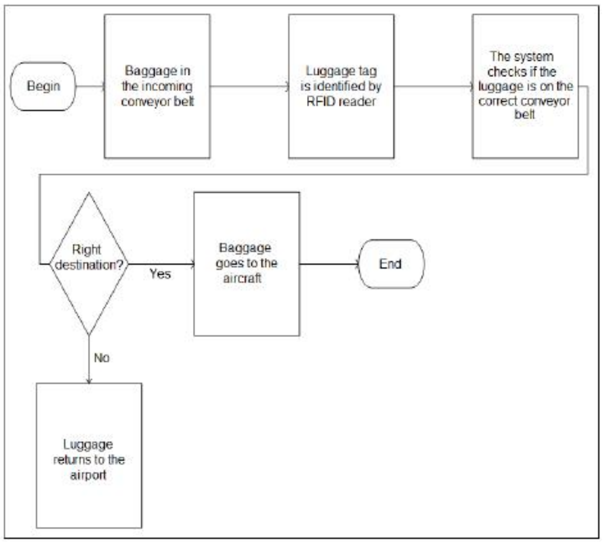

Figure 10 - Flow scenario 01

4.2 SCENARIO 2

In the exit door of the airplane's luggages, and antenna and a RFID reader will be installed to read the tag placed in the luggage, as shown in figure 11.

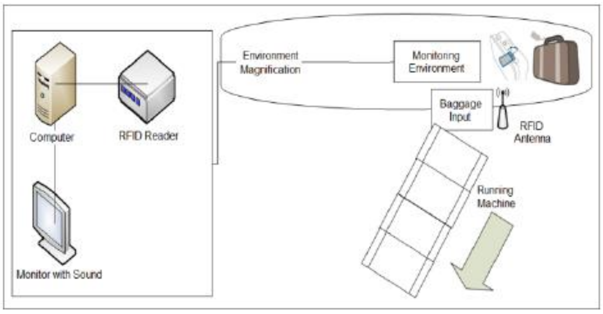

Fig. 11 – Architecture of the equipment of the airplane exit.

The operator should check in the system if the luggage came from the correct destination. If the luggage is in the wrong destination, just like in the first scenario, the system will emit an error beep, preventing the luggage off the airplane as the flow of figure 12.

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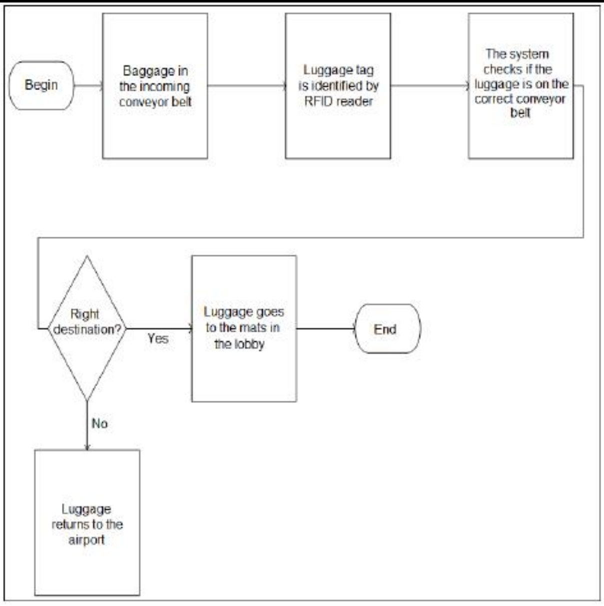

Fig. 12 - Flow Scenario 2

4.3 CENÁRIO 3

In the airport lounge there will be also an antenna and a RFID reader, as shown in figure 13. The passenger who disembark, will pass through the gate where will be held the tag reading of the luggage and tickets. If both tags are attached, the resonant monitor will not accuse, as the flow of figure 14. However, if there's no relationship between the two tags, the system will emit a resonant alert in beep form, preventing the passenger take the luggage and alerting the responsible for monitoring, who should take the proper measures.

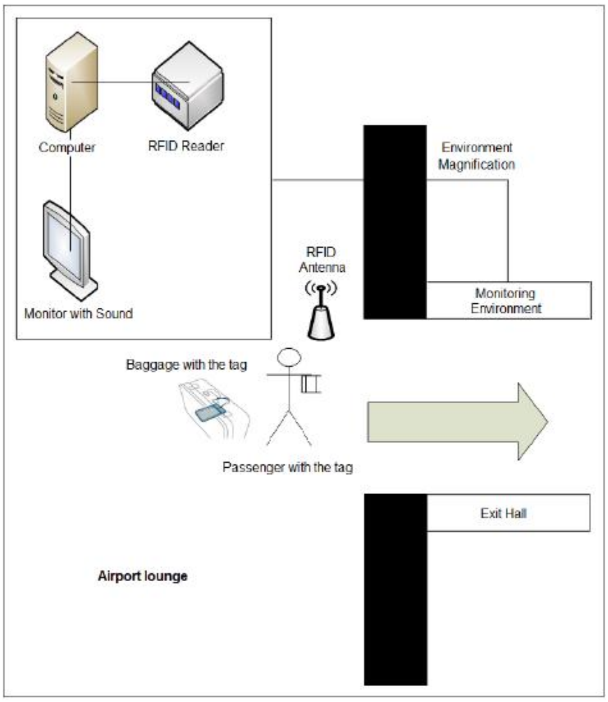

Fig. 13 – Architecture of equipment in the lobby

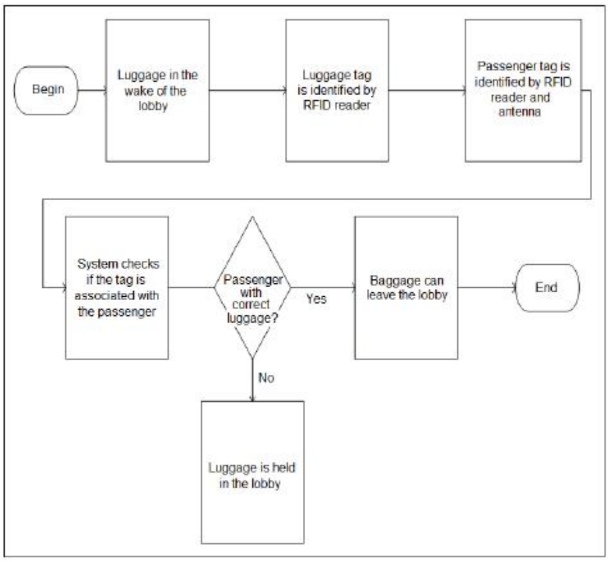

Fig. 14 - Flow scenario 3

4.4 PROTÓTIPO DO SISTEMA

The conceptual model of the prototype of the system is simple. The luggage is associated with a tag, which is associated with its flight and ticket, forming a ternary relationship, as shown in figure 15:

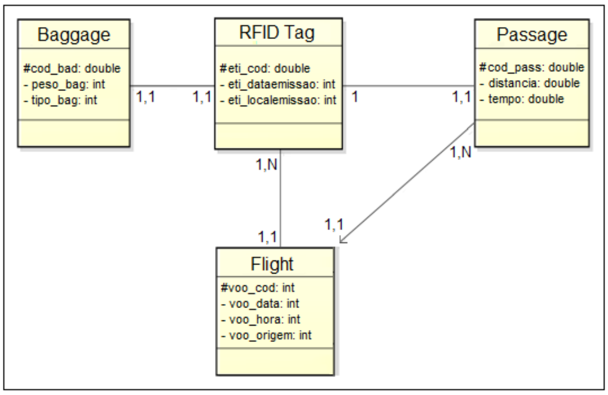

Fig. 15- System Class Diagram

In the presentation screen of the application, that corresponds to the check-in, the operator inserts the individual passenger data, such as name, ID number,flight number, phone number, as shown in figure 16. If the passenger has luggage to be dispatched, it will be generated a random and unique tag loaded from database, for identification of the luggage. After check-in confirmation, the association between the luggage tag, the passenger and the flight are associated. In case of error, the process can be repeated.

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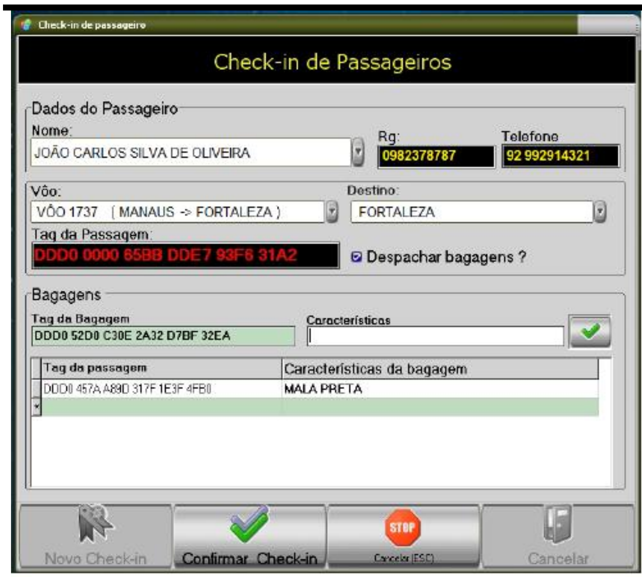

Fig. 16 – Check-in Screen

After check-in, the operator will be directed to as second screen, which represents the simulation of the luggage going to the airplane. The control and the correct entry of baggage occur at this stage, as shown in figure 17. In the system, simply select the flight and click the start button, so the tags will be processed and associated with the desired flight.

Inside the airplane will be carried out a comparison between the selected flight at check-in with the selected flight at this stage of the process. Having information, the luggage is released. Otherwise, the system will accuse error in the process with emission of audible alarm, preventing the luggage of passing.

Fig. 17 – Airplane's Input Screen

In the second scenario, as shown in figure 18, the luggage inside the airplane will be taken on arrival at the destination. At this time, they go through the reader, which identify whether or not to continue to the airport lounge. Not being the final destination of the baggage, the system informs the operator that the the case should remains in the airplane and move on to final destination.

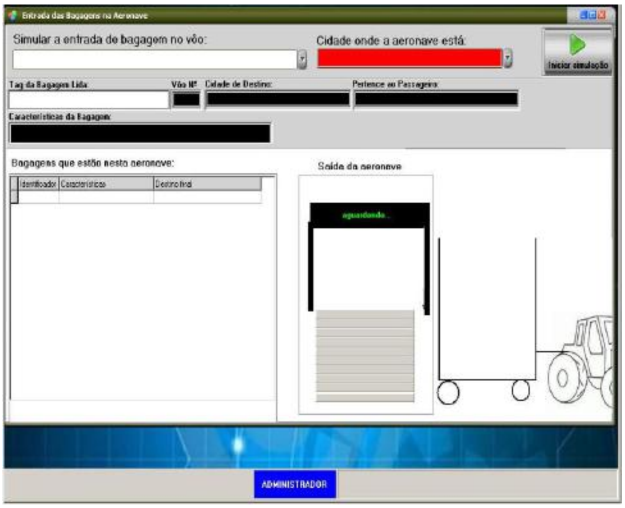

Fig. 18 – Airplane's Ouput Screen

In the last scenario, as shown in figure 19 and illustrated by the airport lobby, will be held the last check. At this stage, there is the comparison between the passage tag and the passenger's luggage tag. The baggage, being removed from the airplane, is directed to the airport. Then, the passenger with luggage in hand will still pass through a portal containing an antenna and a RFID reader. This last check is carried out to avoid the passenger get out with a different luggage of his/hers.

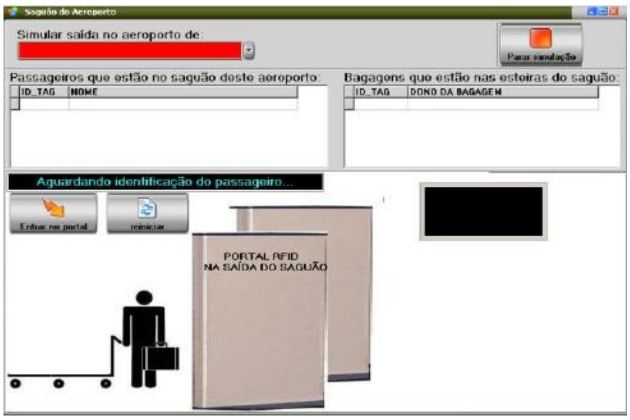

Fig. 19 – Airport's lobby screen

RFID technology is a premise for the control and management of luggage in the airport sector and, no doubt, has the potential to save the aviation industry. The technology used today in air transport is obsolete, mainly because of the lack of investment in transport of bags.

With the support of the emulator, we evidenced the behavior of the system in the proposed scenarios, enabling the development of a viable situation, integrating

to existing systems. The implementation of this system will help to control the spread of frauds attempts and thefts, besides reducing the costs generated by too much misplacement of luggages, such as reimbursements and indemnities. It becomes a solution for companies that need to come into compliance with the resolution 753 of the International Air Transport Association (IATA).
In the simulation environment, the identification tests of tags were carried out successfully. On these aspects, the application becomes a useful tool able to be deployed.

V. CONCLUSION

RFID technology is a premise for the control and management of luggage in the airport sector and, no doubt, has the potential to save the aviation industry. The technology used today in air transport is obsolete, mainly because of the lack of investment in transport of bags.
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